KERR-McGEE CORPORATION

APPLICANTS ENVIRONMENTAL REPORT

USAEC
Docket No. 40-8027

Uranium Hexafluoride Plant

JUNE 1972

Supplemental

KERR-McGEE CORPORATION

KERR-McGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73102

P. S. DUNN
GROUP VICE PRESIDENT

June 30, 1972

Mr. S. H. Smiley, Director
Division of Material Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Smiley:

Please refer to your letter of April 12, 1972 and the letter of your Mr. C. R. Buchanan to our Mr. W. J. Shelley of March 23, 1972, describing certain deficiencies in the Environmental Report-Revised submitted to your office November 24, 1971.

In response to the request, we have prepared an Environmental Report-Supplementary dated June 1972, which is attached. It should be recognized that this report does not contain in duplicate all of the information submitted in the earlier report. As requested by Mr. Buchanan, certain sections have been expanded with additional detail or new material added. We have responded to all of the points raised by Mr. Buchanan in this Supplement.

In accordance with Section 2.790(b) of 10 CFR Part II we have separately requested that Tables VII, VIII and IX be withheld from public disclosure and have obliterated the information on the enclosed Tables.

We would be pleased to discuss all or part of this report at your convenience.

Very truly yours,

P. S. Dunn

P. S. Dunn

PSD:ks

Attachment

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S U P P L E M E N T A L

I. GENERAL

A. Report Content

An Environmental Report-Revised was submitted to the USAEC on November 24, 1971, in accordance with the requirements of Appendix D, 10 CFR Part 50, effective September 9, 1971. On March 23, 1972, the USAEC requested a supplement to the original report containing more detailed and, in some instances, additional analysis of the environmental impact of the Sequoyah Facility. This supplement is submitted in response to this request. These two environmental report sections should be considered as mutually supportive, neither considered as a complete document by itself.

The report does not follow in format the Table of Contents of the earlier report but, instead, is subdivided into four general sections discussing the plant site, the surrounding area, the plant and its processes, the environmental impact and a cost-benefit evaluation.

B. Permits and Licenses

Prior to construction, extensive consultation was held with the Oklahoma Water Resources Board and the Corps of Engineers as to the most acceptable method of diverting Illinois River water for use in plant cooling and potable water. Agreement was reached with the Oklahoma Water Resources Board on January 9, 1968, with the issuance of a "Permit to Appropriate Surface Water No. P-67-765" covering 30,000 acre-feet of water per year to be diverted from the outlet works of the Tenkiller Reservoir.

Subsequently, Contract No. DACW 56-70-C-0083 for water storage space in Tenkiller Ferry Reservoir was completed with the Department of the Army Corps of Engineers. These agreements permitted the diversion system to be designed and installed to remove water from the reservoir dam and pipe it to the site.

The State of Oklahoma is proceeding in an orderly fashion to evolve a set of environmental control regulations that are consistent with the U.S. Government regulatory activities. The Oklahoma Water Resources Board requires a permit for the disposal of water to riverways. This permit, No. IW-70-011, has been granted by the State to the Sequoyah Facility. Waste disposal has been certified as meeting Water Quality Standards.

Because this plant processes nuclear source materials, it was necessary to obtain an operating license from the USAEC. License SUB-1010 was granted February 20, 1970, based upon application submitted on September 25, 1969.

In accordance with applicable regulations under the Refuse Act of 1899, an application for a waste discharge permit was filed with the Corpos of Engineers on June 21, 1971, and supplemented on October 4, 1971. The Discharge Permit Application OK-076-OYI-2-000111 is currently being processed.

A sanitary waste treatment system was designed in accordance with recommendations made by the Oklahoma Department of Health. A Waste Treatment Permit for this sanitary system was issued August 21, 1969, and no further action or approval will be received from the Department of Health.

Appendix I contains a copy of the Waste Treatment Permit, the engineer's report on the sanitary waste treatment system and a technical assessment of the waste treatment system prepared by Dr. R. H. Ramsey of East Central State College.

The regulations of the Air Pollution Control Division of the Oklahoma State Department of Health prohibits open burning of trash materials and requires that an open-pit incinerator be installed and inspected by the Department of Health for such disposal activities. An open-pit, jet-fired incinerator was installed in the Sequoyah Facility and approved by the State Department of Health on July 26, 1971. A copy of

the application and approval is included in Appendix I.

By Executive Order of May 24, 1971, Governor Hall established the Eastern Oklahoma Planning District, including Sequoyah County, to coordinate planning functions with federal government departments charged with the responsibility of financing regional social development activities. As a result of this Executive Order, an Eastern Oklahoma Planning District Committee was formed and includes the counties of Wagoner, Cherokee, Adair, Sequoyah, Muskogee, Okmulgee and McIntosh and most of the municipal governing bodies interested in securing federal grants for the purpose of planning for urban renewal or other public works. Control of the installation and operation of industrial facilities in the region is not included under this agency's responsibilities.

Copies of all permits required by the State and Federal Government are attached in Appendix I of this report.

II. DESCRIPTION OF SITE AND AREA

A. Location

The plant site was selected from 10 potential sites in the Arkansas River Valley. Major factors involved in the decision were transportation, water supply, availability of land, absence of other industrial installations, quality and skill of available labor, low probability of destructive tornadoes, minimal seismic activity and a desire to benefit the chronically depressed economy of eastern Oklahoma.

The plant is located on a 2100-acre tract on the western edge of Sequoyah County. This tract is bounded on the north by U.S. Highway 64, on the west by the Illinois and Arkansas Rivers, on the south by Interstate Highway 40 and on the east by the eastern section line of Section 22. The immediate plant area is a fenced-in restricted area of about 75 acres in Section 21 (T12N-R21E) with access to Oklahoma Highway 10 adjacent to the eastern boundary. The site layout is shown in Figure 1. The plant site is approximately 150 miles east of Oklahoma City, 40 miles west of Fort Smith, Arkansas, and 25 miles southeast of Muskogee, Oklahoma.

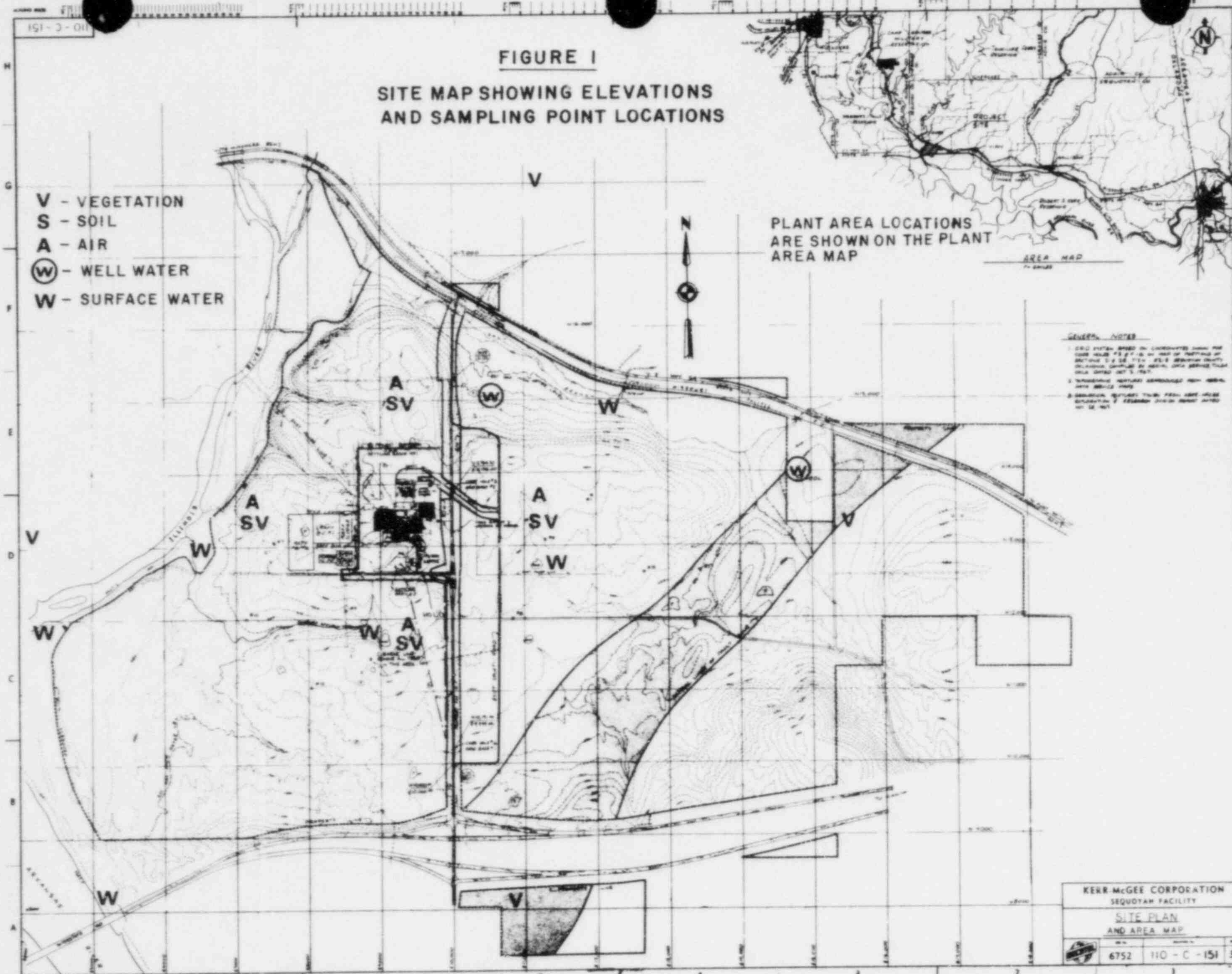


FIGURE 1

SITE MAP SHOWING ELEVATIONS AND SAMPLING POINT LOCATIONS

B. Use of the Site

When the site was acquired, a small soybean field was located at the west edge along the Illinois River and a small wheat field was located in the area now occupied by the plant. No significant cultivation has occurred on the site except for these two small fields. About one-third of the site is open and the rest is heavily wooded. The trees are mostly post and black-jack oak with there being a few hickory, pecan and cedar trees. None of the timber is mature enough to be commercially useful. Some local cutting is done for fuel and, to the east in Arkansas, similar timber is a raw material in the manufacture of charcoal. But the most important prior use of the land was as a cattle pasture.

The original 75-acre site was capable of supporting about 10-20 cattle (Foreman Carlile, previous owner) on a year-round basis providing that the effort was made to keep the land free of scrub, timber and weeds. The plant is located at a high-point on the 2100-acre site. For agricultural purposes, the better land is at lower elevations. The plant is located on marginal agricultural land.

A site map showing the present uses of the land is shown in Figure 2.

The 75-acre plot on which the plant is built has been substantially altered. Inside the plant security fence, two-lane access roads have been built. All major plant roads have been surfaced with asphaltic concrete on a cement treated base in accordance with State of Oklahoma Department of Highways Standard Specifications. Asphaltic concrete paved parking areas have been built for 60 cars near the administration area. Storage areas have been provided for full and empty drums and UF_6 shipping tanks. A tank farm for storage of chemicals is located near the process building. Hazardous chemicals are located in diked areas as required by applicable fire codes. An area 100 feet on all sides of the solvent extraction building is surfaced with clean gravel over a 0.006" black plastic base to keep the area free of vegetation.

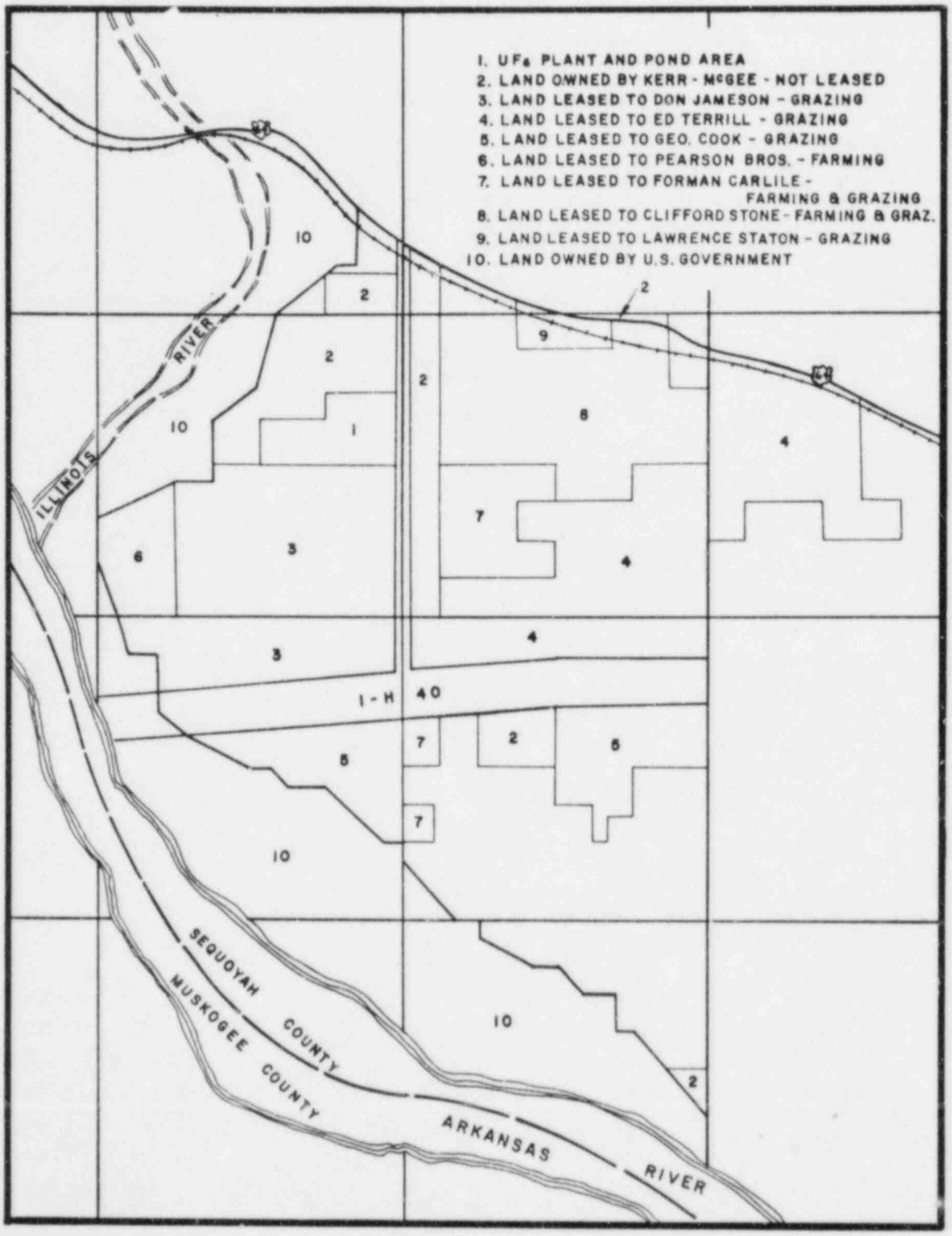


FIGURE 2

SITE MAP SHOWING PRESENT LAND USAGE

Drainage swales and diversion ditches are planted for erosion protection. Slopes and embankments steeper than four horizontal to one vertical were sprigged with bermuda grass crowns while flatter slopes and yard areas were seeded. A six foot high security fence topped with barbed wire surrounds the plant area. Access to the plant is through a motor driven double swing gate remotely controlled from the reception area.

C. Description of Area

The plant area and the surrounding Kerr-McGee site is a mixture of rolling pasture and timberland with some steep slopes and a small amount of cultivated fields. Aerial pictures, Plates No. 1 and 2, taken in May 1972 show three views of the plant and the immediate area while the fourth picture is an aerial view of the small town of Vian lying immediately to the east. The combination of plentiful rainfall, topography and adjacent riverways has produced proliferant forms of wildlife and vegetation.

Since the inventory of the biota requested seemed beyond the normal scope of expertise for the Kerr-McGee organization, members of the staff of East Central State College were retained to prepare certain sections of this report so as to insure reliability and completeness of information. Their contributions are credited and included below.

THE FLORA

C. E. Butler, PhD
Associate Professor of Biology

The vegetation of Sequoyah County, which includes the Kerr-McGee Sequoyah facility, is included in what Bruner[1] has described as the Oak-hickory savannah vegetation region. This type of region is characterized by varying degrees of dominance of woodland and grassland. It is essentially a transition community between forest and prairie.

[1]Bruner, W.E. 1931. The Vegetation of Oklahoma. Ecological Monogr. 1:99-188.

PLATE 1 - Page 8

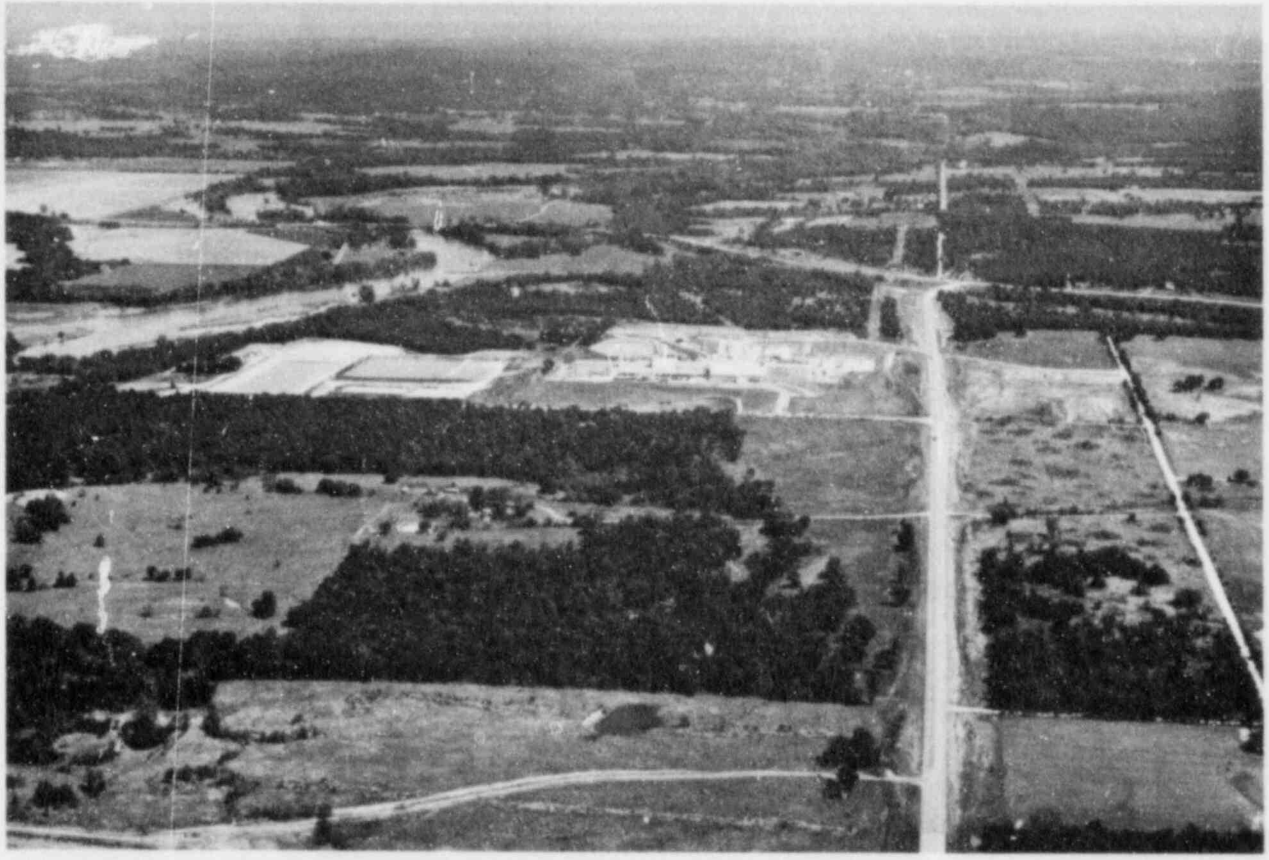
TOP: Sequoyah Facility from the South

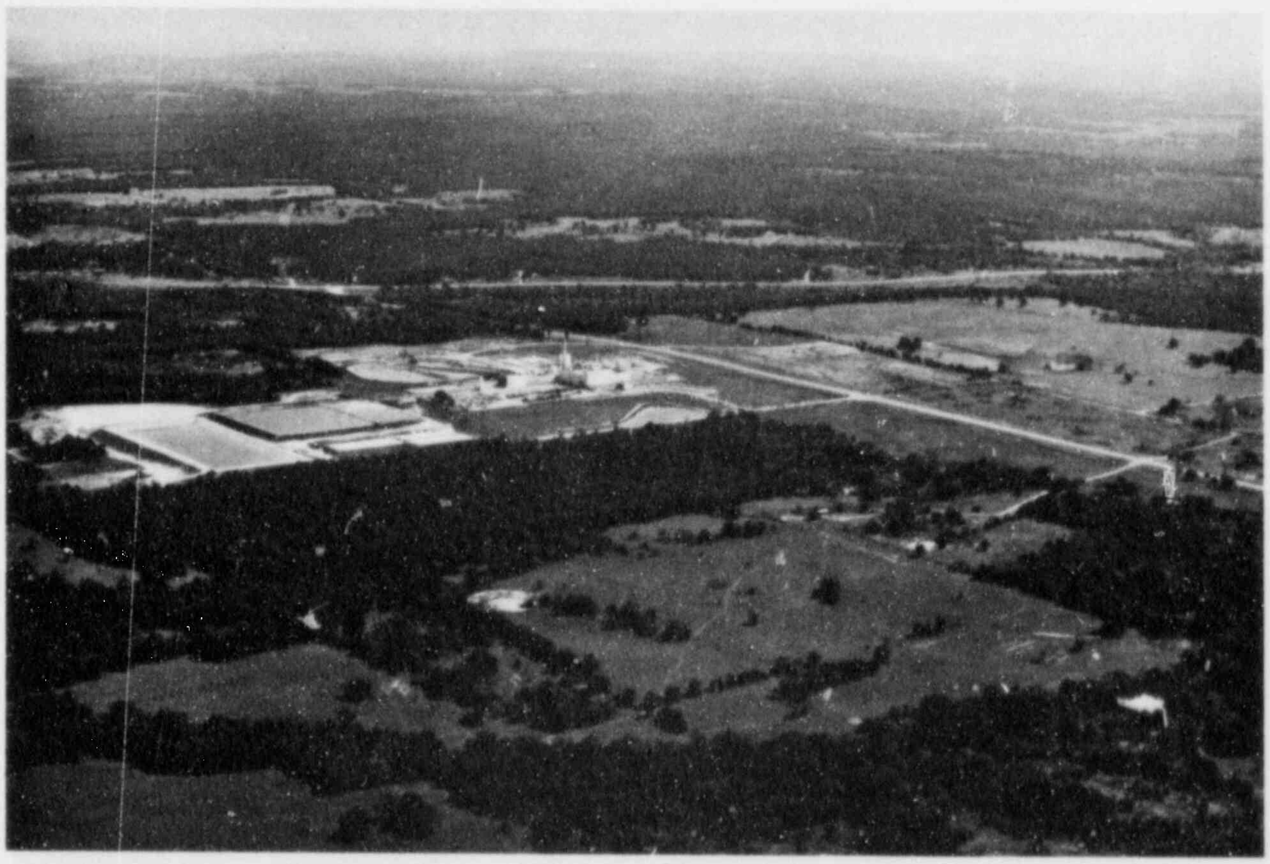
BOTTOM: Sequoyah Facility from the West

PLATE 2 - Page 9

TOP: Sequoyah Facility from the Northeast

BOTTOM: Town of Vian East of the Plant





Wallis[2] examined the flora of the Ozark region of Oklahoma. The region is the northeastern corner of the state with natural boundaries formed by the Grand (Neosho) River on the west and the Arkansas River on the south. Sequoyah County is included in this region. Wallis reported 1,377 species and subordinate taxa from this region. He made twenty-four additions of species and subordinate taxa to the state flora. Two of these were reported from Sequoyah County but neither of the two were found in the Kerr-McGee facility.

The publication of Waterfall and Wallis[3] was used as a checklist in two survey trips during mid-May 1972. Deletions and additions were made to make the list better fit this limited area. The spring and pre-summer aspects were investigated thoroughly. Other aspects could only be checked by vegetative characteristics.

The 2100-acre tract on which the plant is located plus a two mile radius in all directions was investigated. The topography in this area varies from nearly flat in the bottom lands of the Arkansas and Illinois Rivers to gently rolling adjacent to the bottom lands to a high level ridge rising as much as 400 feet above the valley floor. The maximum change in elevation across the plant site is from 450 feet above sea level at the Illinois River to 700 feet in the southeast corner.

Approximately one-third of the site is open and the balance is moderately to heavily wooded.

The flora will be described in the following regions of the plant site: a.) <u>the uplands</u>-this region includes the tops of the hills and the upper slopes of the hills; b.) <u>the lower slopes</u>-this region is composed of the lower slopes of the hills; c.) <u>stream valleys</u>-this region includes the areas on the sides of the streams and the banks of the Arkansas and Illinois Rivers, and; d.) <u>the aquatic</u>-this region includes the stream beds, ponds and rivers in the area.

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[2]Wallis, C.S. 1959. Vascular Plants of the Oklahoma Ozarks, Ph.D. Dissertation, Botany Dept., Oklahoma State University, Stillwater, Oklahoma.

[3]Waterfall, U.T. and C.S. Wallis. 1964. A List of the Vascular Flora of the Oklahoma Ozarks. Studies in the composition and distribution of the Oklahoma flora. No. 29. Proc. Okla. Acad. Sci. Vol. 44:11-22.

The Uplands

There is a gradual sloping of the land of the plant site from east to west and south toward the Arkansas and Illinois Rivers. The sloping on the north and east varies from gradual to steep.

The soils in this region are mostly of the Hector-Linker-Enders Association[4]. These soils are described as being sloping to steep, somewhat excessively drained, stony soils that are very shallow to deep over sandstone or shale.

The region varies from heavily wooded on the upper slopes to sparsely wooded with intermittent open areas. The open areas have been cleared in the past for agricultural purposes and would have trees as climax vegetation.

Much of the open areas in the uplands have been cleared for agricultural purposes. Also some of the cleared area is presently disturbed by roads and mowing. Especially, adjacent to the plant, mowing is practiced. Due to past cultivation and over-grazing by cattle most of the native grasses have been removed. These grasses have been replaced by introduced grasses and invader forbs.

The Lower Slopes and Stream Valley Woodlands

The slopes range from relatively steep on the north and east and to gentle on the south and west.

The woodlands on the north and east vary significantly from those on the south and west. The north and east slopes are composed of mature trees with many trunks and branches littering the forest floor. Also, outcroppings of sandstone are frequent. The trees on the south and west slopes are comparatively young trees with much open area. Many of the tree species on the slopes are common to both but other species are distinctive to one or the other.

There are narrow strips of land along the banks of the two streams and the Arkansas and Illinois Rivers where there are many species of trees, shrubs, woody vines and herbaceous plants, which are typical of a bottomland forest.

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[4]Abernathy, E.J. 1970. Soil Survey of Sequoyah County, Oklahoma. United States Department of Agriculture, Soil Conservation Service.

Adjacent to the fringe of wooded area along the Illinois River just before it joins the Arkansas River is an area of very fertile bottomland soil that is used to grow wheat. Part of the land, at the time of the observation, contained a field of lush wheat. Approximately 1/3 of this cultivated land was fallow. Along the edges of the wheat field and in the fallowed land were found many species of herbaceous plants which are typical of disturbed areas.

Aquatic

In the water and along the banks of the streams and rivers in the area several species of aquatic plants were noted.

The lists should be construed as only a partial identification of the flora of the plant site. It was impossible to note all of the species because of the limited period of time that observations were made. Also the flora changes with the seasons and, thus, it was not possible to identify, from vegetative characteristics, all of the early spring, summer and fall plants. From the observations that were made, no observable adverse effects of the effluents from the plant were noted. Various species of plants are growing profusely along the edges of the liquid effluent storage ponds. Also, plants are growing without apparent detrimental effect in the stream that is used to drain the effluents into the Illinois River. The vegetation growing near the plant and within 1 and 1/2 miles of the plant show no apparent adverse effects from the effluents.

An inventory of known and expected species appears in Appendix II.

D. Climate

Typically, this section of Oklahoma receives ample rainfall in the spring and fall and is prone to have dry weather and high temperatures during the summer months. Vegetation will grow quickly in the spring, tends to be dormant in the hot summer and may brown off in the late summer. Some growth takes place during the cooler, wet fall months although the vegetation does not completely regain its color until the spring.

The normal annual rainfall is about 40 inches and the mean temperature is 62°. During the 62-year period that records have been kept, the extreme high was 115° and the extreme low was -15°.

Winds in the area are somewhat variable and tend to be lighter than those to the west in Oklahoma. Wind roses showing the wind direction and velocity for the year between April 1, 1971, and March 31, 1972, and also for each quarter are presented in Figures 3-7. These will be referred to again later in the report.

Sequoyah County lies in a zone of having an approximate probability of $1.66x10^{-3}$ of having a tornado in any given year (once every 600 years). One family had lived on the site for 100 years before the Company bought it. They had no recall or record of a tornado ever damaging the plant area.

E. Wildlife

THE FAUNA: TERRESTRIAL VERTEBRATES
W. C. Carter, PhD
Chairman, Department of Biology

The species lists of amphibians, reptiles, birds, and mammals presented here are developed from a survey of available literature, limited field observations and estimates based on habitat potential. These lists are "best estimates" and can not be considered as a definitive study of the terrestrial vertebrates of the area. Field observations were made 20, 21 May 1972.

The species found and expected in the area are essentially those of strong eastern (Deciduous Forest) affinities. This is expected as the Sequoyah Facility is in the southwestern edge of the Ozark Uplift. The proximity of both the Illinois and Arkansas Rivers on the west and southwest of the study area presents a floodplain habitat. The remainder of the area is either woodlands or grasslands. Ponds, small streams, or the rivers provide water sources in all habitats.

Development of the river floodplain areas for commercial use has drastically altered much of

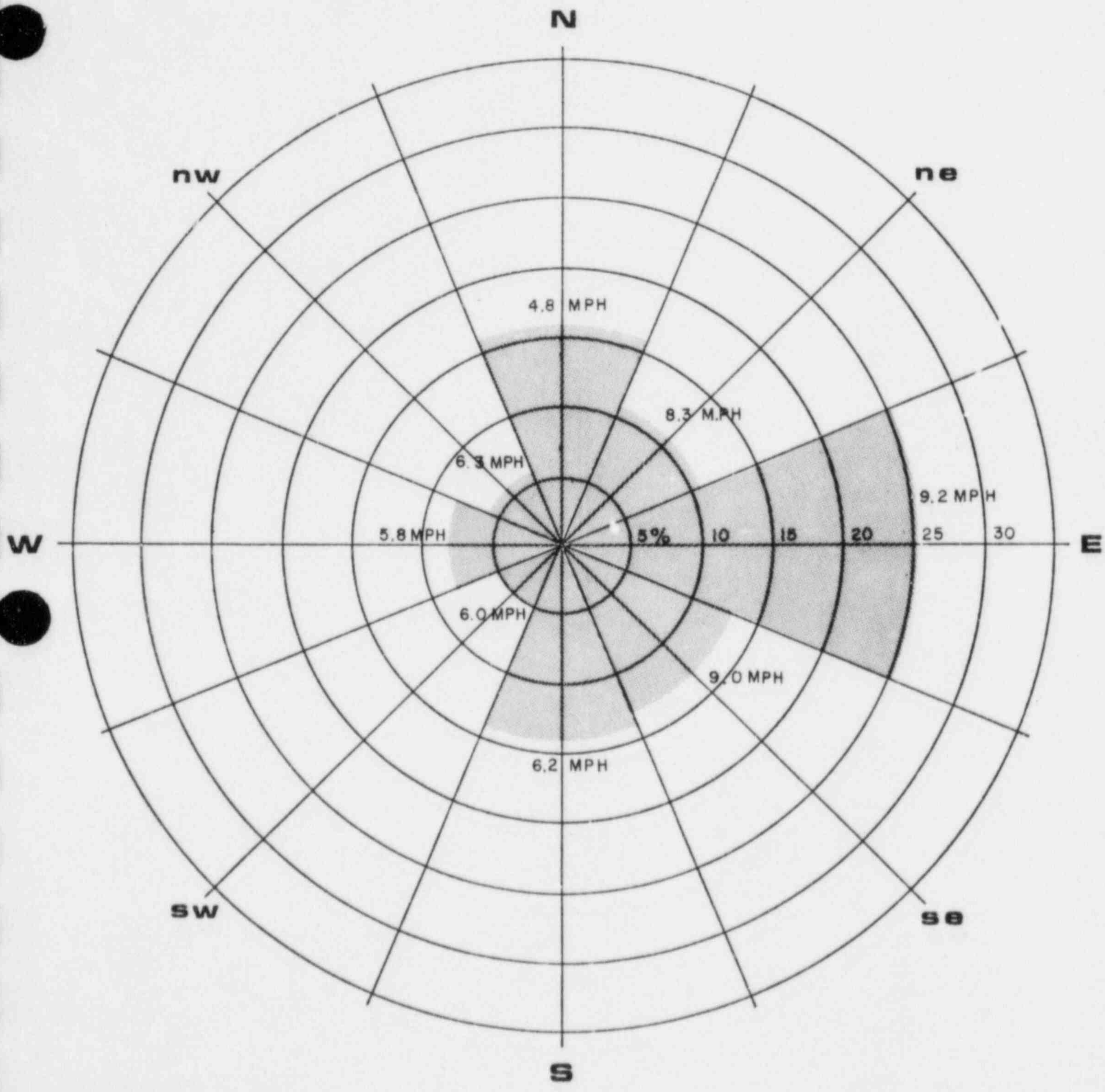

FIGURE 3

WIND ROSE - SEQUOYAH FACILITY
FROM DATA COLLECTED APRIL 1, 1971 - MARCH 31, 1972

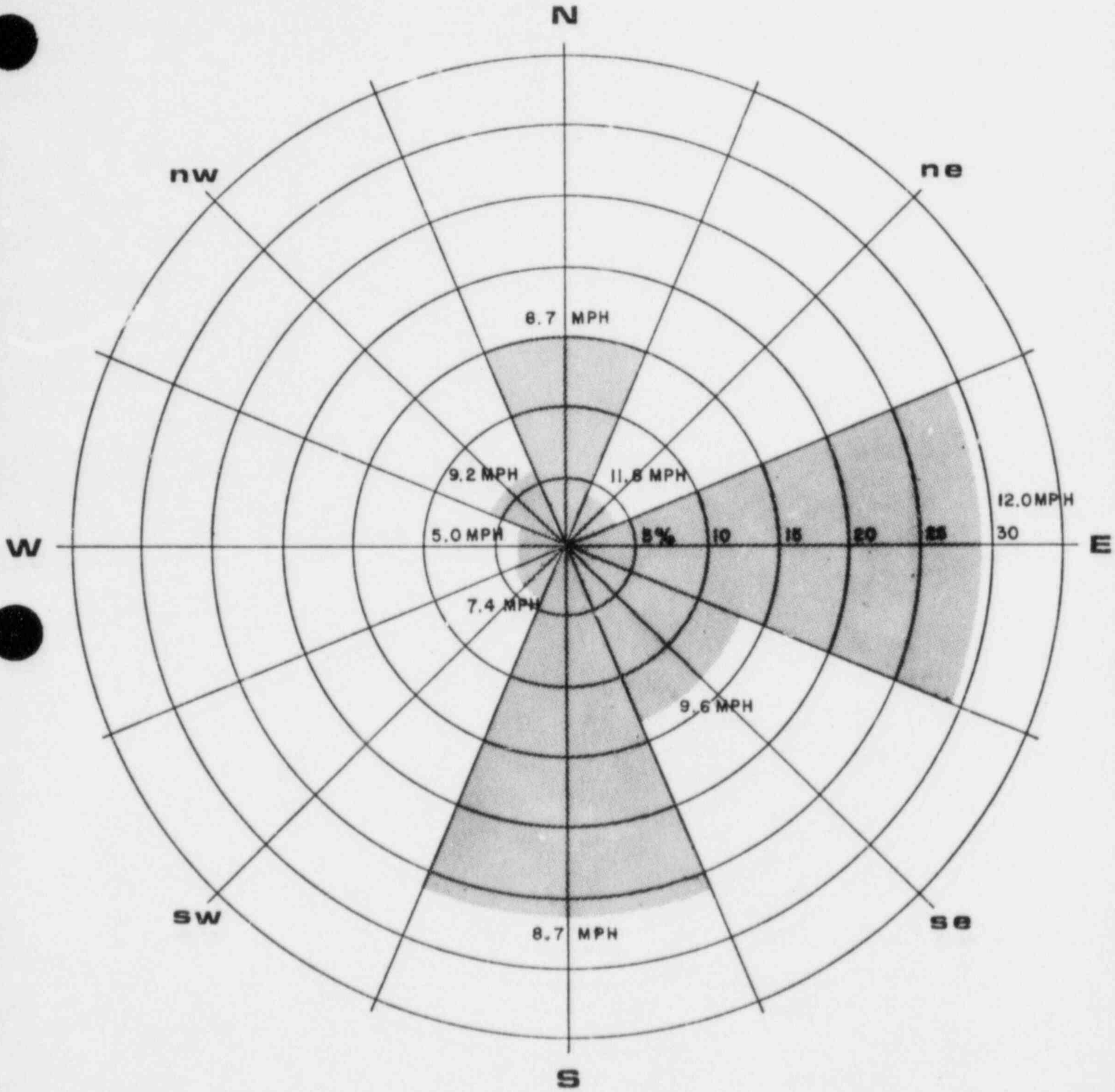

FIGURE 4

WIND ROSE – SEQUOYAH FACILITY
FROM DATA COLLECTED APRIL 1, 1971 - JUNE 30, 1971

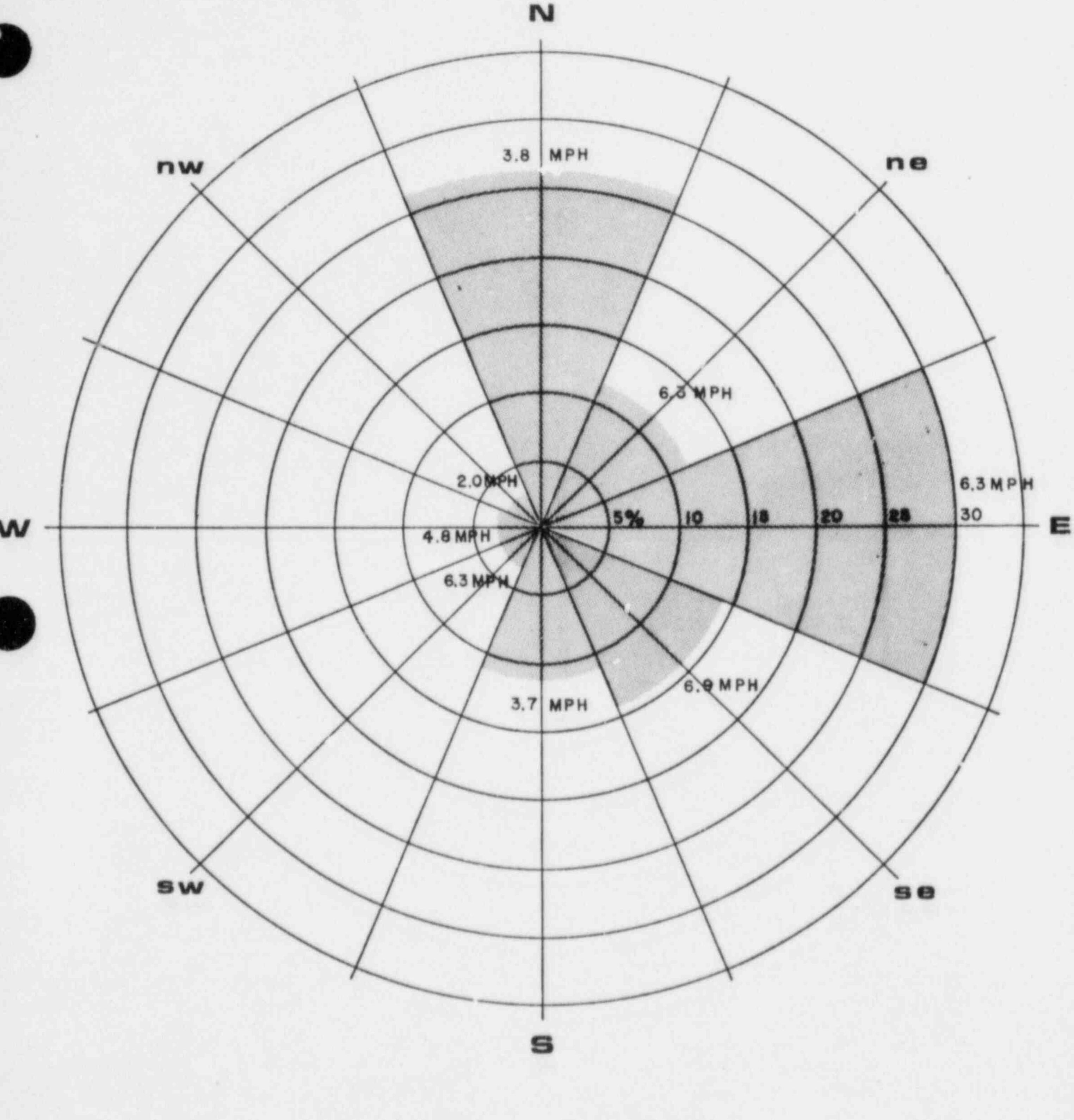

FIGURE 5

WIND ROSE – SEQUOYAH FACILITY
FROM DATA COLLECTED JULY 1, 1971 – SEPT. 30, 1971

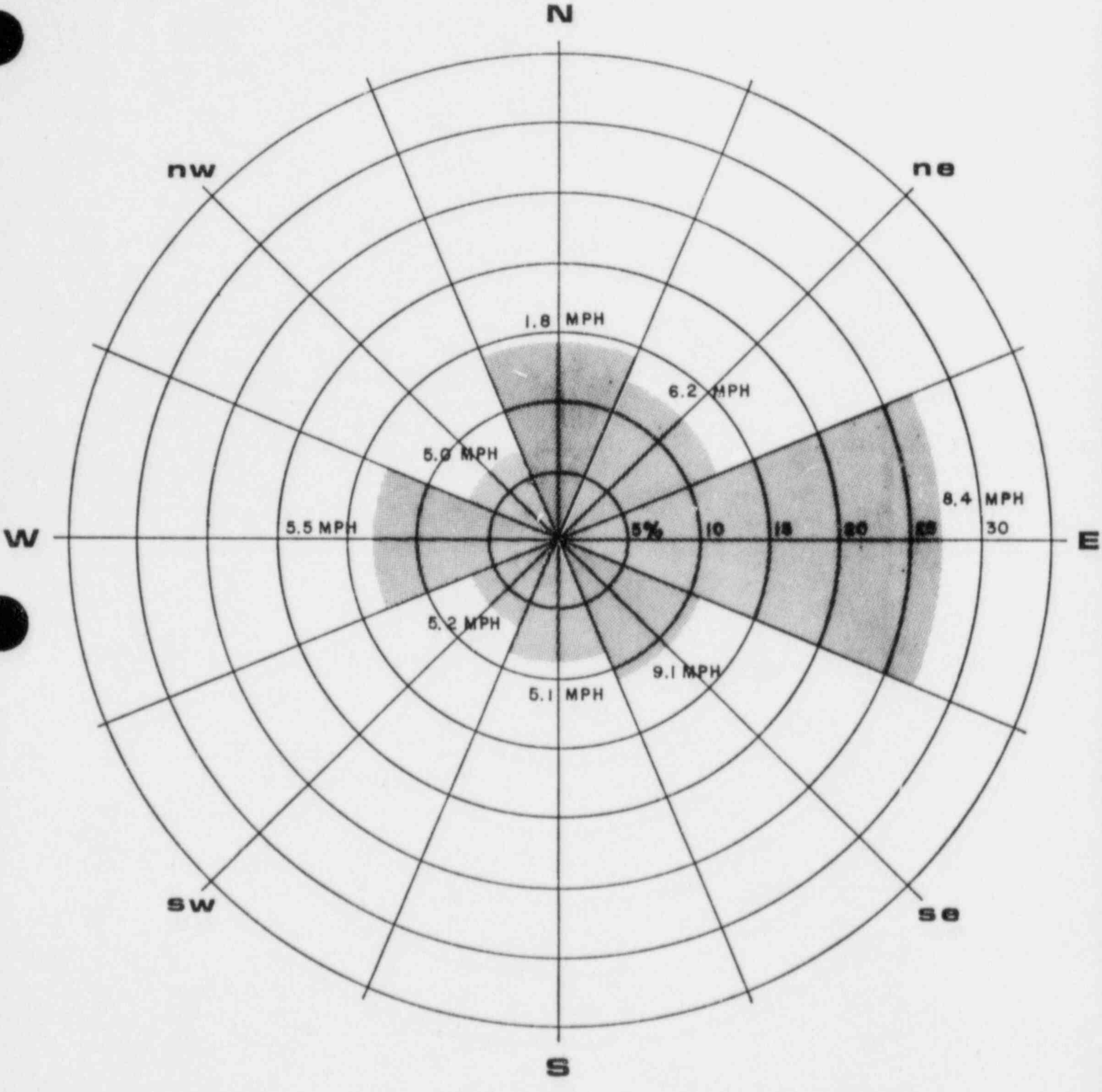

FIGURE 6

WIND ROSE – SEQUOYAH FACILITY
FROM DATA COLLECTED OCT. 1, 1971 – DEC. 31, 1971

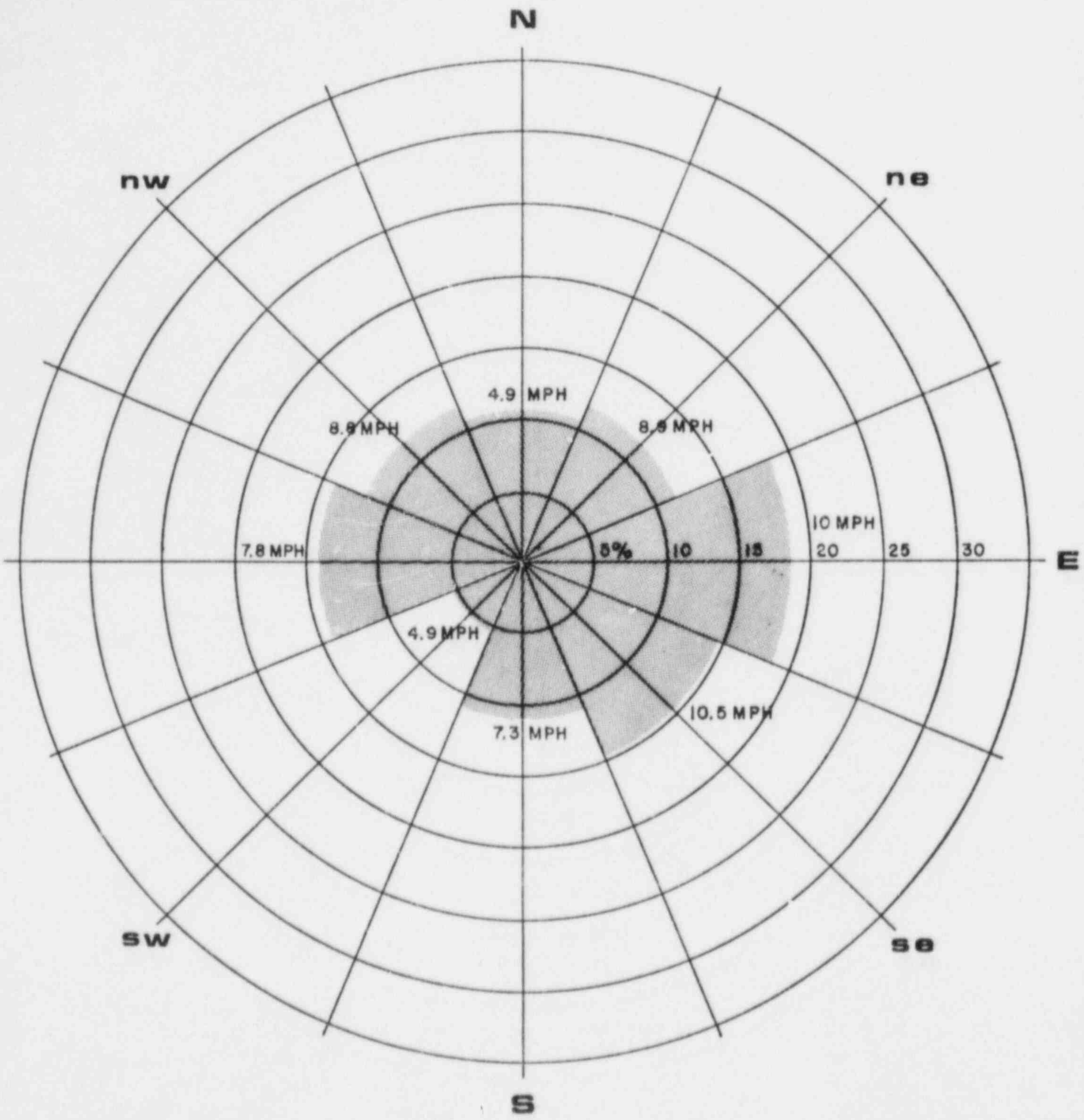

FIGURE 7

WIND ROSE – SEQUOYAH FACILITY
FROM DATA COLLECTED JAN. 2, 1971 – MAR. 31, 1972

this habitat. Some prime mature hardwood forest remains and provides excellent habitat for numbers of wildlife species. Upland areas are altered in the immediate area of the Facility with the remainder of the area either left "wild" or with limited agricultural uses. Thus, the Sequoyah Facility property presents a varied habitat that attracts a rich variety of wildlife. A long-term study of the area would probably verify most forms listed in this report and possibly add others.'

The present land-use practice of the Sequoyah Facility seems to be highly beneficial to wildlife; that is, limited use of the major portion of the property allows a "refuge" effect on the terrestrial vertebrates.

Amphibians: The species list of 14 salamanders and 12 frogs and toads is chiefly compiled from Bragg[5] and Conant[6]. Verification of the amphibian fauna would require a considerable amount of field work under selected seasonal weather conditions. Although, some of the salamanders are known only from a limited Ozark range, none are considered rare or endangered.

Reptiles: The species list of 12 turtles, 8 lizards, 26 snakes, is compiled from Conant and Webb[7]. Although the Scarlet Snake is rarely encountered, and the Red Milk Snake is represented by only a few specimens for Oklahoma, none of the reptilian species are considered rare or endangered. Nine species were observed on a two-day study in May 1972.

Birds: The list of birds representing 47 families and over 260 species is chiefly compiled from Sutton[8]. This reference notes the considerable amount of field work done in adjacent Muskogee County and lists a number of references for Sequoyah County.

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[5]Bragg, A.M., et al. 1950. Researches on the Amphibia of Oklahoma. Univ. of Okla. Press, Norman, Okla.

[6]Conant, R. 1958. A field guide to reptiles and amphibians of eastern North America. Houghton-Mifflin, Boston.

[7]Webb, R.G. 1970. Reptiles of Oklahoma. Univ. of Okla. Press, Norman.

[8]Sutton, G.M. 1967. Oklahoma birds. Univ. of Okla. Press, Norman.

As the Facility property presents a wide variety of habitats, a large number of avian species may be expected in the area. Also as birds are highly mobile, other species may be expected in the area from time to time. Fifty-seven species were recorded on a two-day study in May 1972.

Of the species known and expected for the area, the Bald Eagle (an uncommon Winter Visitant) and the Peregine Falcon (a rare Winter Visitant) are considered rare and endangered[9]. The Bald Eagle and the Golden Eagle would be attracted to the areas along the rivers along the western edge of the property. The Peregine Falcon would be attracted to the upland woodland edge areas. The Osprey is listed in the Rare and Endangered species lists as "status undetermined". This species is probably a low density regular migrant along the rivers. These species would be affected by activities of the Facility only in case contamination of river fisheries occured.

Some birds--waterfowl and Bobwhite--are of economic importance as hunting species.

Mammals: The list of 53 species of mammals is compiled from Burt and Grossenheider[10] and Hall and Kelson[11]. Some small game species--rabbit and squirrels--are of economic importance as hunting species. The White-tailed Deer is also a game species. Fur-bearing species are not utilized to a great extent at this time. Recent records indicate the presence of the Mountain Lion as a visitant species in this area of Oklahoma.

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[9]U.S. Fish and Wildlife Service. 1968. Rare and endangered fish and wildlife of the United States.

[10]Burt, W.J. and R.P. Grossenheider. 1964. A field guide to the mammals. Houghton-Mifflin, Boston.

[11]Hall, E.R. and K.R. Kelson. 1959. The mammals of of North America. Vol. I and II. Ronald Press, New York.

An inventory of known and expected species appears in Appendix II.

F. Population

This area of Eastern Oklahoma is relatively sparsely populated with very little industrial growth. The population grew about 3% in the period 1960-1970. Population figures from the 1970 Census for the immediate area are Presented in Table I.

TABLE I

1970 CENSUS POPULATION FIGURES FOR THE IMMEDIATE AREA AROUND THE PLANT

County or City	Direction	Distance Miles	Population
Sequoyah County			23,370
Vian	E	4	1,137
Sallisaw	E	19	4,888
Gore	NW	2	478
Muskogee County			59,542
Muskogee	NW	25	37,331
Warner	W	15	1,217
Webber Falls	W	3	485
Other			
Fort Smith, Arkansas	E	40	62,802

A discussion of population distribution as a function of distance from the plant and projected population growth was prepared by East Central State College and appears below.

DEMOGRAPHIC CHARACTERISTICS OF THE KERR-McGEE PLANT AREA
R. V. Garner, PhD
Dean, School of Environmental and Health Sciences

Population

A detailed study of population location and density within ten miles of the Kerr McGee plant was made. Using the plant as the center, a series of six circles were drawn. The first circle was placed at one mile on a map with a scale of 1/63360". Four additional circles were drawn for every mile up to

five miles, then the sixth circle was drawn at the ten mile interval.

The circles were then divided into sixteen segments of 22½° each, with true north bisecting segment A. Proceeding around the circle to the right, each 22½° segment was then given a subsequent alphabetical letter thru (P), the 16th letter. The 96 subsequent sub-division were identified by an alphabet letter and number. The population of each segment and sub-totals for both distance and direction are shown in Table II.

Within this charted area, are three small towns on which population statistics were available from the 1970 census. These towns and their population and location on Table II are: Gore (478/O-3), Tamaha (83/G-10), Vian (1131/E-10, 7 mi). The inhabited areas outside the three small towns were identified by using the 1969 county cultural maps of the Oklahoma Highway Department. All housing, schools and churches outside municipal limits are identified on the maps. The 1970 census indicated the population per household was 2.97 in Sequoyah County, 2.71 in Muskogee County and 2.70 in Haskell County. Using the 1970 census for the small towns a population estimate for the 10 mile radius was made by counting the number of houses in each of the 96 sections.

Transient population figures and estimates for the area were obtained from several sources. Recreation figures were obtained from the U.S. Army Corps of Engineers, and the Oklahoma Industrial Development Parks Department. Traffic figures for the Interstate highway were obtained from the State Highway Department. Supplementary data were obtained from local industrial development sources, county extension and civic leaders.

The concentration of population varies considerably in distance and direction from the plant, as shown in Table II and Figure 8. Within one mile of the plant the population estimate is 54 people. The second mile the amount doubles to approximately 126. Most of the population within the second mile are located south and southeast of the plant. Within three miles of the plant, the heaviest concentration of population is found. It is west and northwest of the plant and primarily in the two small towns of Gore and Webbers Falls. The population count for that zone is estimated to be 808 persons. Smaller, but still relatively heavy population concentrations

TABLE II
POPULATION DISTRIBUTION WITHIN 10 MILE
RADIUS OF THE KERR-MCGEE SEQUOYAH PLANT

Segment	1 mile	2 mile	3 mile	4 mile	5 mile	10 mile	subtotal
A	3	9	3	12	42	303	372
B	3	9	21	9	6	143	188
C	9	3	0	6	3	309	330
D	12	15	3	15	6	190	241
E	3	27	33	24	53	1422	1562
F	0	15	36	50	3	241	345
G	0	6	3	48	15	53	125
H	6	9	6	0	0	33	54
I	3	12	0	0	12	12	39
J	0	3	0	3	30	119	155
K	3	0	0	12	6	160	181
L	3	0	6	9	3	122	143
M	0	0	24	202	27	176	429
N	3	0	170	164	5	70	412
O	3	18	489	46	27	103	686
P	3	3	14	49	19	122	210
Subtotal	54	126	808	649	257	3578	
						Total	5472

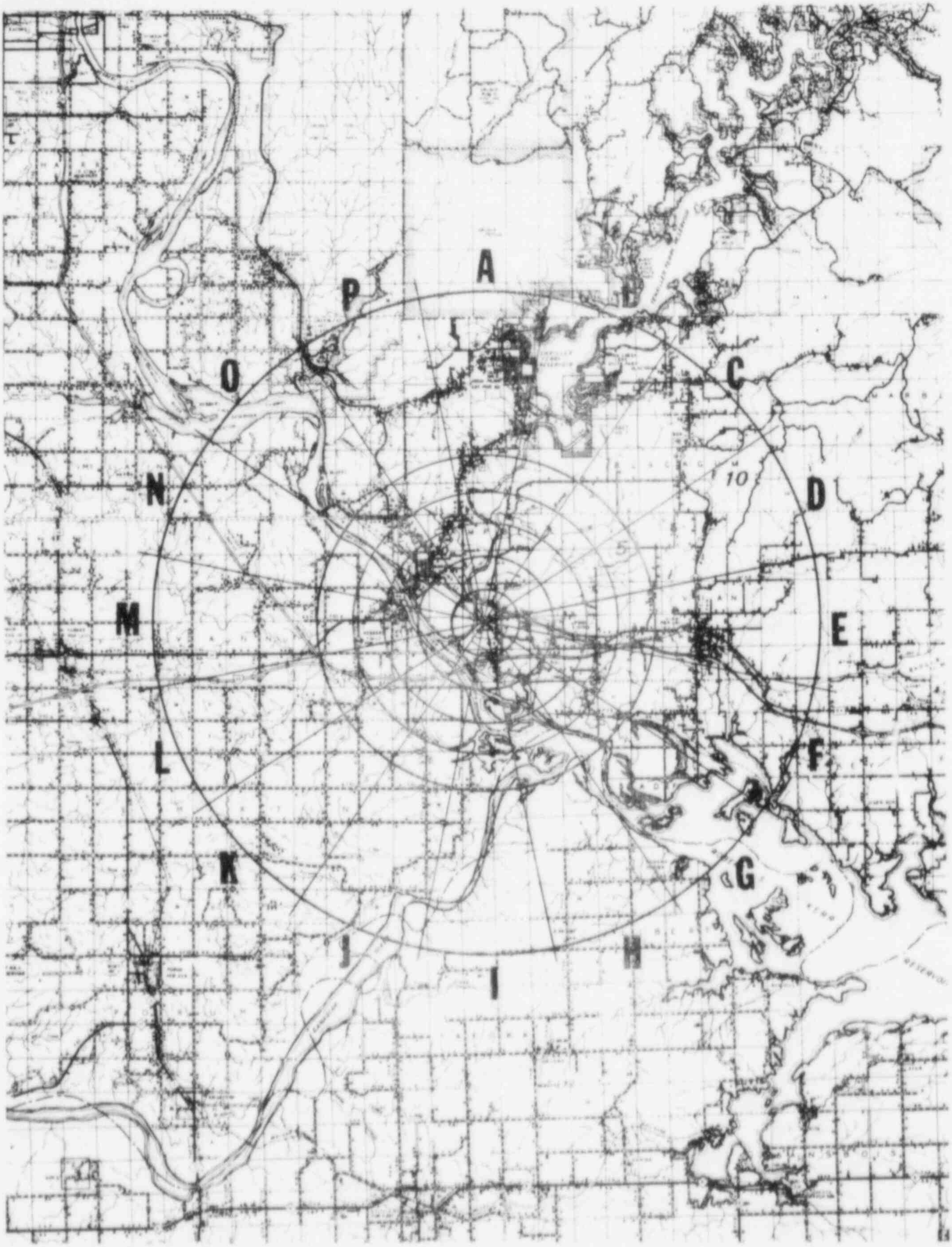

FIGURE 8

POPULATION DISTRIBUTION MAP

are found almost due north along state highway 100 from Gore to Tenkiller Lake. The four mile zone has rather heavy concentration of population in a north-northwesterly direction and also to the southeast. This area has 649 people. The population patterns continue from the four mile zone into the five mile zone with little change, except there is a notable decline to 257 people.

The zone that includes the population from five to ten miles has the largest accumulative population. The 3578 people residing in this area are evenly distributed except for heavy concentrations approximately six miles to the east in the town of Vian, and the northwest along state highway 10. The sparsest concentration of population is due south in northern Haskell County, north-northeast near the southern end of Lake Tenkiller and west-northwest in the hill region of southern Muskogee County. The current estimated permanent resident population in a ten mile radius of the plant is 5,472.

In estimating the number of population within the ten mile region, one must also evaluate the temporary population the numerous recreational facilities attract. In section B-10, Tenkiller Ferry Reservoir, with the very popular Pine Creek State Park will have large crowds on weekends and holidays for a six-month period. Northwest, in section P-10 is the small but popular Greenleaf State Park. Other resorts with weekend cabins, trailer parks, and camping sites are located on the two reservoirs of Robert S. Kerr and Webbers Falls. During the year of 1971, Greenleaf State Park and Tenkiller State Park had 417,007 and 1,011,928 visitors respectively according to figures supplied by the Oklahoma Industrial Development and Parks Department. These figures represent a total increase of 170,000 over 1970. Figures for the first four months of 1972 indicate a similar increase is probable.

Though exact figures were not availabe for the Robert S. Kerr and Webbers Falls Reservoirs, Robert Hensley of the U.S. Army Corps of Engineers, Tulsa district, estimated that the two reservoirs and related attractions drew 2 million visitors in 1971.

With the realization that part of these facilities are just outside the ten mile area, the Corps of Engineers estimate and the Industrial Development and Parks Department figures place between 3½ to 4 million persons within or adjacent to a ten mile radius of the Kerr McGee plant each year. Since this

temporary population is seasonal and is highest on weekends, it can far exceed the permanent resident population at a given time.

Another factor which must be considered is Interstate Highway 40 which passes one mile to the south of the plant. The traffic count is 6000 vehicles per day per annum in 1971[12]. Although this population is transient, it does place many people passing within close proximity to the plant daily.

Growth of population in this part of Oklahoma will be moderate over the next several years. Most growth will be as the direct result of the Kerr-McClellan canal system and an increase in recreationally related jobs. Ports are being constructed upstream at Muskogee and downstream at Sallisaw. It is generally believed most of the industrial growth impact will fall within the immediate environs of those two cities and will have slight residual, commuter-type effects on this area. The Kerr-McGee plant itself is already functioning and will add some (but not much) in the way of new jobs to the area. It has, however, already made its greatest impact on the area, particularly the small town of Vian.

The construction of new recreational facilities on Robert S. Kerr and Webbers Falls Reservoir will more than likely have a more profound effect on the growth patterns of the plant area. However, these jobs are generally regarded as seasonal thus having a limited effect on permanent population.

The Eastern Oklahoma Development District estimates the 1980 population will exceed 30,000 in Sequoyah County and by 1990, the population will be 72,000. Using these estimates, optimistic as they might be, the projected population in the year 2000 would then be around 100,000. The ten mile area around the Kerr-McGee plant has a current population of 5,472. Using the percentages of the E.O.D.D. the area permanent resident population would be 1980-7026, 1990-16,862, and 2000-21,583 respectively. It must be pointed out, that these figures are the based on optimum growth factors. A more realistic set of figures would range from 50% to 75% of those quoted according to Phillip Knowlin, Sequoyah County Extension Agent.

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[12]Oklahoma Highway Department, Division of Traffic Studies.

With the current trend in recreation and the fact that the Corps plans to build additional recreation facilities on Robert S. Kerr Reservoir the temporary population will be a significant factor during the next 30 years. Robert Hensley of the U.S. Army Corps of Engineers estimates that by the year 1977, the four reservoirs and related recreational facilities will have an annual visitation rate of 14 million persons. Assuming that the area will eventually reach what might be termed a recreational saturation point, a figure of 25 million visitors per year is quite possible by the year 2000.

In summary, it would appear that the temporary population resulting from a rapidly growing recreational pattern must be considered equal in importance to the permanent resident population. The transient nature of the recreational population should certainly be considered also.

Projected Use of Land

The location of the Kerr-McGee plant has caused a small change in the landuse patterns. The removal of 2175 acres has caused an increase in the farm land values and has created a demand for land reflected particularly in the western part of Sequoyah County. Except for a slight intensification within the urban areas and a slight modifying of land useages, the plant has had little effect upon land use patterns. By far, the greater impact within the region has been the creation of the large reservoirs and subsequent flooding of much bottomland.

The city of Sallisaw is now attempting to negotiate a site for its port facilities. A Sallisaw Chamber of Commerce spokesman stated that Sallisaw has had many inquiries concerning potential plant site location, most desired location either at the port site or situated somewhere between Sallisaw and Ft. Smith. He stated that to his knowledge, no plants planned to locate anywhere between Sallisaw and Muskogee. Mark Rader, terminal manager for the Port of Muskogee said that at this time he knows of no plants planning to locate in the area between Muskogee and Sallisaw. He pointed out that there is already one liquid storage plant 2 miles south of Muskogee and a coal company loading facility below Lock #16.

The fact that recreational development constitutes the primary thrust in the area at this time also indicates that land use patterns will not change appreciably. In most of the recreational areas surrounding large reservoirs, typical pasture and limited farming patterns are continued. No residential areas other than cabin sites and only a few recreation-related businesses such as lodges, service facilities and docks, will be located in the area adjacent to the reservoirs.

Exact percentages of landuse within a ten mile radius of the plant are not available. Based on topographic data from maps, previously cited population statistics, limited agricultural use data, and recreation statistics, the following percentages are estimated. (1) agricultural; (mostly pasture with some farming): 30%. (2) Recreation: 35%. (3) Residential (towns and rural settlements): 20%. (4) Commercial and industrial: 15%. (5) Vacant rough terrain, river bed, etc: 25%. (Figures total over 100% due to multiple use in some cases.)

Land Values

The per acre value of farm land has changed 56.63% in the period from 1964 to 1969. This is due in part to the location of the Kerr-McGee Plant and the inundation of farm land by the large reservoirs. The value per acre for Sequoyah County in 1964 was \$113.04. The 1969 value per acre of land sold was \$197.66[13]. The 1972 estimate is \$225.00 per acre. The value varies widely due to location and physical features. Bottom land sells generally from a low of \$400.00 to \$600.00 per acre. Some farm land will sell for a \$1,000.00 or more per acre when the land has any possible industrial or recreation developmental potential according to Phillip Knowlin, Sequoyah County Agricultural Agent.

The value is much less in hill regions. For instance the isolated, rocky hill soil may bring no more than \$75.00-\$100.00 per acre. Again these values will be influenced by commercial or recreational development potential. If land is located between Sallisaw and Ft. Smith or near the new river port in the county, the value will be proportionally higher.

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[13]Leo Strickland, Agriculture Economics Specialist, Oklahoma State University.

G. Areas of Historical Significance

The plant site does not intrude into any site of historical significance. No part of the site nor nearby area is listed in The National Register of Historic Places.

The plant site was a part of the land given to the Cherokee Nation after their move from the Southeastern United States. The State of Oklahoma Historical Society lists two locations of interest. Talonteeskee, western capital of the Cherokee Nation was located in the area from 1829 to 1839. Sam Houston is known to have visited often. Dwight Mission was established by Rev. C. Washburn in 1821 and served the Cherokees until after the Civil War. Sequoyah, a Chief of the Cherokees and originator of their alphabet, lived and worked north of Sallisaw. His home is preserved as a public attraction.

The Carlile House was on the property and served at one time as a station for a stage running from Fort Smith to Fort Gibson. This house has been moved from the site to a location on U.S. Highway 64 near State Highway 10 as a public attraction. The ford of the Illinois River, which was known as Carlile Ford, has been flooded by the completion of the Robert S. Kerr Reservoir.

H. Waterways

As can be seen in Figure 1, the plant site is bounded on the west by the Illinois and Arkansas Rivers and the Arkansas River lays a short distance to the south of the site. The natural drainage of the plant area is to the west into the Illinois River.

In recent years, the Arkansas River has become a working commercial waterway for the movement of freight. Barge traffic has not yet developed significantly but is expected to grow at a steady rate for the next decade. One important effect of this change is that water levels and flows are greater during the dry summer months than when the river was in its original state.

The Illinois River is the only spring-fed cold water river in Oklahoma. Tenkiller Ferry Reservoir was completed and opened for recreational use in 1953, approximately seven miles up river from the site. Tenkiller has become very popular with Oklahoma residents and many small businesses serving the recreational market are located near the lake. When the Tenkiller Dam was completed, the water temperature was decreased below the reservoir. This made it possible for the Illinois River, from the dam to its junction with the Arkansas River, to become one of two artificially stocked trout streams in Oklahoma. Most of the stocking and trout fishing is done between the Highway 64 Bridge and the dam.

When the Robert S. Kerr Reservoir was completed in 1970, the headwater of the reservoir's normal pool level became extended upstream the Illinois River to the Highway 64 Bridge. As a result, the Illinois River from the Highway 64 Bridge to its mouth at the Arkansas River is classified as part of the reservoir. The reservoir filled in December 1970. Measurements of turbidity and conductance indicates that the surface water from the Arkansas River has flowed up the Illinois River past the plant outfall discharge point. The area around the highway Bridge has not become commercialized for recreational purposes but it is quite possible that this will eventually happen since the Corps of Engineers has designated the west bank of the Illinois River immediately north of U.S. 64 as a public access area for the reservoir.

The area on the shoreline of the Robert S. Kerr Reservoir from the I-40 bridge to Vian Creek has been established as a wildlife refuge. The area is partially reserved exclusively for wildlife with controlled waterfowl hunting permitted in a portion.

The Corps of Engineers has control of the Illinois River at Tenkiller Reservoir, the downstream water to the Arkansas River and the area reserved for the flood level (490 feet elevation) of the Robert S. Kerr Reservoir. The dams and their lock mechanisms are the only government installations in the vicinity of the plant.

The Arkansas and Illinois Rivers, the reservoirs and many small streams in this area contain many varieties of native and introduced species of fish. As described above, the Illinois River, from the Tenkiller Reservoir Dam to the Arkansas River, is a put-and-take trout fishery under the control of the Department of Wildlife Conservation. In the warm water lakes and rivers large-mouth bass, crappie and catfish are the most popular sport species though all species have their enthusiasts. The levels of fish populations are especially sensitive to quantities of food supplies and optimum spawning conditions. Many small ponds have been known to become overpopulated with consequent reduction in size, general malnutrition and deteriorated quality of occupying species. Heavy pollution will tend to reduce fish populations by interfering with spawning conditions and food supplies. Neither the Illinois nor Arkansas River systems at this location show any evidence of such conditions.

The recent completion of the Robert S. Kerr Reservoir is expected to alter the species population in the direction of providing more typically impoundment populations as contrasted to the previous river channel populations. Striped Bass apparently migrated from plantings in Keystone Lake or the Dardenelle Reservoir in Arkansas and are now found in Kerr Reservoir. Bass and Channel Catfish were stocked when the lake was filled.

None of the resident species are endangered and seem to be flourishing with completion of the reservoir.

No commercial fishing is permitted.

An inventory of fish species in the Illinois and Arkansas Rivers is included in Appendix II.

I. Geology and Geohydrology of the Plant Site

The Sequoyah Plant site is located on the southwest flank of the Ozark Uplift, a major tectonic feature which extends from eastcentral Missouri to northwest Arkansas and northeast Oklahoma. The Arkoma Basin lies immediately to the south and southeast and the Ouachita Mountains are fifty miles

south of the plant. A section of "Tectonic Map of the United States 1961" by U.S.G.S. and A.A.P.G. is shown on Figure 9.

1. Topography and Drainage

The area surrounding the plant consists of open pasture, heavily wooded slopes and wooded stream channels. Drainage is by small intermittant streams which empty into the Illinois River, the west boundary of the Kerr-McGee property. Maximum relief across the area is 250 feet, with elevations ranging from 450 feet adjacent to the Illinois River to a maximum of 700 feet above sea level in the southeast corner of Section 22 (USGS NE Stigler, Okla. 1963 and Webbers Falls, Okla. 1948 Topo. Quad.). Slopes are moderate except in the northcentral part of Section 21 where sandstone ledges form a steep escarpment above the Illinois River.

2. Structure

The regional dip in the study area is 2-3° southwest into the Arkoma Basin. In the vicinity of the faults shown on the geologic map of Oklahoma (Miser 1954) dips of 15-20° were observed. The block faulting occurred in post-Atokan time as a result of tensional forces developed by the emergence of the Ozark geanticline and the concurrent subsidence of the Arkoma Basin. This tectonic activity, which formed NE-SW trending folds and normal faults, ended in middle Des-Moinesian time. The region has been structurally stable since this middle Pennsylvanian period. (Huffman 1958, Oklahoma Geological Survey Bulletin #77.) The fault nearest to the plant site is located one mile to the east in the vicinity of Carlile School. The Carlile School fault can be traced on the surface from the road cut on U.S. Highway 64 in the northeast corner of Section 22 to a point at the center of the south line of Section 22. Based on surface and subsurface data, the throw on this down-to-the-east fault is estimated to be approximately 800 feet.

3. Stratigraphy

Rocks exposed at the surface are lower Atokan in age and consist of a 100 foot thick sequence of brown sandstone

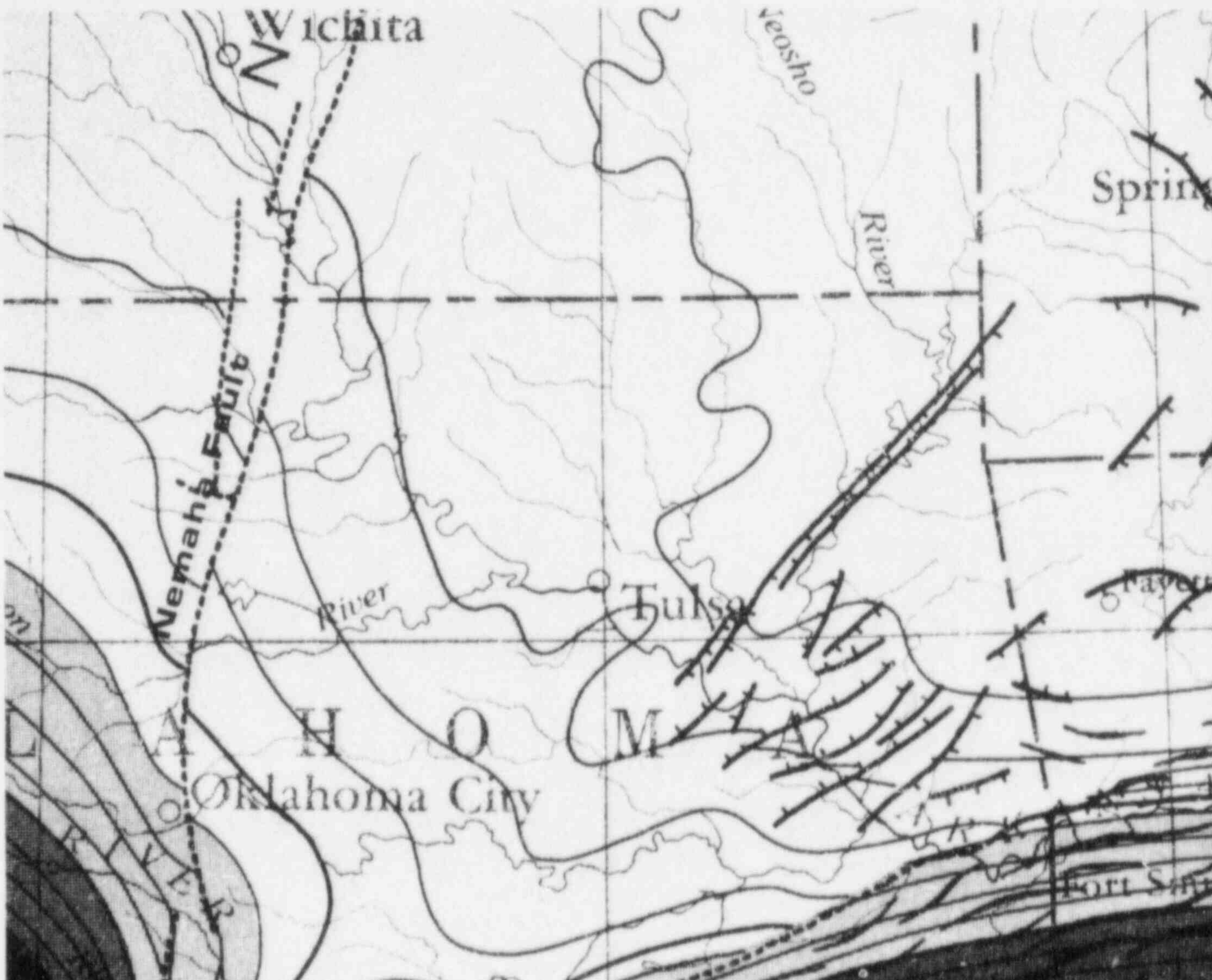


FIGURE 9

SEISMIC MAP OF OKLAHOMA

and dark gray to black shale. In the immediate area of the plant site the Atoka formation is covered by a 15 foot thick terrace gravel. Three separate sandstone beds were mapped at the outcrops in the bluff above the Illinois River in the north-central part of Section 21. These sandstone beds which make up 40% of the Section are fine grain, medium to thick bedded and they weather to a dark reddish-brown color. Siderite concretions are common and the sandstone contains thin irregular streaks of carbonaceous material. A microscopic examination of the sandstone reveals that it is made up of fine to very fine grain subangular quartz grains. The intergranular space is completely filled with tan clay and there is essentially no visible porosity.

As part of a foundation evaluation study of the plant site, some 20 core holes were drilled in the east half of Section 21 and the west half of Section 22 (Figure 1). Because of the limited number and poor quality of the outcrops in the area, core descriptions from the foundation investigation holes were used to prepare a composite stratigraphic section of the surface and near-surface beds.

LOWER ATOKA SECTION-KERR-McGEE PLANT SITE

Sandy clay at surface	3' thick
Sandstone, fine grain, brown, weathered	7' thick
Shale, tan, soft, weathered	2' thick
Sandstone, fine grain, gray with irregular thin streaks of carbonaceous material	8' thick
Shale, dark gray, compact	18' thick
Sandstone, fine grain, light gray, slightly shaly with irregular thin streaks of carbonaceous material	10' thick
Shale, dark gray to black, slightly sandy, hard	30' thick
Sandstone, fine grain, light gray to white, slightly shaly, calcareous, hard	10' thick

Two of the core holes, located near the Carlile School fault, encountered zones of fractured shale which contained minor amounts of fresh water. In contrast, cores of sandstone and shale recovered from the test holes located near the plant facilities exhibited no severe fracturing and were totally lacking in moisture. In the absence of severe fracturing, the Atoka sandstone and shale beds are not capable of storing any significant amount of water.

4. Groundwater Geohydrology

Information on the geohydrology of the fresh water aquifers at the plant site and vicinity has been taken primarily from Oklahoma Geological Survey Hydrologic Atlas #1, "The Water Resources of the Ft. Smith Quadrangle" by M. V. Marcher, 1969.

The only significant fresh water aquifer in the area under discussion is the alluvium of the Arkansas River Valley. The lower part of the alluvium consists of up to 15 feet of coarse sand with a productivity of as much as 900 gpm. Marcher states that the water is "hard to very hard" (greater than 180 ppm) but is suitable for irrigation and watering stock. A typical alluvium water well is located in the SE SE/4 of Section 19-12N-21E. The depth of the hole is 44 feet, static water level is 4 feet below ground level and the reported yield is 400 gpm.

The recharge and storage capacity of an aquifer is dependent upon the thickness and permeability of the soil mantle and the porosity and permeability of the bed rock. Marcher considers the Atoka formation to be a very poor aquifer since the soil cover is thin, has poor permeability and the underlying sandstone and shale beds require fracturing to provide permeability and storage capacity. Water quality is poor and yields average only 0.5 gpm. Marcher estimates that, because of the very low permeability of the Atoka rocks, approximately 95% of the rainfall is lost by run-off.

The hydrologic conditions in the immediate area of the Kerr-McGee Sequoyah Facility are typical of those described

by Marcher for the Atoka formation. In the absence of severe fracturing, the sandstone and shale beds lack sufficient porosity and permeability to constitute a reliable aquifer. The only area capable of supporting a marginal water well is adjacent to the Carlile School fault where fracturing of the shale is sufficient to provide a reservoir of limited areal extent. The best water well in the plant site area is located in the NW NW/4 of Section 27-12N-21E, in the belt of fracturing. Depth of the hole is 84 feet, static water level is 29 feet and the yield is one gpm. Water quality of this well is better than average for the Atoka formation with total dissolved solids of approximately 460 ppm. In contrast, water wells drilled at the three former home sites west of State Highway 10 were insufficient for domestic purposes and it was necessary to construct cisterns to maintain an adequate supply of potable water (Foreman Carlile, prior owner, personal communication).

Exploration of the area has demonstrated no commercial deposits of oil and gas. Dry holes are located approximately two miles east and three miles south of the plant site. These two wells were plugged and capped with concrete after completion of drilling to 200 and 4600 feet, respectively. All of the dry holes abandoned in the 16 township area surrounding the site were abandoned by leaving the surface casing in the hole and placing one or more cement plugs on top.

Other minerals in the area consist of coal, sandstone, sand and gravel from the Arkansas River floodplain. The nearest coal production is 14 miles west at the town of Warner. Coal is being mined from a depth of 1400 feet at Stigler in Haskell County 18 miles south of the site. The nearest coal deposits are located approximately 12 miles southeast of the plant site but these low-quality mines are currently inactive.

J. Seismicity

As discussed in the section on regional structure, the southwest flank of the Ozark uplift has been tectonically stable since middle Pennsylvanian time. As a consequence, the

area has a very low seismic risk and is classified as being in Zone One by the Coast and Geodetic Survey (see Appendix III, "Seismic Risk in Oklahoma," by the staff of the University of Oklahoma, Earth Sciences Observatory). The possible minor damage which might occur in Zone One is classified as V or VI on the Modified Mercalli scale: very minor damage to dishes and windows (MMV); a few cases of slight damage to plaster or chimneys (MMVI).

The Coast and Geodetic Survey report 41-1 (revised) lists only one earthquake epicenter within a radius of 50 miles from the plant. This earthquake, located 40 miles south of the plant near Poteau, Oklahoma, occurred on April 27, 1971, and is classified as Itensity V on the Modified Mercalli scale. The probability of damage to the plant in the event of a recurrence of the Poteau earthquake is extremely small because of the low intensity of the recorded earthquake and the distance between the plant site and the epicenter.

On the record, the frequence and severity of earthquakes in the plant site area are remarkably low. The Coast and Geodetic Survey report includes recurrence tables that show that damage equivalent to MMVII may occur on an average of once every 55 years in Oklahoma outside the El Reno area. Since the plant site area has never, in recorded history, experienced an earthquake of magnitude MMVII, the time span of damaging earthquakes of this order of magnitude must be much greater than 55 years. As quoted in the attached report (Appendix III) by the Oklahoma Earth Sciences Observatory, Trygvason (1965) concluded that strong earthquakes causing minor damage may occur at any particular place in Oklahoma once every 2,000 years.

A further reduction of the seismic risk is gained by virtue of the plant design specifications. The design criteria contain the following stipulations for seismic load:

1. The design forces will be as specified by N.B.C. Zone L.
2. Structure will be designed as directed in Appendix J of the N.B.C.

3. Allowable working stresses will be increased 33% for the above loading conditions.
4. The factor of safety against overturning will be not less than 1.50 for the above loading conditions.

In summary, all of the available data indicate that earthquakes do not constitute an environmental hazard at the Sequoyah Plant.

K. Floods

The possibility of flooding does not exist. One of the objectives of the Tenkiller and Robert S. Kerr Reservoir projects is flood control. The normal water level is 450 feet above sea level. High water level is 490 feet. All of the 75-acre plant site is above 540 feet. No storage ponds, dikes or buildings are located in the area below 540 feet.

III. THE PLANT AND THE PROCESS

A. Physical Description of the Facility

The Sequoyah Facility was designed and built by Bechtel Corporation based upon design criteria furnished by Kerr-McGee. The plant consists of about 69,000 square feet of manufacturing, warehousing and office floor space in three separate buildings. The main process and administration building contains offices and a laboratory (10,600 square feet), fluorine generation (17,250 square feet), maintenance (5,500 square feet), utility (5,500 square feet) and main process areas (26,900 square feet). A separate solvent extraction building (4,000 square feet) contains only the solvent extraction system. A separate warehouse building was provided for storage of mechanical parts. Retention ponds for (1) sanitary sewage, (2) fluoride precipitation and clarification of dilute waste stream, and (3) raffinate are located to the west of the plant. The plant employs approximately 100 people of whom 75 are production and maintenance workers.

Bechtel Corporation designed the plant with the objective of minimizing the number of operating and maintenance personnel required to the maximum extent economically justified. All plant control functions are centralized where possible. Existing proven AEC equipment designs were used whenever possible for process equipment. This approach provided the greatest assurance of reliable operation with demonstrated minimum risk to the environment.

B. Plant Capacity, Lifetime and Disposal

The lifetime of a chemical processing plant is not readily estimated. The nuclear industry is considered to be an investment in the future rather than an opportunity to make an immediate satisfactory return on investment. The nuclear power industry is new. Technology has changed and may continue to change. In time, the Sequoyah Facility may become obsolete if it is not progressively modified as required. The Company expects to be in the nuclear fuel industry as long as a market for these services exist. For this report the plant life has been assumed to be 30 years.

The Company has no plans to close the plant. Should the Company ever dispose of the site, the Company would seek a buyer able and willing to use the property at its highest economic value. With improvements on the site, the Company would probably be able to sell the property to a commercial user thus reducing the economic impact on the area. In the unlikely event that no commercial, residential, charitable or educational use could be made of the facility, the Company would take measures to restore the property to a condition compatible with the surrounding unimproved countryside.

C. Process Description

The plant was designed to make maximum use of demonstrated production technology. Consequently, this involved the application of processes developed and installed at the several USAEC sites engaged in similar processing.

Briefly, the process flow involves the receipt of uranium concentrates (normally ammonium diuranate), known as yellowcake, in 55 gallon drums from Kerr-McGee owned or other concentration mills in the Western United States and Canada. The drums are emptied into a sampling system which removes a representative sample. The material is stored briefly then digested in hot nitric acid solution and the resultant solution is processed by countercurrent extraction to recover uranium values as a solution of uranyl nitrate hexahydrate. This solution is concentrated, dehydrated and denitrated to uranium trioxide. This oxide is then reduced to UO_2 with ammonia and subsequently converted to UF_4 with anhydrous hydrafluoric acid. The UF_4 is converted to UF_6 by reacting with elemental fluorine, condensed and packaged into shipping cylinders as final product. A schematic process outline is shown in Figure 10. This process is described in more detail below.

1. Feed Preparation

Yellowcake feed is received in 55-gallon drums that normally contain 500-800 pounds each with an average of 700

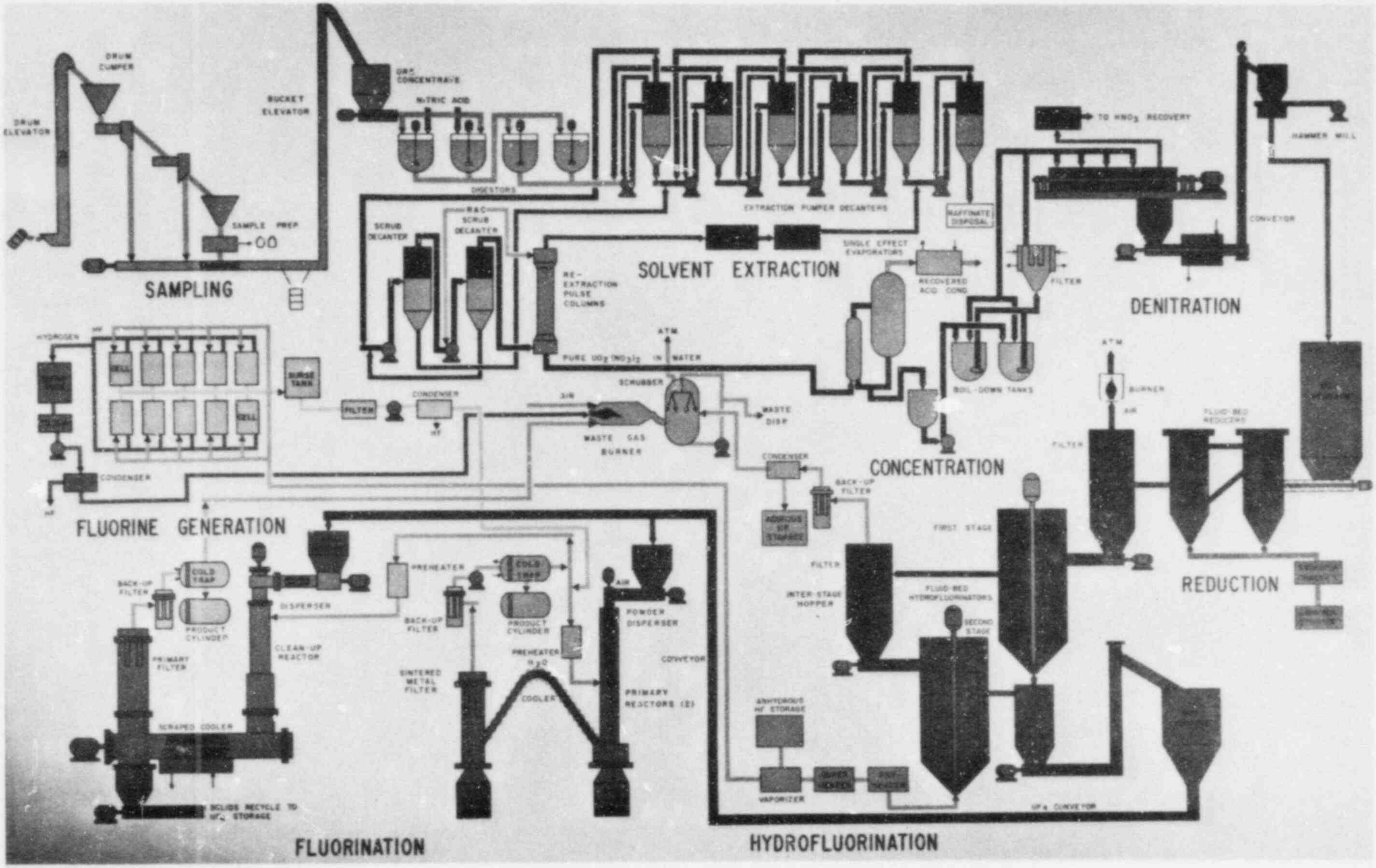


FIGURE 10

SCHEMATIC PROCESS OUTLINE - SEQUOYAH CONVERSION FACILITY

pounds. Open storage on a pad is provided for 3000 drums (about 1000 tons). The drums are stored on stacked pallets (four drums per pallet, three pallets high). There is also a storage area for empty drums. Facilities are provided for handling larger drums containing 1500 pounds of feed.

Yellowcake is removed from the drums by dumping each drum into a sampling system which removes .1% as a representative sample of the material. This sampling system is the same as that employed by the USAEC at Grand Junction, Colorado, and Weldon Spring, Missouri. The drums are dumped and the falling stream of material is regulated and passed through a reciprocating sampler removing 10% of the stream. The sample is subsequently passed through a second and third sampler reducing the quantity to .1% of the total. Each rejected portion is returned to the main stream. The main stream is conveyed to either a redrumming station if the material is to be stored or to storage hoppers located in the digestion area.

All movement of the material is done in completely enclosed equipment. Dumping and packaging systems are ventilated as are all other openings so as to remove any dust generated to a bag-type blowback dust filter. No changes to the physical or chemical nature of the material occurs in the sampling area.

The stored yellowcake is fed to one of two digest tanks and is reacted with 40% nitric acid to yield an acidic uranyl nitrate solution. Under present operating conditions, the digesters are operated for 15 shifts a week with the equivalent of one shift being devoted to start-up and shutdown. Digestion is a batch operation using two 4000 gallon vessels. The charge per batch is 10,300 pounds of uranium and 2630 gallons of 40% nitric acid (HNO_3/U molar ratio of 4.0). 3100 gallons of solution containing 3.33 pounds of uranium per gallon results. The normal digester operating temperature is 90-105°C with the minimum temperature being 60-70°C. At 5000 tons of uranium per year, the average flow through the digesters will be 1717 pounds per hour. When the plant is expanded to 10,000 tons of uranium per year, it is planned to operate the entire plant

on a continuous 21 shift a week basis. Then the uranium flow rate through the digester system will be 2686 pounds of uranium per hour or 806 gallons of a solution containing 3.33 pounds per gallon of uranium.

The digester process produced appreciable amounts of nitric oxide (NO) and nitrogen dioxide (NO_2) which are recovered in the plant nitric acid recovery system. Operating pressure slightly below atmospheric is maintained in the digester system so that air flows into the system and nitrogen oxides do not escape.

Primary liquid feeds to the system include recovered nitric acid from the plant acid recovery system, commercial concentrated nitric acid to boost acidity as needed and special chemical additions such as aluminum nitrate solution, phosphoric acid, caustic and iron solution. These latter special solutions are added as needed to control impurities. These solutions are made up as needed in a 1000 gallon tank.

Uranium values recovered from other parts of the process are recycled to the miscellaneous digester. This includes dust collected on the exit filters from the tower reactors and tower reactor feed material which escaped conversion to UF_6. These values are dissolved in aluminum nitrate solution ($Al(NO_3)_3$). The offgas from the miscellaneous digester contains HF as well as nitrogen oxides. The gas is first scrubbed with caustic and then piped to the nitric acid recovery system. The spent caustic solution is combined with the raffinate.

The miscellaneous digester is a 1500 gallon vessel that is operated on a batch basis. The charge is about 750 pounds of uranium and 950 gallons of 2 molar $Al(NO_3)_3$ solution. Presently, this solution is blended with the main digester solution.

Conventional control systems are provided for normal operations. Level alarm and automatic cutoffs are used to avoid overfilling of vessels, terminate feeds and reduce operating temperature in the event of boilover or excessive off-gas flow. A curb system around the area contains solutions in

the event of nominal pump leakage or total failure of a vessel or piping.

Pressure in the heating/cooling coils is maintained at a pressure above the solution pressure to minimize leakage of process solutions into the coil in the event of coil failure. In addition, a pH meter is used to detect inleakage of process solutions into the plant condensate system from the digesters.

2. Purification

The solvent extraction system is of the same design as the AEC plant at Weldon Spring, Missouri, and uses tributylphosphate-hexane solvent, pumper-decanters for extraction, a two-stage scrub (wash) section and a pulsed-column strip (re-extraction) section.

The organic extractant is a 30 volume percent (range 20-35%) solution of TBP in hexane. The organic-to-aqueous volume ratio is 4.0. The system processes 1717 pounds of uranium per hour (14 shifts per week) on a 5000 ton-per-year production rate and would handle 2692 pounds of uranium per hour (21 shifts per week, 85% on time) on a 10,000 ton-per-year production rate. Flow rates through the system are listed in Table III.

TABLE III

FLOW RATES THROUGH THE SOLVENT EXTRACTION SYSTEM

Stream	Temperature	Normal Gallons/Hour	Range Gallons/Hour
Primary Aqueous Feed	25-35°C	520	400-900
TBP-Hexane Solvent	25-35°C	2300	1600-3600
Aqueous Scrub to Scrub System	25-60°C	230	120-380
Aqueous Reextractant to Strip Column	50-60°C	2100	1300-2900
Aqueous Raffinate		800	600-1350
Each Pumper Decanter Unit			
Net Organic Inflow and Outflow		7200	
Organic Recycle		7500	1200-12,000
Net Aqueous Inflow and Outflow		1800	

The TBP-hexane solution is first washed with a 10-25% solution of ammonium sulfate followed by a wash with a 1-5% sodium hydroxide solution. After contact with the aqueous phase, the extractant is scrubbed to remove impurities and the uranium is reextracted by a pulsed stripping column. The organic is recycled to the washing system. The uranium rich aqueous stream is then concentrated .

The waste stream from the extraction system, known as raffinate, is primarily composed of ammonium nitrate, nitric acid, metallic salts and minute quantities of uranium and the radioactive daughter products of normal uranium decay. This stream is combined with spent sodium hydroxide from the solvent treatment system and the miscellaneous digest scrubber and any excess recovered weak acids from the absorber for treatment. The solution is neutralized by ammonia and impounded in earthen-walled retention basins for permanent storage.

Two storage ponds have been constructed with a combined capacity of about 25 million gallons providing for three feet of freeboard height above the maximum liquid level to protect against accidental release by overflow. Basin No. 2, with approximately 15 million gallon capacity, has just been put into use. This basin provides storage capacity for approximately two years at planned production rates.

It would be desirable to develop an appropriate method of safe disposal of a solid containing the radioactive heavy elements. Currently, no practicable process for solidification has been developed. Several alternatives have been considered by the Kerr-McGee technical staff and studies and experimental work is being done with the objective of selecting the most suitable alternative.

If trace radioactive elements can be removed, the residual solution contains sufficient ammonium nitrate to be a useful fertilizer. This solution could be used on the site to promote the growth of cover for wildlife or concentrated and sold locally. It could be possible that with fertilization the site

could support more animal and plant life than it did before the plant was built.

The concentration is completed in two steps. In the primary evaporation system, the solution is concentrated from 0.833 pounds of uranium per gallon to 4 pounds per gallon. The feed to the evaporator is first scrubbed with hexane to remove any TBP. The aqueous phase is passed through a second decanter to remove any residual organic matter. This is done to eliminate the potential danger due to a combination of nitrates, organic matter and heat. The evaporator is also located outdoors at a minimum distance of 20 feet from any building. There will be about 2100 gallons per hour of 0.833 pound solution going into the evaporators and about 430 gallons per hour of 4 pound solution coming out. At 10,000 tons-per-year production rate, the flows would be about 3250 and 680 gallons per hour in and out, respectively.

3. Conversion to UF_4

The secondary evaporation system consists of two 4000 gallon boildown tanks equipped with heating coils and vapor offgas piping. The solution is concentrated to 10 pounds per gallon and sulfuric acid is added in order to enhance the activity of the decomposition product.

This concentrated solution is decomposed in a trough-type denitrator containing approximately 5000 pounds of product heated to 525°F. A small stream of UNH is added continuously to this bed, stirred by the agitator, and decomposed to UO_3, oxides of nitrogen gases and nitric acid vapor. The offgas is separated from any entrained powder and is piped to a nitric acid recovery system described below.

Nitrogen oxides are recovered and converted to nitric acid in a conventional recovery system. Nitrogen oxides are generated at three points in the process.

1. Ore concentrate dissolution (digestion and feed make-up system).
2. Fluorination ash dissolution (miscellaneous digestion system).

3. Denitration as $UO_2(NO_3)_2$ to UO_3.

The nitrate values from the raffinate are not currently recovered.

Nitrogen oxide loads on the recovery system were calculated as follows:

a. Ore Dissolution

Potential Reactions are:

(i) $M_2U_2O_7 + 6HNO_3 \rightarrow 2MNO_3 + 2UO_2(NO_3)_2 + 3H_2O$ *

(ii) $U_3O_8 + 8HNO_3 \rightarrow 3UO_2(NO_3)_2 + 2NO_2 + 4H_2O$
(maximum evolution)

(iii) $U_3O_8 + 20HNO_3 \rightarrow 9UO_2(NO_3)_2 + 2NO + 10H_2O$

b. Fluorination Ash Dissolution

The worst case would be

$UF_4 + 4Al(NO_3)_3 + 2H_2O \rightarrow UO_2(NO_3)_2 + 4AlF^{2+} +$
$3NO_3 + 2NO_2$

c. Denitration

$UO_2(NO_3)_2 \cdot 6H_2O \rightarrow UO_3 + 6H_2O + 2NO_2 + \frac{1}{2}O_2$

*M is symbol for one of several possible cations

The denitration step is conducted continuously and it has been assumed that NO_2 is released in the dissolution steps over a two hour period.

The results of maximum NO_2 release rate calculations (pure U_3O_8 feed) are presented in Table IV.

TABLE IV

NO_2 RELEASE RATES

	5,000 Ton Per Year Capacity	10,000 Ton Per Year Capacity
Ore Digesters	600 lbs/Hr Peak	600 lbs/Hr Peak
Miscellaneous Digester	133 lbs/Hr Peak	133 lbs/Hr Peak
Denitration	520 lbs/Hr Steady	1040 lbs/Hr Steady
Total from Ore Digesters	5,280 lbs/Day	8,350 lbs/Day
Total from Miscellaneous Digester	266 lbs/Day	532 lbs/Day
Total from Denitration	12,480 lbs/Day	24,960 lbs/Day
	18,030 lbs/Day	33,840 lbs/Day

Since the probability of prolonged operation with U_3O_8 at a maximum NO_2 production is remote, the system has been designed to handle 14,000 pounds per day of NO_2 at 5000 ton capacity and 27,000 pounds at 10,000 ton capacity. Calculations have been made on a NO_2 basis but NO and N_2O_4 are also present.

The offgases from the denitrator are first scrubbed with 40% HNO_3. This step removes particulate matter and about a third of the nitrogen oxides. From the wet scrubbers, the offgases pass through a vertical fin-tube gas cooler cooling the gas to below 95°F. Another third of the nitrogen oxides are removed in this step. The gases leaving the gas cooler are combined with the offgases from the digestion processes and are sent to the nitric acid absorber column. Here, the nitrogen oxides are converted to 40% HNO_3. Plant measurements have shown that 0.2-1.2% of the nitrogen oxides are lost. NO_2 losses would be 216 pounds per day or 9 pounds per hour. The gases are released from the top of a 150 foot high stack.

UO_3 is converted to UO_2 using dissociated ammonia at a temperature of 1000°F. The fluid bed reactor is designed for a capacity of 20 tons per day of uranium or 1950 pounds per hour of UO_3. Reducing gas is furnished by ammonia crackers at a rate of twice the stoichiometric amount required for complete reduction. The reactor offgas is filtered through sintered metal filters and burned. Gas is released as a mixture of NO_2, H_2O, N_2 and O_2.

UO_2 produced in the reduction system is converted to UF_4 by reaction with anhydrous HF at an operating temperature of 650-1000°F. The fluid reactor design is similar to that used in the AEC's Paducah, Kentucky Facility. The uranium processing rates are the same as that of the reduction section.

The HF flow rate is 1.1 times the amount required for stoichiometric reaction. Offgases are condensed and the aqueous acid returned to AHF supplier. The noncondensable vent gases are combined and scrubbed with water before being vented through a 150 foot high stack. Anhydrous HF is transferred from storage by pressuring storage tanks with nitrogen.

4. Fluorination

UF_4 is converted to UF_6 by reaction with elemental fluorine. The design is based upon technology and experience developed at the Paducah, Kentucky, and Portsmouth, Ohio, plants. The feed to the fluorinators is approximately 92% UF_4, 3% UO_2F_2 and 5% UO_2. Each reactor has a normal processing rate of about seven tons of uranium per day. At 5000 ton-per-year capacity, three primary and one cleanup reactors are used. To reach 10,000 ton-per-year capacity, two additional primary reactors will be needed.

The gases leaving the reactors are passed through 30°F primary and -75°F secondary cold traps (AEC design) to strip and recover valuable UF_6 in the gas streams.

The fluorine flow rate is about 2.26 moles F_2 per mole of uranium, twice the stoichiometric rate. Under normal operating conditions with the F_2 cleanup reactor performing as expected, essentially no F_2 is discharged from the system. However, provisions have been made to dispose of a flow of about 25 pounds of F_2 per hour by burning it with H_2 from the fluorine plant to form HF. The HF is quenched and scrubbed with water. The scrubbed waste gases are discharged through the top of a 150 foot stack. The water scrub is neutralized with lime precipitating insoluble calcium fluoride.

The UF_6 product is drained into cylinders (AEC design) containing 10 tons each. The cylinders are placed on rail-mounted carts, filled and are removed by forklift truck. The product is carried from the plant in trucks. The cylinders are approved by the Department of Transportation for natural UF_6 shipments.

Fluorine production equipment is similar to that used at the Paducah, Kentucky, plant. F_2 is produced from HF by the electrolysis of HF dissolved in a fused saltbath of KF-HF in medium temperature, water-cooled cells.

At 5000 tons of uranium per year capacity, 249 pounds per hour of fluorine is needed. Twice as much would be needed at a 10,000 ton-per-year production rate. The present

facility has 34 cells at 6000 amps and operates at 8-12 volts. This allows 30 cells to be in operation and 4 to be serviced. In an emergency, F_2 is vented and purged to the top of a 150 foot high stack. Fluorine gas is delivered to the fluorination reactors under positive pressure. The F_2 production unit is located in a separate building.

5. Waste Disposal

The original plant design provided that the raffinate and the fluoride scrubber solution would be discharged as generated into a deep well disposal system. This well had been drilled to the depth of approximately 3700 feet into a porous Arbuckle limestone formation saturated with salt solution. This saline salution is unfit for agricultural or industrial use due to large amounts of dissolved salts. Approval for its use was granted by the Oklahoma Water Resources Board in April 1969. However, the AEC Source Material License SUB-1010 has not approved the use of this well because additional data is needed as to the extent and capacity of the underground reservoir, the permeability of the formation and the probable waste distribution within the formation.

Recently, Kerr-McGee employed a consultant firm, H. J. Gruy and Associates, Inc., to supply this data. The program involved the measurement of injection rates and dissipation of injection pressures over time periods at various depths. The consultant correlated the actual reservoir data with mathematical models of similar reservoirs. It is believed that this definitive program permits definition of the reservoir capacity and confirms the absence of any risk of communicating waste liquids to potable and surface water. Kerr-McGee has conducted a geological and engineering review of these tests and has proposed the authorization for the use of the well to the AEC.

While awaiting approval of the use of the deep disposal well, raffinate is stored in surface ponds.

a. Liquid Wastes

The waste stream from the extraction system, known as raffinate, is primarily a solution of ammonium nitrate, nitric acid, metallic salts and minute quantities of uranium and the radioactive daughter products of normal uranium decay. This stream is combined with spent sodium hydroxide from the solvent treatment and miscellaneous digester scrubber systems along with any recovered weak acids. This liquid is neutralized by ammonia and impounded in storage ponds. For the present, this treatment is satisfactory but a better, long-term solution is being sought.

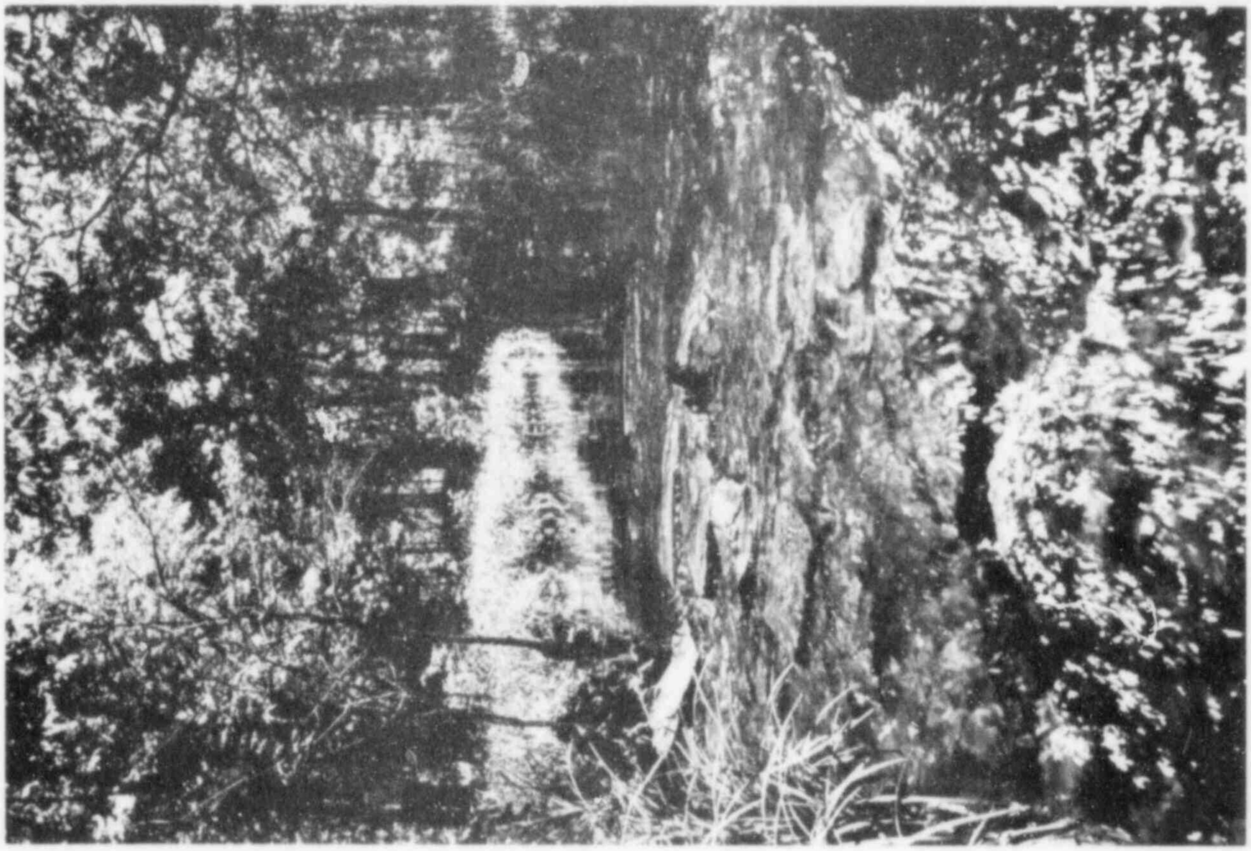
A second liquid waste stream is generated by the hydrofluoric acid scrubber. The scrubber is connected to all emergency vent headers located on process vessels and storage tanks so that gases evolved through the overpressurization of vessels and tanks are absorbed. This fluoride waste stream is combined with waste sodium carbonate solutions originating in the fluorine cell rework area, any acid spilled in the HF vaporizer room sump and laboratory wastes. The combined stream is treated with lime which neutralizes acids and precipitates fluorides as calcium fluoride.

The alkaline sludge is permitted to settle in a retention basin to permit flocculation and sedimentation. The overflow is treated with sulfuric acid to adjust the pH and precipitate excess calcium. It is then permitted to clarify in a second basin. The clarified treated waste overflows and is combined with clean waste water and the sewage lagoon overflow. A concrete stilling basin at the point of combination allows for mixing of the flow and controlled release through a slotted weir so that the rate of discharge can be measured. Discharge flows to the Illinois River through a natural watercourse. Two views of the effluent stream are shown on Plate 3. In January of 1971 a baffle system, consisting of a series of floating metal plate baffles, was installed in the fluoride sludge pit and clarifier lagoon. This system, combined with an improved acid neutralization operation, has resulted in better solid settling. The overflow effluent stream from the clarifier lagoon is clear.

PLATE 3 - Page 52

LEFT: Main Plant Effluent Stream

RIGHT: Main Plant Effluent Stream



Sanitary waste from the process facilities is kept in a stabilization lagoon having a holding time of about 60-70 days. Effluent from the lagoon is discharged with the excess cooling water into the Illinois River through natural watercourses. The State Health Department considered the existing design to be preferable to a treatment facility. Specifications, drawing and a technical assessment is included in Appendix I.

The design, construction and operation of the waste treatment systems comply fully with applicable State and Federal regulations, specifically "Water Quality Standards of the State of Oklahoma-1968" and "Title 10 Code of Federal Regulations Part 20". Permits and licenses required are included in Appendix I.

Retention basins constructed for raffinate storage and fluoride stream settling and clarification are built to AEC standards "Licensing Guide-Information and Criteria Pertinent to the Evaluation of Embankment Retention Systems". These storage pits are monitored by seepage wells located at the periphery. Figure 11 shows effluent flows and well locations. Specifications of these ponds are in Appendix I.

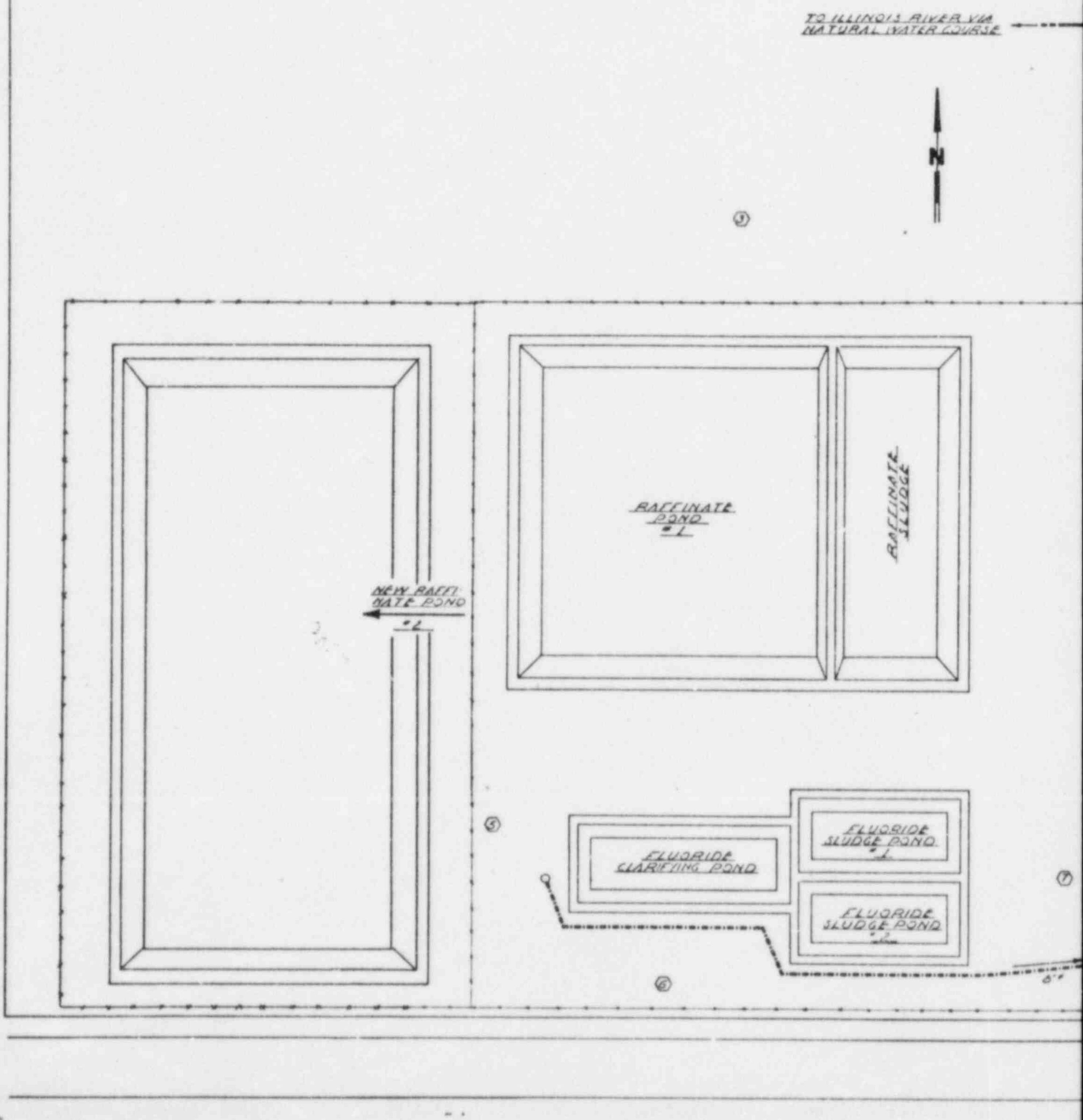
b. Solid Wastes

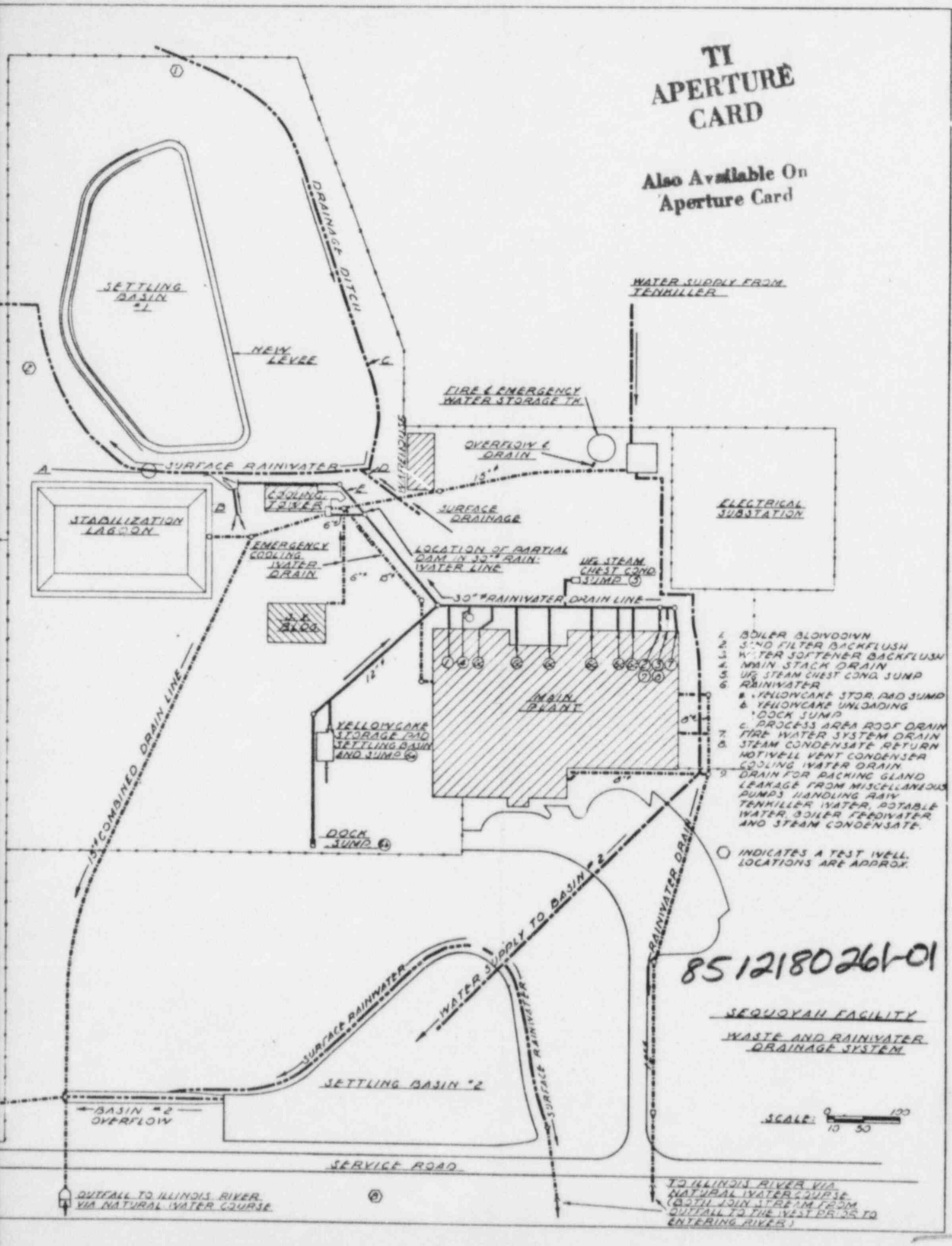
Clean combustable materials such as boxes, crates, paper and rags are burned in an open-pit incinerator. These units were designed by DuPont and modified as a result of operating experience gained by Glidden Company in Reading, Pennsylvania, and Bell Refinery in Ardmore, Oklahoma. The design capacity is one ton per day but actual loads are of the order of 100-150 pounds per day.

Permission to construct the incinerator was granted by the Oklahoma State Department of Health on November 12, 1970. The unit was tested by the State Department of Health on July 14, 1971, and found to be operating satisfactorily. Copies of the permit and inspection letter are included in Appendix I.

FIGURE II

PLANT AREA MAP SHOWING SAMPLING POINT LOCATIONS AND DRAINAGE FLOW




SETTLING BASIN #1
NEW LEVEE
DRAINAGE DITCH
WATER SUPPLY FROM TENKILLER
FIRE & EMERGENCY WATER STORAGE TK.
OVERFLOW & DRAIN
SURFACE RAINWATER
STABILIZATION LAGOON
COOLING TOWER
SURFACE DRAINAGE
ELECTRICAL SUBSTATION
EMERGENCY COOLING WATER DRAIN
LOCATION OF PARTIAL DAM IN 30" RAINWATER LINE
UF6 STEAM CHEST COND. SUMP
30" RAINWATER DRAIN LINE
MAIN PLANT
YELLOWCAKE STORAGE PAD SETTLING BASIN AND SUMP
DOCK SUMP
15" COMBINED DRAIN LINE
WATER SUPPLY TO BASIN #2
RAINWATER DRAIN
SURFACE RAINWATER
SETTLING BASIN #2
BASIN #2 OVERFLOW
SERVICE ROAD
OUTFALL TO ILLINOIS RIVER VIA NATURAL WATER COURSE
TO ILLINOIS RIVER VIA NATURAL WATERCOURSE (BOTH JOIN STREAM FROM OUTFALL TO THE WEST PRIOR TO ENTERING RIVER)
1. BOILER BLOWDOWN
2. SAND FILTER BACKFLUSH
3. WATER SOFTENER BACKFLUSH
4. MAIN STACK DRAIN
5. UF6 STEAM CHEST COND. SUMP
6. RAINWATER
a. YELLOWCAKE STOR. PAD SUMP
b. YELLOWCAKE UNLOADING DOCK SUMP
c. PROCESS AREA ROOF DRAIN
7. FIRE WATER SYSTEM DRAIN
8. STEAM CONDENSATE RETURN HOTWELL VENT CONDENSER COOLING WATER DRAIN
9. DRAIN FOR PACKING GLAND LEAKAGE FROM MISCELLANEOUS PUMPS HANDLING RAW TENKILLER WATER, POTABLE WATER, BOILER FEEDWATER AND STEAM CONDENSATE.
○ INDICATES A TEST WELL. LOCATIONS ARE APPROX.
8512180261-01
SEQUOYAH FACILITY
WASTE AND RAINWATER DRAINAGE SYSTEM
SCALE:

Solid combustable wastes that are not suitable for open-pit burning are burned in an enclosed unit located within the plant and discharging to the boiler stack. The capacity of the incinerator is 50 pounds per hour with loads being about 50 pounds per day. No radioactive material nor chemicals capable of releasing noxious vapors are treated in this unit. Combustion gases are vented out the 150 foot high stack.

Radioactive materials such as contaminated drums, sludges and other solids, where burning is impractical or undesirable, are buried underground. Materials so treated are essentially water insoluble. As of June 19, 1972, 305 pounds of material has been buried. It is not anticipated that buried wastes will adversely affect underground water supplies. The plant process does not create new radioactive elements nor increased radioactivity. Consequently, burial represents a transfer of natural water-insoluble radioactivity from one location to another. The plant site is a licensed burial ground.

c. Gaseous Wastes

The treatment of gases containing nitrogen oxides, HF and hydrogen have been discussed in the sections of this report describing the appropriate functions of the plant. Considerable ambient air is moved through solid uranium streams (1) as displaced gas when hoppers are emptied and filled and (2) to pneumatically convey uranium dusts to a collection point to avoid their uncontrolled release. Uranium dusts are removed from such air streams by cyclone separators and blowback filters of closely woven fabric felt. These filters are installed on all exhaust gas streams to eliminate release of uranium dust to the environment.

6. Raw Materials Handling

All tanks, vessels, pumps, valves, lines and agitators that come in contact with nitric acid are of type 304 stainless steel. Nitric acid storage tanks are located out-of-doors and surrounded by a four foot high concrete wall. Inside

the boundaries of the wall is sufficient limestone to neutralize the acid that would be released in the event of a tank rupture.

All tanks, vessels, valves, lines and agitators that come in contact with anhydrous HF are of carbon steel. Storage tanks are located out-of-doors with similar type concrete walls as used for nitric acid. Wet HF is held in polyvinylchloride-lined carbon steel vessels. HF is moved through lines by nitrogen pressure.

All tanks, vessels, valves and lines that come in contact with elemental fluorine are of carbon steel. Fluorine is not stored but is generated as needed. Nitrogen is used to flush fluorine lines.

All parts of the solvent extraction system, inclu including hexane storage tanks, are of type 304 stainless steel. The hexane storage tank is located out-of-doors, underground, and is located 120 feet from the truck unloading station.

TABLE V

CHEMICAL STORAGE VOLUMES

	Number of Tanks	Nominal Capacity Gallons
Anhydrous Hydrofluoric Acid	2	30,000
Aqueous Hydrofluoric Acid	2	30,000
60% Nitric Acid	1	15,000
40% Nitric Acid	1	15,000
Ammonia	1	15,000
Sulfuric Acid	1	1,000
Fuel Oil	1	30,000
Diesel Oil	1	2,000
Hexane	1	19,000

D. Material Balances

The following tables provide information as to chemical consumption, distribution of major materials and total effluent distribution. These data are based upon actual consumption experienced from July 1971 to March 1972 and are subject to change

as operating efficiencies improve or production rates increase. Data is included for the operating rate experienced in this period and extrapolated data for capacity production.

Process changes are contemplated that will alter these flows. An additional ventilation system is being installed to better control in-plant ambient air uranium concentrations and to provide a secondary filter for exhaust streams from the current blowback-type air filters. It is planned to provide for recycle for primary fluorination ash returning directly to fluorinators thus reducing the recycle material recovered in the miscellaneous digest tank. This change will reduce the amount of aluminum hydroxide used for complexing fluoride in the solvent extraction feed.

Storage of intermediate products is provided to permit continued operation of downstream equipment during interruptions. A hopper of sufficient size to contain ten days production of UF_4 was installed to permit campaigning of operations in two sections when schedules did not require capacity production.

TABLE VI

LAG STORAGE CAPACITY OF INTERMEDIATE PRODUCTS

Material and Location	5,000 Ton Plant	10,000 Ton Plant
Ore concentrate as received in drums	3,000 Drums	6,000 Drums
Ore concentrate after sampling	750 $Feet^3$	750 $Feet^3$
$UO_2(NO_3)_2$ as 4 lb U/gal Solution	2,000 Gal	2,000 Gal
$UO_2(NO_3)_2$ as 10 lb U/gal Solution	75,200 lbs U	112,800 lbs U
Milled UO_3	32,250 lbs U	32,250 lbs U
UF_4 in Storage Bin	64,500 lbs U	64,500 lbs U
UF_4 in 10-Day Hopper	322,000 lbs U	322,000 lbs U
Fluorine	None	None

TABLE VII

CONSUMPTION OF CHEMICALS
BY THE SEQUOYAH FACILITY
(July 1971 - March 1972)

KERR-McGEE HAS REQUESTED THAT THIS INFORMATION BE WITHHELD FROM PUBLIC DISCLOSURE IN ACCORDANCE WITH SECTION 2.790(b) OF 10 CFR PART 2.

TABLE VIII

SEQUOYAH FACILITY

RECEIPTS, SHIPMENTS AND LOSSES (INCLUDING STORAGE) OF URANIUM, FLUORIDE AND COMBINED NITROGEN AT A PRODUCTION RATE OF 175.3 METRIC TONS PER MONTH OF URANIUM AS URANIUM HEXAFLUORIDE (2312 SHORT TONS PER YEAR)

KERR-McGEE HAS REQUESTED THAT THIS INFORMATION BE WITHHELD FROM PUBLIC DISCLOSURE IN ACCORDANCE WITH SECTION 2.790(b) OF 10 CFR PART 2.

TABLE IX

SEQUOYAH FACILITY

RECEIPTS, SHIPMENTS AND LOSSES (INCLUDING STORAGE) OF URANIUM, FLUORIDE AND COMBINED NITROGEN AT A PRODUCTION RATE OF 378.8 METRIC TONS PER MONTH OF URANIUM AS URANIUM HEXAFLUORIDE (5000 SHORT TONS PER YEAR)

KERR-McGEE HAS REQUESTED THAT THIS INFORMATION BE WITHHELD FROM PUBLIC DISCLOSURE IN ACCORDANCE WITH SECTION 2.790(b) OF 10 CFR PART 2.

TABLE X

METRIC TONS OF EFFLUENTS IN ALL PROCESS STREAMS AT A PRODUCTION RATE OF 175.2 METRIC TONS PER MONTH OF URANIUM CONTENT AS URANIUM HEXAFLUORIDE[a] (2312 SHORT TONS U/YEAR)

(All Quantities are in Metric Tons)

	Stored					Ⓐ	Ⓑ	Air Stream								Ⓒ	Ⓓ	
	Neutralized Raffinate	Ammonia to Retention Basins	Fluoride Retention Basins	Fluoride Cell Sludge	Used Anode	TOTAL STORED	Aqueous Combination Stream	Sample Prep Room Air Exhaust	Hexane Vents	Absorber Tail Gas	UO_3 Dust Collector Exhaust	Reduction Off-Gas to Plant Stack	HF Scrubber	Fluorine Emergency Vent	F_2 Cell Rework Hood Exhaust	TOTAL AIR STREAM	Other Losses All Sources	TOTAL LOSSES A+B+C+D
Uranium	0.1		0.10			0.20		$2x10^{-5}$	-	-	$2x10^{-6}$	-	$9x10^{-4}$			$922x10^{-6}$	0.70	0.701
Hexane	-		-			-		-	9.7	-		-	-			9.7		9.7
Nitrate	87.3		-			87.3		-	-	-		-	-			-		87.3
Water[b]	961.4		172			1133.4	9888	-	-	274.6		29.3	62			365.9		11.387
Ammonia	19.0	1.5	-	-	-	20.5				-			-	-	-	-		20.5
Fluoride			13.1	.03	-	13.1	.06			-			.021	.19	.014	.225		13.4
Hydrofluoride				.21	.001	.21				-			-	-	-	-		0.21
Nitrogen Oxide				-	-	-				3.1			-	-	-	3.1		3.1
Sulfur Dioxide						-	-			-		0.67	-	-		0.67		0.67
Fluorine						-	-			-		-	-	.079		.079		.079
Nitrogen[b]						-	-			543.5		777	3726	-		5046		5046
Oxygen[b]						-	-			164.2		218	1116	-		1498		1498
TOTAL						1254.7	9888									17722[c]		

a. Matter such as sodium, potassium and calcium that is present in small amounts and is relatively innocuous has been left off this table.

b. These are diluents that serve to dilute pollutants.

c. 28.1 Million cubic feet (568 metric tons) of natural gas are (assumed tube) burned in (stoichimetric) air, yielding 1562 metric tons of CO_2, 1278 metric tons of H_2O and 7958 metric tons of nitrogen. This is not a process stream but it contributes to dilution at the stack.

TABLE XI

METRIC TONS OF EFFLUENTS IN ALL PROCESS STREAMS AT A PRODUCTION RATE OF 378.8 METRIC TONS PER MONTH OF URANIUM CONTENT AS URANIUM HEXAFLUORIDE[a] (5000 SHORT TONS U/YEAR)
(All Quantities are in Metric Tons)

	Stored					Ⓐ	Ⓑ	Air Stream							Ⓒ	Ⓓ	
	Neutralized Raffinate	Ammonia to Retention Basins	Fluoride Retention Basin	Fluoride Cell Sludge	Used Anodes	TOTAL STORED	Aqueous Combination Stream	Sample Prep Room Air Exhaust	Hexane Vents	Absorber Tail Gas	Reduction Off-Gas to Plant Stack	HF Scrubber	Fluorine Emergency Vent	F_2 Cell Hood Rework Exhaust	TOTAL AIR STREAM	Other Losses All Sources	TOTAL LOSSES A+B+C+D
Uranium	0.1		0.20			0.30	0	$4x10^{-5}$	-	-	-	$9x10^{-4}$			$94x10^{-5}$	0.7	1.2
Hexane						-	-		9.7	-	-	-			9.7	-	9.7
Nitrate	167.5					167.5	.1[illegible]		-	-	-	-			-	-	167.6
Water[b]	1397.2		180			1577.2	119[illegible]		-	276	91	62			429	-	13926
Ammonia	37.5	1.4				38.9						-	-	-	-		38.9
Fluoride			11.1	.06		11.2	.0[illegible]					.021	.047	.030	.098		11.4
Hydrofluoride				.43		.43						-	-	-	-		.43
Nitrogen Oxide										4.6	-				4.6		4.6
Sulfur Dioxide											1.51		-		1.51		1.51
Fluorine													.048		.048		.048
Nitrogen[b]										543.5	1690	3741			5975		5975
Oxygen[b]										164.2	472	1104			1740		1740
TOTAL						1795.5	11920								25836[c]	0.7	

a. Matter such as sodium, potassium and calcium that is present in small amounts and is relatively innocuous has been left off this table.
b. These are diluents that serve to dilute pollutants.
c. 46 million cubic feet (930 metric tons) of natural gas are assumed to be burned in stoichimetric air, yielding 2557 metric tons of CO_2, 1278 metric tons of H_2O and 7958 metric tons of nitrogen. This is not a process stream but it contributes to dilution at the stack.

IV. ENVIRONMENT IMPACT

The National Environmental Policy Act of 1969, Public Law 91-190, states as its purpose "a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere, and stimulate the health and welfare of man; . . ." At least by implication it recognizes that any improvement in the welfare of man has some effect upon the natural environment and the policy seeks to minimize the adverse effects of such impact.

Such effects can be subdivided into several levels of interest for the purpose of our analysis primarily by the current level of knowledge about total impact. Such a subdivision might be classified as (1) those impacts which have been well recognized due to experienced adverse effects of some level resulting in intensive technical effort to measure and reduce such adverse effect, (2) technical impacts whose degree of adverse effect has not been established with any degree of technical precision, and (3) those impacts which intrude into man's subjective appreication of his environment and, hence, is not subject to technical quantification.

Where sufficient technical examination of the impact of effluents on the total environment has been established, there generally exists competent technical discussion, evaluation of the degree of impact and establishment of standards of effluent quality known to avoid adverse impact. Often, as in the case of some recently discovered adverse effects, these same effluent characteristics when reduced to barely detectable levels only cause an adverse impact after long exposure to a narrow and specialized segment of the environment. Much of the work to define such long-range cumulative effect of low levels of exposure of the environment to effluent contaminants has not been completed to the extent that standards can be established.

Impact resulting in adverse effect upon the subjectively evaluated environment is extremely difficult to quantitatively evaluate and to measure realistically for the population existing in that particular environment. Therefore, any evaluation must attempt to balance the effect of improvement resulting from new economic activity with the marginal impact caused to the subjective evaluation of that environment. It has been well demonstrated that the cumulative effect of disregarding man's subjective evaluation of his environment can lead to deterioration and eventual destruction of the total environment for the great majority of population in a given area.

This report will speak initially to those technical subjects well defined by current literature as to the adverse effect of excessive effluent concentrations and describe, where possible, the marginal limitations where long-range low level accumulations are outside of the current state-of-the-art. Subsequently, it will examine those items of marginal economic or subjective influence on the total environment.

A. <u>Effluent Quality</u>

Process streams in a UF_6 conversion plant must be carefully designed and controlled to prevent uncontrolled release of processing materials that would be harmful to the environment or hazardous to the health of individuals. The design criteria established for the use by Bechtel in plant design were based upon levels established in other areas of the United States where experience had demonstrated that certain effluent chemicals, if indiscriminately released from chemical processing plants, would result in deterioration of the environment. Tolerable target levels of effluent content were established by researching available established environmental control criteria. The design criteria and sources from which such criteria were derived are presented in Table XII. Kerr-McGee believes that under

TABLE XII

DESIGN CRITERIA FOR THE
FACILITY EFFLUENT CONTROL

Constituent	Facility Limit	Maximum Ground Level Conc. Beyond Site Fence	Reference
Hexane	500 ppm	500 ppm	1.2
SO_2-Ground level	5 ppm	0.2 ppm	2.3.4.5.6
-Stack emission	2000 ppm		
Smoke	Less than #2 Ringlemann neglecting water vapor effect		7
NO_x-Ground level	5 ppm	2 ppm	3.8
Stack emission	300 ppm		
HF -Ground level	3 ppm	10 pp billion	3.9
Stack emission	15 ppm		
F_2 -Ground level	0.1 ppm	10 pp billion	3.9
Stack emission	1 ppm		
Particulates	0.3 grain/ft^3 at the point of release		6
UF_4	0.25 mg/$meter^3$	0.006 mg/m^3	10
UF_6	0.05 mg/$meter^3$	0.009 mg/m^3	2.11.12
Radionucleides			11.12
Raffinate	N.A.	No discharge	
Sanitary & Laundry	N.M.		13
Thermal [Cooling water]	N.M.	Max. Rise 5°F. Max. Temp. of Water 93°F.	13

REFERENCES

1. San Francisco Bay Area, Air Pollution Control District, Req. 2, Div. 4 (1962).
2. American Conference of Government and Industrial Hygienists (1962). Recommended Threshold Limit Values.
3. City of New York, Air Pollution Control Code, Article 9, Section 9.07 (1964).
4. S.F. Bay Area, Air Pollution Control District, Req. 2, Div. 31 (1962).
5. County of Sarasota, Florida Air Pollution Control Resolution, Section 8 (1959).
6. County of Los Angeles, Air Pollution Control District, Requisition IV (1965).
7. U.S. Bureau of Mines Information Circular 7718.
8. State of California Public Health Department.
9. State of Florida Air Pollution Control Commission Rules (1965).
10. Harrington and Ruehle, "Uranium Production Technology" (1959).
11. State of Oklahoma Radiation Rules/
12. USAEC Regulation. Title 10, Port. 20
13. State of Oklahoma Regulation.

normal plant operating conditions these criteria are being met and the testing and surveillance program in effect at the Sequoyah Facility is adequate to detect incidences when they are exceeded. If more stringent standards of effluent quality are established by authority to which the Sequoyah Facility is subject, Kerr-McGee will comply with these revised regulations within its capability considering the state-of-the-art of measurement and control available.

To meet the design criteria certain well defined techniques of effluent control were recognized and installed during the construction of the plant. These systems provide for the recovery of nitric acid, the scrubbing of fluoride containing effluent streams and continuous blowback air filters to remove uranium particulates from the air and gases exhausted. With such treatment, effluent levels are low enough that gases can be dispersed from the top of a 150 foot stack and reach tolerable ground level concentrations. Such process control facilities have been described in the earlier sections of this report.

Also described earlier was the planned disposal of raffinate to a deep well during initial plant design. Subsequent disapproval of this method of disposal resulted in the installation, as described, of holding ponds for interim storage of such raffinates until such time that solidification and/or disposal techniques could be determined.

B. Environmental Surveillance Program

Once that effluent criteria, designs and construction had been established, it was realized that such precautionary measures could not insure against the accidental release of potentially hazardous materials. Consequently, an environmental surveillance program was established to monitor the effectiveness of the plant design and operation. Subsequently, certain facets

and activities have been modified under this surveillance program to respond to additional problems or alteration in planned operation. The current environmental surveillance program consists of collecting the following samples and analyzing monthly for fluoride, nitrate and alpha and beta radioactivity:

1. The liquid effluent stream consisting of the combined (1) fluoride treatment effluent, (2) sanitary effluent, (3) water bypassed around the water treatment facility, and (4) overflow from the cooling tower plant is sampled at the point where it leaves the immediate plant control area South of the road. This stream is sampled continuously and daily cumulative samples are analyzed for control daily and composited on a weekly and monthly basis for analysis. The four individual streams are sampled bi-weekly.
2. Air samplers are located at the fence perimeter and at a radius of 1000 feet in four directions. Continuous samples are taken for a week and analyzed.
3. The Illinois and Arkansas Rivers are sampled upstream and downstream of the outfall discharge once each week and analyzed in a monthly composite.
4. Soil and vegetation samples are collected near the location of the four air samplers (1000 feet) monthly and vegetation samples are collected at 6000 feet distances from the plant in all four directions. Vegetation is protected by cages and entirely collected at the time scheduled. Soil is taken from a four-square-foot area, one-inch deep near the cages.
5. Samples are removed from the monitoring wells near the storage ponds and from water wells on the site monthly.
6. Surface ponds on the site are sampled and analyzed monthly.

All composited environmental samples are analyzed by an independent laboratory. Results of these analyses are presented in Tables XIII-XXII on the following pages. These samples have now been taken over a period of more than one year. This includes hot and cold and wet and dry seasons.

The results of these independent analyses show that radioactive discharge is well within the alpha, beta and radium limits of 10 CFR 20 (Table XIII). Except for two months during plant startup, the fluoride precipitation and clarification system has kept the fluoride level in the effluent below the U. S. Public Health Service drinking water standards (Table XIV) of 1.2 ppm.

Sampling a well mixed liquid solution is straighforward. Sampling a gas stream is more involved particularly if it is not know whether complete mixing has taken place. In sampling solids, the greater limitation on measurement accuracy may be sampling rather than analysis. This means that results obtained from soil and vegetation samples are usually less reliable than results obtained from analyses of liquids.

When measuring low levels of radiation and concentration, the analyst may be working at or near the detection limits. With the growing interest in ppm and ppb analyses of trace elements, the uncertainties in a determination by a careful analyst may be more than 100% of the analysis. Consequently, the average of a number of analyses is more reliable and useful than any single determination.

Measuring and tracing the flow of liquids from a plant is relatively straightforward since the drainage flow can be predicted and, to a fair extent, controlled. For gases, it is far less predictable. Wind speeds and directions (see wind roses, Figures 3-7), atmospheric temperatures and humidity are very variable. Pasquill and Gifford[14] derived an equation for

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[14] "Workbook of Atmospheric Dispersion Estimates, "U.S. Department of Health, Education and Welfare, U.S. Public Health Service, Cincinatti (1969).

TABLE XIII

GROSS ALPHA, BETA AND RADIUM 226 ANALYSES OF SEQUOYAH FACILITY COMBINATION STREAM AND THE ILLINOIS AND ARKANSAS RIVERS - $\mu Ci x 10^{-7}/ml$

	Combination Stream at Plant			Illinois River Upstream			Illinois River Downstream			Arkansas River Upstream			Arkansas River Downstream		
	α	β	226 Ra	α	β	226 Ra	α	β	226 Ra	α	β	226 Ra	α	β	226 Ra
Operational															
1971[a]															
January	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
February	1.6	.8	.01	<.01	.01	<.01	.04	.09	<.01	.02	.06	<.01	.03	.05	<.01
March	6.8	4.0	<.01	.01	.09	<.01	.20	.14	<.01	.02	.14	<.01	.29	.37	<.01
April	31.8	13.0	.26	.02	<.01	.04	1.10	.50	.01	.03	.10	<.01	.04	.06	<.01
May	26.4	47.4	.02	.01	.09	.01	.04	.12	<.01	.03	.12	<.01	<.01	<.01	.02
June	NS	NS	NS	<.01	.09	<.01	.04	.12	<.01	.03	.12	<.01	<.01	<.01	.02
July	4.2	3.3	.03	.03	.03	.01	<.01	.14	<.01	<.01	.04	.02	<.01	.01	.02
September	3.6	3.0	.02	.08	.05	<.01	1.80	1.70	.02	<.01	.10	.02	.01	.17	.01
October	30.6	17.4	.05	.08	1.22	.10	.57	.40	<.01	.02	.27	.02	.09	.19	.01
November	36.7	14.3	.05	.06	.29	0	1.52	.72	<.01	.07	.42	<.01	.13	.60	<.01
December	11.4	9.2	.04	.24	.06	<.01	.41	.17	.02	.13	.71	.03	1.87	1.55	.03
1972															
January	13.1	8.0	<.01	.08	.11	<.01	.31	[illegible]	<.01	.03	.15	<.01	.02	.08	<.01
February	18.0	8.2	<.01	.04	.06	<.01	1.12	.46	<.01	.04	.16	<.01	.06	.54	<.01
March	17.3	9.1	<.2	.17	.09	<.01	.74	.48	<.01	.03	.05	<.01	.34	.10	<.01
Ave Last 12 Months	18.6	12.6	.06	.07	.18	.02	.71	.58	.01	.03	.20	.01	.22	.30	.01
Preoperational															
1969[b]															
July	No Effluent			.03	.08			NS		.03	.06		.04	.03	
August	"			.03	.07			NS		.04	.05		.02	.04	
September	"			.02	.03			NS		.02	.05		.02	.01	
October	"			.02	.03			NS		.02	.01		.01	.02	
November	"			<.01	<.01			NS		<.01	.04		<.01	.01	
December*	"			<.01	<.01			NS		NS	NS		NS	NS	
Average				.02	.04			NS		.02	.04		.02	.02	

(a) Control for Environmental Pollution Results
(b) R. Y. Nelson's Preoperational Survey Results
NS - Not Sampled
* - Sequoyah Lab Results

TABLE XIV

FLUORIDE AND NITRATE ANALYSES OF SEQUOYAH FACILITY COMBINATION STREAM AND THE ILLINOIS AND ARKANSAS RIVERS CONCENTRATION IN PPMF⁻ AND NO_3 AS N

	COMBINATION STREAM AT PLANT		AVERAGE TEMPERATURE INCREASE	ILLINOIS RIVER UPSTREAM		ILLINOIS RIVER DOWNSTREAM		ARKANSAS RIVER UPSTREAM		ARKANSAS RIVER DOWNSTREAM	
	F	N	oF	F	N	F	N	F	N	F	N
Operational											
1971[a]											
January	NS	NS		NS	NS	NS	NS	NS	NS	NS	NS
February	1.0	1.8		.5	1.8	.4	1.8	2.0	1.3	1.3	.5
March	2.6	<.1		<.1	<.1	.2	<.1	.4	.1	.2	<.1
April	2.6	22.0	2.4	.1	.2	.1	.2	.4	.4	.3	.4
May	.8	8.1	4.3	<.1	2.6	.3	1.2	.6	.6	.3	1.8
June	NS	NS	5.0	<.1	1.1	.2	.8	.4	1.1	.4	.8
July	.4	.9	4.5	<.1	.5	.2	.5	.2	.3	.2	.2
August	.7	13.7	5.0	.1	.3	.2	.2	.4	.3	.3	.2
September	.6	3.1	5.4	.1	.5	.2	.7	.2	.9	.2	.7
October	1.0	14.4**	4.7	.1	40.9**	.1	52.1**	.2	44.0**	.2	40.0**
November	.6	1.3	4.3	.1	.3	.1	.2	.3	.8	.2	.7
December	.7	.6	4.7	.2	.2	.2	.3	.2	.6	.2	<.1
1972											
January	1.1	.1	5.5	.4	.1	.6	.1	.6	.7	.5	.1
February	1.0	<.1	6.1	.6	<.1	.5	<.1	.4	<.1	.8	<.1
March	.4	3.1	4.3[c]	.6	.1	.6	.4	.7	.1	.8	.3
Ave Last 12 Months	.9	5.3	4.7	.2	.6	.3	.5	.4	.6	.4	.6
Preoperational											
1969[b]		Not Operating									
July		"		.2	.5	NS	NS	.4	.2	.1	.3
August		"		.2	.4	NS	NS	.5	.1	.2	.3
September		"		.2	.3	NS	NS	.5	.1	.4	.3
October		"		.3	.3	NS	NS	.4	.4	.3	.3
November		"		.1	.3	NS	NS	.4	.5	.1	.3
December		.3*		<.1	NS	NS	NS	.3	NS	.1	NS
Average				.2	.4			.4	.3	.2	.3

(a) Controls for Environmental Pollution Results
(b) R. Y. Nelson's Preoperational Survey Results
* Sequoyah Lab Results
** Analyses Suspect - Not Included in Calculation: Possibly due to storage for long period with continuing bacterial action.

TABLE XV

GROSS ALPHA, GROSS BETA AND RADIUM-226
SEQUOYAH FACILITY SEEPAGE WELLS µCix10^{-7}/ml

	Well 1			Well 2			Well 3			Well 4*			Well 5			Well 6		
	α	β	Ra	α	β	Ra	α	β	Ra	α	β	Ra	α	β	Ra	α	β	Ra
Operational																		
1971[a]																		
January	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
February	1.0	.7	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	.1	<.1	.2	.6	<.1	.3	.2	<.1
March	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
April	.1	.2	<.1	<.1	.2	<.1	1.9	1.9	<.1	<.1	.4	<.1	<.1	.2	<.1	.3	.3	<.1
May	.4	1.2	.3	.3	.8	<.1	.2	.6	<.1	<.3	.6	<.1	.8	1.8	<.1	.4	.7	<.1
June	.8	1.1	<.1	2.5	1.1	<.1	.6	.8	<.1	NS	NS	NS	.3	.7	<.1	.2	.4	<.1
July	.7	1.0	.4	.5	.7	<.1	.4	1.2	<.1	NS	NS	NS	.2	1.0	<.1	<.1	.2	<.1
August	.9	.5	.3	1.0	.3	<.1	NS	NS	NS	NS	NS	NS	.3	.8	<.1	.1	.2	<.1
September	1.4	.8	.1	.5	.4	<.1	.3	1.5	<.1	NS	NS	NS	.2	.5	.2	<.1	<.1	<.1
October	1.2	.8	.3	.6	.6	<.1	.7	.5	<.1				<.1	.2	<.1	.3	.2	<.1
November	.8	.8	<.1	.8	.6	<.1	.6	.6	<.1		NS		.3	.5	<.1	.2	.5	<.1
December	1.1	1.3	.3	.5	.4	<.1	.5	.5	<.1				.3	.4	<.1	.6	.9	<.1
1972																		
January	.1	.9	<.1	.5	.4	NS	.4	.7	NS				.3	<.1	NS	.1	.9	NS
February	1.4	.5	<.1	1.1	.5	NS	.8	.7	NS		NS		1.0	.6	NS	1.2	.6	NS
March	1.4	.5	<.2	.5	.3	<.2	1.2	1.2	<.1				1.4	.6	<.2	1.5	.2	<.1
Ave. Last 12 Months	.8	.8	.1	.7	.5	<.1	.7	.9	<.1				.4	.6	<.1	.4	.4	<.1

Preoperational
Wells were not drilled prior to facility operation

(a) Control for Environmental Pollution Results
* Well No. 4 abandoned in June
NS - Not Sampled
Well locations shown on Fig. 3.
Due to Ra contents generally below detectable levels and low analytical precision, analysis for Ra will be performed quarterly in 1972.

TABLE XVI

FLUORIDE AND NITRATE ANALYSES - SEQUOYAH FACILITY SEEPAGE WELLS
CONCENTRATION IN PPM F^- AND NO_3 AS N

	WELL 1 F	WELL 1 N	WELL 2 F	WELL 2 N	WELL 3 F	WELL 3 N	WELL 4 F	WELL 4 N	WELL 5 F	WELL 5 N	WELL 6 F	WELL 6 N
Operational												
1971[a]												
January	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
February	1.8	11.0	.4	4.3	2.0	3.3	6.0	5.5	6.3	5.5	.7	5.5
March	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
April	.5	32.0	.2	<1.6	1.5	6.5	.6	3.1	1.0	4.4	.7	3.5
May	1.3	30.0	1.0	44.0	.9	5.5	.8	6.3	.9	3.9	.7	3.5
June	1.0	43.1	.6	14.7	1.1	2.3	NS	NS	1.1	1.8	.5	1.5
July	1.4	3.9	.9	23.3	1.2	.5			.8	19.5	.3	.3
August	1.0	2.2	.8	3.2	NS	NS	NS	NS	.9	44.3	.4	.2
September	1.2	4.1	.9	2.5	.6	4.3			1.0	3.1	.4	1.6
October	1.1	10.5	.9	8.1	.5	4.9			1.1	5.5	.3	5.7
November	.8	11.0	.8	1.1	.5	.6	NS	NS	.6	1.4	.4	.3
December	.6	7.1	.8	1.0	.5	1.0			.6	2.3	.4	.2
1972												
January	1.2	.2	1.0	<.1	.9	.1			1.2	.6	1.0	.2
February	1.0	<.1	1.1	1.0	.9	<.1	NS	NS	.7	1.1	.7	<.1
March	1.0	24.0	1.2	.3	1.1	.9			.8	1.0	.5	.2
Ave. Last 12 Months	1.0	14.0	.9	8.4	.9	2.7			.9	7.4	.4	1.4

Preoperational

Wells were not drilled prior to facility operation

(a) Control for Environmental Pollution Results
* Well No. 4 abandoned in June
NS - Not Sampled

Well locations shown on Fig. 3.

TABLE XVII

GROSS ALPHA, GROSS BETA AND RADIUM-226 ANALYSES
SEQUOYAH FACILITY FAULT AND DOMESTIC WELLS $\mu Ci \times 10^{-7}/ml$

	FAULT WELL			CARLISLE SCHOOL WELL			RESIDENCE WELL 1			RESIDENCE WELL 2		
	α	β	Ra	α	β	Ra	α	β	Ra	α	β	Ra
Operational												
1971[a]												
January	NS	NS	NS	NS	NS	NS	NS	NS	NS			
February	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1		NS	
March	NS	NS	NS	NS	NS	NS	NS	NS	NS			
April	.1	.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1			
May	.1	.2	<.1	<.1	<.1	<.1	<.1	<.1	<.1		NS	
June	<.1	.3	<.1	<.1	<.1	<.1	<.1	<.1	<.1			
July	.2	.3	<.1	<.1	<.1	<.1	<.1	<.1	<.1			
August	.2	.2	<.1	<.1	<.1	<.1	<.1	<.1	<.1		NS	
September	.1	.2	<.1	<.1	<.1	<.1	<.1	<.1	<.1			
October	.1	.2	<.1	<.1	.1	<.1	<.1	.1	<.1			
November	.2	.5	<.1	<.1	.5	<.1	.1	.3	<.1			
December	.1	.4	<.1	<.1	.1	<.1	.4	.6	<.1			
1972												
January	.3	.5	NS	<.1	.3	NS	.2	.2	NS			
February	.7	.7	NS	<.1	.1	NS	.4	.2	NS			
March	.4	.4	<.1	<.1	.1	<.1	.4	.3	<.1			
Ave Last 12 Months	.2	.3	<.1	<.1	.2	<.1	.2	.2	<.1			
Preoperational												
1969[b]												
July				<.1	<.1		<.1	.1		<.1	.1	
August				<.1	<.1		<.1	.1		<.1	.1	
September				<.1	<.1		<.1	.1		< 1	.1	
October				<.1	.1		NS	NS		<.1	.1	
November				<.1	<.1		NS	NS		<.1	.1	
December	<.1	.4	<.1	<.1	.4		<.1	.3		<.1	.6	
Average	<.1	.4	<.1	<.1	.1		<.1	.2		<.1	.2	

(a) Controls for Environmental Pollution Results - Residence Well 2 abandoned prior to facility operation
(b) R. Y. Nelson's Preoperational Survey Results
NS - Not Sampled
* Sequoyah Lab Results
Well locations shown on Fig. 1
Due to Ra contents generally below detectable levels and low analytical precision, analysis for Ra will be performed quarterly in 1972.

TABLE XVIII

FLUORIDE AND NITRATE ANALYSES - SEQUOYAH FAULT AND DOMESTIC WELLS
CONCENTRATION IN PPM F^- AND NO_3 AS N

	FAULT WELL		CARLISLE SCHOOL WELL		RESIDENCE WELL 1		RESIDENCE WELL 2	
	F	N	F	N	F	N	F	N
Operational								
1971[a]								
January	NS	NS	NS	NS	NS	NS		
February	1.8	6.6	1.0	4.4	1.8	5.5	NS	NS
March	NS	NS	NS	NS	NS	NS		
April	2.6	2.6	.1	6.2	.2	3.5		
May	2.9	2.7	<.1	3.2	.3	25.5	NS	NS
June	3.0	1.5	.2	1.6	.4	.8		
July	2.4	.1	.2	.5	.2	<.1		
August	2.7	.6	.2	.4	.3	.4	NS	NS
September	2.7	.1	.2	.4	.3	.3		
October	2.8	2.6**	.1	4.0**	.3	4.0**		
November	2.4	.2	.2	.7	.3	.3	NS	NS
December	2.2	.2	.3	.5	.5	.2		
1972								
January	4.0	.9	.9	<.1	1.1	<.1		
February	4.2	.5	.5	<.1	.7	<.1	NS	NS
March	4.7	.5	.6	.3	1.0	.1		
Ave. Last 12 Months	3.1	.9	.3	1.3	.3	2.8		
Preoperational								
1969[b]								
July			.3	.3	.2	.3	.1	.6*
August			.4	.4	.2	.1	.2	
September			.3	.5	.2	NS	.3	.4
October			.3	.4	NS	NS	.3	.6
November			.2	.3	NS	NS	.2	.4
December*	.7	2.3	.1	NS	<.1	NS	<.1	NS
Average	.7	2.3	.3	.4	.2	.2	.2	.5

(a) Controls for Environmental Pollution Results - Residence Well 2 abandoned prior to facility operation
(b) R. Y. Nelson's Preoperational Survey Results
NS Not Sampled
* Sequoyah Lab Results
** Analyses Suspect - not included in calculations: Possibly due to storage for long period with continuing bacterial action.
Well locations shown on Fig. 1

TABLE XIX

GROSS ALPHA ACTIVITY AND FLUORIDE RESULTS - SEQUOYAH FACILITY ENVIRONMENTAL AIR
ALPHA RESULTS $\mu Ci \times 10^{-14}/ml$ FLUORIDE RESULTS - CONCENTRATION IN PPM F

	1000 Ft. East[1] of Facility		1000 Ft. North[2]		1000 Ft. South[2]		1000 Ft. West[3]	
	α	F	α	F	α	F	α	F
Operational								
1971[a]								
April	5.4	<.001						
May	1.9	.001	<.3		3.0	.003		
June	5.8	<.001	10.6	<.001	3.4	<.001		
July	2.4	.002	7.0	.001	3.6	<.001		
August	3.0	.001	7.2	.002	2.8	.002		
September	<.3	<.001	4.6	.001	5.2	.005		
October	2.6	.006	5.0	.025	1.2	.001		
November	1.8	.017	5.4	.007	4.0	.001		
December	1.8	.003	3.2	.002	2.6	.003		
1972								
January	1.6	.001	3.6	.002	1.4	.001		
February	1.6	.001	2.6	.001	.8	.001		
March	1.4	<.001	4.8	<.001	1.4	.013		
Ave. Last 12 Months	2.3	.003	4.9	.004	2.7	.003	1.4	<.001
Preoperational								
1969[b]								
June through November Average	< 100	NS	< 100	NS	< 100	NS	< 100	NS

1 East station installed in April 1971.
2 North and South stations installed in May 1971
3 West station installed in March 1972.
a Controls for Environmental Pollution Results
b R. Y. Nelson's Preoperational Survey Results

TABLE XX

RADIOACTIVITY AND CHEMICAL ANALYSES - SEQUOYAH FACILITY PONDS[1] - ALPHA, BETA AND RA-226 RESULTS $\mu Ci \times 10^{-7}/ml$, FLUORIDE AND NITRATE RESULTS - CONCENTRATIONS IN PPM F^- AND NO_3 AS N

	Pond 1 (1/4 Mile South of Facility)					Pond 2 (1/4 Mile East of Facility)				
	α	β	Ra	N	F	α	β	Ra	N	F
Operational										
1971[a]										
January	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
February	.2	.2	<.1	5.5	5.4	<.1	.2	<.1	11.0	1.5
March	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
April	.1	.4	<.1	1.7	.3	.1	.2	<.1	.5	.2
May	<.1	.2	<.1	1.4	<.1	<.1	.1	<.1	1.4	.1
June	.1	.1	<.1	1.3	.4	<.1	.1	<.1	.2	.3
July	.1	.1	<.1	<.1	1.2	.1	.1	<.1	.5	.1
August	.7	.4	<.1	.2	2.7	.1	.1	<.1	.3	.2
September	.2	.2	<.1	.3	1.7	<.1	.1	<.1	.6	.1
October	.9	.7	<.1	21.8**	1.0	.3	.9	<.1	37.4**	.2
November	.1	.5	<.1	.3	.6	<.1	.4	<.1	.3	.1
December	.7	.5	<.1	.3	.5	.1	<.1	<.1	.3	.2
1972										
January	.4	.6		.2	.7	.1	.2	NS	.1	.4
February	.3	.7		.3	.7	.1	.3	NS	<.1	.5
March	.8	.6	<.1	.1	1.0	.2	.1	<.2	.1	.8
Ave. of Last 12 Months	.4	.4	<.1	.3	1.0	.1	.2	<.1	.4	.3
Preoperational										
1969[b]										
July	<.1	.1	NS	.4	.1	<.1	<.1	NS	.2	<.1
August	<.1	<.1	NS	.5	<.1	<.1	<.1	NS	.3	<.1
September	<.1	.1	NS	.4	<.1	<.1	<.1	NS	.3	<.1
October	<.1	.1	NS	.3	.1	<.1	.1	NS	.3	<.1
November	<.1	.1	NS	.2	<.1	<.1	<.1	NS	.2	<.1
December	<.1	<.1	NS	NS	.1	<.1	.4	NS	NS	<.1
Average	<.1	.1		.4	.1	<.1	.1		.3	<.1

1 Ponds were constructed for water supplies when the land was farmed and are fed by runoff and/or small springs.
a Controls for Environmental Pollution Results
b R. Y. Nelson's Preoperational Survey Results
NS Not Sampled
* Sequoyah Lab Results
** Analysis Suspect - Not included in average.

TABLE XXI

GROSS ALPHA RESULTS - SEQUOYAH FACILITY RESTRICTED AREA FENCE LINE AIR SAMPLES $\mu Ci \times 10^{-12}/ml$ ASSUMING ALL ALPHA ACTIVITY DUE TO NATURAL URANIUM - FLUORIDES - PARTS PER BILLION

	West Fence		South Fence		North Fence		East Fence	
	Gross Alpha	Fluoride	Gross Alpha	Fluoride	Gross Alpha	Fluoride	Gross Alpha	Fluoride
Operational								
1971[a]								
January			.78		.76			
February			1.02		.84			
March			1.30		1.06			
April			2.0		1.20			
May			.68		.76			
June			.74		1.04			
July			.78		.86			
August			.80		.64			
September			.22		.42			
October			.22		.33			
November			.13		.20			
December			.11		.17			
1972	Started Feb. 1972						Started Feb. 1972	
January			.13		.13	< 1		
February	.35		.15	< 1	.14	< 1	.13	.2
March	.17		.15	< 1	.19	< 1	.13	.2
Ave. Last 12 Months			.51		.51	< 1		
Preoperational								
1969[b]								
June - October Average						< 1		

[a] Sequoyah Facility Health Physics Monthly Average Results
[b] R. Y. Nelson's Preoperational Survey Results

TABLE XXII

FLUORIDE, NITRATE AND URANIUM RESULTS
SEQUOYAH FACILITY ENVIRONMENTAL SOIL AND VEGETATION
Results in ppm, Nitrate reported as N

	1000 Feet South of Facility			1000 Feet West of Facility			1000 Feet North of Facility			1000 Feet East of Facility			South Fence			North Fence		
	N	F	U	N	F	U	N	F	U	N	F	U	N	F	U	N	F	U
Soil																		
Operational																		
1971[a]																		
June		1.0	0.3		4.1	.7		5.8	.84		2.7	3.7		9.8	7.0		31	50
September	28.1	3.4	3.0	86.2	<.1	80	21.3	3.9	15.0	13.1	2.0	3.0	20	7.6	64	29	3	51
December	3.7	4.0	<5.0	3.5	3.0	<5.0	33	<.1	<5.0	3.8	<.1	<5.0	5	13.0	19.0	4	10	<5
1972																		
March	8	116	1.2	3.0	160	20	5.0	176	2.6	2.0	100	2.7	57	280	16.6	20	224	24
June*		11			41			32			22							
Preoperational																		
1969[b]																		
June			13.2			29.7			25.2			22.5						
October			29.1			22.0			18.6			17.1						
Average			21.3			25.9			21.9			19.8						
Vegetation																		
Operational																		
1971[a]																		
September	<1	3	32	4	2	75	2	4	13	4	1	11	1770	123	167	<1	71	10
Preoperational																		
1969[b]																		
June			38.1			34.5			25.2			13.2						
October			31.5			18.9			20.4			22.8						
Average			34.8			26.7			22.8			18.0						

[a]Controls for environmental pollution results
[b]R. Y. Nelson's Preoperational Survey Results. These uranium analyses were done by a different outside laboratory.
*Sequoyah Laboratory
Security line samples are taken for control. No stock are pastured west of State Highway 10 nor north of the service road.

TABLE XXII (Continued)

FLUORIDE, NITRATE AND URANIUM RESULTS
SEQUOYAH FACILITY ENVIRONMENTAL VEGETATION-1972 RESULTS
Results in ppm, Nitrate reported as N

	January 1972						March 1972			April 1972			May 1972		
	Laboratory No. 1			Laboratory No. 2[a]			Laboratory No. 2			Laboratory No. 2			Laboratory No. 2		
	N	F	U	N	F	U	N	F	U	N	F	U	N	F	U
North															
Security Fence					3.6		200	11.9	141	< 10	91	33.4			
1000 Feet from Plant		5.4			< 1.0		5	11.2	13.1	< 10	21	5.2	40	11	<5
2000 Feet from Plant		8.3			8.1										
6000 Feet from Plant										30	10.7	<5	40	22.4	<5
South															
Security Fence					6.4		700	43.3	2025	< 10	70	69			
1000 Feet from Plant		5.5			4.2		700	11.7	33.2	< 10	19.5	51.3	100	13	<5
2000 Feet from Plant		4.4			6.6										
3000 Feet from Plant		8.7			12.9										
6000 Feet from Plant										10	8.9	5.5	40	17.7	<5
East															
Security Fence										20	270	121			
1000 Feet from Plant		8.8			11.1		400	6.7	13.1	30	20	<5	180	7.0	<5
2000 Feet from Plant		10.3			9.0										
3000 Feet from Plant		83.7			< 1										
4000 Feet from Plant		18.9			14.4										
6000 Feet from Plant										10	15.4	<5	40	19	<5
West															
Security Fence										10	115	97			
1000 Feet from Plant		14.3			19.8		400	326	608	60	147	7	520	58	<5
2000 Feet from Plant		4.0			10.5										
6000 Feet from Plant										10	15.1	<5	100	13.1	<5

[a] The sample was split, half being sent to each laboratory

STATE OF WASHINGTON STANDARDS FOR FLUORIDE NOT TO EXCEED

1. 40 ppm - Average over 12 consecutive months
2. 60 ppm - Each month for no more than two (2) consecutive months
3. 80 ppm - More than once in two (2) consecutive months

calculating the dispersion of gases in air. Five stability conditions, A, B, C, D and F, ranging from very rapidly dispersed (A) to stable (F) have been defined. For sampling point calculations, an average condition of one-third each C, D and F is recommended by the AEC. Using Pasquill and Gifford's equation, graphs are presented in the "Workbook" for estimating dispersion as a function of distance from the point of emission.

The equation of Holland from the "Workbook" was used to calculate the effective stack height of the Sequoyah stack. This was found to be 170 feet. Representative calculations are found in Appendix IV.

The Pasquill-Gifford treatment makes the following assumptions needed to make calculations workable:

1. The plume spread has a Gaussian distribution in both horizontal and vertical planes and is from a single source.
2. None of the material emitted is removed from the plume as it moves downwind and there is complete reflection at the ground.
3. There is no diffusion in the direction of plume travel.
4. The release is continuous or equal to or greater than the travel time from the source to the location of interest.
5. The material diffused is a stable gas or aerosol (less than 20 microns diameter) which remains suspended in air over long periods of time.
6. The terrain is a relatively flat open rural area.
7. The sampling time is not greater than 10 minutes or concentrations are corrected for sampling time according to Meade.

Some of these assumptions may not be applicable to a dense uranium-containing dust and suspended liquids. This

material may settle faster than assumed. Ground level sampling stations around the perimeter of the plant are useful to measure this fallout and also ground or roof level accidental releases.

The data in Table XXIII is presented in terms of the maximum value of $\frac{XU}{Q}$, a dilution factor and the distance in feet from the emission point both where $\frac{XU}{Q}$ is equal to the minimum value and one-half the maximum value.

TABLE XXIII

GAS DISPERSION DATA FROM U.S. PUBLIC HEALTH SERVICE CALCULATIONS

Stability Condition	Minimum XU/Q	Distance from Emission Point in Feet: Half-Minimum XU/Q	Minimum XU/Q	Half-Minimum XU/Q
A	3.45×10^{-5}	1000	1800	2600
B	4.7×10^{-5}	800	1400	3000
C	4.5×10^{-5}	1450	2050	3050
D	4.4×10^{-5}	2000	3600	16000
F	1.45×10^{-5}	8000	13200	38000
1/3C, 1/3D, 1/3F	3.5[illegible]x10^{-5}	3800	6300	19000

These calculations suggest that the build-up of concentration is relatively rapid compared to the dispersal and that, if the primary reliance for environmental control is on ground level sampling stations, they would need to be located at varying distances around the plant up to at least a 6300 foot radius. But the maximum value of $\frac{XU}{Q}$ under any set of conditions is less than 5×10^{-5}. This means that if the stack is being monitored you can rely on a dilution factor of at least 10^{-4} regardless of atmospheric conditions. Hence, if 6 ppm fluoride leaves the stack, at no point will the ground level fluoride concentration exceed 0.6 ppb (6×10^{-10} or 6 ppm$\times 10^{-4}$). Fluoride levels in the offgases from the fluoride scrubbers are measured.

Table XXIV gives calculated discharge levels after stack dilution.

TABLE XXIV

FLUORIDE LEVELS - OFF GASES FROM FLUORIDE SCRUBBER

	At Top of 150' Stack Levels in ppm			Off-Site Assuming 10^4 Dilution Levels in ppm		
Month	Average	High	Low	Average	High	Low
February 1972	0.91	5.26	.02	0.09	.53	.002
March 1972	0.91	5.81	.02	0.09	.58	.002
April 1972	1.72	16.9	.01	0.17	1.69	.001

It should be noted that this treatment assumes a continuous discharge of material of uniform composition. It is not applicable to a burst of material such as might result from a breakdown followed by a shutdown. Under these conditions, ground level surveillance would be superior.

The environmental surveillance program will be appreciably strengthened with the addition of a main stack sampling and analysis of the gases issuing from the 150 foot stack for alpha and beta radioactivity, nitrogen oxides and sulfur dioxide. The offgas from the fluoride scrubber stack is already being analyzed for fluoride and alpha activity. The main stack sampler is currently being designed and when installed in 1972 it will be possible to calculate the concentration of gaseous effluents on or off the site. It is planned to continue the use of this method of calculation for plant control.

C. Evaluation

1. Water

Recent literature[15] was examined in a search for data as to the result of continued environmental exposure to nitrate and fluorides. No concern is demonstrated for nitrate levels below 10 ppm as nitrogen. But infant methemoglobinemia has been

[15] McKee and Wolf, "Water Quality Criteria, 2nd Ed.", State Water Quality Control Board, Sacramento, California.

caused by the use of drinking water containing 50 ppm nitrate. It is widely recommended that water containing more than 10 ppm nitrate should not be used for infants. Other threshold limits are higher. Consequently, levels of nitrate discharged from the Sequoyah Facility are well below those which cause harmful effects.

Some well-publicized ecologists have taken vigorous positions about a nitrogen crisis in water supplies. However, nitrogen accumulation or depletion from soil and water cannot be understood without considering the pertinent parts of both the nitrogen and carbon cycles. For example, nitrate in water is readily depleted by material with a high biological oxygen demand (BOC). Available information[16] indicates that current use of fertilizers is finally keeping nitrogen in cropland about in balance. One estimate is that cultivated soils in the 48 states have lost 1.75 billion tons of organic nitrogen from the top 40 inches of soil in the last 100 years. Total fertilizer usage in 1968 was only 6.8 million tons compared with an estimated removal of 6.5 million tons. Consequently, the model of an ecosystem glutted with nitrogen seems rather unrealistic.

There is no evidence that nitrate levels in water below 30-40 ppm have any harmful effects. The current control limit of 10 ppm would seem to be realistic. Consequently, it would seem that no adverse environmental impact can or will result from the nitrate levels in the discharge stream of the Sequoyah Facility.

There could be adverse effects if one or more raffinate pond ruptured or was sabotaged and the full contents were delivered into the Illinois River during a dry season. While the current method of raffinate storage is licensed by the AEC, the Company is vigorously pursuing the development of a process for the alternate disposal method of both currently produced and stored raffinate.

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[16] "Factors Affecting the Accumulation of Nitrate in Soil, Water and Plants" by Frank G. Viets, Jr. and Richard H. Itageman, The United States Department of Agriculture.

Fluoride levels at approximately 1 to 2 ppm are known to be beneficial in preventing the presence of caries in teeth. Levels of 3 to 4 ppm can cause mottled enamel but are not likely to cause other effects. No damage has been reliably reported from waters containing up to 5 ppm. Municipal water supplies in Amarillo and Lubbock, Texas, contain from 3.8-5.5 ppm fluoride. For waters used for industrial purposes, a limit of 1 ppm is suggested. For the food processing industry no serious effects have been noted until a concentration of 10 ppm is reached. Cattle, stock and wildlife apparently show no deleterious effects below approximately 10 ppm. In view of a control point of 1.5 ppm, the emission of fluorides in aqueous discharges from the Sequoyah Facility are well below any possible danger level.

The plant liquid effluent drains into the Arkansas and Illinois Rivers. The environmental impact of UF_6 plant on the water supply can be evaluated by comparing averages of the last 12 months and preoperational levels and charging all changes against the plant. The average preoperational levels have been subtracted from the average operational levels. No allowance is made for analytical uncertainty. Results are shown in Table XXV and are compared with recommended maximum levels for off-plant emissions.

Oklahoma Water Quality Standards require that the temperature of a stream be raised no more than 5°F by man-made causes with the maximum water temperature allowed being 93°F. The temperature from the raw water sump and the combined exit stream are measured daily. During the first months of 1972, the average rise for onsite water was 5.4°F (Range 0-10). For July-August, 1971, when air conditioning loads were at a maximum, the average rise was 4.8°F (range 0-10). More heat is dissipated from the waste steam resulting from heating the plant than is removed by the air conditioners.

TABLE XXV

CHANGES IN THE ILLINOIS AND ARKANSAS RIVERS

DURING OPERATION OF THE SEQUOYAH FACILITY

	Recommended Maximum	Illinois River	% of Recommended Maximum	Arkansas River	% of Recommended Maximum
α	$2x10^{-5}$ μCi/mℓ[a] Natural Uranium	$0.69x10^{-7}$ μCi/mℓ	0.35	$0.20x10^{-7}$ μCi/mℓ	0.10
β	$2x10^{-5}$ μCi/mℓ[a] Natural Uranium	$0.54x10^{-7}$ μCi/mℓ	0.27	$0.26x10^{-7}$ μCi/mℓ	0.13
Ra-226 (d)	$1x10^{-8}$ μCi/mℓ[a]	$0.1x10^{-8}$ μCi/mℓ	10	$0.1x10^{-8}$ μCi/mℓ	10
Fluoride	1	0.1 ppm	10	0.1 ppm	10
Nitrate	10 ppm	0.1 ppm	1	0.3 ppm	3

[a]National Committee on Radiation Protection Standards

[b]Level added in water fluorination programs

[c]McKee and Wolf, "Water Quality Criteria, 2nd Editions," State Water Quality Control Board, Sacramento, California

[d]Assume preoperational is zero

The discharge rate into the Illinois River in November, 1969, was 540 cubic feet per second or 240,000 gallons per minute (minimum flow for the year). Since the dilution factor is 150, even if the process water has been heated by 10°F (the maximum value recorded), the Illinois River will not be heated by any more than 0.1°F. Consequently, thermal pollution is not a problem.

It is recognized that seepage from the holding ponds could develop into a pollution hazard if undetected. Seepage from an earthen pit can occur in several ways. If leakage occurred within the earth embankment, it would be immediately detected by visual inspection of the downstream slope of the embankment. Another way seepage could develop would be through a leak in the bottom of the pond or underneath the embankment. In this case the waste liquid would filter slowly down through the weathered zone until it reached the highest competent shale bed. Because the Atoka beds have a very low vertical permeability, the waste liquid would migrate slowly along a bedding plane until it eventually reached the outcrop area where it would reappear at the surface. Since the dip of the beds in the area is 2-3° to the Southwest, this would be the direction of migration.

In order to detect and eliminate any seepage before it could reach the outcrop, a monitoring system was installed. This system consists of a series of observation holes located down dip from the holding ponds, in the direction of potential fluid migration. As the fluid front advances down dip, some of the migrating fluid would enter the observation holes and be recovered for analysis by periodic sampling of the contained fluid. The effectiveness of this environmental monitoring program is enhanced by periodic soil sampling and inspection of the outcrops.

One additional potential pollution hazard exists in connection with storing waste liquids in ponds; the earth

embankment could conceivably be ruptured by an earthquake shock, thus releasing the liquid waste into the local drainage. The possibility of an accident occurring from this cause must be considered to be extremely remote because the area has a seismic history of both low intensity earthquakes and low recurrence frequency. Tryggrason (1965) estimates that a destructive earthquake may occur at any one place in Oklahoma about once in 10,000 years.

The monitoring wells are used as indicators to detect potential trouble before contamination gets offsite. The highest average levels for all seepage monitor wells (Tables XV and XVI) were α - 0.8×10^{-7} µCi/mℓ, β - 0.9×10^{-7} µCi/mℓ, Ra 226 - 1×10^{-8} µCi/mℓ, nitrate - 14 ppm and fluoride - 1 ppm. Therefore, it appears that the control effort to protect water supplies is satisfactory.

The fault well fluoride level has increased slightly during the period of monitoring as shown on Table XVII. Since this well is located in the fractured zone and the strata East of the fault lies approximately 800 feet below the balance of the site, it is believed that this water accumulates against the fault and contains seepage from other unmeasured aquifers to the East and North of the fault line. Additional sampling and analysis is being performed in an effort to determine the source of this water.

The Company believes that the environmental monitoring program to detect the migration of waste liquids is effective in that:

1. The geological and seismic history of the site has been satisfactorily evaluated.
2. A suitable number of soil coring samples were obtained to properly evaluate the potential path of seepage from ponds. (Figures 12 and 13)

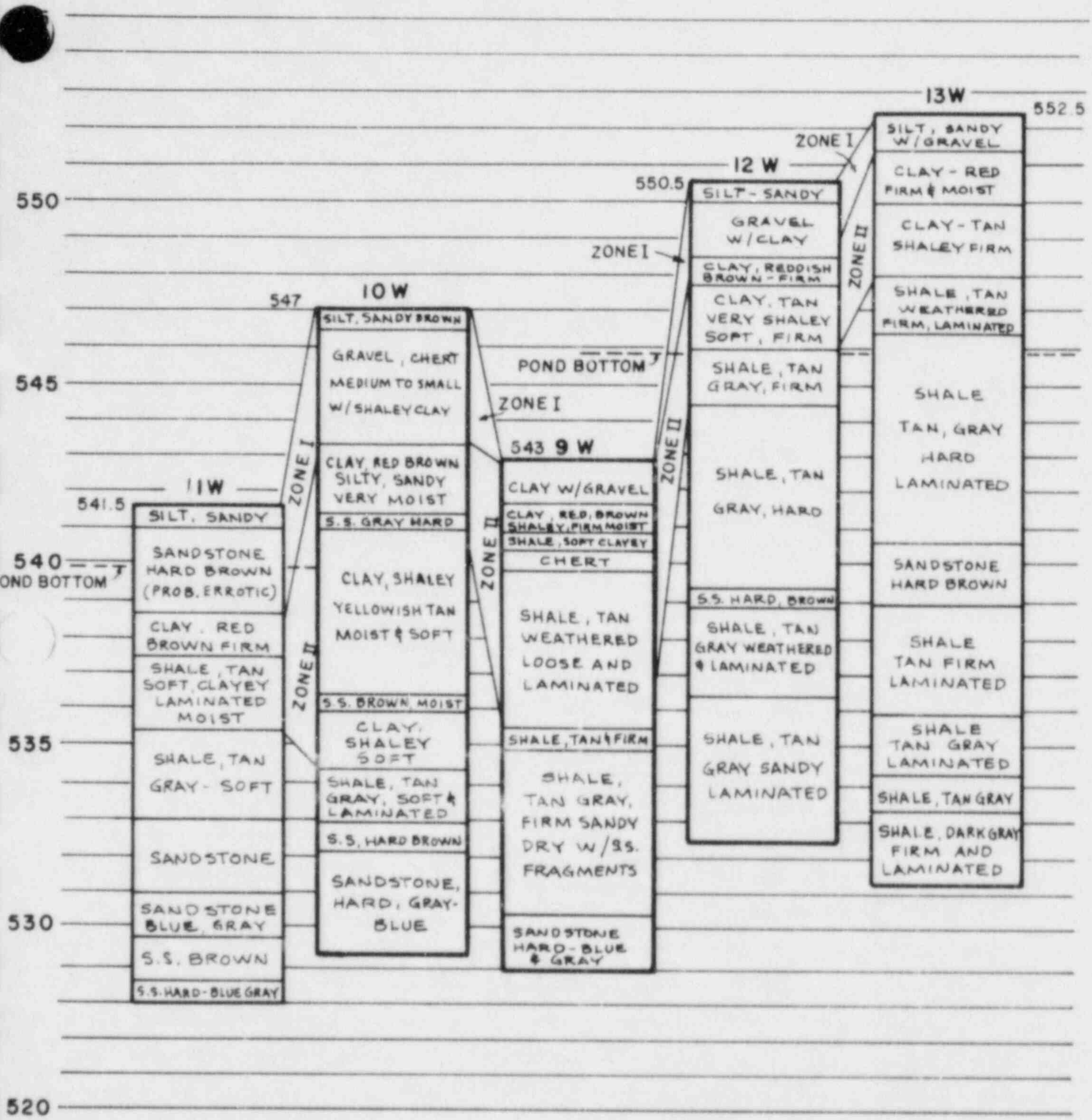

FIGURE 12

CORING LOG PROFILE

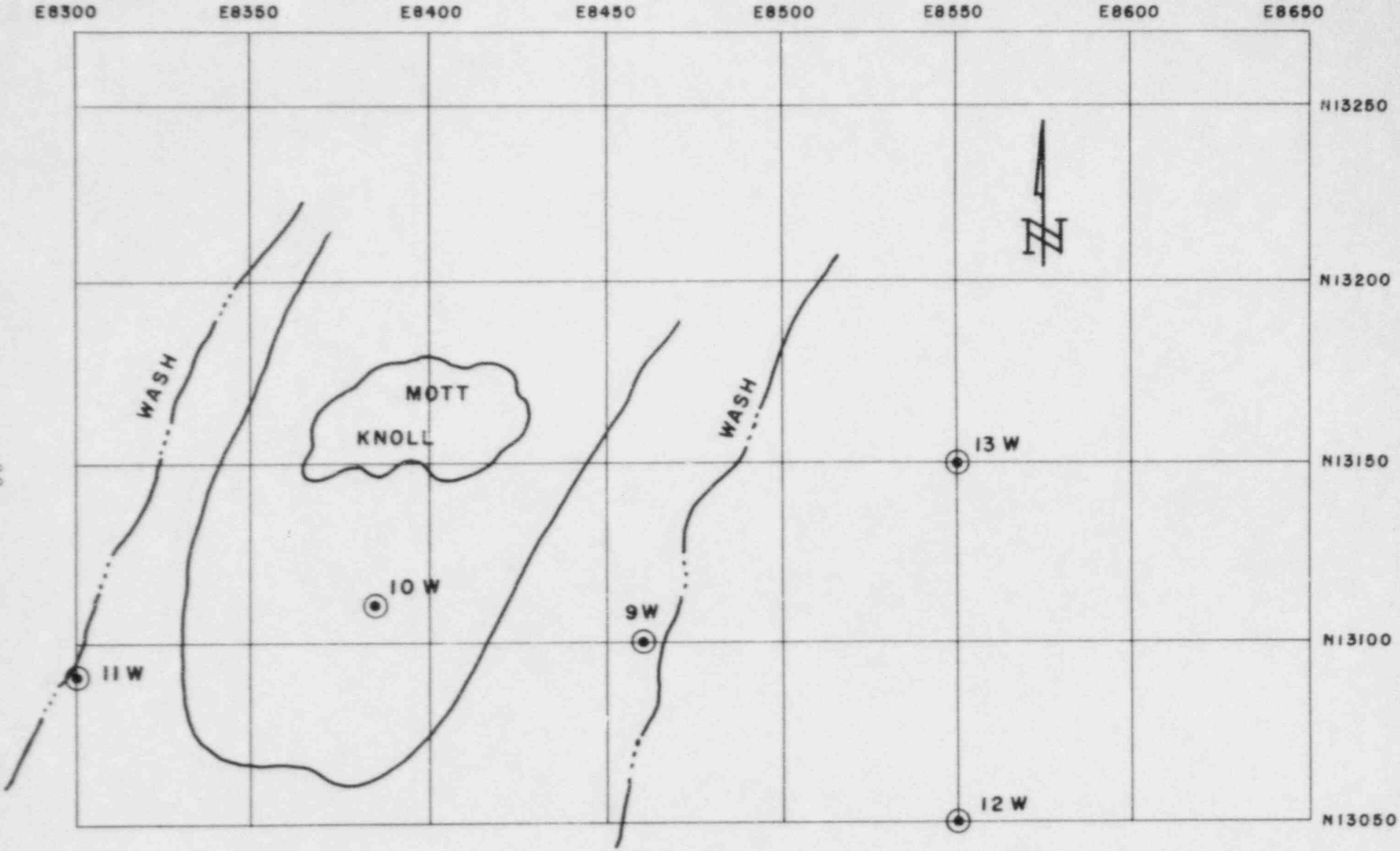

FIGURE 13

LOCATION PLAN, SOIL CORING INVESTIGATION

3. The soil and well water sampling program and regular surface inspections are adequate to detect seepage from ponds before any significant volume of liquid has been lost.
4. The specification for the clearing, grubbing and construction of waste disposal system ponds meet all AEC specifications. Specifications for clearing and grubbing and reduced drawings are presented in Appendix I. Design specifications for the construction of the ponds are consistent with AEC specifications in that:
   a. All ponds are surrounded by fences and only authorized personnel are permitted access.
   b. The ponds do not occupy the channel of any permanent watercourse or natural drainage flow.
   c. The embankments and bottoms of the ponds are constructed of impervious compacted clay. The embankments have been planted with Bermuda grass to reduce the possibility of erosion except for the separation levees in the raffinate and fluoride ponds.
   d. Ponds less than eight feet deep have an eight foot top width. Ponds between eight and twelve feet deep have a 10 foot top width.
   e. Back angles are lined with well-compacted clay. Dikes have deflector plates to reduce the possibility of erosion.
   f. The clay embankments have an upstream face horizontal to vertical side slope ratio of 2.5 to 1 and a downstream face horizontal to vertical slide slope ratio of 2 to 1.

g. The freeboard height of the embankment above the maximum liquid level is 3 feet. Suitable schedule 40 pipe is used as the overflow pipe. The outside of the overflow pipe is cold doped before being embedded in impervious compacted clay.

h. The ponds and embankments are regularly inspected to insure their continuing structural integrity.

Specifications for the design and construction for ponds are available for inspection as full sized engineering drawings (44' x 68').

2. Air

Livestock in the field are exposed to fluoride from the air, forage, feed supplements and water. It can be calculated that inhalation of fluoride from air contributes a negligible amount to the total fluoride intake of animals. For example, in cattle an atmosphere with a fluoride concentration of around 3 milligrams per cubic meter for six hours a day (2.55 ppm) resulted in a fluoride absorption of 0.4-0.8 milligrams per kilogram of body weight. Safe levels for soluble fluoride in the total ration have been reported to be 30-55 ppm for dairy cattle and 40-55 ppm for beef cattle. Corresponding levels for insoluble fluorides are 60-110 ppm. Safe levels are higher for sheep, pigs and poultry.

Most of the fluoride retained by the animal reports to the bones and teeth. Meat will contain 0.14-2 ppm and milk, 0.04-0.55 ppm. Considering that a fluoride level of 1 ppm in water is usually considered beneficial to teeth, the meat and milk of a cow that has been subjected to a high fluoride diet is not a significant source of fluoride in human diet. This is true even if the fluoride level in the animal's feed is high enough that it did not thrive.[17]

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[17] "Air Pollution", Second Edition, Arthur C. Stern, Editor, Academic Press, 1968.

A National Academy of Sciences sponsored study[18] concluded:

> "Meanwhile, we must rely on the evidence that airborne fluoride concentrations that produce no plant response contribute quantities of fluoride that are negligible in terms of possible adverse effect on human health and offer a satisfactory margin of protection for man."

Vegetation shows wide ranges of sensitiveness to fluoride as reported by the same study.[19] Conifers, sorghum and gladiolus seem to be the most sensitive. Plant injury is normally recognized by tip and margin burn of the leaf that proceeds irregularly into the body of the leaf. Interest in developing detailed information has been focused primarily upon ornamental, decorative and human food plants. For the three species listed above it is suggested that the maximum concentration of exposure be restricted to no more than .5 micrograms per cubic meter while a concentration of twice this amount, or 1 microgram per cubic meter, be the limiting factor for forage crops. They further conclude that:

> "In the simplest terms, the minimal effective concentrations of atmospheric fluoride would produce either no necrosis or an acceptable amount of necrosis on susceptible receptor plants or would result in a tolerable accumulation of fluoride in forage."

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[18] "Fluorides, Committee on Biologic Effects of Atmospheric Pollutants," National Academy of Sciences, 1971.

[19] ibid

The soil and vegetation analysis from table XXII shows extremely erratic patterns that are believed to be due mainly to analytical bias and sample contamination. Samples are collected in the field, subdivided and packaged in the plant, and forwarded to the testing laboratory. It is possible that the samples are contaminated during subdivision or the equipment used for analysis is contaminated.

Revisions to the collecting and subdivision technique are being installed to insure a noncontaminated sample. In addition, a control evaluation program to determine analytical precision of the laboratory employed is in the process of implementation. The variation between months and between laboratories does not seem to have another acceptable explanation.

This mechanism seemed to have occurred for fluoride, especially in the month of March soil samples. Samples taken on June 20 appeared to return to more expected levels.

Soil samples collected in 13 different locations between Sallisaw on the East and Warner on the West and along the valley of the Illinois River North of the plant had a total fluoride content of 32-56 ppm. Soluble fluoride content of these samples all measured less than .5 ppm.

Variation in chemical levels of vegetation may be normal.[20] Published data show nitrate levels vary from 274 ppm to 10 million ppm for cornleaf and 23-423 ppm for pigweed, depending upon the season of the year and portion of plant sampled. Fluoride variation in gladiola plant leaves varied from 3-123 ppm in locations along the length of a discolored leaf.[21] In none of the plants sampled near the facility was visual damage apparent.

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[20] Agricultural Handbook No. 413, "Factors Affecting the Accumulation of Nitrate in Soil, Water and Plant", U.S. Department of Agriculture, November 1971, pp 44-46.

[21] "Air Pollution, Injury to Vegetation", U.S. Department of Health, Education and Welfare, National Air Pollution Control Administration, 1970.

The Company does not believe that adverse effects result from release of airborne fluorides at the current levels of the Sequoyah plant.

The lowest SO_2 level reported to cause any human response was 0.2 ppm (humans are more sensitive to SO_2 than the usual laboratory animal). A more general scientific opinion is that a 1 ppm minimum level is needed to generate any response. Prolonged exposure to at least 10 ppm levels is required to produce noticable damage to plants. Since maximum ground level SO_2 concentrations due to the Sequoyah Facility are of the order of 0.1 ppb (See Dames and More report, Appendix IV), no detectable damage has resulted to either plants or animals.

Maximum ground level nitrogen oxide concentrations due to the Sequoyah Facility are of the order of 0.3 ppb (Dames and More report). Average NO_2 concentrations of 6ppb over the North American continent are reported[22]. The lowest reported response due to NO_2 is growth retardation of broad-leaved plants at the 500 ppb level. Some effects on animal life have been reported at the $5x10^3$ ppb level.[23] These levels are orders of magnitude above that resulting from the operation of the Sequoyah Facility. Consequently, the Company believes that nitrogen oxide emission from the Sequoyah Facility is not a significant environmental factor.

It needs to be understood that there are experimental limitations in the accuracy of parts per billion analyses. Precision of measurement is limited by sample volume and concentration and analysis at or below levels of detection.

An evaluation program to determine analytical precision of the laboratories is in progress.

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[22] "Air Quality Criteria for Nitrogen Oxides", Environmental Protection Agency, 1971.

[23] Stern, op. cit.

3. Radiation Levels

The radioactivity associated with uranium conversion to UF_6 results from natural uranium and small quantities of natural daughter products remaining after separation and purification at the mill. Approximately 99% of the daughter products associated with natural uranium in equilibrium conditions are collected at the mill and retained in mill tailings retention systems.[24, 25] The purified uranium known as uranium concentrate or yellowcake serves as feed material for the uranium conversion plant. In the conversion process, further purfication occurs and most of the remaining daughter products are separated and collected in the solvent extraction process.

Radium-226 and thorium-230 are the only significant daughter products involved because thorium-234 decays to uranium with a short half-life of 24 days. Since these daughter products are concentrated in liquids retained in ponds located onsite, our evaluation of radiation doses received by the population was limited to doses received from exposure to airborne uranium.

Since natural uranium is a slightly radioactive material found in nature there are no operations or activities associated with the conversion process which could result in serious radiation exposure to either plant employees or members of the general public even in the case of an accidental release of radioactive materials. External radiation levels associated with uranium conversion activities are low and employees working at the plant rarely receive more than 0.1 the annual occupational

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[24] "Waste Guide for Uranium Milling Industry", U.S. Department of Health, Education and Welfare, Public Health Service, Technical Report W62-12 (1962).

[25] "The Control of Radium and Thorium in the Uranium Milling Industry", Report WIN-112.

radiation exposure limit. Dose rates at the surfaces of process vessels rarely exceed a few milliroentgens per hour.

Soluble natural uranium compounds exhibit chemical toxicity properties when taken into the body in sufficiently large quantities. Approximately 6 mg can produce temporary kidney damage.[26] Since the surrounding population members will not be exposed to sufficiently large quantities to produce chemical toxcity effects, only the radiation dose effect is evaluated for exposure to airborne uranium.

An alternate approach to the location of multiple air samplers is to apply Pasquill's equation to a weighted average weather pattern for the year so as to derive the cumulative deposition and maximum concentrations of air pollutants completely around the plant rather than at specific points. In order to accomplish this approach, it was necessary for Kerr-McGee to employ the services of Dames and More, Consulting Engineers, of Washington, D. C. Since the data gathered at the Sequoyah Facility was not sufficiently complete for computerized calculation programs, it was necessary to use the weather data available from the weather observation station at the Fort Smith airport which had been recorded on tapes by the Department of Commerce and was immediately compatible to the computer program. Hourly observations for a period of record from January 1960 to December 1964 provides data stability. Wind direction for a ten year period from 1953 through 1963 were used. The population distribution within distances of interest from the plant were those prepared and reported previously from the Environmental Sciences Department at East Central State College.

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26 I. S. Eve, "Some Suggested Maximum Permissible Single Intake of Uranium", Health Physics, Vol. 10, pp. 773-776, 1964.

The release rate was determined by estimating or sampling the various sources of release from the plant as shown on Table XXVI.

Through their computer program, Dames and More was able to integrate these data and make a calculation of the exposure of individuals at various distances from the plant. The highest concentration values were found at a distance of one-half mile Southwest of the plant as shown on the following table:

TABLE XXVII
MAXIMUM ANNUAL
DOSE TO INDIVIDUALS AT STATED LOCATIONS
FROM SEQUOYAH FACILITY

	Dose (mrem/yr)		
	Kidney	Lung	Bone
School ENE 1.1 mi	0.04	0.5	0.009
Residence SE 0.5 mi	0.07	1.1	0.02
Residence NW 0.5 mi	0.16	2.6	0.04
Residence NE 0.5 mi	0.19	3.3	0.05
(Max) SW 0.5 mi	0.62	11.2	0.16
Average Natural Background	200	200	200

Cumulative man-rem doses were also calculated for the exposure out to ten miles based upon the same estimated annual released rate. The cumulative man-rem dose for lung, bone and kidney tissue are as follows: kidney - 0.56, lung - .612 and bone - .014 man-rem per year.

It should be noted that these dose values are conservative since no allowance was made in the released rates of radioactive material for nonrespirable particle size nor for dropout between the release point and downwind locations of interest.

TABLE XXVI

ATMOSPHERIC RELEASES

Gaseous Effluent Stream	Method of Determining Release Quantities	Quantities Released: Chemical Pollutant	Chemical Rate (g/sec)	Radioactive Pollutant	Radioactive Rate (g/sec)
150 Foot Stack					
1. HF Scrubber[1]	Continuous daily samples for 1972	F^- (as HF) F^- (assoc U)	.0072 .00005	U (sol)	.00047
2. Fluorine Emergency Vent[2]	Number of Q circuit trips recorded and purge volume	F^- (as HF)	.178	none	none
3. UF_6 Dump Tank Vent[1]	Number of recorded dumps (none to date)	F^- (assoc U)	none	U (sol)	none
4. Reduction H_2 Burner	Design and operating data	SO_2	0.26	none	none
5. Nitric Acid Absorber	Average of five (5) recent samples	NO_x	1.22	none	none
6. Boilers	Design and operating data	NO_x	.76	none	none
7. Incinerator	Uranium content of burned material	F^-	.0000018	U (insol)	.0000175
Ground Level Stacks*					
1. Sampling Plant Dust Collector	Continuous daily particulate samples	none	none	U (insol)	.00034
2. Plant Vacuum System[1,3]	Continuous daily particulate samples	F^- (assoc U)	.0000092	U (sol) U (insol)	.0000092 .000084
3. UO_3 Dust Collector	Continuous daily particulate samples	none	none	U (sol)	.00000062
4. Sample Preparation Hoods	Continuous daily particulate samples	none	none	U (insol)	.000007
5. Roof Vents[1,4]	Each vent sampled for 24 hours every two (2) weeks	F^- (assoc U)	.000073	U (sol) U (insol)	.000073 .00066
6. Lab Hoods	Estimate based on 10% loss of lab chemicals and samples	F^- (as HF) F^- (assoc U)	.00001 .0000001	U (sol)	.000001
7. F_2 Plant Roof Vent	No F_2 released in plant to date	F^- (as F_2)	none	none	none
8. F_2 Cell Rework Hood	Estimate based on fan capacity and average concentration value of 2.5 mg/M^3	F^- (as HF)	.004	none	none

* Roof top stacks and vents evaluated as ground level releases
[1] UF_6 released, reacted to mixture of UO_2F_2 and HF
[2] Quantity to be estimated from frequency of Q circuit trips
[3] 30% UO_3, 30% UF_4, 30% UO_2 and 10% UO_2F_2
[4] 5% UO_3, 30% UF_4, 20% Concentrate, 10% UO_2, 10% UO_2F_2

A complete copy of the Dames and More report is included as Appendix IV to this report.

Background radiation occurs naturally in our environment to such an extent that people in the United States receive an average of about 200 mrem per year from background radiation sources, with a dose of about 140 mrem per year being the minimum received by every individual living in the United States. Further, this naturally occurring radiation exposure can be substantially increased by such things as the type of building materials used for structures, the place where a person lives, and other similar choices that are made in everyday life. These background radiation data are furnished to provide a basis for proper evaluation of the incremental radiation exposure received from the Sequoyah Facility in relation to the radiation exposure received from our environment.

a. Natural Radiation Sources

There are several sources of naturally occurring radiation exposure as shown in Table XXVIII. These naturally occurring radiation sources have been essentially constant for the period of recorded history and, thus, man has been continuously exposed to these radiation exposures since the beginning of time.

One of the principal sources of natural radiation is cosmic radiation. The level of cosmic radiation varies with both latitude and altitude, with the average for a resident of the United States being about 50 mrem/year. Cosmic radiation increases with elevation, and at Denver (elevation 5000 ft) the exposure from cosmic radiation is about 150 mrem/year, or three times the U.S. average. Air travel also increases an individual's radiation exposure, with a roundtrip cross-country jet flight contributing about 4 mrem.

The radioactive materials in the ground are another major natural radiation source which produces an average radiation exposure in the United States of about 45 mrem/year. However, there are wide variations within the United States, and there are areas in India where the radiation exposure from the ground

TABLE XXVIII

TYPICAL NATURAL RADIATION DOSES

	mrem/yr
Cosmic	50-150
Grounds and Structures	95-145
Air	5-10
Food	25
Total	175-330

TYPICAL RADIATION DOSES FROM MAN-MADE RADIATION SOURCES (NOT ASSOCIATED WITH NUCLEAR POWER)

	mrem/yr
Watch Dials	2
TV	1-10
Medical X-ray (Average)	55

TYPICAL X-RAY DOSES TO PARTS OF BODY

Teeth	1000 mrem/series
Chest	500-5000 mrem/exposure
GI Tract	1000 mrem/exposure
Fluoroscopic	10,000-20,000 mrem/min

is about 1300 mrem/year. The type of building materials also has a significant effect on radiation exposure as the natural radioactivity in a wood frame house will produce an exposure of about 50 mrem/year whereas a brick house will produce an exposure of about 100 mrem/year. There are some types of stone, such as some granite and marble that will produce an exposure of 350 to 500 mrem/year. Radioactive gases and particulates in air contribute about 5 mrem/year. Naturally occurring radioactive materials in foods contribute about an additional 25 mrem/year.

b. Variations in Natural Background Radiation

There are substantial variations in natural background radiation levels and a person can affect the radiation exposure he receives from such natural sources by 50 to 100 mrem/year. As indicated previously, cosmic radiation increases with altitude and living in Denver will increase the radiation exposure from this source by about 100 mrem/year. Further, there are significant geographical variations in the radiation exposure from sources of radiation in the ground and even within a few miles this may vary by a factor of two or more (approximately 20 to 50 mrem/year.) The type of building materials utilized in the home in which a person lives and in the building where he works also affects the radiation exposures received. For example, the natural radioactivity in a brick structure will produce a radiation exposure of about 50 mrem/year more than a wooden structure. Further, some forms of stone used for building materials have much higher radiation levels than brick.

Thus the radiation exposure received from natural radiation sources by a person living in the vicinity of the Sequoyah Facility can easily be varied by 50 to 100 mrem/year by choices that are made as a part of everyday living. The fact that people have been living in this environment for thousands of years without discernible effects resulting from such variations in radiation background provides substantial evidence that the effects, if any, produced by such variations are not significant to the general population. This conclusion is further

supported by the lack of radiation effects observed in persons living in areas of the world that have natural background radiation levels from two to ten times that of the average United States background.

c. Man-Made Radiation

There are several sources of man-made radiation not associated with nuclear power which are used routinely by the general population and which contribute to the total radiation exposure received. The most significant of these is the use of medical x-rays which, according to the U.S. Public Health Service, contribute an average of about 55 mrem/year whole body radiation exposure for every person in the United States. The total radiation exposure contributed by such sources is about 60 mrem/year. A summary of such sources and the radiation exposure resulting therefrom is shown in Table XXVIII.

4. Uranium Deposition

In addition to such airborne uranium, the possibility of particulate fallout coming at the source of external radiation or the uranium entering the food chain of man and causing further exposure from internal radiation has been further examined.

To conservatively define the fallout and deposition of effluent particles from the facility, the following assumption were made:

1. All of the effluent particles were uniformly deposited on a circular area inside a one mile radius around the facility. (See Dames and More Report, Appendix IV)
2. The initial interception of the particles by vegetation was 40% with a retention half life on the vegetation of thirty (30) days.
3. All the uranium released was uniformly deposited in the soil at year end and accumulated with an infinite retention time at or near the surface of the soil.

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[27] "Retention of 1-44μ Simulated Fallout Particles by Soybean and Sorghum Plants", J. P. Witherspoon & F. G. Taylor, Jr., Health Physics, November 1971.

By using the above assumptions, calculations show that 0.45 microcuries of soluble uranium per acre would be deposited on the soil each month and vegetation would retain an average of 0.32 microcuries of uranium per acre during a nine (9) month growing season. Soluble uranium buildup in the soil would increase at a yearly rate of 5.4 microcuries per acre.

The soluble uranium deposition is considered in calculations for radiation dose from uptake via the food chain and radiation doses due to external radiation due to buildups in the soil.

Again, using the above assumptions, 0.93 microcuries per acre of insoluble uranium would be deposited in the soil each month and vegetation would retain an average of 0.66 microcuries of uranium per acre during a nine (9) month growing season. Insoluble uranium deposition is significant only from the external radiation dose standpoint and is not considered in calculations of dose from uptake via food chains. Because of rainfall, soil type, ground cover and other aspects of the surrounding terrain, resuspension of deposited uranium into the atmosphere is negligible.

Total uranium deposition was considered only to calculate radiation exposure expected due to external radiation from buildup of uranium in soil. Total uranium deposition is the sum of insoluble and soluble uranium depositions or 16.6 microcuries of uranium per acre per year.

The principal uptake pathways between radioactive material released to the atmosphere and man are shown on the attached chart.[28]

Few, if any, wildlife species in the area are used by man as food and cotton, wheat and soybeans are the commercial crops grown in the immediate vicinity. Only a very small fraction of uranium deposited in the soil is expected to be taken up by vegetation.[29] The critical pathway is considered to be the inhalation of airborne uranium particles by man and animals.

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[28] I CRP Publication Number 7, "Principals of Environmental Monitoring Related to the Handling of Radioactive Materials", Pergaman Press, 1965.

[29] J. P. Witherspoon & F. G. Taylor, Jr., op. cit.

Simplified pathways between radioactive material released to atmosphere and man

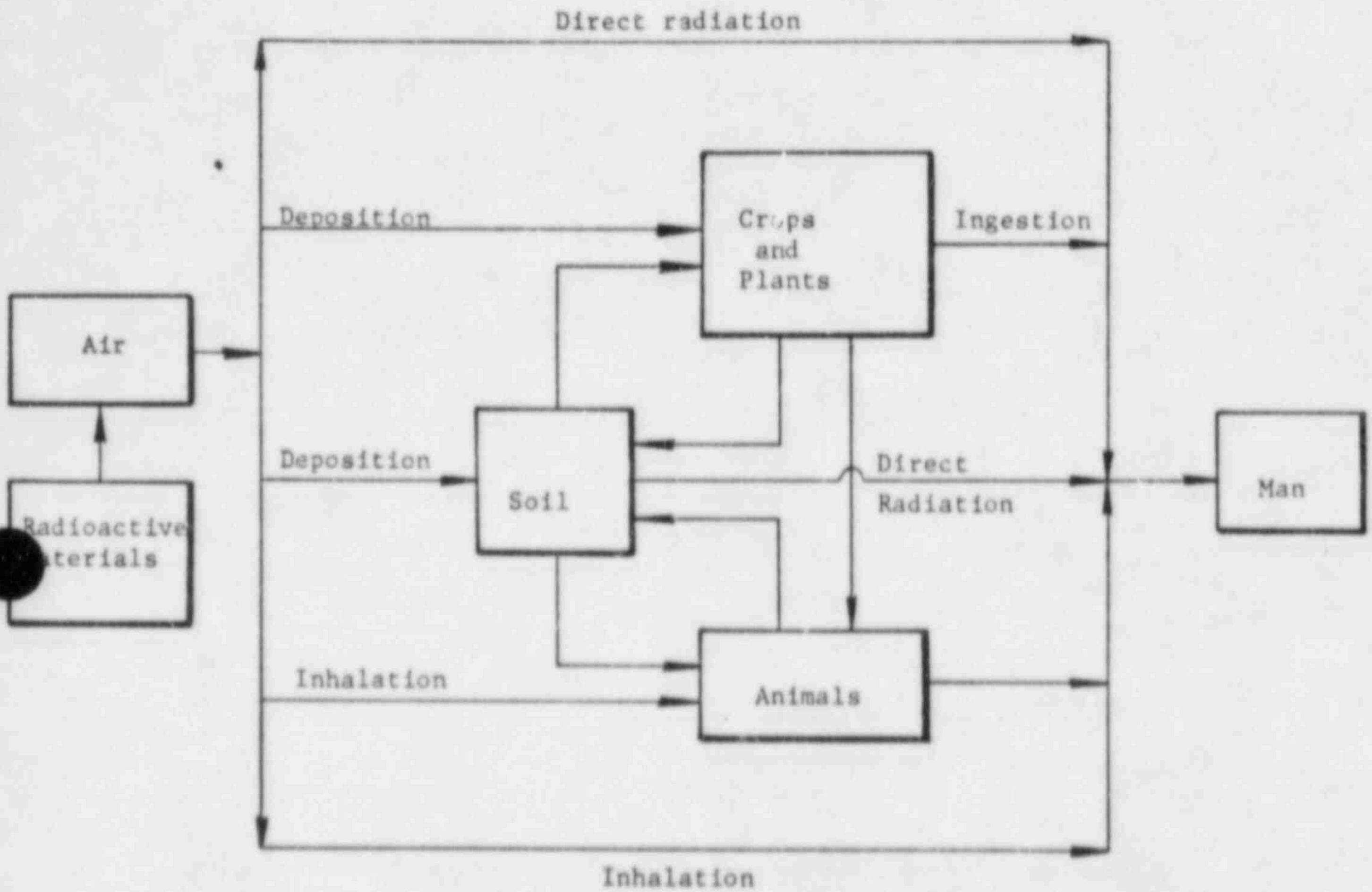

FIGURE 14

Reference: PRINCIPLES OF ENVIRONMENTAL MONITORING RELATED TO THE HANDLING OF RADIOACTIVE MATERIALS, ICRP PUBLICATION 7, September 13, 1965.

A REPORT BY COMMITTEE 4 OF THE INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

FIGURE 14

Additional important pathways considered of flesh, by man, of animals foraging on grass contaminated by airborne uranium particles and the external exposure possible from uranium deposited on the soil.

a. Estimated Uranium Uptakes and Effects

Calculations to arrive at an estimated uptake of uranium by man via the vegetation--beef cattle pathway assumes the following:

a. One acre of grazing land is required to support one head of stock during the growing season and each animal is grazed for one nine (9) month season.

b. The cattle consumed all the forage grown on the land during the season and ingested the average amount of uranium retained on the forage.

c. All vegetation was forage.

d. The kidney is the critical organ of cattle and man.

e. The fraction of ingested uranium retained by the kidney of cattle and man was 1.1×10^{-3}.[30]

f. A man consumes half a beef kidney each year.

Using the assumptions in parts a. through f., above, the kidney of man would retain 1.2×10^{-6} microcuries of uranium with a biological half life of 15 days.[31] The total radiation dose to the kidney of man would be less than .02 mrem.

b. External Exposure from Uranium Deposited on the Soil

The yearly uranium depositicn to the soil in the immediate vicinity of the facility has been calculated to be 16.6 µCi per acre assuming that all the uranium contained in the gaseous effluent were deposited in a circular area one mile in radius around the facility. This amount of uranium would produce 7.4×10^{7} d/m per acre or 1.8×10^{3} d/m per square meter or 18 d/m per 100 square centemeters. The dose rate from this if assumed concentrated to one meter square would be .0032 mrem/year.

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[30] ICRP Publication Number 2, "Permissible Dose for Internal Radiation", Pergamon Press, 1959.

[31] ibid.

Long term buildup of uranium in the soil of vicinity is not expected to increase lin·arly in relation to the yearly deposition due to rainfall and surface runoff of rainwater. The average amount of uranium remaining in the soil is estimated to be approximately 50% of that deposited. It is assumed that the readily soluble deposition will be quickly dissolved and percolated to lower soil layers and the insoluble portion will be washed away by rainwater or will slowly migrate to the lower soil layers. The buildup of uranium in the soil (.096 mrem/yr) and the subsequent runoff of uranium by rainwater to nearby streams (.0001 MPC) is considered to contribute an insignificant radiation hazard during or after the 30 year estimated life of the facility.

5. Conclusion

Based upon these investigations and on data, it is concluded that the population in the vicinity is exposed to an insignificant amount of additional radiation due to the installation of the Sequoyah Facility.

D. Other Facilities

The modifications to the site required for the installation of the plant has been described previously. In addition to these modifications for the plant installation, a road was improved and new powerline constructed.

At the time of site acquisition, an unimproved road extended from the county road just to the East of the present location of State Highway 10 to the location of Carlile Ford and the bottomland field across to the Illinois River. As shown on Figure 1, and as can be seen on the aerial views of the plant, this unimproved dirt road was improved by additional base grade and surfaced with asphaltic concrete to the plant entrance road. Beyond this, the surface was covered with heavy gravel for approximately 1000 feet. The road formed the retention dike for the settling basin located immediately South of the plant building. This installation resulted in an additional 500 feet of surfaced road and 100 feet of improved gravel road, considerably more stable and weather resistant than the county road it

replaced. Its construction did not intrude on any other property, interfere with any other highway nor with the movement of fauna in the area. The settling basin, located immediately to the North of the road, is an attractive front for the plant and has been stocked with native fish. The settling basin will not become stagnant because a small stream of water is diverted from the water supply and piped to the basin. The basin overflows at the West end of the dike and joins the combined effluent stream as it passes under the roadway. No significant environmental effect has been observed as a result of this construction.

The power line shown as existing on Figure 1 which crosses the site from Northwest to East is a 67 kva line located there prior to the plant construction. A portion of the line was relocated by OG&E to permit erection of the plant and to supply the electrical substation which supplies electric power to the plant. In addition, since the plant was constructed OG&E has installed a 131 kva line from the plant's switch yard North approximately one mile and then West to the Gore substation to provide an alternate source of power for continuous operation. The erection of this power line required the removal of timber along its route and the maintenance of a fire lane through the timber immediately North of the plant. As can be seen in the aerial photographs, the effect of this power line installation due to the opening of the fire lane through the timber has been minor.

Examination of the aerial photos reveals two other anomalies. The first is located immediately East of the plant between State Highway 10 and the county road. This area appears disturbed with no uniform covering of vegetation. This area was used by the highway contractor as a location for his asphaltic concrete preparation plant which was used to surface State Highway 10. No effort was made to replace a uniform grade or plant a cover vegetation.

In the aerial photographs, an area immediately North of the No. 2 Raffinate Pond appears white to the camera. This area was the borrow pit for the fill material used for the dikes around

these ponds. The area appears white because of the high rock content at this particular location. No undue erosion has been noted of the current surface and natural reseeding has not occurred It is planned to prepare this surface for planting as soon as material becomes available.

E. Lowest Practicable Value

Licensing conditions require that releases of radioactive materials be maintained at the "lowest practicable" value. The processes and procedures installed at the Sequoyah Facility must be examined in an effort to determine if these requirements are being met.

The Sequoyah Facility effluents of radioactive chemicals occur from:

1. Release of gaseous normal UF_6.
2. The release of normal liquid UNH solutions.
3. The release of natural radioactive daughter products (Thorium 230 and Radium 226) of natural uranium in soluble or insoluble form.
4. The release of normal Uranium compounds (UO_3, UO_2 and UF_4) through entrainment in ambient air streams from leakage in packing glands, spillage or inadequate functioning of particulate filters installed to prevent such loss.

It is concluded that, due to appropriate design, environmental surveillance and restricted area control programs, such losses are not occurring undetected and are promptly corrected if detected. In all cases, design criteria have been met. In examples where control has not been measured as being sufficiently effective, equipment has been added, i.e. additional dust filtration equipment, to further control emissions. Active programs to reduce hazards of accidental uncontrolled release are under way to improve upon current control programs or to avoid builup of quantities of contaminating pollutants.

In the area of unregulated chemical pollutants, efforts have been diligent to meet design criteria, measure environmental releases and improve control to provide measurable safety factors.

From the surveillance program results and ongoing efforts, it is concluded that the Sequoyah Facility meets all current standards of emission control and requirements of the "lowest practicable" release.

F. Accident Analysis

1. Waste Retention Ponds, Rupture

The waste ponds contain raffinate from solvent extraction and other nitrate or soluble fluoride materials. The original Emergency Holding Basin (Basin 1) contains 0.5×10^6 gallons of rainwater with nitrates above the 10 ppm level. This basin was used for raffinate but was pumped empty, then accumulated rainwater and was emptied again and is thus low in uranium, thorium or radium content. Waste Pond No. 1 contains approximately 8.0×10^6 gallons of $Ca(OH)_2$ and NH_3 neutralized waste with the pH slightly basic. Waste Pond No. 2 currently contains approximately 3.5×10^6 gallons of NH_3 neutralized waste with some $Ca(OH)_2$ neutralized liquor from the No. 1 Pond with the pH slightly basic. (Volume and pH on May 5, 1972).

The total amount of uranium, thorium and radium 226 estimated to be present in the pond liquids has been tabulated. The total uranium, thorium and radium 226 present in liquids and sludge has been calculated. The maximum thorium and radium 226 was calculated using a separate analysis. These maximums are compared to the totals for radioactive materials in the liquids and sludge.

The following information in Tables XXIX and XXX was obtained by calculation using the pond volumes on May 5, 1972 and concentrations for uranium, radium and thorium from samples taken February 23, 1972. The No. 1 Pond was sampled with a pH of 2.5. The No. 2 Pond was sampled with a pH of 6.9 (after

direct NH_3 neutralization). Values for the Basin No. 1 are omitted since it contained rainwater.

TABLE XXIX

URANIUM RADIUM 226 AND THORIUM IN LIQUIDS WITH pH OF 2.5 IN PONDS

Location	Volume in Liters	Uranium in Kg	Radium 226 in Curies	Thorium in Curies
Raffinate Pond No. 1	22.7×10^6	12.2×10^2	0.0318	0.0134
Raffinate Pond No. 2	13.2×10^6	7.13×10^2	0.0184	0.0087
Raffinate Sludge Pond	7.57×10^6	4.08×10^2	0.0105	0.0045
Basin 1	1.89×10^6	-	-	-
Total	45.36×10^6	23.41×10^2 or 2341 Kg	0.0607	0.0266

TABLE XXX

URANIUM, RADIUM 226 AND THORIUM IN LIQUIDS WITH pH OF 6.9 IN PONDS

Location	Volume in Liters	Uranium in Kg	Radium 226 in Curies	Thorium in Curies
Raffinate Pond No. 1	22.7×10^6	8.1×10^1	0.0242	0.00025
Raffinate Pond No. 2	13.2×10^6	4.75×10^1	0.0141	0.00015
Raffinate Sludge Pond	7.57×10^6	2.79×10^1	0.0081	0.00008
Basin 1	1.89×10^6	-	-	-
Total	45.36×10^6	15.64×10^1 or 156.4 Kg	0.0464	0.00048

The amount of uranium discharged to the ponds from March 1970 through April 1972 was 7760 Kg by totaling the uranium in each raffinate hold tank based upon sampling and analysis of each tank's contents. The uranium accounted for in Table XXIX in liquids is 2341 Kg. By using the ratio of the known uranium discharged to the ponds to the uranium in the liquids, or $\frac{7760}{2341} = 3.3$, as a multiplier for the values in Table XXIX the data in Table XXXI was obtained.

TABLE XXXI

URANIUM, RADIUM 226 AND THORIUM IN LIQUIDS AND SOLIDS OF PONDS

Location	Uranium in Kgs	Radium 226 in Curies	Thorium in Curies
Raffinate Pond No. 1	4060	0.1049	0.0442
Raffinate Pond No. 2	2350	0.0607	0.0287
Raffinate Sludge Pond	1350	0.0347	0.0149
Total	7760	0.2003	0.0878

Since the ponds are now maintained slightly basic, the totals from Table XXX may be subtracted from the totals of Table XXXI to find the distribution of the three materials in the sludge.

TABLE XXXII

URANIUM RADIUM 226 AND THORIUM - TOTALS AS LIQUIDS AND SOLIDS

	Uranium in Kg	Radium 226 in Curies	Thorium in Curies
Total to All Ponds (Table XXXI)	7760	0.2003	0.0878
Less Liquid Contents (Table XXX)	156	0.0464	0.0005
Amount of Sludge of All Ponds	7604	0.1539	0.0873

As an approximate confirmation of the total radium 226 and the total maximum thorium, spot analysis made of fresh unneutralized raffinate were examined. The sample results indicated:

Uranium	84.2×10^{-3} Gms/1
Radium 226	173×10^{-8} μCi/mℓ
Total Thorium	47×10^{-8} μCi/mℓ

The radium 226 is calculated as follows:

$$\frac{173 \times 10^{-8}\ \mu Ci/m\ell}{84.2 \times 10^{-3}\ gms\ U/lt} \times 1000\ gms/Kg \times 1000\ ml/l =$$

$$\frac{173 \times 10}{84.2} = 2.055 \times 10 = 20.55\ \frac{\mu Ci\ radium\ 226}{Kg\ uranium}$$

Multiplying by 7760 Kg. U to the retention ponds:

7760 x 20.55 = 159,300 μCi radium 226

or = 0.1593 Ci radium 226

The maximum total thorium is calculated as follows:

$$\frac{47 \times 10^{-8}\ \mu Ci/m\ell}{84.2 \times 10^{-3}\ gms\ U} \times 1000\ gms/Kg \times 1000\ ml/l =$$

$$\frac{470}{84.2} = 5.5\ \frac{\mu Ci\ Th}{Kg\ U}$$

Multiplying by 7760 Kg of U to the retention ponds:

7760 x 5.5 = 43,200 μCi total thorium

or = .043 Ci total thorium

The 0.1593 Ci for radium 226 compares well with the 0.2003 of Table XXX. The .043 Ci total thorium compares well with the 0.0878 of Table XXXI.

The total radioactivity for soluble and insolube radioactive materials in waste retention ponds is summarized in Table XXXIII. The information is presented both in terms of μCi/m and MPC's (maximum permitted concentration). It is apparent that the potential problem is the possibility of soluble Ra-226 getting off-site since it contains the highest fraction of soluble radioactivity.

TABLE XXXIII

RADIOACTIVITY - WASTE RETENTION PONDS

	Raffinate Pond #1	Raffinate Pond #2	Raffinate Sludge Pond
Volume-mℓ	2.27×10^{10} (8 Million Gallons)	1.32×10^{10} (3.5 Million Gallons)	$.757 \times 10^{10}$ (2.7 Million Gallons)
Ra-226 Activity-μCi/mℓ			
Soluble	107×10^{-8}	106×10^{-8}	10.7×10^{-8}
MPC	107	106	10.7
Insoluble	$.356 \times 10^{-5}$	$.353 \times 10^{-5}$	$.035 \times 10^{-5}$
MPC	0.12	0.12	0.01
Th-230 Activity-μCi/mℓ			
Soluble	1.1×10^{-8}	1.1×10^{-8}	---
MPC	.01	.01	---
Insoluble	1.94×10^{-6}	2.17×10^{-6}	$.20 \times 10^{-6}$
MPC	1.94	2.17	0.20
Natural Uranium Activity-μCi/mℓ			
Soluble	1.2×10^{-7}	1.2×10^{-7}	1.23×10^{-8}
MPC	.01	.01	<.01
Insoluble	5.9×10^{-5}	5.1×10^{-5}	5.9×10^{-6}
MPC	3.0	2.6	0.3

Based upon the evaluation of the seismic history of the area, described previously, Kerr-McGee does not consider the complete delivery of a pond's content into the watershed to be a credible accident. If an act of sabotage occurred where Raffinate Pond No. 1, Raffinate Pond No. 2 and the Raffinate Sludge Pond are simultaneously destroyed, then complete contents may be delivered to the Illinois River. The act is assumed to happen in November when the average flow of the river is 540 cubic feet per second, the lowest average monthly flow rate of the year. A volume of 1.59 billion gallons would be required for dilution to MPC concentrations ($8 \times 10^6 \times 112 + 3.5 \times 10^6 \times 111 + 2.7 \times 10^6 \times 11.2$). This would be equivalent to 3.8 days flow for the Illinois River at this time and place.

However, the minimum monthly average flow rate for the Arkansas River near Sallisaw was 9310 cubic feet per second or 5.9 billion gallons per day. Hence, dilution below MPC levels would take place readily in the Arkansas River. The Illinois River would be above MPC levels for not more than a few days.

The combined stream would be about 3% by weight in both ammonium and nitrate nitrogen. Dilution by a factor of 100 would still leave a nitrate and ammonium nitrogen level of about 300 ppm each. Published information[32] indicates that at these concentrations and pH, the resultant ammonium solution would cause fish kills in the reservoir. The potential chemical consequences are more harmful than any effects of radioactivity. It is not believed that such an action is credible.

2. UNH Evaporator, Rupture

The UNH evaporator is located within an undrained curbed area immediately North of the solvent extraction building. The evaporator operating inventory is 2,000 gallons of approximately 1.66 Sp. Gr. pure uranyl nitrate. Product from the evaporator

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[32] J. E. McKee and H. W. Wolf, "Water Quality Criteria", Second Edition, Resources Agency, California State Water Resource Control Board, Sacramento. 1963, pp. 133-137.

is also within the same curbed area in a 2,000 gallon UNH surge tank.

The evaporator is operated at approximately 225°F and near atmospheric pressure by keeping the condenser continuously vented. The most likely spillage would occur accidentally, e.g., by breaking a line or breaking of a sample valve. All liquid within the area would be contained in the dike with 2,479 gallons extra capacity. See calculations following this analysis. Similar equipment has operated without difficulty for over a decade at the Fernald, Ohio AEC installation. Only one known explosion of a similar evaporator has occurred and was due to "Red Oil" in the evaporator. This reportedly occurs only when the temperature is over 130°C (266°F). Rupture of this type is accordingly considered remote since the temperature is maintained below the 266°F.

Should rupture occur some mist might splash over the immediate area. Liquid would be caught in the curb. Discharge beyond the facility fence would be Low Specific Activity uranium based material and free of thorium or radium.

Evaporator Area Curb -

33' x 30' = 990 Sq. Ft.

Less-- 2 x 1.0' x 5.0' = 10.00 Sq. Ft.

Equipment
Bases 2 x 1.58' x 4.0 = 12.64 Sq. Ft.

4 x 1.5' x 1.5' = 9.00 Sq. Ft.

$\frac{6 \times (1.17)^2 (3.1416)}{4}$ = 6.45 Sq. Ft.

2 x 1.83' x 5.0 = 18.30 Sq. Ft.

(990 Sq. Ft. - 57 Sq. Ft.) x 1.00 Ft. = 933 Cu. Ft.

933 Cu. Ft. x 7.48 =	6,979 gals.
Evaporator (Working Volume	2,000 gals.
UNH Surge Tank @ 50% Full	1,000
RAC Storage Tank @ 50% Full	1,000
S-X Seal Water Tank	500
Total (Max. dumped by disaster)	4,500 gals.
Curb	6,979
Minus Working Volume	4,500
Excess Volume	2,479

3. Acid Tank, Rupture

Acid tanks are within a curb containing limestone to neutralize any spilled acid. Storage area information is tabulated as follows:

Number of Tanks	Content Description	Filled Tank Volume, Gal.	Limestone Required for Neutralization, Pounds
1	40% Nitric	15,000	35,200
1	60% Nitric	15,000	74,800
2	Aqueous HF	7,500	50,250
2	Anhydrous HF	12,000	250,500

Rupture of a single tank is considered the most credible accident. Tank rupture of an anhydrous HF tank would require the most limestone. The anhydrous HF tanks are only filled to 80% capacity, i.e., 12,000 gallons. Following is the calculation for the limestone required for this worst case.

$$\underset{40}{2\ HF} + \underset{100}{CaCo_3} = CaF_2 + H_2CO_3$$

$$12{,}000 \text{ gal.} \times 8.35 \frac{\text{lb HF}}{\text{gal}} = 100{,}200 \text{ lbs. HF}$$

$$\frac{100}{40} \times 100{,}200 = 250{,}500 \text{ lbs. limestone}$$

The curbed area is 61 feet by 46 feet in area and 2.5 feet deep. The volume of this is:

$$61' \times 46' \times 2.5' \times 7.48 \text{ gal/ft}^3 = 52{,}500 \text{ gal.}$$

The limestone is to a depth of 2 feet and the limestone available is:

$$61' \times 46' \times 2' \times 100 \text{ lb/ft}^3 = 560{,}000 \text{ lb. crushed limestone}$$

The absolute limestone volume is:

$$\frac{560{,}000 \text{ lb}}{175 \text{ lb/ft}^3} \times 7.48 \frac{\text{gal}}{\text{ft}^3} = 24{,}000 \text{ gal.}$$

The "free" volume of the curbed retainer is:

$$52{,}500 - 24{,}000 - 28{,}500 \text{ gal.}$$

From the preceding calculations 250,500 pounds of limestone are needed for the contents of one anhydrous HF tank and the 560,000 pounds of limestone available would neutralize any release.

APPENDIX IV

1. Sequoyah Stack Diffusion Calculations
2. Dames and Moore Report

Sequoyah Stack Diffusion Calculations

In order to place samplers to measure the concentrations of pollutants at the point of maximum ground level concentration from the plant stack and to calculate concentrations at the Facility boundary the following has been done:

From Hay and Pasquill:
The vertical distribution of spreading particles from an elevated point is related to the standard deviation of the wind elevation angle E at the point of release.

From Pasquill and Gifford:
Gifford converted Pasquill's values of angular spread and height into standard deviations of plume concentration distribution σy an σz. The following expression results:

$$\chi(x, y, z; H) = \frac{Q}{2\,\Pi \sigma y \sigma z U} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma y}\right)^2\right]$$

$$\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma z}\right)^2\right]\right\}$$

Where:

χ= concentration of gas or aerosol (gm^{-3} or CiM^{-3})
H= effective emission height (meters)
U= mean wind speed affecting the plume ($M\ sec^{-1}$)
Q= uniform emission rate of pollutants (g or Ci sec^{-1})
σy= horizontal plume conc. distribution
σx= vertical plume conc. distribution

From this equation, curves of standard deviations of plume concentration distribution, σx and σy, as a function of distance downwind have been established for several stability classes. The maximum concentration can then be found by finding $\frac{\chi U}{Q}$ as a function of effective stack emission height and stability and multiplying by Q/U.

The assumptions necessary to use this method for calculating the point of maximum downwind concentration of pollutants from the Sequoyah Facility stack are as follows:

1. The plume spread has a Gaussian distribution in both horizontal and vertical planes and is from a single source.

2. None of the material emitted is removed from the plume as it moves downwind and there is complete reflection at the ground.

3. There is no diffusion in the direction of plume travel.

4. The release is continuous or equal to or greater than the travel time from the source to the location of interest.

5. The material diffused is a stable gas or aerosol (less than 20 microns diameter) which remains suspended in air over long periods of time.

6. The terrain is a relatively flat open rural area.

7. The sampling time is not greater than 10 minutes or concentrations are corrected for sampling time according to Meade.

The stability class and mean effective wind speed to be used is that defined in the proposed "License Requirements for Measuring and Reporting of Effluents" recently circulated by the AEC for comments:

> "In lieu of measurements of atmospheric stability, concentration estimates may be calculated by using the mean effective wind speed and assuming the following Pasquill categories: 1/3 type F; 1/3 type D and 1/3 type C."
>
> "The mean effective wind speed is defined as the reciprocal of the mean of the reciprocal of hourly average wind speeds."

$$\frac{n}{\sum_{i=1}^{n} \frac{1}{U_i}}$$

EFFECTIVE STACK HEIGHT

The effective stack height is a function of exit gas velocity, exit gas pressure, stack diameter, wind velocity and ambient temperature.

The effective height of emission may then be calculated by using the equation of Holland:

$$\Delta H = \frac{V_s\, d}{U} \left(1.5 + 2.68 \times 10^{-3}\ p\ \frac{Ts - Ta}{Ts}\ d\right).$$

Where:

ΔH = Rise of plume above the stack - in meters
V_s = Stack gas exit velocity - in meters sec^{-1}
d = Inside stack diameter - in meters
U = Wind speed in meters sec^{-1}
P = Atmospheric pressure - in millibars
T_s = Stack gas temperature - in °k
Ta = Air temperature - in °k
and 2.68×10^{-3} is a constant having units of $mb^{-1}\ m^{-1}$

FLORA (Continued)

Arenaria patula	Sandwort
Lespedeza cuneata	Buxh clover
Oxalis stricta	Upright yellow wood sorrel
O. violacea	Sheep sour
Grasses	
Native	
Andropogon gerardi	Big bluestem
A. scoparius	Little bluestem
A. virginicus	Broomsedge bluestem
Aristida oligantha	Prairie three awn
Panicum virgatum	Switch grass
Sorgastrum nutans	Indian grass
Se ia geniculata	Foxtail
Intr. ced	
Bromus catharticus	Rescue grass
B. japonicus	Japanese brome
B. tectorum	Chess grass
Festuca paradoxa	Fescue
F. obtusa	Nodding fescue
Cynodon dactylon	Bermuda grass
Forbs	
Open Areas	
Rumex hastatulus	Wood sorrel
Erigeron strigosus	Wooly fleabane
E. annua	Annual fleabane
Chaetopappa asteroides	Chaetoppa
Coreopsis tinctoria	Prairie tickseed
C. grandiflora	Large-flowered tickseed
Valerianella radiata	Beaked corn salad
Specularia biflora	Venus looking glass
Heterotheca latifolia	Camphor weed
Echinacea pallida	Purple cone flower
Hymenopappus scabiosaus	Smooth white hymenopappus
Pyrrohopappus caroliniana	Leafy false dandelion
Redbeckia amplexicaulis	Clasping-leafed coneflower
R. hirta	Black-eyed Susan
Vernonia baldwinii	Baldwin's ironweed
Solanum carolinense	Horse nettle
Physalis angulata	Cut-leaf ground cherry
Penstemon arkansanus	Beard-tongue
Euphorbia dentata	Toothed spurge
E. dictyosperma	Spurge
Viola kitaibeliana	Johnny jump-up
Verbena canadensis	Large flowered verbena
Asclepias viridis	Milk-weed
Achillea lanulosa	Yarrow
Plantago aristita	Large bracted plantain
Lepidium virginicum	Pepper grass

L. densiflorum	Pepper grass
Lespedeza cuneata	Bush clover
Psoralea tenuiflora	Scurvy pea
Baptisia leucophaea	Bush pea
Schrankia nuttalli	Sensitive brier
Trifolium procumbens	Low hop clover

LOWER SLOPES AND STREAM VALLEY WOODLANDS

Trees	
Lower Slopes	
Quercus stellata	Post oak
Q. marilandica	Black jack oak
Celtis laevigata	Southern hackberry
Juglands nigra	Black walnut
Fraxinus americana	Green ash
Ulmus alata	Winged elm
Bumelia languginosa	Chittam wood
Carya tomentosa	White hickory
South and West Lower Slopes	
Cercis canadensis	Red bud
Gleditisia triacanthos	Honey locust
North and East Lower Slopes	
Quercus falcata	Southern white oak
Juniperus virginiana	Eastern red cedar
Ostrya virginiana	Hop hornbeam
Shrubs and Woody Vines	
Understory of Lower Slope Areas	
Vitis linsecumii	Post oak grape
V. vulpina	Winter grape
Crataegus spathulata	Hawthorn
Smilax bona-nox	Cat brier
Rhus glabra	Smooth sumac
R. copallina	Winged sumac
Symphoricarpos orbiculatus	Coral berry
Shrubs	
North and East Slopes	
Vaccinium arboreum	Tree huckleberry
Callicarpa americana	Beauty-berry
Herbaceous Plants	
Understory and Open Areas of Lower Slopes	
Tradescantia ohiensis	Ohio spiderwort
T. ernestiana	Spiderwort
Phlox pilosa	Downy phlox
Phacelia hirsuta	Hairy phacelia
Lobelia Specularia biflora	Venus's Looking glass
Krigia dandelion	Dwarf dandelion

FLORA (Continued)

Sisyrinchium campestre	Blue-eyed grass
Oxalis stricta	Upright yellow wood sorrel
Uniola latifolia	Broadleaf uniola
Panicum spp.	Panic grass
Monarda fistulosa	Wild bergamot
Salvia lyrata	Fiddle-leaf sage
Galium aparine	Common Cleavers
Oenothera biennis	Biennial evening primrose
Geranium carolinianum	Cranesbill

BOTTOMLAND FOREST

Trees

Populus detloides	Cotton wood
Quercus nigra	Water oak
Q. macrocarpa	Bur oak
Q. falcata	Southern red oak
Q. velutina	Black oak
Salix nigra	Black willow
Ulmus americana	American elm
U. crassifolia	Cedar elm
Morus rubra	Red mulberry
Cornus florida	Flowering dogwood
C. drummondi	Rough leaf dogwood
Viburnum rufidulum	Southern black haw
Plantanus occidentalis	Sycamore
Gymnocladus dioica	Kentucky coffee tree
Fraxinus americana	White ash
Cercis canadensis	Redbud
Juglans nigra	Black walnut
Acer negundo	Box elder
A. saccharinum	Silver maple
Betula nigra	River birch
Gleditsia triacanthos	Honey locust
Robinia pseudoacacia	Black locust
Sapindus drummondii	Chinaberry

Shrubs and Woody Vines

Cepholanthus occidentalis	Button bush
Callicarpa americana	Beauty berry
Lonicera spp.	Honeysuckle
Sambucus canadensis	American elder
Ampelopsis arborea	Pepper vine
Berchemia acandens	Supplejack
Amorpha fruticosa	Water locust
Rubus trivialis	Black berry
Campsis radicans	Trumpet vine

Herbaceous Plants

Understory and Open Areas

Prunella carolina	Heal all
Teucrium canadense	Virginia germander
Polygonum convolvulus	Black bindweed
Scuttellaria ovata	Scullcap
Polygonum hydropiperiodes	Smartweed
P. pennylvanicum	Pennsylvania smartweed
Passiflora incarnata	Passion flower
Chaerophyllum tainturieri	Spreading chervil
Cicuta maculata	Water hemlock
Caucus pusillus	American wild carrot
Zizia auria	Golden meadow parsley
Arisaema dracotium	Green dragon
Podophyllum peltatum	May apple
Elymus canadensis	Canada wild rye
Carex spp.	Sedge
Juncus interior	Prairie rush
J. diffusissimus	Rush
Geum canadense	Avens
Ranunculus pusillus	Low spearwort
Stellaria media	Chickweed
Commelina communis	Day flower
Tradescantia ohiensis	Ohio spiderwort
Allium canadense	Wild onion
Camassia scilliodes	Wild hyacinth
Polygonatum canaliculatum	Solomon's seal
Trifolium repense	White clover
Phytolacca americana	Poke berry
Euphorbia dentata	Spurge

CULTIVATED BOTTOMLAND

Herbaceous Plants

Poa annua	Annual blue grass
Achillea lanulosa	Yarrow
Ambrosia trifida	Giant ragweed
A. artemisiifolia	Common ragweed
Anthemis cotula	Mayweed
Cirsium altissimum	Tall thistle
Echinacea pallida	Purple cone flower
Lactuca canadensis	Wild lettuce
Pyrrohopappus carolineanus	Leafy false dandelion
Specularia perfoliata	Venus looking glass
Lepidium densiflorum	Pepper grass
Chenopodium album	Lambsquarters
Rumex crispus	Curly dock
R. pulcher	Fiddle dock
Linaria canadensis	Field toad flax
Verbascum blattaria	Moth mullein
Cynodon dactylon	Bermuda grass

Digitaria sanguinalis	Crab grass
Sorghum halapense	Johnson's grass
Setaria geniculata	Bent foxtail grass
Polytaenia nuttallii	Prairie parsley
Oenothera laciniata	Cut-leaf evening primrose
O. linifolia	Thread-leaf sundrop
Verbena urticifolia	White verbena
Lamium amplexicaule	Henbit
Plantago aristita	Large bracted plantain
Delphinium tricorne	Larkspur
Asclepias virides	Green milk weed

AQUATIC

Typha dominginsis	Cattail
Sagittaria calycina	Arrow head
Cyperus acuminatus	Sedge
Cyperus spp.	Sedge
Scirpus rotunda	Nut Sedge
Eleocharis macrostachya	Rush
Jussiae decurrens	Primrose Willow
Polygonum pensylvanicum	Lady's thumb
Polygonum hydropiper	Smart weed

AMPHIBIANS AND REPTILES
KNOWN AND EXPECTED FROM KERR-MCGEE SEQUOYAH FACILITY AREA
SEQUOYAH COUNTY, OKLAHOMA

AMPHIBIANS

Order Caudata	
Family Ambystomatidae	
Ambystoma annulatum	Ringed Salamander
Ambystoma maculatum	Spotted Salamander
Ambystoma opacum	Marbled Salamander
Ambystoma texanum	Small-mouthed Salamander
Ambystoma tigrinum tigrinum	Eastern Tiger Salamander
Family Salamandridae	
Notophthalmus viridescens louisianensis	Central Newt
Family Plethodontidae	
Eurycea multiplicata griseogaster	Gray-bellied Salamander
(Eurycea longicauda melanopleura	Dark-sided Salamander
(Eurycea lucifuga	Cave Salamander)
(Eurycea tynerensis	Oklahoma Salamander)
Plethodon dorsalis angusticlavius	Ozark Red-backed Salamander
Plethodon glutinosus glutinosus	Slimy Salamander
(Typhlotriton spelaeus	Grotto Salamander) (includes T. nereus)
Family Proteidae	
Necturus maculosus maculosus	Mudpuppy
Order Anura	
Family Pelobatidae	
Scaphiopus holbrooki hurteri	Hurter's Spadefoot
Family Bufonidae	
Bufo terrestris charlesmithi	Dwarf American Toad
Bufo woodhousei fowleri	Fowler's Toad
Family Hylidae	
Acris crepitans blanchardi	Blanchard's Cricket Frog
Hyla crucifer crucifer	Northern Spring Peeper
Hyla versicolor versicolor	Eastern Gray Treefrog
Pseudacris triseriata feriarum	Upland Chorus Frog
Family Ranidae	
Rana areolata circulosa	Northern Crayfish Frog
Rana clamitans melanota	Green Frog
Rana pipiens	Leopard Frog
Rana catesbeiana	Bullfrog
Family Microhydlidae	
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad

REPTILIA

Order Testudines	
Family Trionychidae	
Trionyx muticus muticus	Smooth Softshell
Trionyx spinifer hartwegi	Western Spiny Softshell
Family Chelydridae	
Chelydra serpentina	Common Snapping Turtle
Macroclemys temmincki	Alligator Snapping Turtle
Family Kinosternidae	
(Kinosternon subrubrum hippocrepis	Mississippi Mud Turtle)
Sternotherus odoratus	Stinkpot
Family Testudinidae	
(Graptemys geographica	Map Turtle)
Graptemys kohni	Mississippi Map Turtle
(Graptemys pseudogeographica ouachitensis	Ouchita Map Turtle
Pseudemys flordiana hoyi	Missouri Slider
Pseudemys scripta elegans	Red-eared Turtle
Terrapene carolina triunguis	Three-toed Box Turtle
Order Sauria	
Family Iguanidae	
Crotaphytus collaris	Collard Lizard
Sceloporus undulatus hyacinthinus	Northern Fence Lizard
Family Scincidae	
Eumeces fasciatus	Five-lined Skink
(Eumeces anthracinus pluvialis	Southern Coal Skink)
Eumeces laticeps	Broad-headed Skink)
Lygosoma laterale	Ground Skink
Family Teiidae	
Cnemidophorus sexlineatus	Six-lined Racerunner
Family Anguidae	
Ophisaurus attenuatus attenuatus	Western Slender Glass Lizard
Order Serpentes	
Family Colubridae	
Carphophis amoenus vermis	Western Worm Snake
(Cemophora coccinea	Scarlet Snake)
Coluber constrictor flaviventris	Eastern Yellow-bellied Racer
(Diadophis punctatus arnyi	Prairie Ringneck Snake)
Elaphe obsolete obsolete	Black Rat Snake
Heterodon platyrhinos	Eastern Hognose Snake
(Lampropeltis calligaster calli-gaster	Prairie Kingsnake)
(Lampropeltis triangulum syspila	Red Milk Snake)
Lampropeltis getulus holbrooki	Speckled Kingsnake

REPTILES (continued)

Masticophis flagellum flagellum	Eastern Coachwhip
Natrix rhombifera rhombifera	Diamond-backed Water Snake
Natrix erythrogaster transversa	Blotched Water Snake
Natrix sipedon pleuralis	Midland Water Snake
Opheodrys aestivus majalis	Western Rough Green Snake
Family Colubridae	
Storeria dekayi texana	Texas Brown Snake
(Storeria occipitomaculata occipitomaculata	Northern Red-bellied Snake)
Tantilla gracilis	Flat-headed Snake
Thamnophis proximus proximus	Western Ribbon Snake
Thamnophis sirtalis parietalis	Red-sided Garter Snake
Virginia striatula	Rough Earth Snake
(Virginia valeriae elegans	Western Smooth Earth Snake)
Family Crotalidae	
Agkistrodon Contortrix	Copperhead
Agkistrodon piscivorus Leucostoma	Western Cottonmouth
Crotalus atrox	Western Diamondback
(Crotalus horridus	Velved-tailed Rattler) (? 2 subsp)
(Sistrurus miliarius streckeri	Western Pigmy)

(. . .) indicates species reported from adjacent area which may be expected within study area

References:

Bragg, A.N., et al. 1950
Researches on the Amphibia of Oklahoma. University of Oklahoma Press, Norman 154 pp.

Conant, Roger. 1958
A Field Guide to Reptiles and Amphibians of Eastern North America Houghton Mifflin Co., Boston. 366 pp.

Webb, Robert G., 1970
Reptiles of Oklahoma. University of Oklahoma Press, Norman. 370 pp.

BIRDS KNOWN AND EXPECTED FROM THE KERR-MCGEE SEQUOYAH FACILITY AREA, SEQUOYAH COUNTY, OKLAHOMA

Gaviidae	
Common Loon	M,WV
Podicipedidae	
Horned Grebe	M, WV
Eared Grebe	M
Western Grebe	rM
Pied-billed Grebe	M,uSR
Pelecanidae	
White Pelican	M
Phalacrodoracidae	
Double-crested Cormorant	M
Anhingidae	
Anhinga	rSV
Ardeidae	
Great Blue Heron	PR
Green Heron	M, SR
Little Blue Heron	M, SR
Cattle Egret	USR
Common Egret	M, SR
Snowy Egret	M, SR
Louisiana Heron	rSV
Black-crowned Night Heron	M, uSR
Yellow-crowned Night Heron	M, SR
Least Bittern	M, SR
American Bittern	M, SR
Anatidae	
Canada Goose	M
White-fronted Goose	M
Anatidae	
Snow Goose	M
Blue Goose	M
Mallard	M, WR
Black Duck	M, WV
Gadwall	M, WV
Pintail	M, WV
Green-winged Teal	M, WV
Blue-winged Teal	M, WV
American Widgeon	M, WV
Shoveler	M
Wood Duck	M,uSR
Redhead	M, WV
Ring-Necked Duck	M, WV
Canvasback	M, WV
Greater Scaup	uM,UWV
Lesser Scaup	M, WV
Common Goldeneye	M, WV
Bufflehead	M, WV
Ruddy Duck	M, WV
Hooded Merganser	M, WV
Common Merganser	M, WV
Red-breasted merganser	M, WV
Cathartidae	
Turkey Vulture	PR
Black Vulture	PR
Accipitridae	
Mississippi Kite	uM
Sharp-shinned Hawk	M, WR
Cooper's Hawk	uPR
Red-Tailed Hawk	PR
Harlan's Hawk	WR
Red-shouldered Hawk	PR

Seasonal Status Code

M Migrant	WR Winter Resident
V Visitant	WV Winter Visitant
PR Permanent Resident	r rare
SR Summer Resident	u uncommon

Accipitridae	
Broad-winged Hawk	M,SR
Rough-legged Hawk	uWV
Golden Eagle	uWV
Bald Eagle	uWV
Marsh Hawk	M,WR
Pandionidae	
Osprey	M
Falconidae	
Peregine Falcon	rWV
Pigeon Hawk	rWV
Sparrow Hawk	PR
Phasianidae	
Bobwhite	PR
Rallidae	
King Rail	M,uSR
Virginia Rail	M,uSR
Sora	M
Common Gallinule	uM,rSR
American Coot	M
Charadriidae	
Semipalmated Plover	uM
Piping Plover	uM
Killdeer	PR
American Golden Plover	M
Black-bellied Plover	M
Ruddy Turnstone	
Scolopacidae	
American Woodcock	M
Common Snipe	M,WR
Upland Plover	M
Spotted Sandpiper	M
Solitary Sandpiper	M
Willet	
Greater Yellowlegs	M
Lesser Yellowlegs	M
Pectoral Sandpiper	M
White-rumped Sandpiper	M
Baird's Sandpiper	M
Least Sandpiper	M
Dunlin	rM
Long-billed Dowitcher	uM

Scolopacidae	
Stilt Sandpiper	M
Semipalmated Sandpiper	M
Western Sandpiper	M
Buff-breasted Sand-piper	uM
Sanderling	rM
Recurvirostridae	
American Avocet	uM
Phalaropodidae	
Wilson's Phalarope	uM
Laridae	
Herring Gull	M,WV
Ring-billed Gull	M,WV
Franklin's Gull	M
Bonaparte's Gull	M
Forster's Tern	M
Least Tern	uSR
Caspian Tern	uM
Black Tern	M
Columbidae	
Mourning Dove	PR
Cuculidae	
Yellow-billed Cuckoo	M,SR
Black-billed Cuckoo	uM
Roadrunner	PR
Tytonidae	
Barn Owl	PR
Strigidae	
Screech Owl	PR
Great Horned Owl	PR
Barred Owl	PR
Long-eared Owl	uPR
Short-eared Owl	uM,uWV
Caprimulgidae	
Chuck-will's-widow	M,SR
Whip-poor-will	M
Common Nighthawk	M,SR
Apodidae	
Chimney Swift	M,SR

BIRDS (Continued)

Trochilidae	
Ruby-throated Hummingbird	M,SR
Alcedinidae	
Belted Kingfisher	PR
Picidae	
Yellow-shafted Flicker	PR
Red-shafted Flicker	WV
Pileated Woodpecker	PR
Red-bellied Woodpecker	PR
Red-headed Woodpecker	M,SR
Yellow-bellied Sapsucker	M,WR
Hairy Woodpecker	PR
Downy Woodpecker	PR
Tyrannidae	
Eastern Kingbird	M,SR
Western Kingbird	uM,uSR
Scissor-tailed Flycatcher	M,SR
Great Crested Flycatcher	M,SR
Eastern Phoebe	M,SR
Yellow-bellied Flycatcher	uM
Acadian Flycatcher	M,uSR
Traill's Flycatcher	M,uSR
Least Flycatcher	M
Eastern Wood Pewee	M,SR
Olive-sided Flycatcher	uM
Alaudidae	
Horned Lark	PR
Hirundinidae	
Tree Swallow	M
Bank Swallow	M,SR
Rough-winged Swallow	M,SR
Barn Swallow	M,SR
Cliff Swallow	M
Purple Martin	M,SR
Corvidae	
Blue Jay	PR
Common Crow	PR
Fish Crow	uSR
Paridae	
Carolina Chickadee	PR
Tufted Titmouse	PR
Sittidae	
White-breasted Nuthatch	PR
Red-breasted Nuthatch	uWV
Carthidae	
Brown Creeper	WV
Troglodytidae	
House Wren	M,SR
Winter Wren	WV
Bewick's Wren	PR
Carolina Wren	PR
Long-billed Marsh Wren	uM
Short-billed Marsh Wren	uM
Mimidae	
Mockingbird	PR
Catbird	M,SR
Brown Thrasher	SR
Turdidae	
Robin	PR
Wood Thrush	M,SR
Hermit Thrush	M,WV
Swainson's Thrush	M
Gray-cheeked Thrush	M
Veery	uM
Eastern Bluebird	PR
Sylviidae	
Blue-gray Gnatcatcher	M,SR
Golden-crowned Kinglet	M,WR
Ruby-crowned Kinglet	M,WR
Motacillidae	
Water Pipit	uM
Spregue's Pipit	uM
Bombycillidae	
Cedar Waxwing	M,WR

Laniidae	
Northern Shrike	uWV
Loggerhead Shrike	PR
Sturnidae	
Starling	PR
Vireonidae	
White-eyed Vireo	M,SR
Bell's Vireo	M,SR
Yellow-throated Vireo	M,SR
Solitary Vireo	M
Red-eyed Vireo	
Philadelphia Vireo	M,SR
Warbling Vireo	M,SR
Parulidae	
Black-and-white Warbler	M,SR
Prothonotary Warbler	M,SR
Swainson's Warbler	rSR
Worm-eating Warbler	rSR
Tennessee Warbler	M
Orange-crowned Warbler	M
Nashville Warbler	M
Parula Warbler	M,SR
Yellow Warbler	M,SR
Magnolia Warbler	uM
Black-throated Blue Warbler	rM
Myrtle Warbler	M,WR
Black-throated Green Warbler	M
Cerulean Warbler	rSR
Blackburnian Warbler	M
Yellow-throated Warbler	SR
Chestnut-sided Warbler	uM
Bay-breasted Warbler	uM
Blackpoll Warbler	M
Pine Warbler	rV
Prairie Warbler	M,SR
Palm Warbler	rM
Ovenbird	M
Parulidae	
Northern Waterthrush	M
Louisiana Waterthrush	M,SR
Kentucky Warbler	M,SR
Mourning Warbler	M
Yellowthroat	M,SR
Yellow-breasted Chat	M,SR
Hooded Warbler	M,rSR
Wilson's Warbler	M
Canada Warbler	rM
American Redstart	M,uSR
Ploceidae	
House Sparrow	PR
Icteridae	
Bobolink	M
Eastern Meadowlark	PR
Western Meadowlark	rWV
Yellow-headed Blackbird	uM
Red-winged Blackbird	PR
Orchard Oriole	M,SR
Baltimore Oriole	M,SR
Rusty Blackbird	M,WR
Brewer's Blackbird	M,WV
Boat-tailed Grackle	uSR
Common Grackle	PR
Brown-headed Cowbird	PR
Thraupidae	
Scarlet Tanager	M,SR
Summer Tanager	M,SR
Fringillidae	
Cardinal	PR
Rose-breasted Grosbeak	M
Blue Grosbeak	M,SR
Indigo Bunting	M,SR
Lazuli Bunting	rM
Painted Bunting	M,SR
Dickcissel	M,SR
Evening Grosbeak	rWV
Purple Finch	M,WV
Pine Siskin	M,WV
American Goldfinch	PR

BIRDS (Continued)

Fringillidae	
Red Crossbill	rWV
Eastern Towhee	M,WR
Spotted Towhee	M,WR
Savannah Sparrow	M,WV
Grasshopper Sparrow	M,SR
Le Conte's Sparrow	M,WV
Vesper Sparrow	M,WV
Lark Sparrow	M,SR
Slate-colored Junco	M,WV
Oregon Junco	uM,UWV
Tree Sparrow	uWV
Chipping Sparrow	M
Clay-colored Sparrow	M
Field Sparrow	PR
Harris' Sparrow	M,WR
White-crowned Sparrow	M,WR
White-throated Sparrow	M,WR
Fox Sparrow	M,WR
Lincoln's Sparrow	M,WR
Swamp Sparrow	M,WR
Song Sparrow	M,WR
Lapland Longspur	uM,uWV
Smith's Longspur	rWV
Chestnut-collared Longspur	rWV

References:

Peterson, R. T. 1963
A Field Guide to the Birds of Texas and Adjacent States. Houghton Mifflin, Boston. 304 pp.

Robbins, C. S., B. Bruun, and H. S. Zim, 1966.
A Guide to Field Identification of Birds of North America. 340 pp.

Sutton, S. M. 1967
Oklahoma Birds. University of Oklahoma Press, Norman 674 pp.

MAMMALS KNOWN (OR EXPECTED) FROM THE
KERR-MCGEE SEQUOYAH FACILITY AREA

Order Marsupialia	
Family Didelphidae	
Didelphis marsupialis	Oppossum
Order Insectivora	
Family Soricidae	
Cryptotis parva	Least shrew
Blarina brevicauda	Short-tailed shrew
Family Talpidae	
Scalopus aquaticus	Eastern mole
Order Chroptera	
Family Vespertilionidae	
Myotis keeni	Keen myotis
Myotis lucifugus	Little brown myotis
(*Myotis sodalis*	Indiana myotis)
(*Myotis grisescens*	Gray myotis)
Myotis subulatus	Small-footed myotis
Lasionycteris noctivagans	Silver-haired bat
Pipistrellus subflavus	Eastern pipstrel
Lasiurus borealis	Red bat
Lasiurus cinereus	Hoary bat
Eptesicus fuscus	Big brown bat
Nycticeius humeralis	Evening bat
Plecotus townsendi	Western big-eared bat
Plecotus rafinesquei	Eastern big-eared bat
Order Edentata	
Family Dasypodidae	
Dasypus novemcinctus	Armadillo
Order Lagomorpha	
Family Leporidae	
Lepus californicus	Black-tailed jackrabbit
Sylvilagus floridanus	Eastern cottontail
Sylvilagus aquaticus	Swamp rabbit
Order Rodentia	
Family Sciuridae	
(*Citellus tridecemlineatus*	13-lined ground squirrel)
Tamias striatus	Eastern chipmunk
Sciurus carolinensis	Eastern gray squirrel
Sciurus niger	Eastern fox squirrel
Glaucomys volans	Southern flying squirrel
Family Geomyidae	
Geomys bursarius	Plains pocket gopher
Family Castoridae	
Castor canadensis	Beaver

MAMMALS (Continued)

Family Cicetidae	
(_Reithrodontomys montanus_	Plains harvest mouse)
(_Reithrodontomys humulis_	Eastern harvest mouse)
Reithrodontomys fulvescens	Fulvous harvest mouse
Peromyscus leucopus	White-footed mouse
Peromyscus maniculatus	Deer mouse
Peromyscus boylei	Brush mouse
Neotoma floridana	Eastern woodrat
Oryzomys palustris	Rice rat
Sigmodon hispidus	Hispid cotton rat
Microtus (Pitymys) pinetorum	Pine vole
Ondatra zibethicus	Muskrat
Family Muridae	
Rattus norvegicus	Norway Rat
Mus musculus	House Mouse
Order Carnivora	
Family Procyonidae	
Procyor lotor	Raccoon
Family Mustelidae	
Mustela frenata	Longtail weasel
Mustela vison	Mink
(_Lutra canadensis_	River otter)
Spilogale putorius	Eastern spotted skunk
Mephitis mephitis	Striped skunk
Family Canidae	
Canis latrans	Coyote
(_Canis niger_	Red wolf)
Vulpes fulva	Red fox
Urocyon cinereoargenteus	Gray fox
Family Felidae	
(_Felis concolor_	Mountain lion)
Lynx rufus	Bobcat
Order Artiodactyla	
Family Cervidae	
(_Odocoileus (Dama) virginianus_	White-tailed deer)

(. . .) indicates species reported from adjacent area which may be expected within the study area.

References:

Burt, W. H., and R. P. Grossenheider. 1964 2nd ed. A Field Guide to the Mammals Houghton Mifflin Co. Boston 284 pp.

Hall, E. R., and K. R. Kelson. 1959 The Mammals of North America. Vol. I and II. The Ronald Press, New York 1083 pp.

FISH
KNOWN AND EXPECTED FROM SEQUOYAH FACILITY AREA
SEQUOYAH COUNTY, OKLAHOMA

ARKANSAS RIVER

FETROMYZONTIDAE	
Ichthyomyzon castaneus	Chestnut lamprey
Ichthyomyzon gagei	Southern brook lamprey
ACIPENSERIDAE	
Scaphirhynchus platoynchus	Shovelnose sturgeon
POLYODONTIDAE	
Polyodon spathula	Paddlefish
LEPISOSTEIDAE	
Lepisosteus ocalatus	Spotted gar
Lepisosteus asseus	Longnose gar
Lepisosteus platostomus	Shortnose gar
Lepisosteus spatula	Aligator gar
CLUPEIDAE	
Alosa chrysochloris	Skipjack herring
Dorosoma cepedianum	Gizzard shad
SALMONIDAE	
Salmo gairdneri	Rainbow trout
HIODONTIDAE	
Hiodon alosoides	Goldeye
CYPRINIDAE	
Campostoma anomalum	Stoneroller
Cyprinus carpio	Carp
Chrosomus erythrogaster	Southern redbelly dace
Chrosomus eos	Northern redbelly dace
Hybognathus nuchalis	Silvery minnor
Hybopsis biguttata	Horneyhead chub
Notemigonus crysoleucas	Golden shiner
Notropis buchanani	Ghost shiner
Notropis girardi	Arkansas River shiner
Notropis lutrensis	Red shiner
Notropis percobromus	Plains shiner
Notropis potteri	Chub shiner
Notropis umbratilis	Redfin shiner
Notropis volucellus	Mimic shiner
Phenacobius mirabilis	Suckermouth minnow
Pimephales notatus	Bluntnose minnor
Pimephales promelas	Fathead minnow
Pimephales tenellus	Slim minnow
CATOSTOMIDAE	
Carpiodes carpio	River carpsucker
Carpiodes velifer	Highfin carpsucker
Castostomus commersoni	White sucker
Cycleptus elongatus	Blue sucker
Erimyzon oblongus	Creek chubsucker
Ictiobus bubalus	Smallmouth buffalo

FISH (Continued)

CATOSTOMIDAE	
Ictiobus cyprinellus	Bigmouth buffalo
Ictiobus niger	Black buffalo
Minytrema melanops	Spotter sucker
Moxostoma carinatum	River redhorse
Moxostoma duquesnei	Black redhorse
Moxostoma erythrurum	Golden redhorse
Moxostoma macrolepidotum	Northern redhorse
ICTALURIDAE	
Ictalurus furcatus	Blue catfish
Ictalurus melas	Black bullhead
Ictalurus natalis	Yellow bullhead
Ictalurus nebulosus	Brown bullhead
Ictalurus punctatus	Channel catfish
Pylodictis olivaris	Flathead catfish
Noturus flavus	Stonecat
Schilbeodes miurus	Brindled madtom
Schilbeodes nocturnus	Freckled madtom
ANGUILLIDAE	
Anguilla rostrata	American eel
CYPRINODONTIDAE	
Fundulus notatus	Blackstripe topminnow
POECILIDAE	
Gambusia affinis	Mosquitofish
SERRANIDAE	
Morone saxatilis	Striped bass
Morone chrysops	White bass
Raccus mississippiensis	Yellow bas
CENTRARCHIDAE	
Ambioplites rupestris	Rock bass
Lepomis gulosus	Warmouth
Lepomis auritus	Redbreast sunfish
Lepomis cyanellus	Green sunfish
Lepomis humilis	Orangespotted sunfish
Lepomis macrochirus	Bluegill
Lepomis megalotis	Longear sunfish
Lepomis microlophus	Redear sunfish
Lepomis punctatus	Spotted sunfish
Micropterus dolomieui	Smallmouth bass
Micropterus punctulatus	Spotted bass
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
Pomoxis nigromaculatus	Black crappie
PERCIDAE	
Etheostoma cragini	Arkansas darter
Etheostoma gracile	Slough darter
Etheostoma spectabile	Orangethroat darter
Perca flavescens	Yellow perch
Percina caprodes	Log perch
Percina copelandi	Channel darter
Percina maculata	Blackside darter
Percina phoxocephala	Slenderhead darter

FISH (Continued)

PERCIDAE	
Stizostedion canadense	Sauger
Stizostedion vitreum	Walleye
SCIAENIDAE	
Aplodinotus grunniens	Freshwater drum
SPARIDAE	
Archosargus probatocephalus	Sheepshead
COTTIDAE	
Cottus carolinae	Banded sculpin
ATHERINIDAE	
Labidesthes sicculus	Brook silverside

ILLINOIS RIVER

CENTRARCHIDAE	
Ambloplites rupestris	Rock bass
Micropterus dolomieui	Smallmouth bass
COTTIDAE	
Cottus carolinae	Banded sculpin
SALMONIDAE	
Salmo gairdneri	Rainbow trout
CATOSTOMIDAE	
Minytrema melanops	Spotter sucker

Reference: Fishes of Oklahoma, Department of Wildlife Conservation

EARTH SCIENCES OBSERVATORY
OFFICE OF THE DIRECTOR
830 So. Van Vleet Oval, Rm. 107

THE UNIVERSITY OF OKLAHOMA
NORMAN, OKLAHOMA 73069

May 5, 1972

Mr. William J. Shelley
Nuclear Division, Technical Services
133 Robert S. Kerr Avenue
Kerr-McGee Corporation
Oklahoma City, Oklahoma

Dear Mr. Shelley:

The attached report has been prepared for you concerning "Seismic Risk in Oklahoma," by the staff at the University of Oklahoma Earth Sciences Observatory. There appears to be some small earthquake damage risk in the El Reno-Nemaha Ridge area, but even a smaller chance in other areas of Oklahoma. Our micro-earthquake recording studies have just begun but preliminary meager results suggest small seismic risk. These studies will be continued and will give us much more information concerning this problem in the future.

With my best regards and should we be able to provide you with additional information, please call us.

Sincerely yours,

Robert L. DuBois
Director

RLDB:km

SEISMIC RISK IN OKLAHOMA

In 1969, the Coast and Geodetic Survey published a new "Seismic Risk Map of the United States" (Algermissen, 1969). On that map, all of Oklahoma outside the El Reno-Nemaha Ridge area is in Zone 1, which is defined a zone of possible "minor damage." The El Reno-Nemaha Ridge area (96.2° W longitude to 97.8° west longitude, from 35° N latitude northward to the Kansas border and continuing northward through Kansas and Nebraska) which includes Oklahoma City, Norman, Stillwater, Ponca City, and Enid is in Zone 2, which is the Zone of possible "moderate damage." The possible minor damage of Zone 1 is stated on the risk map to correspond to a Modified Mercalli Intensity of V or VI (M.M.V, M.M.VI). Intensity VI is defined in part as "felt by all . . .some heavy furniture moved; a few instances of fallen plaster or damaged chimneys; damage slight." The El Reno-Nemaha Ridge moderate damage zone corresponds to VII on the M.M. scale: "damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures . . .some chimneys broken." The Algermissen (1969) Seismic Risk Map is also accompanied by earthquake recurrence tables suggesting that damage corresponding to M.M. VII may occur on an average of once each 27 years in the El Reno-Nemaha Ridge area and once every 55 years elsewhere in Oklahoma.

In a study based on historical records, and on 21 months of seismograms from the University of Oklahoma Observatory, Professor Eysteinn Tryggvason (1965) concluded that:

"Destructive earthquakes (may occur at any particular place in Oklahoma) approximately once per 100,000 years and strong earthquakes causing minor damage...once every 2,000 years. Major earthquake catastrophies are not likely to happen in Oklahoma. . ."

Since September, 1970, the OU Observatory has operated its short period seismographs at twice the magnification which was used during the Tryggvason study, and there has been no indication of any greater seismic risk than that assessed by Tryggvason. In April, 1972, a special micro-earthquake seismograph, operating at a magnification exceeding a million, was installed at the Observatory. During its first three weeks of operation it recorded two micro-earthquakes. It will require at least a year to accumulate enough micro-earthquake data to realistically extrapolate the frequencies to larger earthquakes but the meager data so far does not suggest increased seismic risk.

There has been considerable publicity about the New Madrid, Missouri earthquakes of 1811-1812. The New Madrid area has experienced several earthquakes that have been "felt" every year since 1812. If a catastrophic earthquake occurred in the New Madrid area, because of the distance involved, it would be unlikely to damage any structure in Oklahoma unless the structure was very poorly built or was large enough to have a free vibration made of one second or greater period.

The El Reno area is, according to Tryggvason (1965) the only area showing a historical concentration of earthquakes compared to the rest of Oklahoma.

In conclusion it appears that there is some small chance of slight damage to well-built structures in the El Reno-Nemaha Ridge area, and an even smaller chance elsewhere in Oklahoma. The probability of serious damage, leading to

collapse or radiation leakage, from an Oklahoma nuclear power plant appears to be too small to assess numerically.

REFERENCES:

Algermissen, S. T. (1969) Seismic Risk Studies in the United States, 20 pp. This preprint was later published in the Proceedings of the Fourth World Conference on Earthquake Engineering.

Tryggvason, Eysteinn (1965) Seismicity of Oklahoma, unpublished paper presented at the Annual Meeting of the Seismological Society of America.

Appl ation No. ____________

APPLICATION FOR MANUFACTURER'S AIR POLLUTION CONTROL FACILITIES AND/OR INCOME TAX CREDIT

Oklahoma State Department of Health
Division of Air Pollution Control

Name of Taxpayer Kerr-McGee Corporation
(Indicate exact type of legal entity)

Name of Taxpayer's Correspondent Mr. D. J. Foley Title Manager
Project Engineering, Nuclear Division

Address Kerr-McGee Building, Oklahoma City, Oklahoma 73102
(Headquarter's Office)

1. Legal Description of Plant Location NE 1/4, Sec. 21, Twp. 12N, Rge. 21E, Sequoyah County, Oklahoma. Kerr-McGee Sequoyah Facility (UF_6 Conversion Plant) located 2-1/2 miles southwest of Gore, Oklahoma off Highway 64, Sequoyah County, Oklahoma.

   (Also give directions for reaching plant, if necessary)

2. List Product(s) Manufactured or Processed Conversion of uranium ore concentrates to uranium hexafluoride (UF_6).

3. Describe or Identify Pollutant(s) to Be Controlled by Proposed Control Facility Plant refuse consisting of materials such as combustible packing materials, shipping boxes and crates, office waste, and uncontaminated rags and wipes.

   3(a) Amount Being Discharged Variable; perhaps up to one ton/day.

4. Describe Method(s) or Principle(s) of Control to Be Utilized Open burning for theoretical complete combustion using overfire air-jet system in an open-pit incinerator.

   4(a) Name and Amount of Product(s) Recovered Fused ash and incombustible residues.

5. What Degree of Control of the Pollutant(s) Will the New Facility Provide

   See Attachment

6. On What Basis Is the Degree of Effectiveness Calculated General design criteria and specified arrangement proven by two years developmental work and four years operating experience.

Date Construction of New Facility Will Begin October, 1970

8. Date Construction of New Facility Will Be Completed December, 1970

9. If Presently Under Construction, Indicate - - -

10. Will Additional Income or Savings of Any Sort Result from This Air Pollution Control Facility No additional income or savings results.
(Indicate amount annually)

ATTACH COMPLETE COST BREAKDOWN BY PRINCIPAL ITEMS.

Subscribed and sworn to before me this 7th day of October 19 70

Martha J. Manning
Notary Public

KERR-McGEE CORPORATION
(Name of Taxpayer)

My Commission Expires Jan 25, 1972

P. S. Dunn
(Officer Signing Application)
P. S. Dunn, Group Vice President
Nuclear Operations Division

Application received and plans filed in this office this ________ day of ________, 19____.

DIVISION OF AIR POLLUTION CONTROL

By ____________________
Director

(To Be Filed in Triplicate)

ATTACHMENT TO Application to Oklahoma Air Pollution Control Division

Subject: Kerr-McGee Sequoyah Facility

It is proposed that the open-pit incinerator using an overfire air-jet system as shown on drawings #SF08-2 and #CF06-4 will control the visible emissions, smoke and equivalent opacity so as not to exceed No. 1 Ringlemann.

Fly ash or other particulate matter will be controlled within the allowable emissions of Figure 1 of Regulation No. 5 of the Air Pollution Control Division of the Oklahoma State Department of Health.

The proposed location for the open-pit incinerator at the Sequoyah Facility is shown on the plot plan drawings #SF08-1 (Rev. 1).

Estimated Capital Investment

We submit that an estimated $19,000.00 capital investment for the Sequoyah Facility qualifies as "non-profitable" investment for installation of the proposed open-pit incinerator for control against air pollution.

Oklahoma
State Department of Health
3400 N. Eastern, Oklahoma City, Oklahoma 73105

July 26, 1971

Mr. George Wuller
Ker McGee Building
133 Robert S. Kerr Avenue
Oklahoma City, Oklahoma 73102

Dear Mr. Wuller:

A visible emission evaluation test was made on your open-pit incinerator located at Kerr-McGee's Seqouyah Facility in Gore, Oklahoma, July 14, 1971. The test consisted of making periodic visible readings of the stack emissions during the time period from 10:00 a.m. to 10:15 a.m., while the incinerator consumed approximately 2000 lbs. of type 0 waste.

The stack emissions ranged from a 0 to 3/4 Ringelmann during the test. It is our estimation that your incinerator will operate in compliance with the Air Pollution Control Division Regulation No. 5, if it is maintained and charged properly.

This letter is not intended to be a formal permit and does not waiver any requirements for stack sampling for determining exact emission rates in the future.

As we discussed, it is now necessary for the cost accounting and certification of cost to be submitted to our office so that your tax credit application can be completed.

We want to take this opportunity to thank you and your company for helping to protect Oklahoma's environment.

Please contact our office if we may be of any further assistance to you.

Very truly yours,

Doyle McWhirter

Doyle McWhirter, R.P.S.
Air Pollution Control Division

DMW:MJS
cc Mr. Loyd F. Pummill
Deputy Commissioner
for Environmental Services
cc Mr. Sam Trzcinski, R.P.S.
District Sanitarian
cc Mr. Homer Pace, R.P.S.
Sequoyah County Health Department
cc Mr. Robert V. Blanche, Director
Air Pollution Control Division

Kerr-McGee Sequoyah Facility

Waste Disposal System Ponds

1.0 TECHNICAL PROVISIONS FOR CLEARING AND GRUBBING

1.1 Work Included

The work included under this item shall consist of clearing and grubbing in the area within the "Limits of Grubbing and Stripping" as shown on drawings.

1.2 Work Not Included

Cutting and removal of trees designated to be saved is not included.

1.3 Definitions

1.3.1 Clearing

Clearing consists of the felling and cutting up of trees and the disposal of such trees together with the disposal of down timber, snags, brush and rubbish occuring within the areas to be cleared.

1.3.2 Grubbing

Grubbing consists of the removal of all stumps, roots larger that 1-1/2 inches in diameter and other objectionable buried vegetable matter to a depth of 18 inches below subgrade or existing ground.

1.3.3 Brush

Brush consists of that natural vegetation which is two inches or less in diameter measured at ground level or six feet or less in height measured above the ground level on the uphill side.

1.3.4 Trees

Trees consist of that woody growth not falling within the limits of brush as defined above.

1.4 Clearing

All trees, stumps, and brush within the designated clearing area shall be cut to a height not exceeding twelve inches above the ground surface, measured on the uphill side. In addition thereto, isolated snags, downed trees and unstable trees located outside of the areas to be cleared, which in falling would fall into the cleared areas shall be removed to the extent directed. Clearing operations shall be conducted so as to prevent damage to trees designated to remain and to trees or vegetation outside the areas to be cleared.

1.5 Grubbing

Grubbing shall be performed within the limits designated as "Limits of Grubbing and Stripping" on the design drawings.

1.6 Disposal

1.6.1 All debris resulting from removal of fences, clearing and grubbing shall be disposed of in the area designated for this purpose on the design drawings. All materials to be burned shall be as completely burned as possible eventhough it might result in considerable delay, the burning operations shall be performed only at such times and in accordance with the applicable state and local laws and regulations. Special precautions shall be taken to prevent fire from spreading beyond the limits of the burning area and suitable equipment and supplies shall be available at all times to control fires.

1.6.2 All of the non-combustible material resulting from clearing, and grubbing shall be wasted in the areas designated for this purpose on the design drawings or as directed by the contractor.

1.7 Measurements

Field measurements will be made immediately after completion of clearing and/or grubbing and area of portions thereof.

2.0 TECHNICAL PROVISIONS FOR EARTHWORK

Note: The AEC Licensing Guide - "Information and Criteria Pertinent to Evaluation of Embankment Retention Systems" is part of this specification.

2.1 Work Included

The work shall include the following items:

a. Topsoil excavation and stock piling.
b. General excavation and backfill.
c. Select excavation and backfill.
d. General excavation and stockpiling.

2.2 Excavation Classification

2.2.1 Common excavation shall consist of all excavation which is not otherwise classified herein.

2.2.2 Rock excavation shall consist of igneous, metamorphic and sedimentary rock which cannot be excavated by normal ripping procedures or without blasting, and all boulders or detached rock each having a volume of one-half (1/2) cubic yard or more.

2.2.3 Topsoil excavation shall consist of friable residual surface soils, containing humes and naturally deposited organic matter, capable of supporting a satisfactory turf as demonstrated by suitable growth in its undisturbed location, and shall be free of harmful quantities of clay, sand or gravel.

2.2.4 Select excavation shall consist of materials, as identified by the owner, which comply with the requirements for inclusion in road and yard base and surfacing or for use as trench backfill.

2.3 Embankment Classification

2.3.1 Type "A" embankment shall consist of suitable common or rock excavation placed and compacted on prepared subgrade, as herein specified, to ninety five (95%) percent of laboratory density determined for laboratory test according to ASTM D 698 method C or D. The field density test shall be determined according to ASTM D 1556.

2.3.2 Type "B" embankment shall consist of suitable common or rock excavation placed on prepared or unprepared subgrade without specified compaction or treatment other than that achieved by the wheel or track effect of hauling, leveling and grading and maintaining the moisture content within plus or minus five percent (5%) of optimum moisture content determined by laboratory test according to ASTM D 698.

2.3.3 Type "C" embankment shall consist of selected zone II material, as shown on drawing. Compaction shall be to 95% of laboratory density, at two or five percent above optimum moisture content, according to ASTM D 698, method C or D. Field density shall be determined according to ASTM D 1556. The type "C" embankment shall be utilized in the imprevious core of raffinate pond dike as shown on drawing.

2.4 Excavation

2.4.1 No common, rock or select excavation shall commence until clearing, grubbing, topsoil excavation, concrete culvert installation, subgrade preparation, cross-sectioning and engineering staking are substantially complete.

2.4.2 Excavation of all classifications shall be done in such a manner or sequence that excavated material can be placed directly in final position in embankments, authorized stockpiles, or waste areas. Expenses connected with unauthorized rehandling or excavated materials shall be borne by the contractor.

2.4.3 Topsoil excavation and stockpiling may be done at any time after the stock pile area is cleared and prior to the start of other excavation. Topsoil, unless otherwise directed by the engineer, shall be excavated from within the limits of grubbing and stripping and placed in a neat, well-drained stockpile in substantial conformance to the location shown on the drawings. Topsoil excavation shall be done in thin strips to avoid inclusion of unsuitable underlaying materials. Any material excavated and found unsuitable for topsoil shall be wasted as directed by the owner.

2.4.4 Common excavation shall be finished to a reasonably smooth and uniform surface. Subgrade in common excavation shall vary no more than two-tenths (0.2) foot at any point from the typical section as related to the design profile elevation yard and area subgrade in common excavation shall vary no more than two-tenths (0.2) foot at any spot elevation or from the theoretical elevation determined from a line drawn between any two given adjacent elevations as shown on the drawings. If excavation to the design elevation may be ordered by the owner and the excavated area backfilled with suitable material to the

design elevation. Prior to such backfilling, the owner will take necessary cross-sections and may order subgrade preparation as hereinafter specified. Backfill will be considered as type "A" embankment unless otherwise ordered by the owner. At any interface between common and rock excavation the common material shall be completely removed in sections of one hundred (100) feet or more so that cross-sections can be made prior to the start of rock excavation.

2.4.5 Select excavation and stockpiling may be done at any time that suitable material, as determined by the owner, is encountered. Select excavation shall be stockpiled in a convenient location as directed by the contractor and excavated in the same manner specified for topsoil excavation.

2.5 Embankment Construction

2.5.1 Material for type "A" embankment shall be placed in horizontal layers not exceeding eight (8) inches in thickness by loose measurement and shall be compacted to density required under Section 9.4 Embankment Classification. Sufficient spreading, watering, leveling, mixing and compaction equipment shall be required to achieve uniform density on each successive lift or layer. Where type "A" embankment is to be placed against an existing slope steeper than four (4) horizontal to one (1) vertical, the existing slope shall be continuously benched as the embankment is brought up in layers. Water shall be added by spray and mixing (hose or spray bar shall have minimum pressure of 30 p.s.i.) or moisture removed by aeration as necessary to obtain the required density. A minimum of one (1) in-place density test per 500 cubic yards of embankment will be made by contractor.

2.5.2 Material for type "B" embankment shall be placed or dumped in areas shown on the drawings or directed by the owner. If the moisture content of the material as placed is maintained as required, the wheel and track action of hauling, leveling, and grading equipment will produce an adequate degree of compaction.

2.5.3 Construction of type "C" embankment shall be as specified for type "A" embankment except the moisture content shall be maintained at two to five percent above the optimum moisture content and degree of compaction shall be that specified for type "C" embankment.

2.6 Subgrade Preparation

2.6.1 Subgrade preparation shall consist of scarifying, blading and compacting all foundation areas upon which type "A" embankment is to be placed. Scarifying shall be carried to a uniform depth of at least six (6) inches. Unless otherwise shown on the drawings, bring the scarified area to optimum moisture content and compact to a density required under Section 2.3, embankment classification. The results of subgrade preparation shall be tested for compliance prior to the placing of any material.

2.7 Measurements

2.7.1 The owner will take cross sections of the ground and of the completed work for each station or fraction thereof, and will compute the volume of excavation, embankment or stock piling by the average end-area methods. The measurements will not include the yardage excavated without authorization beyond slope lines as defined on the drawings.

The measurements for rock excavation will include:

a. Authorized excavation of rock below grade.

b. Overbreakage which, in the opinion of the contractor was not due to carelessness of the subcontractor.

3.0 SPECIFICATION FOR EROSION CONTROL

3.1 Work Included

The work included in this section covers erosion control on the non-liquid faces of the levees for both the raffinate and fluoride ponds. Contractor will furnish all materials, equipment and supervision required.

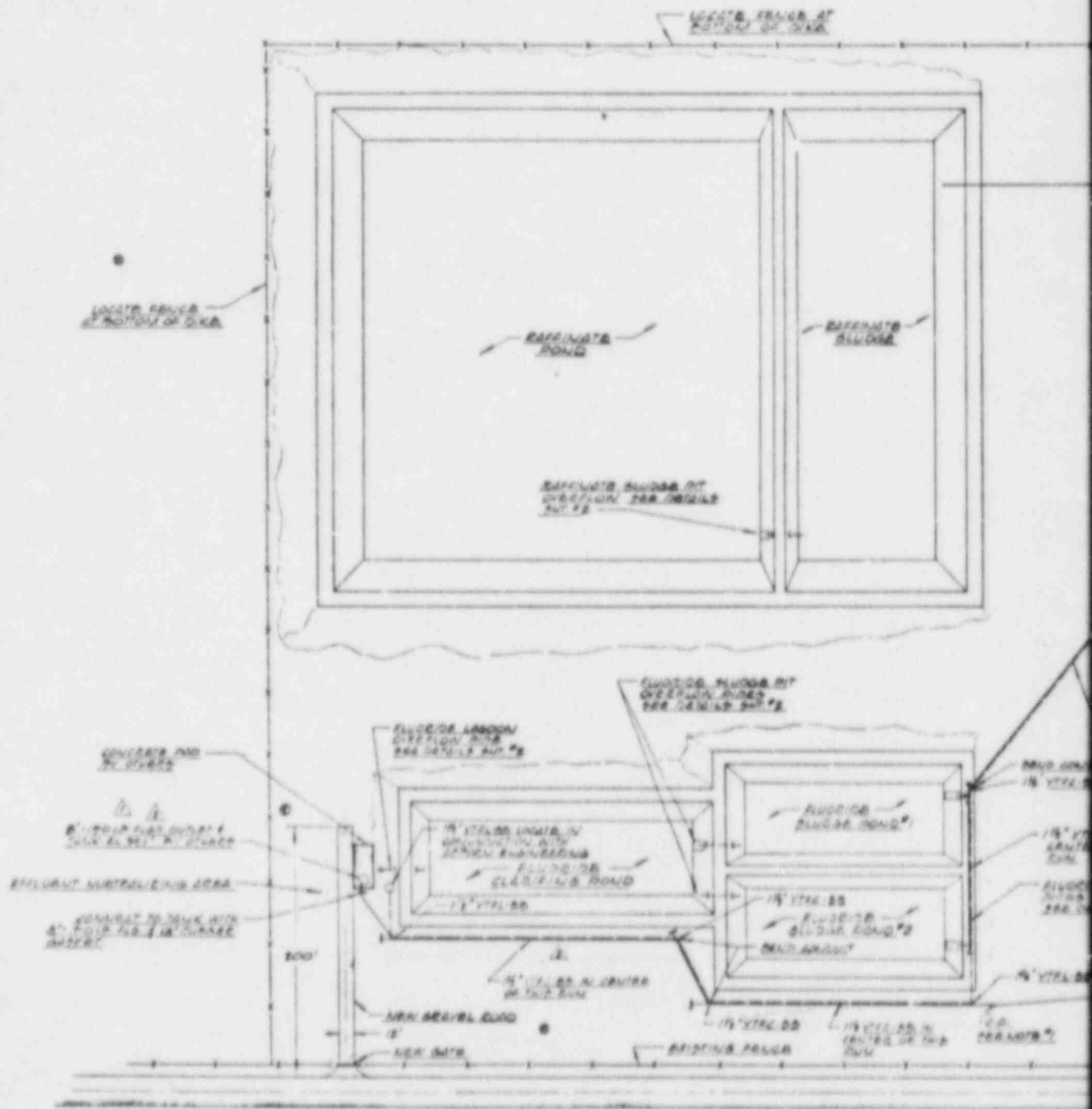
3.2 <u>Erosion Control by Bermuda Grass Spriging</u> (backslopes of levees and cuts above benches).

Strips consisting of Bermuda grass shall be planted in horizontal lines spaced three feet apart on the slopes. Contractor shall mulch, water, etc. until growth is established.

3.3 <u>Erosion Control by the Spraying of Asphalt</u>

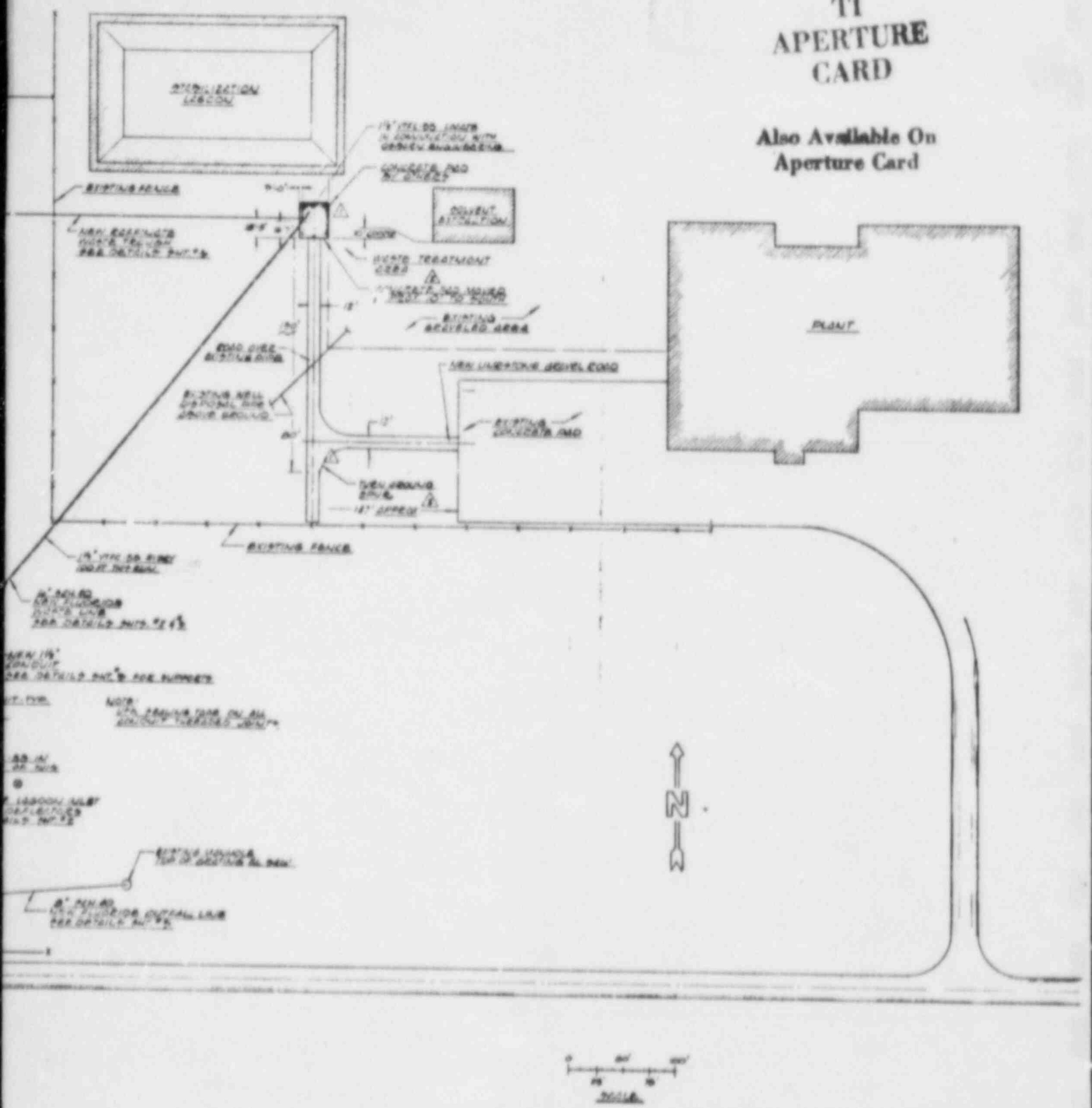
3.3.1 The separation levees in the raffinate and fluoride ponds will be stabilized by spraying with asphalt.

3.3.2 Asphalt used for the purposes above will by type MC-0 (medium curing grade 0), manufactured by Kerr-McGee Corporation and applied at the rate of 1/2 gallon per square yard. If the specified coverage is applied to rapidly for absorbtion by the soil the asphalt will be sprayed in multiple passes.



NOTES:

2. USE MITER JOINTS FOR ALL TURNS

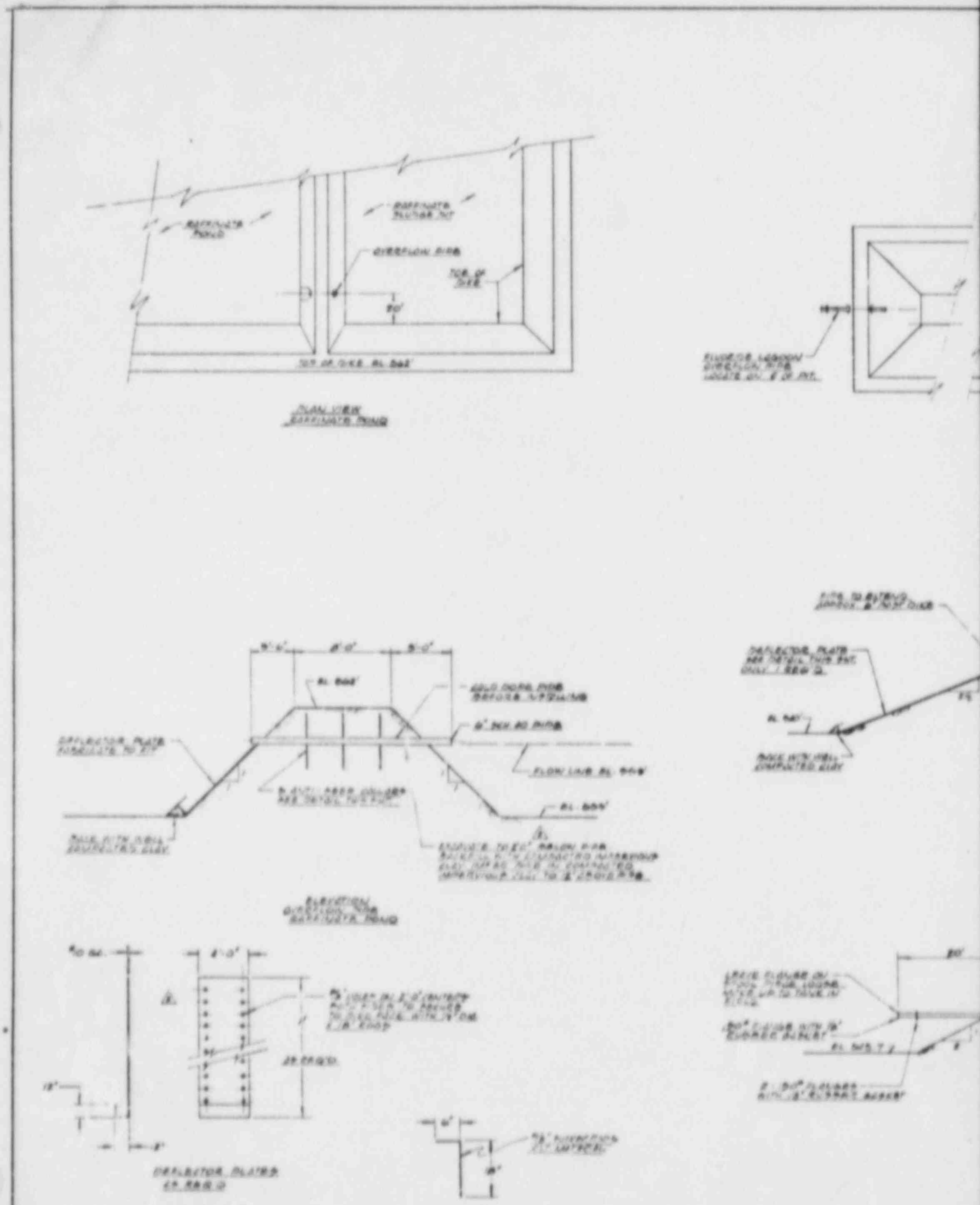


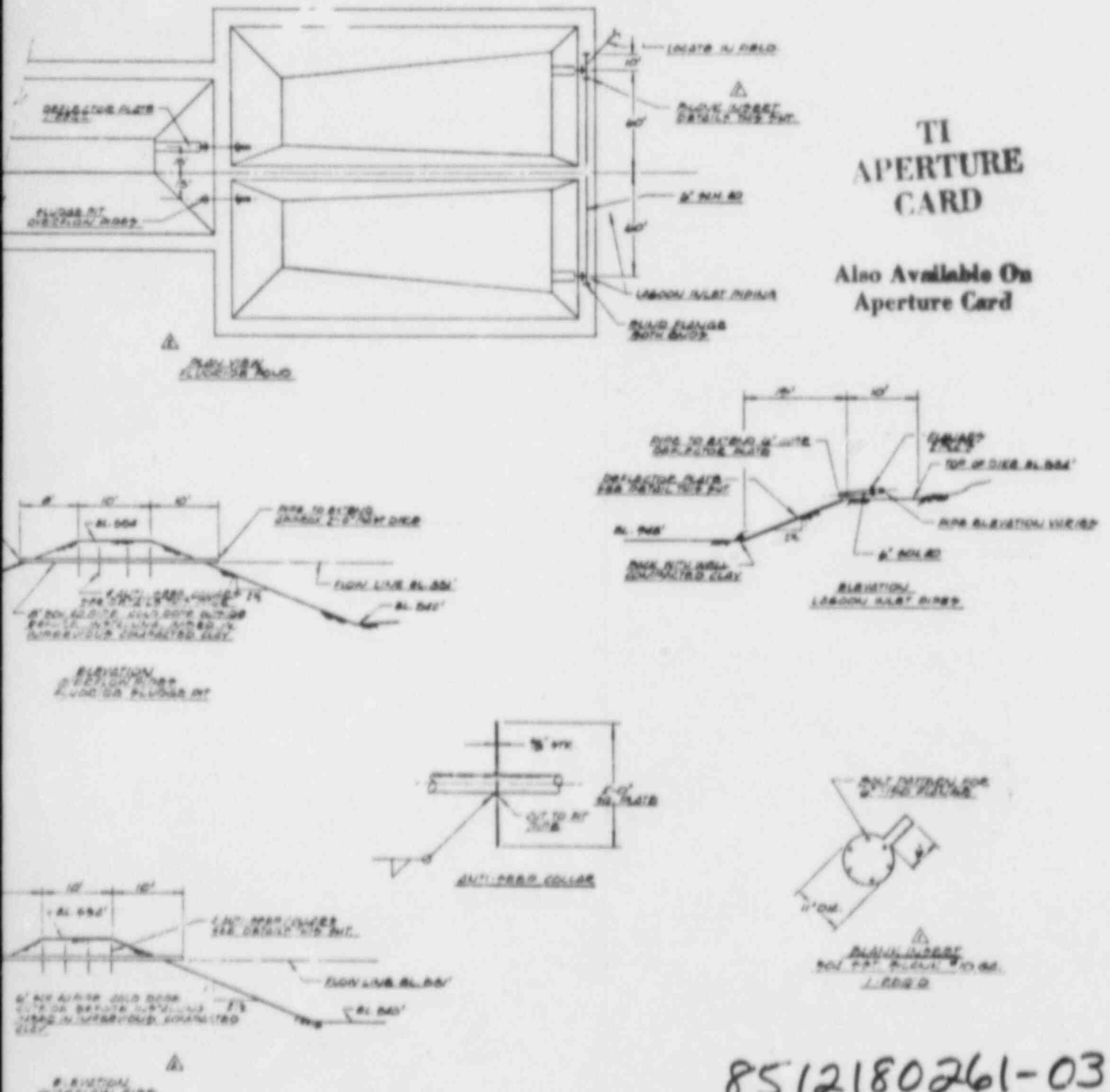
TI
APERTURE
CARD

Also Available On
Aperture Card

8512180261-02

	DESCRIPTION	BY	DATE	APPR	KERR-McGEE CORPORATION
1	[illegible]	[illegible]	[illegible]		PLOT PLAN
2	[illegible]	[illegible]	[illegible]		
3	[illegible]	[illegible]	[illegible]		
4	[illegible]	[illegible]	[illegible]		99 02-1


OVERFLOW PIPE
PLAN VIEW
ELEVATION
DEFLECTOR PLATE
FLOW LINE
DEFLECTOR PLATES
DEFLECTOR RODS



TI APERTURE CARD

Also Available On Aperture Card

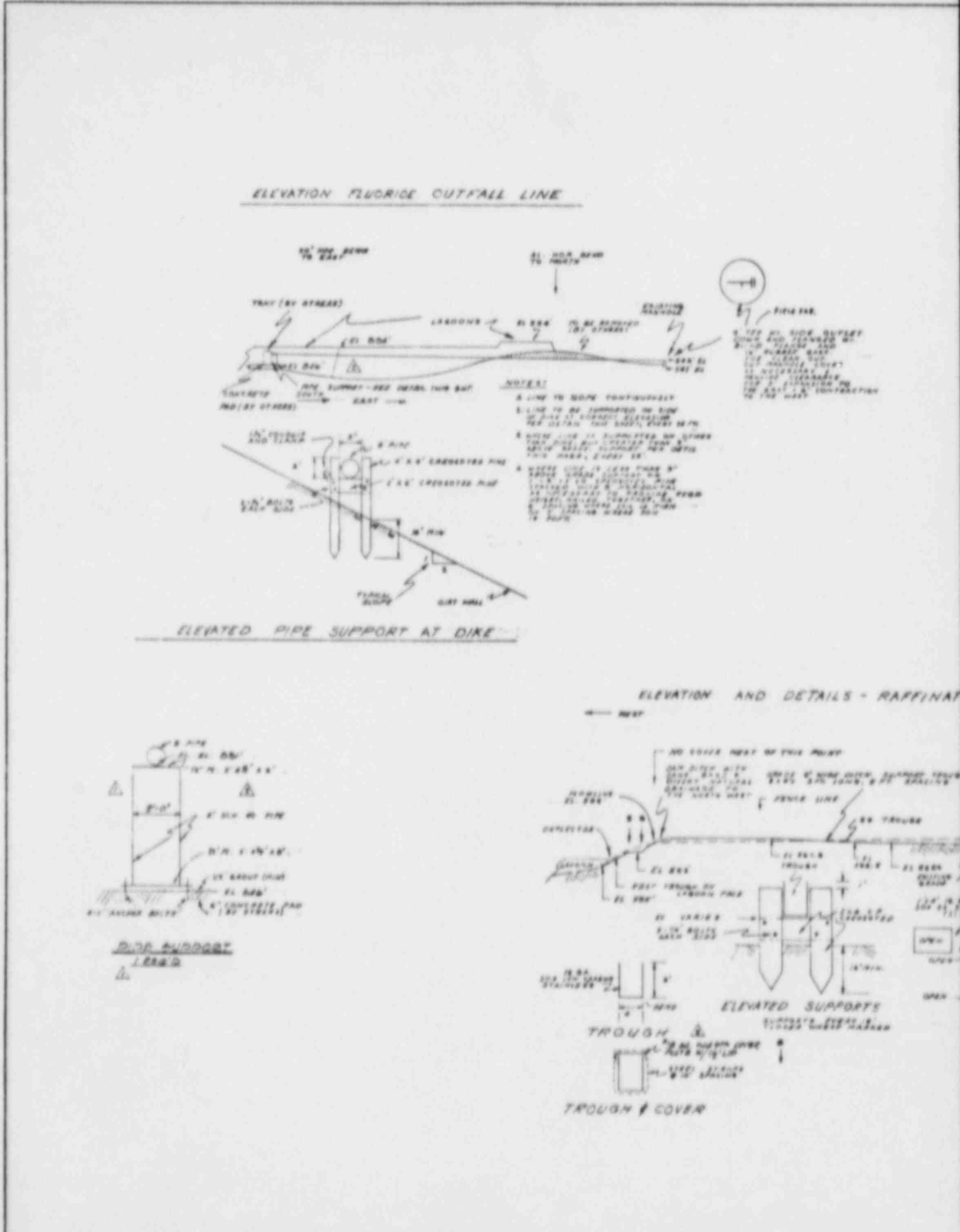
8512180261-03

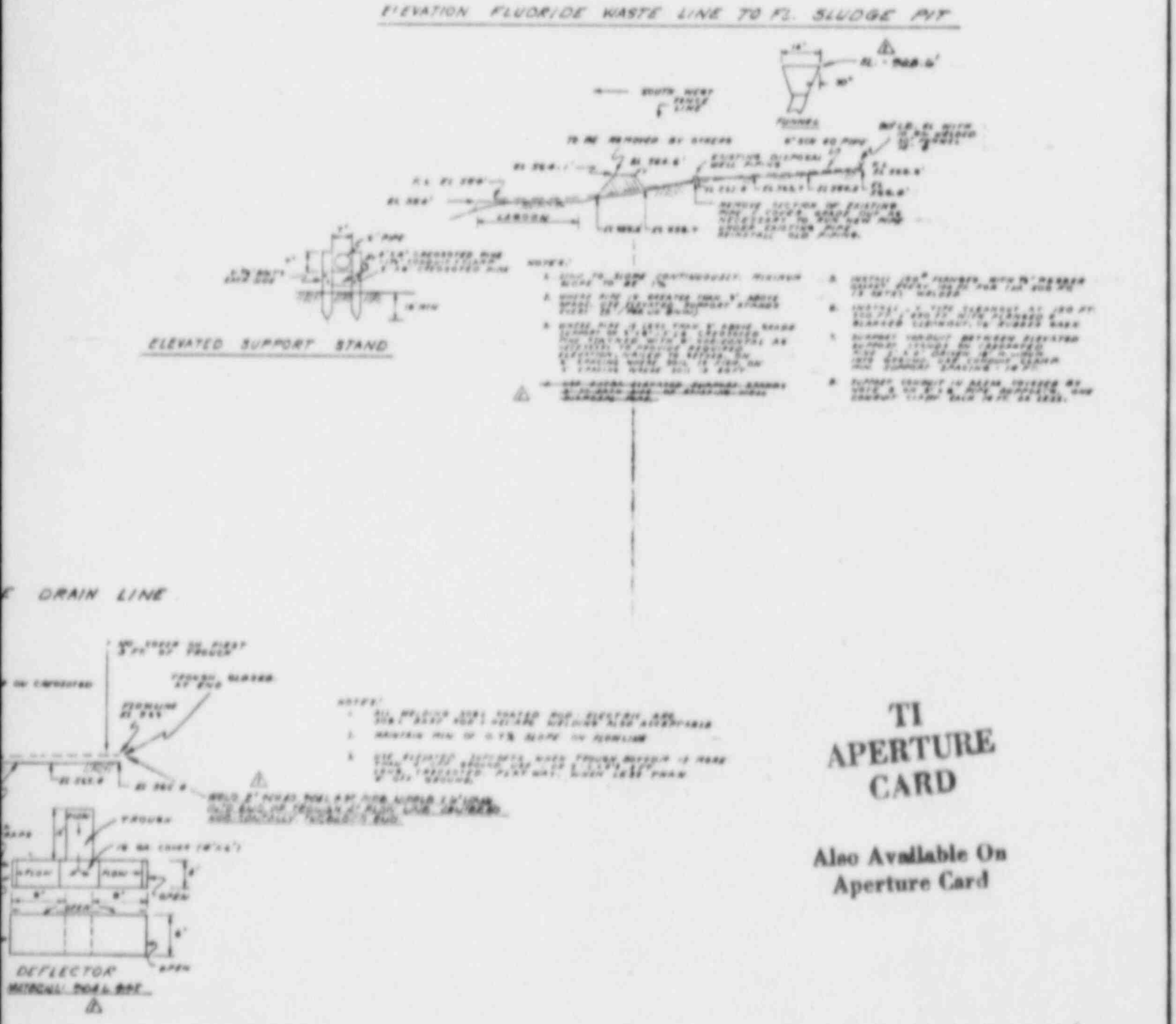
KERR-McGEE CORPORATION

NUCLEAR DIVISION

OKLAHOMA CITY, OKLA.

DETAILS


ELEVATION FLUORIDE OUTFALL LINE
ELEVATED PIPE SUPPORT AT DIKE
ELEVATION AND DETAILS - RAFFINAT
PIPE SUPPORT
ELEVATED SUPPORTS
TROUGH
TROUGH & COVER



TI APERTURE CARD

Also Available On Aperture Card

8512180261-04

KERR-McGEE CORPORATION

DETAILS SEQUOYAH WASTE DISPOSAL

APPENDIX II

BIOTA INVENTORY

1. Flora
2. Amphibians and Reptiles
3. Fish

FLORA
KNOWN AND EXPECTED FROM SEQUOYAH FACILITY AREA
SEQUOYAH COUNTY, OKLAHOMA

UPLANDS

Trees	
Heavily and Sparsely Wooded Areas	
Quercus stellata	Post oak
Q. marilandica	Black jack oak
Ulmus alata	Winged elm
Carya tomentosa	White hickory
C. ovalis	Pignut hickory
Prunus mexicana	Wild plum
Bumelia lanuginosa	Chittam wood
Juniperus virginiana	Red cedar
Juglans nigra	Black walnut
Sparsely Wooded Areas	
Maclura pomifera	Osage orange
Sassafras albidum	Sassafras
Diospyros virginiana	Persimmon
Robinia pseudoacacia	Black locust
Shrubs and Woody Vines	
Heavily and Sparsely Wooded Areas	
Symphoricarpos orbiculatus	Coral berry
Rhus radicans	Poison ivy
Smilax Bona-nox	Cat brier
Parthenocissus quinquefolia	Virginia creeper
Vitis vulpina	Winter grape
Open Wooded Areas	
Prunus americana	Wild plum
Rosa setigera	Wild rose
Rhus copallina	Winged sumac
Rhus glabra	Smooth sumac
Herbaceous Plants	
Heavily Wooded Areas	
Galium aparine	Common Cleavers
Antennaria plantaginifolia	Pussy toes
Gnaphalium perpureum	Cudweed
Hypericum drummondii	St. John's wort
Pamicum spp.	Panic grass
Monarda fistulosa	Wild bergamot
Viola spp.	Wild violets
Plants	
Open Wooded Areas	
Rudbeckia hirta	Black-eyed Susan
Senecio obovatus	Round-leaf squaw weed
Vernonia baldwinii	Baldwin's ironweed
Phlox pilosa	Downy phlox
Rumex hastatulus	Wood sorrel

PERMIT TO APPROPRIATE SURFACE WATER

SW¼ & SE¼ Sec. 14; NW¼ & NE¼
Sec. 23, Twp 13N, Rge. 21EIM
(Legal Description, Office Use Only)

Stream System Illinois Number 2-17 County Sequoyah

Application No. 67-765 Date of Filing October 18, 1967

Permit No. P67-765.

This is to certify that the Oklahoma Water Resources Board has held a public hearing on the application of Kerr-McGee Corporation By: R. M. Fryar, Vice President; Att.: Carter Dudley, Attorney whose address is Kerr-McGee Bldg., Oklahoma City, Okla., for a Permit to appropriate 30,000 acre-feet of water, for the purpose of Commercial nuclear processing and allied facilities.

Water to be diverted from directly out of Tenkiller Reservoir in SW¼ & SE¼ Sec. 14 and NW¼ and NE¼ Sec. 23, Twp 13N, Rge. 21EIM

at a rate not to exceed 18,650 gpm.

The application is hereby approved and the applicant is authorized to proceed with the construction of the project in compliance with the above described application, which is made a part hereof and subject to the following terms, conditions and limitations:

1. Providing prior rights and domestic uses downstream are not affected by this diversion of water.

2. Work on the project must be started by the 18th day of October 1969, and the applicant has until the 18th day of October 1974 to complete the project.

3. Upon completion of the project applicant must file with the Executive Director of the Oklahoma Water Resources Board a NOTICE OF COMPLETION OF PROJECT in the manner prescribed.

4. In order to keep this Permit in full force and effect and retain the PRIORITY DATE, a WATER USE REPORT must be filed each year on forms furnished by the Board.

5. Acceptance of this Permit by applicant shall be an acknowledgement and agreement that application will comply with all the terms, conditions and limitations embodied in this Permit.

DATED this 9th day of January, 19 68.

OKLAHOMA WATER RESOURCES BOARD

enclosures Copy App. 67-765
Completion of Works
S.B. 324 & Receipt /200

Forrest Nelson, Acting Director

DACW56-70-C-0083

CONTRACT BETWEEN THE UNITED STATES OF AMERICA
AND
THE KERR-MCGEE CORPORATION, DELAWARE,
FOR
WATER STORAGE SPACE IN TENKILLER FERRY RESERVOIR

THIS CONTRACT, entered into this 27th day of February, 1970, by the UNITED STATES OF AMERICA (hereinafter called the ("Government"), represented by the Contracting Officer executing this contract, and the KERR-McGEE CORPORATION, a corporation organized and existing under the laws of the State of Delaware, with its principal office at Oklahoma City, Oklahoma, (hereinafter called the "User"), WITNESSETH THAT:

WHEREAS, the Act of Congress approved June 28, 1938 (Public Law 761, 75th Congress, 3rd session), as modified by the River and Harbor Act approved July 24, 1946, authorized the construction, operation and maintenance of the Tenkiller Ferry Dam and Reservoir on the Illinois River, Oklahoma,(hereinafter called the "Project"); and,

WHEREAS, under provisions of the Water Supply Act of 1958, as amended (43 USC 390 b-f), the Government is authorized to make contracts with States and local interests for water supply storage for municipal and industrial purposes; and,

WHEREAS, the User is empowered so to contract with the Government and is vested with all necessary powers for the accomplishment of the purposes of this contract;

NOW, THEREFORE, in consideration of the faithful performance of each party of the mutual covenants and agreements hereinafter set forth, the parties hereto do mutually agree as follows:

ARTICLE 1. WATER STORAGE SPACE.

a. The User shall have the right to utilize an undivided 3.780 percent of the storage space in the Project between elevations 632.0 and 594.5 feet above mean sea level as deemed necessary by the User to impound water for its present municipal and industrial use, and to make such diversions as granted to the User by the State of Oklahoma,

CONTRACTOR'S COPY

to the extent such storage space will provide, subject to the retention by the Government and others of the remaining undivided 96.220 percent of the storage space between said elevations for such purposes as the Government may deem desirable. Although the User's storage space is estimated to provide a dependable yield of about 10,000 acre-feet of water per year for municipal and industrial use, it is understood and agreed that the Government in no way guarantees such a yield.

b. The User shall have the right to withdraw water from the aforesaid 3.780 percent of the storage space between elevations 632.0 and 594.5, so long as the elevation of the water within the Project is above elevation 594.5 feet above mean sea level, and provided that such releases when combined with local runoff below the dam will not cause flooding.

c. The design and location of any future installations or facilities which the User may construct at the Project for the purpose of diversions or withdrawals shall be subject to the approval of the Contracting Officer, and the cost of such installation or facilities, or any modification thereof, shall be borne by the User. The User shall be responsible for operation and maintenance of all installations or facilities which may be provided and owned by the User.

d. The User recognizes that this contract provides storage space only, as stated above, and that any water that may be impounded therein will be raw water. The Government makes no representation with respect to the quality or availability of water and assumes no responsibility therefore, or for treatment of the water.

e. The User shall utilize such storage space in a manner consistent with Federal and State laws.

ARTICLE 2. MEASUREMENT OF WITHDRAWALS AND RELEASES.

a. For the purpose of maintaining an accurate record of water supply withdrawals, the User agrees to install, or cause to be installed, meters or measuring devices satisfactory to the Contracting Officer, without cost to the Government, at such times and places as the User, may construct facilities for the withdrawal of water from the Project by any means other than through the Project outlet works. The User shall furnish to the Contracting Officer regular monthly records of all such withdrawals, and shall furnish interim records at more frequent intervals upon specific request.

b. In the event the User desires releases through the Project works either as a sole source or as a supplement to facilities referred to in subparagraph "a" above, water will be released through the Project outlet works from water supply storage space in accordance with schedules prescribed in writing from time to time by the User and transmitted to the Contracting Officer. The measure of all such releases shall be by means of a rating curve of the outlet works, or by other suitable means, agreed upon in advance of the commencement of operation of the Project for water supply purposes.

ARTICLE 3. REGULATION OF THE USE OF WATER. The regulation of the use of water stored under this contract shall be the responsibility of the User and shall not be considered a part of this contract.

ARTICLE 4. CONSIDERATION AND PAYMENT.

a. The User shall pay the following sums to the Government:

(1) Annual payments of $9,717, based on the yearly amount required to amortize the investment cost for providing the aforesaid water supply storage space in the project over a 50-year period as determined in the manner set out in Exhibit A attached hereto and made a part hereof. Except for the first payment, which shall be applied solely to the retirement of the principal, all payments shall include accrued interest at the rate of 2.5 percent per annum on the unpaid balance. A schedule of annual payments is shown in Exhibit B attached hereto and made a part hereof. The first annual payment will be due and payable within 30 days of the date the User is notified that this contract has been approved by the Secretary of the Army. Payments thereafter shall be due and payable within 30 days of the yearly anniversary date of the first payment under this contract. Payments for any fractional part of a year which may result from termination of this contract shall be prorated on the basis of the annual charge.

(2) 55.12 percent of the annual loss in power revenue resulting from the operation of the Project for providing 25,400 acre-feet of storage for water supply. The annual payment shall be in the amount of $1,100. The first annual payment shall be due and payable on the date set forth in subparagraph a(1) of this Article. Annual payments thereafter shall be due and payable on the anniversary date of the first payment under this contract.

(3) 1.504 percent of the joint-use costs of ordinary operation and maintenance of the Project. Items of operation and maintenance which form the basis of computation and which will be used in future computation of operations and maintenance charges are shown in Exhibit A. Payments due prior to availability of actual experienced specific costs and joint-use costs of operation and maintenance shall be in the amount of $1,600. Payments thereafter shall equal to 1.504 percent of the joint-use costs of operation and maintenance for the preceding Government fiscal year. The first annual payment shall be due and payable on the date set forth in subparagraph a(1) of this Article. Annual payments thereafter shall be due and payable on the anniversary date of the first payment under this contract. Payments following the first complete fiscal year of operation shall be adjusted to reflect the difference between the prior payment or payments for operation and maintenance and the actual experienced specific costs for water supply and joint-use costs of operation and maintenance for the period covered by such payments.

(4) 1.084 percent of the joint-use cost of major capital replacement items and sedimentation resurveys, when incurred. Payment shall be made with the first annual payment becoming due after the date said cost is incurred.

(5) 2.50 percent per annum on any overdue payment until paid, to be compounded annually from the date such payments are due. The amount charged on payments overdue for a period of less than one year shall be figured on a monthly basis. For example, if the payment is made within the first month after being overdue (31 to 60 days after the anniversary date), one month's interest shall be charged.

b. If the actual construction cost of the Project differs from the estimated cost as set forth in Exhibit A, whether increased or decreased, the aforesaid cost to be repaid by the User as set forth in subparagraph a(1) above shall be adjusted accordingly upon final determination of Project costs. If the cost is increased or decreased, an adjustment, as determined by the Contracting Officer, of payments made prior to determination of the final Project cost shall be made in the first payment after such cost is determined. Exhibits A and B shall be modified to reflect the final Project costs, and the adjusted payments and such modifications shall form a part of this contract.

c. The extent of operation and maintenance of the Project shall be determined by the Contracting Officer, and all records and

accounting shall be maintained by the Contracting Officer. Records of the cost of operation and maintenance of the Project shall be available for inspection and examination by the User.

d. Should the User request additional operation and maintenance for water supply storage over and above that determined by the Contracting Officer, and over and above that which formed the basis for determination as set out in Exhibit A, the User shall bear the entire cost of such additional expense.

ARTICLE 5. PERIOD OF CONTRACT. This contract shall become effective as of the date of approval of the Secretary of the Army, and shall continue in full force and effect for a period of one year. The User shall have the right to renew this contract each year thereafter as long as storage remains available under the interim plan for providing water supply storage space in the Project or for a total period of 50 years, whichever expires first. Payment of each annual payment will constitute renewal for the ensuing year.

ARTICLE 6. NEW CONTRACT. It is understood that in the event of a change in project purposes, physical modification of the Project and/or reallocation of storage in the Project to provide for water supply by an Act of Congress, and upon equitable allocation of Project cost among purposes served by the reservoir, prior to expiration of 50 years, a new contract shall be negotiated for use of storage space, with the new contract providing for appropriate modification in quantity, elevations and annual payment. The new contract shall include permanent rights to storage space under the provisions of Public Law 88-140. The terms of the new contract shall be subject to mutual agreement at that time; however, it is further understood by the parties hereto, that credit will be given for the amount of repayment, applied to amortization of investment, which has been paid to the Government under this contract in computing the amount due under the new contract for investment allocable to the water supply storage space.

ARTICLE 7. WATER SUPPLY STORAGE, AND OPERATION AND MAINTENANCE.

a. The Government shall operate and maintain only the Project owned by the Government.

b. The Government shall not be responsible for diversions by others, nor will it become a party to any controversies between users of the aforesaid storage space, except as such withdrawal may affect storage space reserved by the Government.

c. The Government reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property.

ARTICLE 8. RIGHT-OF-WAY. The grant of an easement for rights-of-way over, across, in, and upon Government-owned lands under the control of the Secretary of the Army, required for transmission of water from the point of withdrawal, shall be by separate instrument without additional cost to the User under the authority of and in accordance with the provisions of 10 U.S.C. 2669.

ARTICLE 9. RELEASE OF CLAIMS. The User shall hold and save the Government, including its officers, agents, and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of storage and withdrawal or release of water from the Project made or ordered by the User or as a result of the construction, operation, or maintenance of the features or appurtenances owned and operated by the User.

ARTICLE 10. TRANSFER OR ASSIGNMENT. The User shall not transfer or assign this contract nor any rights acquired thereunder, nor suballot said water storage space or any part thereof, nor grant any interest, privilege, or license whatsoever in connection with this contract, without approval of the Secretary of the Army or his authorized representative; provided that, this restriction shall not be construed to apply to any water which may be obtained from the water supply storage by the User and furnished to any third party or parties.

ARTICLE 11. OFFICIALS NOT TO BENEFIT. No member of Congress, or resident commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE 12. COVENANT AGAINST CONTINGENT FEES. The User warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the User for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this contract without liability, or in its discretion to add to the

contract price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 13. APPROVAL OF CONTRACT. This contract shall be subject to the written approval of the Secretary of the Army, and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties hereto have executed this contract as of the day and year first above written.

APPROVED:

Stanley R. Resor
Secretary of the Army

Date: 15 JUL 1970

THE UNITED STATES OF AMERICA

By Vernon W. Pinkey
VERNON W. PINKEY
Colonel, CE
District Engineer
Contracting Officer

KERR-McGEE CORPORATION

By F. C. Love
President

Attest:

By ____________
Asst.
(Seal) Secretary

FORREST NELSON, Executive Director

OKLAHOMA WATER RESOURCES BOARD

DIALEX BU... STREET • OKLAHOMA CITY • OKLAHOMA • 73112

RECEIVED
MAR 23 1971

March 22, 1971

G.S.
XC L974 BCB 3-23-71
XC L880 3-24-71

P. S. DUNN

Mr. P. S. Dunn, Group Vice-President
Nuclear Operations
Kerr-McGee Corporation, Sequoyah Facility
Kerr-McGee Building
Oklahoma City, Oklahoma 73102

PERMIT NO: IW-70-011

DATE APPROVED: March 9, 1971

Dear Mr. Dunn:

This is to advise you that your application for Waste Disposal Permit has been approved by the Oklahoma Water Resources Board. This letter, accompanied by the enclosed copy of the application, constitutes the issuance of a Waste Disposal Permit.

Your permit will remain in effect so long as you are not in violation of the Oklahoma Water Quality Standards. In accordance with the Pollution Control Act of 1955:

SECTION 905 (a)

It shall be unlawful for any person to cause pollution of any waters of the State or to place or cause to be placed any wastes in a location where they are likely to cause pollution of any waters of the State.

SECTION 905 (b)

It shall be unlawful for any person to carry on any of the following activities without first securing such permit from the Board, as is required by it, for the disposal of all industrial wastes which are or may be discharged thereby into the waters of the State.

1. The construction, installation, modification or operation of any industrial disposal system or part thereof or any extension or addition thereto.

SECTION 905 (b) (cont.)

2. The increase in volume or strength of any industrial wastes.

3. The construction, installation or operation of any industrial or commercial establishment or any extension or modification thereof or addition thereto, the operation of which would cause an increase in the discharge of wastes into the waters of the State or would otherwise alter the physical, chemical or biological properties of any waters of the State in any manner not already lawfully authorized.

4. The construction or use of any new outlet for the discharge of any wastes into the waters of the State.

The above activities can be carried out only after securing a Permit from the Oklahoma Water Resources Board or revising an existing Permit.

On occasions personnel from the Oklahoma Water Resources Board will be visiting your facilities; if a special visit is desired at any time, please notify our office.

Very truly yours,

Forrest Nelson

Forrest Nelson, Executive Director
OKLAHOMA WATER RESOURCES BOARD

FN/ph

Encl:

XC [illegible]

OKLAHOMA WATER RESOURCES BOARD
2241 N. W. 40th, Dialex Bldg. (East)
Oklahoma City, Oklahoma 73112

APPLICATION FOR WASTE DISPOSAL PERMIT
(Must be Typewritten and Filed in Triplicate)

Application No. IW-70-011

Stream System ______ (Office Use Only)

1. Name of Industry Kerr-McGee Corporation, Sequoyah Facility

2. Address Kerr-McGee Building, Oklahoma City, Oklahoma 73102
(Street No. or Box No. / City / State / Zip Code)

3. County Sequoyah

4. Legal Description of Plant Location ____ ¼ NE ¼ Sec. 21
Twp. 12N Rge. 21E

5. Legal Description of Point of Discharge ____ ¼ NE ¼ Sec. 21
Twp. 12N Rge. 21E

6. Treated waste is discharged into the waters of Illinois River
tributary to the Arkansas River

7. Source of Water Supply: Lake Tenkiller Reservoir Amount: 30,000 acre-ft/yr

8. Products Manufactured and Quantity: 5,000 tons per year of uranium hexafluoride

9. Type of Effluent (waste): Surface: Clarified effluent of lime-treated HF scrubber waste and cooling tower blowdown, boiler blowdown, domestic waste and water treatment brine. Surface retention: Solvent extraction raffinate waste after lime treatment.

10. Amount Discharged: ~1500 G.P.M. to Illinois River

WASTE TREATMENT FACILITIES:

11. Primary Treatment: Lime treatment (Type and Capacity)

A. Sludge Produced: None

B. Final Sludge Disposal: Four (4) earthen pits (2 sludge pits, clarifier lagoon and raffinate evaporative lagoon 10,000,000 gal - one year waste capacity)

12. Secondary Treatment: pH adjustment of waste effluent (Type and Capacity)

13. Waste Stabilization Pond: Sanitary waste oxidation lagoon - 1,400,000 gal. (Type and Capacity)

14. Solid Waste Disposal: ______ (Type, Capacity and Life)

15. INJECTION WELL: (Pending AEC License Approval)

A. Date Constructed: October 26, 1969

B. Total Depth of Well: 3,100 feet

C. Receiving Strata: Arbuckle limestone

D. Total Thickness of Receiving Strata:

16. Laboratory Schedule for Quality Control: Radioactivity, F^-, soluble sulfate and calcium, Cl^-, pH, turbidity, dissolved solids. Grab sampling at frequency to demonstrate quality standards compliance.

SIGNATURE OF APPLICANT

P. S. Dunn, Group Vice-President
Nuclear Operations

(Office Use Only)

Application received and filed in this office, this ______ day of ______, 19____

OKLAHOMA WATER RESOURCES BOARD

[signature]
Executive Director

OWRB 2 5/70

FORREST NELSON, Executive Director

OKLAHOMA WATER RESOURCES BOARD

DIALEX BUILDING • 2241 N.W. 40TH STREET • OKLAHOMA CITY • OKLAHOMA • 73112

June 22, 1972

Mr. W. J. Shelley, Director
Regulation and Control Nuclear Division
Kerr-McGee Corporation
Kerr-McGee Building
Oklahoma City, Oklahoma 73102

Re: Kerr-McGee, Sequoyah Facility

Dear Mr. Shelley:

Enclosed please find our formal certification for waste discharges from the above referenced facility.

Very truly yours,

Glenn Sullivan
Assistant Director

GS:mt
Encl.

TO WHOM IT MAY CONCERN

This is to verify that the applicant has been issued a Waste Disposal Permit by the Oklahoma Water Resources Board and is in compliance with Oklahoma's Water Quality Standards.

1. Name of Applicant Kerr-McGee Sequoyah Facility

   Address Kerr-McGee Building, Oklahoma City, Oklahoma 73102

   Oklahoma Water Resources Board No. IW-70-011

   Corps of Engineers Application No. 0760Y1 2 000111

2 The applicant has been issued a Permit by the Oklahoma Water Resources Board and has assured the Board that his activities will be conducted in a manner which will not violate Oklahoma's Water Quality Standards.

3 The Oklahoma Water Resources Board has considered the effect the applicant's activities will have in Intra-state and Inter-state waters and the beneficial uses of these waters, has reviewed the general and specific criteria as outlined in Oklahoma's Water Quality Standards, and has determined through Public Hearings that the applicant complies with Oklahoma's Water Quality Standards.

4. Conditions: None

5. Other Considerations Applicant's waste disposal facilities are routinely monitored by the Oklahoma Water Resources Board.

Form AEC—410 (1-61)

UNITED STATES
ATOMIC ENERGY COMMISSION

SOURCE MATERIAL LICENSE

Pursuant to the Atomic Energy Act of 1954, and Title 10, Code of Federal Regulations, Chapter 1, Part 40, "Licensing of Source Material," and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, possess and import the source material designated below; to use such material for the purpose(s) and at the place(s) designated below; and to deliver or transfer such material to persons authorized to receive it in accordance with the regulations in said Part. This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954 and is subject to all applicable rules, regulations, and orders of the Atomic Energy Commission, now or hereafter in effect, including Title 10, Code of Federal Regulations, Chapter 1, Part 20, "Standards for Protection Against Radiation," and to any conditions specified below.

Licensee		
1. Name	Kerr-McGee Corporation	3. License No. SUB-1010
2. Address	Kerr-McGee Building Oklahoma City, Oklahoma 73102	4. Expiration Date February 28, 1975
		5. Docket No. 40-8027

6. Source Material	7. Maximum quantity of source material which licensee may possess at any one time under this license
Uranium	No quantity limitation

CONDITIONS

8. Authorized use (Unless otherwise specified, the authorized place of use is the licensee's address stated in Item 2 above.)

Subject to the conditions specified herein, this license authorizes the activities described in the licensee's application dated September 23, 1969, as supplemented January 14 and February 3, 1970, in accordance with the representations, specifications, and procedures in Appendix A of the said application, including supplements.

9. This license does not authorize the disposal of liquid waste containing radioactive constituents by injection into any disposal well.

10. Authorized place of use: The licensee's Sequoyah facility located about 2 1/2 miles southeast of Gore, Oklahoma.

11. This license authorizes the use of respirators in determining employee exposures to airborne radioactive materials subject to the conditions and specifications in the attached Annex A.

License Number SUB-1010

MATERIAL LICENSE

Supplementary Sheet

12. The licensee is exempt under the requirements of this license from compliance with Section 20.203(e)(2) of 10 CFR 20 provided all entrances to the plant are conspicuously posted in accordance with Section 20.203(e)(2) and with the words, "Any area within this plant may contain radioactive material."

13. The licensee shall immediately notify the Director, Region IV, Division of Compliance, USAEC, Denver, Colorado, by telephone and telegraph of any failure in an earth dam retention system which results in a release of liquid wastes containing radioactive material. This requirement is in addition to the requirements of 10 CFR 20.

14. Pursuant to Sections 20.106(b) and 20.302 of 10 CFR 20, this license authorizes the incineration of licensed material in accordance with the procedures specified in the application, including supplements, listed in Item 8 of this license.

15. As a minimum, the licensee shall conduct the environmental monitoring program described on pages V1-6.1.1 and V1-6.1.2 (Rev. 2/3/70) of the licensee's application listed in Item 8 above, including supplements.

16. This license authorizes the disposal or transfer of articles contaminated with source material to persons not possessing appropriate licenses provided the conditions in Annex B are met.

For the U. S. Atomic Energy Commission

Don F. Harmon

Date [illegible]

by Don F. Harmon
Division of Materials Licensing
Washington, D. C. 20545

cc: P.S Dunn/W T. Shelley
D.J. Foley/A.W. Korortson
B E Brown
D.K. Sly
A R Valentine
Orig → G.E. Wuller ✓
~~Orig~~ – J Pyle

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

JAN 1 5 1971

DML:MB:RLL
40-8027
SUB-1010, Amendment No. 1

Kerr-McGee Corporation
ATTN: Dr. Frank K. Pittman, Director
Technical Services
Kerr-McGee Building
Oklahoma City, Oklahoma 73102

Gentlemen:

Your application dated November 5, 1970 has been incorporated into the "demonstration" portion of your application for License No. SUB-1010. In order to provide continued continuity in the license for subsequent construction of waste disposal facilities Condition 17 has been added to License No. SUB-1010 to read as follows:

"17. In the location, design, construction, maintenance and inspection of waste disposal systems into which effluents containing radioactive material in excess of the limits specified in Column 2, Table II of Appendix B, 10 CFR Part 20 are disposed, the licensee shall follow the criteria established in Section 4, page 5 of the enclosure entitled "Information and Criteria Pertinent to Evaluation of Embankment Retention Systems." In addition, the licensee shall establish appropriately located test holes near retention ponds to check for seepage, if any, of radioactive materials."

All other conditions of this license shall remain the same.

FOR THE ATOMIC ENERGY COMMISSION

Robert L. Layfield
Materials Branch
Division of Materials Licensing

Enclosure:
"Information and Criteria
Pertinent to Evaluation of
Embankment Retention Systems"

KERR-McGEE
NUCLEAR DIVISION
JAN 19 1971
CONTRACT ADMINISTRATION

RECEIVED
JAN 19 1971
NUCLEAR DIV.
MARKETING

RECEIVED
JAN 18 1970
TECH. SERVICES
NUCLEAR DIV.

PERMIT

OKLAHOMA STATE DEPARTMENT OF HEALTH
OKLAHOMA CITY 5, OKLAHOMA

Date August 21, 19 69

The Kerr-McGee Corporation having complied with the requirements of the law is hereby granted permission to construct sanitary waste collection and treatment facilities to serve the Kerr-McGee Corporation's Sequoyah facility east of Gore in Sequoyah county, Oklahoma, to be constructed in accordance with the plans approved by this department on August 12, 1969.

subject to the following provisions :

1) That all details relative to the project not covered in the plans and specifications as approved will be constructed and accomplished in accordance with good public health practice.

2) That the recipient of the permit is responsible that the project receive supervision and inspection by competent and qualified personnel.

3) That wherever water and sewer lines are constructed with spacing of 10 feet or less, sanitary protection will be provided in accordance with Section 21 of the Standards for Water Pollution Control Facilities, ODH Engineering Bulletin No. 0587.

4) That this office will be notified approximately 10 days prior to completion of the project, so that a final inspection can be made by an engineer from this department before final payment is made to the contractor.

A. B. Colyar, M.D. Commissioner of Health

Loyd F. Pummill State Sanitary Engineer

ODH Form No. 535

ENGINEER'S REPORT

SANITARY WASTE TREATMENT

AND DISPOSAL

FOR

KERR-McGEE CORPORATION

SEQUOYAH FACILITY

SEQUOYAH COUNTY, OKLAHOMA

A. GENERAL

This report covers the collection, treatment and disposal of sanitary sewage and waste for a Uranium Hexafluoride Production Facility to be located in the SE 1/4 of the NW 1/4 of Section 21, Township 12 North, Range 21 East, Sequoyah County, Oklahoma.

The proposed plant is sited on gently rolling terrain and an average plant elevation will be approximately 565 feet above M. S. L. Its location with respect to surrounding communities and dwellings is shown on Drawing 110-C-151 as appended to this report. Waste treatment and disposal facilities are sized to serve the ultimate plant population. No future additions to the serviced population are contemplated but variations in sewage strength may occur, and daily contribution may fluctuate.

B. DESIGN DATA

1. Volume and Strength of Sewage - Process Area

Anticipated equivalent contributing population is 75 persons based upon the following:

a. Day Shift - 80 persons

b. Night and Swing shifts @ 40 person/shift

c. 20-30 gal. PC/shift - 3200-4800 GPD

d. Shower use at shift change - 3800-4500 GPD

e. Clothes washing and misc. - 200- 400 GPD

f. Infiltration - 300- 500 GPD

The flow will fluctuate widely, ranging from 1-2 GPM normal to 200 GPM during shift change.

Average strength of the sewage must be estimated. Although experience would indicate a total solids contribution of 0.20 #/C. P. D. and a B. O. D. of 0.15 #/C. P. D., sufficient uncertainties exist to consider design assumptions on a higher basis. Treatment facilities for the process area are therefore predicated on a B. O. D. of 0.20 #/C. P. D.

2. Garbage and Rubbish Disposal

Garbage and rubbish is expected to consist of primarily volatile waste and trash in the amount of 50 #/day, which will be reduced to approximately two pounds per day of residual ash and incombustibles in a gas or oil fired incinerator. The residue will be collected at intervals and disposed of at the closest public sanitary dump or by burial on the owners' property.

3. Sewage Collection Systems

Sewage collection from the process building will consist of a single line, approximately 500 feet long, placed in stiff weathered shale and sandstone. Pipeline plans and profiles are shown on Drawing 197 as appended to this report.

No ground water is anticipated or likely above the invert of the line serving the process building.

4. Location of Treatment Facilities

Location of treatment facilities for plant sewage has been evaluated on the basis of nuisance potential, topography, and the necessity for a location within the compound. All factors indicate an area approximately 350 feet north west of the process building represents optimum siting. Drawing 110-C-152 as appended to this report, shows the background for this conclusion.

5. Process Facility Water Supply

The source for all process, service and potable water will be Tenkillar Ferry Reservior which is primarily charged by and dis[illegible]rges into the Illinois River. A four month sampl[illegible] [illegible]nd testing program has furnished the following dat[illegible] on water discharging from the reservoir. Samples were taken from the Illinois River approximately 100 feet south of Tenkillar ferry dam. Analysis results are given in parts per million (p.p.m.)

Date	9/12/67	10/13/67	11/15/67	12/12/67
T °C	--	13°	12°	11°
pH	6.8	7.4	7.4	7.8
Susp. Matr.	8	6	28	1
Diss. Matr.	143	120	160	107
Na^+	6	8	14	4
HCO_3^-	93	105	105	100
$SO_4^=$	12	7	6	7
CI^-	5.4	7.4	22.0	6.2
F^-	.42	.02	.09	.07
NO_3^-	0.6	0.7	0.3	0.2
Total Hardness as $CaCO_3$	95	92	97	88

6. Receiving Waters

All sanitary effluent will be returned close to the confluence of the Illinois and Arkansas Rivers. The resultant at the point of return is not clear since this point will be within the navigation pool limits of the Robert S. Kerr Reservoir and the quality of receiving waters will vary indeterminately according to the varying contributory influence of the two streams.

The Illinois River is defined as having the following beneficial uses:

a. Fish and Wildlife Propagation
b. Recreation
c. Public and Private Water Supplies
d. Hydroelectric Power
e. Agriculture
f. Receiving Treated Wastes
g. Aesthetics
h. Trout Fishery (Put and Take)

The Arkansas River is defined as having the following beneficial uses:

a. Emergency Public and Private Water Supplies
b. Fish and Wildlife Propagation
c. Agriculture

d. Hydroelectric Power
e. Cooling Water
f. Receiving Treated Wastes
g. Recreation
h. Navigation

For the Illinois River, the record minimum daily flow appears to be approximately 2.1 M. G. D. with a 28 year average of 1,469 C. F. S. or 950 M. G. D. The minimum weekly flow appears to be approximately 18.5 M. G.

For the Arkansas River the minimum recorded daily flow appears to be approximately 49.2 M. G. D. with a ten year average of 19,300 C. F. S. or 12,500 M. G. D. The minimum weekly flow appears to be approximately 734 M. G.

No 24 hour periods of zero flow are apparent for either stream from available records.

A four month sampling and testing program has furnished the following data on Arkansas River water at Webbers Falls. Analysis results are given in parts per million (p.p.m.)

Date	9/12/67	10/13/67	11/15/67	12/12/67
T °C	--	23°	14°	9°
pH	7.2	7.1	7.4	7.6
Susp. Matr.	9.8	90	28	22
Diss. Matr.	730	290	220	540
Na^+	180	46	18	110
HCO_3^-	120	118	110	159
$SO_4^=$	71	44	35	54
Cl^-	280	67	29	181
F^-	0.40	0.30	0.40	0.41
NO_3^-	6.2	1.1	0.8	1.8
Total Hardness as $CaCO_3$	177	138	123	198

C. ANALYSIS FOR PROPOSED DESIGN

1. Collection System

Because of low anticipated average flow rates of one to three G. P. M. for 90% of an average day, the hydraulic characteristics of a six-inch diameter pipe on a 0.65% gradient are considered preferable to those of a standard eight inch line. A six-inch vitrified clay pipe collector main on a 0.65% slope is recommended for this installation, thus providing a velocity of approximately 0.8 f. p. s. at anticipated minimum flow with adequate capacity for peak contribution.

2. Quality of Total Effluent

Treated effluent, averaging 5 to 7 G. P. M. will be added to discharged service water which will flow at rates between 1,100 and 1,600 G. P. M. Service waters will have no constituents not found at the source. From this point of mixing, the combined flow will travel along natural water courses within the owners property for approximately 5,000 feet to the point of return to public waters. At the point of return the anticipated average qualities are as follows:

a. Suspended matter	10 p.p.m.
b. Dissolved matter	110 p.p.m.
c. Coliform bacteria	0
d. B. O. D.	0 p.p.m.
e. D. O.	10 p.p.m.
f. Chloride (Cl)	5-50 p.p.m.
g. Sulfate (SO_4)	10-15 p.p.m.
h. Nitrate (NO_3)	Neg. to 5.0 p.p.m.
i. Oil, grease and fats	0
j. Turbidity (Silica Scale)	10 p.p.m.
k. pH	7.0-7.5

3. Sewage Treatment

Under the conditions anticipated, a treatment system capable of producing high quality effluent under heavy shock loading conditions from influent is required. To satisfy these conditions, a conventional stabilization lagoon having an operating depth of 3 to 5 feet and an effective loading of less than 30 #B. O. D. per surface acre is provided as shown on Drawing No. 170-C-101 appended hereto.

Prepared by

Thomas C. Moore
Reg. Prof. Eng. No. 1736

THOMAS C. MOORE 1736

DOMESTIC WASTE DISPOSAL PROCEDURES

The domestic wastes for the facility are generated in the main process and administration building. These wastes are piped to a waste stabilization lagoon of approved design where they are biologically oxidized during a detention time which is a minimal of 43.8 days. Effluent from the lagoon is drawn off and mixed with the cooling tower overflow stream. The combined stream flows underground and is then released into a natural channel. This channel empties into the Illinois River a short distance away. The wastes sources and treatment systems are discussed in more detail in following sections.

Sources of Domestic Sewage.

The domestic sewage generated at the Sequoyah facility consists of spent water from toilets, lavatories, showers, and laundry facilities. The waste treatment system was designed for an equivalent contributing population of 75 persons based on a predicated day shift employment of 80 people and 40 people each on the night and swing shift. The plant staff at present is lower than the design figures and consists of some 100 people of whom 75 are production and maintenance workers.

Per capita usage of 20 to 30 gallons of water with a B.O.D. of .2 pounds was allowed for the design population to satisfy estimated toilet and lavatory usag Safety requirements associated with the handling of the process products necessitated an allowance for production workers to bathe at the end of each shift, and for their apparel

to be laundered periodically. Since individuals vary widely in their shower water requirement, a conservative data allowance for 60 gallons per capita was provided. Daily laundry operation at the facility require approximately 600 gallons. The wastes added to the water consists of human feces, urine, toilet tissue, soap, detergents, and some process material. The amounts of process material which enter the waste water system from bathing and laundering operations are probably extremely small. These products will be effectively trapped in the sludge deposits of the lagoon. The waste water flows emerging from these uses will fluctuate widely and will range from less than a gallon per minute to several hundred gallons per minute at the end of the shifts.

Collection System

The waste water is collected at the process building and piped through a six-inch vitrified, clay pipe sewer line to the waste stabilization lagoon. The sewer line, which is approximately 500 feet long, is laid in stiff weathered slate and sandstone. No ground water is likely above the invert of the sewer. Data from a water well at the plant site in Section 27-12N-21E substantiates this. This 84 foot deep well has a static water level of 30 feet. Some infiltration to the sewer line from surface seepage can occur during rainy seasons to temporarily increase the flows to the lagoon. In like answer, some effluent flow to soil can occur from the sewer. The permeability of the soil in this area is low and sewage organisms

which are contained in the effluent flow would be removed within a short distance of the sewer.

Stabilization Lagoon

The design of the stabilization lagoon was approved by the Oklahoma State Department of Health and a permit for construction was issued by that agency on August 21, 1969. This facility was subsequently constructed and put into operation. The lagoon effluent has been tested and conforms to the requirements specified by the State Health Department.

The surface area at the lagoon minimum depth of 3 feet is .51 acres. The design load of the system was based on 30 pounds of P.O.D. per surface acre per day. This loading is well within the range advocated by current design practioners for facultative basins. (1) The amount of B.O.D. which is expected from the design equivalent population at the facility is 15 pounds.

The pond volume at the minimal depth of 3 feet is approximately 438,000 gallons. With a design flow of 10,000 gallons per day, the average detention time is 43.8 days. This figure is well above the 7 - 30 days which is recognized as acceptable in current practice. At the normal operating depth of 4.5 feet, the detention period is 70.2 days.

Liquid wastes are discharged below the water surface at the center of stabilization basis. Any production process sediments obtained from laundering and bathing can be expected to settle out close to the outfall due to the high density of the process material.

was filed with the Corps of Engineers on June 21, 1971 and supplemented on October 4, 1971 to meet federal regulations stipulated under the Refuse Act of 1899. The discharge permit application OK-076-OYI-2-000111 is currently being processed for the facility.

(1) Eckenfelder, W. Wesley. Industrial Water Pollution Control. New York: McGraw-Hill Book Company, 1966.

(2) Oklahoma Water Resources Board. Appraisal Of The Water and Related Land Resources of Oklahoma For Region Five and Six. Oklahoma City: Mercury Press, 1969.

The long detention time in the basin should promote a high degree of biological oxidation for the waste organics entering the system. Per capita levels of nutrients similar to those found in sanitary wastes of muncipalities can be expected in the basin effluent.

Lagoon Effluents

Effluents are drawn from the system by a baffle board weir arrangement. The outlet is located at the three feet level and the pond can be controlled over an operational span from 3 to 5 feet. Seepage rates should be low through the weathered slate and sandstone material which comprises the basin bottom. This facility lies in an area with an average annual precipitation of 43 inches and an average annual lake evaporation of 49 inches. (2) Since no other surface inflow is permitted to the lagoon this results in an annual net evaporation loss equal to 9 days of waste flow from the facility. The normal .7 gpm effluent from the stabilization basin combines with the average flow of 1200 gpm emerging from the cooling tower overflow. The resultant stream flows underground some 1000 feet to an outfall into a natural channel. This flow proceeds downstream for a short distance and then joins the Illinois River some 1000 yards upstream from its confluence with the Arkansas River. The point of unity is now an arm of the Robert S. Kerr Reservoir.

In order to dispose these waste liquids to the river, Kerr-McGee first obtained a state permit, No. IW-70-011, from the Oklahoma Water Resource Board. Later, an application for a waste discharge permit

4. <u>Solvent Extraction Plant, Fire</u>

The original design considered the solvent extraction process as a special hazard and located the building over 100 feet from the main building.

The solvent extraction plant building is equipped with a foam deluge system. The building area is curbed without drains (divided into two areas) and the pulse column and UNH evaporator adjacent to the building have separate curbs. The curbed volumes were sized to contain the entire liquid contents in the event of an accident such as misoperation or equipment failure.

The solvent extraction foam system was purchased and installed in accordance with Standards 11 and 16 of NFPA Code for Foam and Solvent Extraction Processes, respectively, and has been accepted by Factory Insurance Association. The original system test revealed below specification foam density and, after changing foam proportioners, the system was retested as acceptable November 30, 1971. Both tests were witnessed and approved by the Facility's insurers, Nuclear Energy Liability Insurance Association and Nuclear Energy Property Insurance Association (Appendix V).

In the event of a fire the foam deluge system would be automatically activated, spraying the building and pulse column areas with a water-foam mixture from one foam tank (two are maintained full) for approximately eight minutes. One foam tank was deemed sufficient to extinguish a fire.

The foam system is actuated by a decrease in gas pressure when a sensor head melts. Corrosion, accidental sensor breakage, tornado or earthquake will not operate the system. Additionally, the deluge system can be manually actuated from the solvent extraction or main process buildings.

The results from a fire could cause considerable interruption to the plant operation; however, the impact on

the environment would be expected to be minimal due to retention of aqueous liquids within the curbed areas. Should a fire be widespread and violent, it is expected that it would still be contained to the building area by the use of four fire hose stations spaced around the building. In the most severe case, contamination local to the building might occur. Since the radioactive materials involved are either Low Specific Activity or in very low concentrations, any discharge beyond the plant fence line is considered to be inconsequential.

In addition to the previously mentioned tests, several inadvertent equipment failure trips occurred deluging this area with the waterfoam mixture. These interruptions normally required 16 to 24 hours for pumping the liquids to the raffinate retention basins, washing down of the area and checking and starting the equipment. Time for repair would be additive to the 16 to 24 hours.

Examination of the curbed areas and tankage in calculations, which follow, indicate that the case with least excess volume is the solvent rework side of the building. The spacing of tanks is such that spillage of more than half the tanks is unlikely. Also, the contents of the vessels are high in percentage of hexane so this material would be burning off. For these two reasons, a maximum volume spilled would be 7,000 gallons.

Allowing for maximum spillage, the effective curb volume would be 10,564 gallons (17,564-7,000). Foam and water discharge at 1420 total GPM. Assuming that half the flow or 710 GPM goes to the solvent rework side, the time to fill the curb would be $\frac{10,564}{710}$ = 14.9 minutes. This is almost double the capacity of the foam system.

Some low density foam, contaminated with nitric acid and uranyl nitrate, may spill out door openings in the preceeding example. It would be contained on site.

Working Capacity S-X Curbed Areas

A. Solvent Extraction Curb - 26.5' x 80' = 2120 Sq. Ft.

Less) Equipment)- Bases)	2 x 1.5' x 1.5' = 4.50 Sq. Ft.	9 x 1.58' x 4.5' = 63.99 Sq. Ft.
	4 x 1.33' x 1.33' = 7.02 Sq. Ft.	2 x 1.5' x 3.67' = 11.01 Sq. Ft.
	5 x 1.0' x 1.0' - 5.00 Sq. Ft.	2 x 1.83' x 5.0' = 18.30 Sq. Ft.
	1 x 2.5' x 3.83' = 9.58 Sq. Ft.	$\frac{8 \times (1.17')^2}{4}$ 3.1416 = 8.60 Sq. Ft.
	1 x 4.5' x 11.0' - 49.50 Sq. Ft.	$\frac{6 \times (1.33)^2}{4}$ 3.1416 = 8.34 Sq. Ft.
	1 x 2.0' x 5.0' = 10.00 Sq. Ft.	

(2120 Sq. Ft. - 196 Sq. Ft.) x 1.1875 Ft. = 2285 Cu. Ft.

2285 x 7.48 = 17,091 gallons usable curb volume

S-X Tankage:

Boildown Condensate Tank	300	gal.
Slurry Feed Break Tank	300	
Pumper-Decanter @ 1000 gal/ea	6,000	
Scrub Decanter @ 1000 gal/ea	2,000	
	8,600	gal.
Pulse Column	2,400	(possibly to S-X)
	11,000	(Total possibly to S-X)
Raffinate Decanter	1,000	
Sump Liquor Tanks @ 500 gal/ea	1,000	
Solvent Cleaning Tanks @ 1000 gal/ea	3,000	
Ammonium Sulfate Tank	1,000	
	6,000	(Improbable, but possible spill to S-X side)
	17,000	(Maximum, but improbable spill to S-X curb)

B. Solvent Rework Curb - 26.5' x 80' = 2120 Sq. Ft.

Less) Equipment) - Bases)	1 x 2.0' x 5.0' = 10.00 Sq. Ft.	2 x 1.5' x 1.5' = 4.50 Sq. Ft.
	2 x 2.17 x 5.0' = 21.70 Sq. Ft.	3 x 1.33' x 1.33' = 5.31 Sq. Ft.
	2 x 1.58 x 4.0' = 12.64	$\frac{35 \times (1.17')^2}{4}$ 3.1416 = 37.63
	7 x 1.50 x 3.67' = 38.54	$\frac{2 \times (1.33)^2}{4}$ 3.1416 = 2.78
	1 x 2.0' x 2.0' = 4.00	
	2 x 1.5' x 2.0' = 6.00	

(2120 Sq. Ft. - 143 Sq. Ft.) x 1.1875 Ft. = 2348 Cu. Ft.

2348 Cu. Ft. x 7.48 gals/cu ft = 17,564 gals.

Solvent Rework Tank Volumes:

Raffinate Decanter	1,000 gal.
Sump Liquor @ 500 gals. ea	1,000
Solvent Cleaning @ 1,000 gals. ea	3,000
Ammonium Sulfate Work	1,000
5% Caustic Work	1,000
Solvent Work	2,000
Solvent Preparation (normally empty)	-
Hexane Head	50
Hexane Phase Separators @ 50 gals ea	100
Hexane Recovery Still (50% full)	1,000
UNH Decanters @ 2,000 gals. ea	4,000
TOTAL	14,150 gals.

C. Pulse Column Curb

Area = 21' x 26.5' = 556.5 $Ft.^2$

Less Equipment Bases 6.45 $Ft.^2$

550 Ft^2

Volume @ 1' depth = 550 $Ft.^3$

550 x 7.48 = 4,114 Gal.

Pulse Column Volume - 2400 Gal.

5. Fuel Oil Tank, Rupture

The facility boilers normally operate on natural gas but have provisions for operation on fuel oil in an emergency. The fuel oil is stored in a 30,000 gallon tank located within a drained (with shutoff valve) dike. The normal inventory in the tank is approximately 20,000 gallons. The dike is sized to contain the entire liquid contents in the event of an accident. The diked area is 45 x 35 x 3 = 4725 cubic feet. The free area is 3900 cubic feet which would hold about 29,000 gallons.

In the event of a fire or natural disaster rupturing the tank, the incident would be handled by the plant emergency team as any other emergency. The drain valve would be closed to prevent discharge of the fuel oil. Should the rupture be accompanied by fire, the fire would be fought as any fuel fire.

6. Hot 10 Ton UF_6 Cylinder or Cold Trap Rupture

The nominal net weight of UF_6 for a cold trap or Model 48A cylinder is 20,000 lbs UF_6. Since both UF_6 containers are about the same size only one calculation was made to determine the amount of UF_6 lost and the time for the 200°F liquid UF_6 in the cylinder to solidify.

It was calculated that approximately 4550 lbs of UF_6 would be lost in 40 minutes. After 40 minutes, the loss is relatively small because the UF_6 will have solidified. The following assumptions and data were used to arrive at 4550 lbs:

a. The heat lost by convection through the cylinder wall was approximately zero (worst case).

b. The rupture hole is 1.5 inches in diameter and that the hole is above the liquid level.

c. The specific heat and heat of vaporization of UF_6 is constant between 200°F and 133.5°F.

A grapn showing the points at which calculations were made is shown on Figure 15.

In an actual incident, 3800 pounds of UF_6 were lost.[33]

[33] M. W. Boback and R. C. Heatherton, National Lead Co. of Ohio, 12th Annual Bioassay and Analytical Chemistry Meeting, Gatlinburg, Tennessee, October 13-14, 1966.

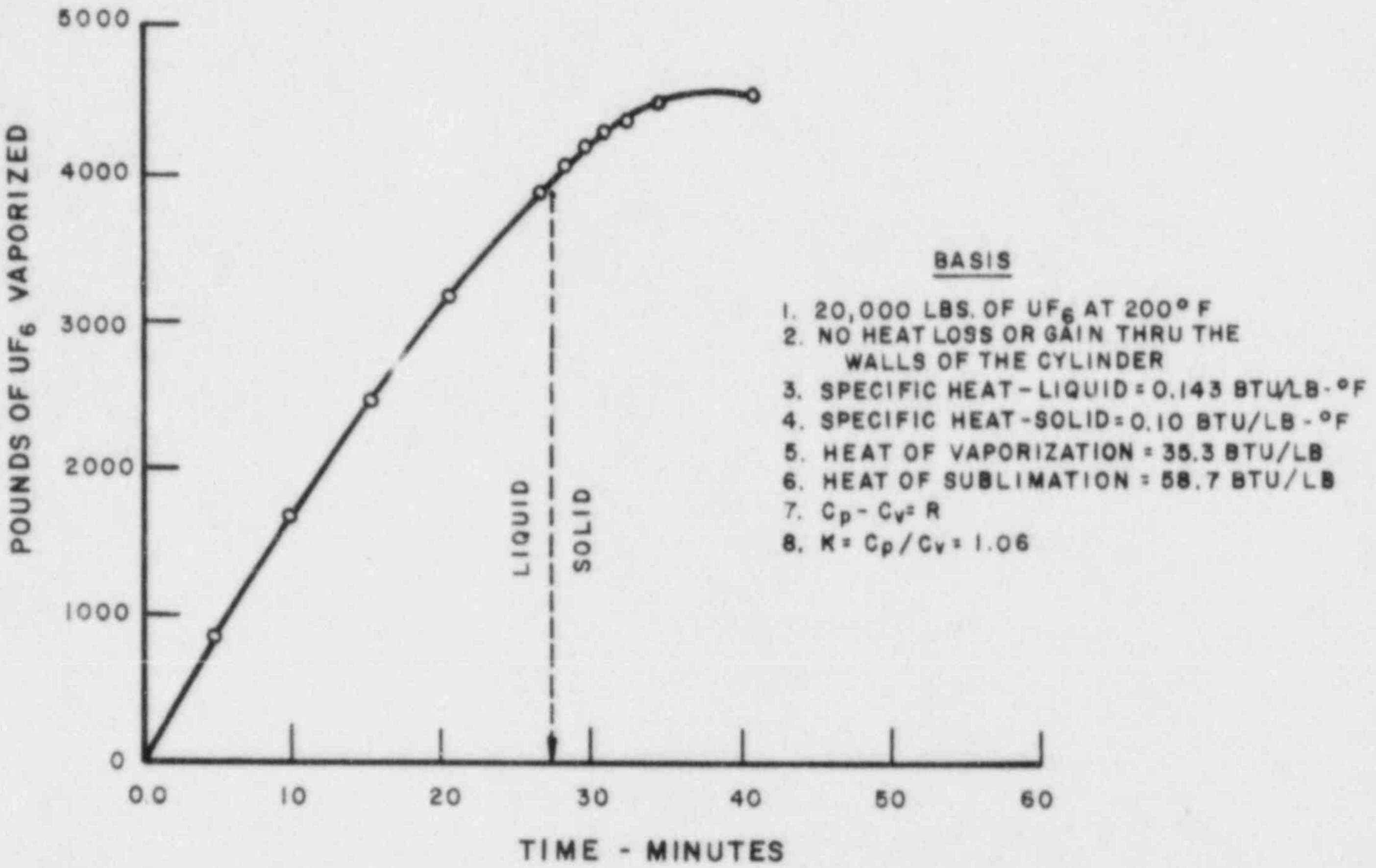


FIGURE 15

UF_6 LOST THRU A 1.5 INCH DIAMETER OPENING IN A 10 TON CYLINDER

An operator who removed the cylinder valve was completely hidden from view by a cloud of white smoke resulting from the hydrolysis of UF_6 to UO_2F_2 and HF. Other operators helped him from the scene and he was immediately hospitalized. He developed pulmonary edema and was treated with oxygen for two days, kept in the hospital for six days and returned to work on the ninth day. He has continued to work for the same employer without difficulty. Eight other operators involved in the incident were not injured. There were no permanent injuries. Based on urine analyses, uranium was rapidly eliminated from the body, the biological half-life being 4-6 hours.

Since this hazard was known to exist, certain precautions were included in the design of the plant and the operating procedure. The cold traps are located in the plant within the building completely covered with insulation and equipped in such a way with block valves and an emergency cold trap to which a leaking unit can be dumped. Leaks in the valves controlling flows have occurred and alternate cold traps used to control such leakage. Such precautions have proved effective control measures for cold traps preventing any significant releases from the system.

The hot UF_6 cylinders, after filling, are disconnected from the filling station, the cart upon which they are resting moved to an aisleway, the cylinder lifted from the cart by a 18-ton capacity fork truck and transported to a steam-heated hot chest. They are held in this hot chest for 12 hours in order to homogenize the contents, removed from the chest, placed upon a rotator, the position adjusted to place the valve below the liquid surface and connected to an evacuated sample cylinder and a sample drained. The valve is then shutoff and cover caps placed on the valve stem and spout. The cylinder is removed by the fork truck and placed on a cradle in the UF storage area where it is permitted to solidify, requiring approximately 72 hours.

Examining this procedure, one concludes that the possibility of accidental release occurs during transportation and sample removal. The valve of the cylinder is located in such a way on the end dish of the cylinder so that it is protected by an overhanging steel skirt, thus preventing damage to the valve during transportation by passing too close to a structural column or structures. In addition, the valve is protected by a valve guard designed for that purpose and placed upon the cylinder during all transportation. A cross-section of this arrangement is shown in Figure 16.

Inadvertent valve removal such as was experienced in the reported case at National Lead Company cannot occur since the sample cylinder prevents turning more than a one-quarter turn. In view of these precautions, we do not believe that the accidental removal or breakage of a valve from a hot UF_6 cylinder constitutes a credible accident.

In the event of such an accident, plant employees would take emergency action as described in "Emergency Procedure for UF_6 Release" attached as Appendix VI. Such action would include spraying the cylinder with water to cool it more quickly and result in less loss of UF_6 than calculated as was experienced in the reported incident.[34]

In addition the consultant was asked to calculate the uranium dose and fluoride concentration downwind for such an incident. Appendix IV includes the results of these calculations. Due to confused communications these calculations assumed 4800 lbs. released in 400 minutes rather than the correct assumptions of 4550 lbs. released in 40 minutes.

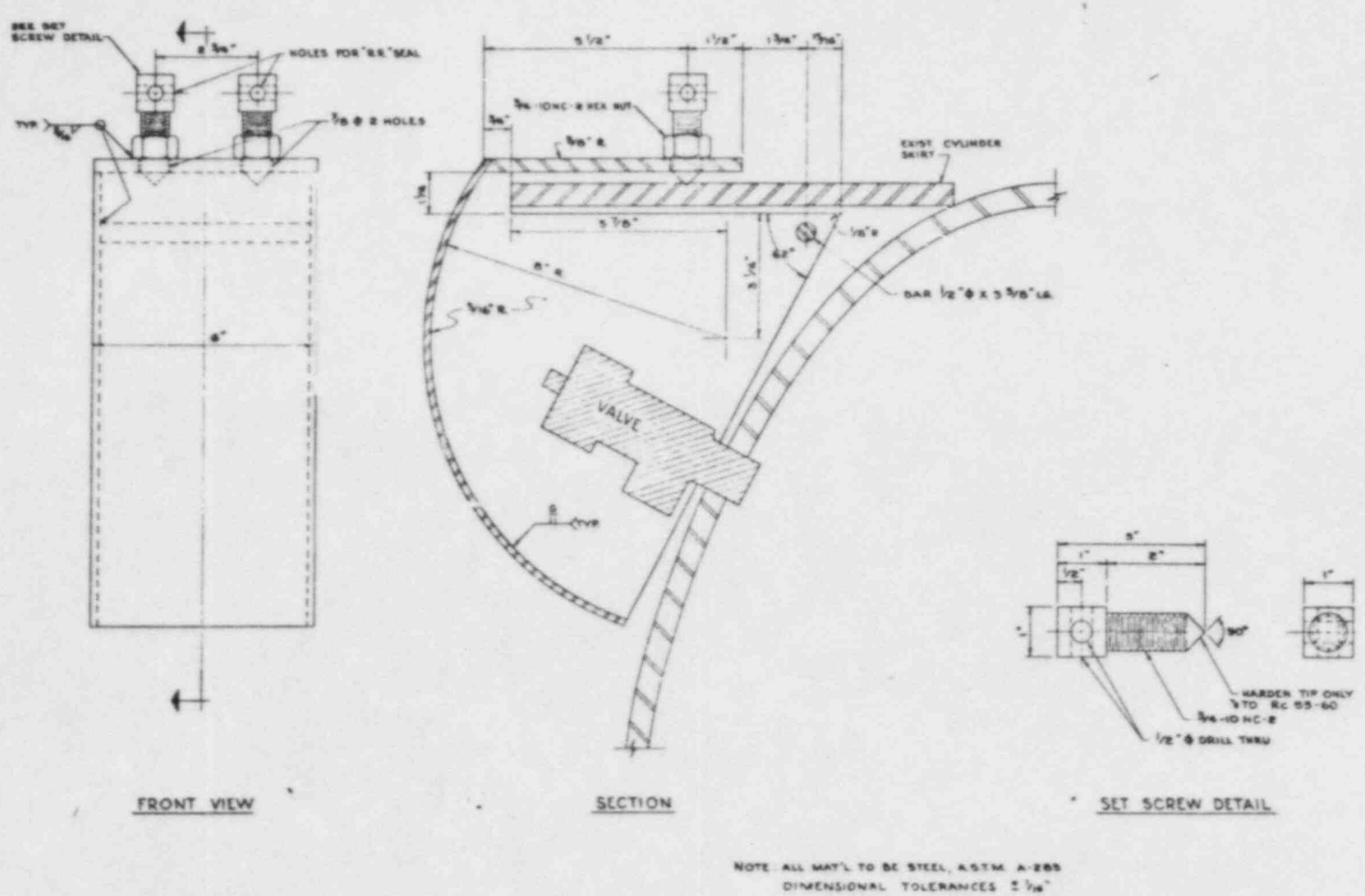
Also the calculation assumes all of the fluorine is available while only two-thirds is available as HF from the reaction with water in the air: $UF_6 + 2H_2O \rightarrow UO_2F_2 + 4HF$

---

[34] M. W. Boback and R. C. Heatherton, op. cit.

Valve Protector

FIGURE 16



VALVE GUARD FOR UF_6 CYLINDER MODELS 48A AND 48F

To correct the exposure for these conditions:

$$\text{Dose: } 20.1 \text{ rem} \times \frac{4550}{4800} \times \frac{396\ \mu Ci/sec}{39.6\ \mu Ci/sec}$$

$$\times \frac{40 \text{ min}}{400 \text{ min}} = 19.9 \text{ rem}$$

F as HF

$$23 \text{ mg/M}^3 \times \frac{76\ F_4}{114\ F_6} \times \frac{4550}{4800} \times \frac{303 \text{ g/sec}}{30.3 \text{ g/sec}}$$

$$\times \frac{20}{19} \frac{HF}{F} = 153 \text{ mg/M}^3$$

The estimated 19.9 rem kidney dose is well below the acceptable 75 rem kidney dose for accidental exposures.[35]

Exposure to 153 mg/M^3 of HF vapor is uncomfortable but not lethal. Animals are reported to tolerate 100 mg/M^3 for five hours while 1000-1500 mg/M^3 was lethal in five minutes.[36] Sax permits brief exposure to 33-165 mg/M^3.[37] Vegetation would be defoliated and small animals in the plume might expire.

In view of the conservative assumptions mentioned previously on such diffusion calculations and the procedural and equipment precautions, we do not believe such an exposure is a credible accident.

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[35] Safety Evaluation by the Division of Material Licensing, USAEC, In the Matter of the Midwest Fuels Reprocessing Facility, Docket No. 50-268, October 6, 1967.

[36] Amer. Ind. Hyg. Assoc., Hygenic Guide Series (A64).

[37] "Dangerous Properties of Industrial Materials", N. Irving Sax, Reinhold, 1968.

7. Shipping Cylinder, Damage in Transit

UF_6 product is shipped by truck in a nominal 10 ton (net UF_6 capacity) properly approved heavy wall cylinder - Model 48A. The carrier has instructions, in writing, on the handling of emergencies. These instructions are included as Appendix VII.

This specific UF_6 container has been in use by the AEC in excess of a decade. Numerous intraplant cylinder moves and less numerous but a significantly large number of interplant shipments of ambient temperature UF_6 cylinders have not resulted in a single known release of significant uranium material. Loads have been involved in accidents but always without serious damage to the vessel. Drop tests have been staged that tested the vessel integrity.

The container contents are in a solidified state, at ambient temperature and below atmospheric pressure (approximately 5 psia maximum partial pressure of UF_6). In order to have UF_6 or other uranium compounds escape from the container at least two contingent conditions must exist:

1. The container must have significant damage resulting in opening the container to atmosphere.
2. There must be a motive force to move UF_6 from the solid state to the gaseous state and cause the gas to leave the opening.

Two motive forces for causing UF_6 to leave the cylinder are pressure (by increasing the cylinder temperatures) or diffusion. Since the cylinder temperature is already in equilibrium with the air, an increase in temperature would be possible only on receiving additional radiant energy or by applying heat directly to the cylinder, e.g., a fire. The probability of an accident rupturing the cylinder and having the accident occur at a railroad crossing resulting in a fire from rail tank car

contents or involving a truck transport of flammable contents is considered to be sufficiently improbable to not warrant further consideration.

The most likely method of having uranium leave the container is as a gas or very small particle. This is dependent on a diffusion process and chemical reaction. Air containing moisture must diffuse into the cylinder. The moisture must react with the UF_6 forming UO_2F_2 and HF. The HF must diffuse (back through the same opening) to the outside carrying minute quantities of UO_2F_2 with the HF. Accordingly, while it is possible that an accident could cause damage to the cylinder and escape of trace amounts of uranium, release of large amounts of material would not occur by this diffusion, chemical reaction and back diffusion process.

In the event of an accident the driver, utilizing the written instructions takes immediate action and then notifies the Facility. All receipt points are within 24 hours driving time of the Facility and should aid be needed this could be supplied with personnel handling UF_6 daily.

G. Alternatives

The plant site was chosen for its relative isolation, access to transportation and other advantages listed elsewhere in this report. These criteria were used to evaluate and reject alternate locations. The plant has operated for two years with no observed adverse environmental impact. The existing location seems to have been the best choice.

Alternate conversion processes were not available in the public domain at the time of initial planning without extensive development work. A proprietary commercial process exists but little is known about its characteristics. This other process should offer no advantage in terms of gaseous effluent but it produces no liquid effluent similar to the raffinate stream generated at Sequoyah. Some technologists would view

this as an advantage. But the AEC developed process which is used at Sequoyah has been in use longer. This as a considerable advantage in anticipating, controlling and minimizing the facility's environmental impact.

H. Site Restoration and Reclamation

Except for the 75 acres occupied by the production facilities, the land on the 2,100-acre site is being used in essentially the fashion it would have been used if there were no plant. Consequently, restoration and reclamation of 75 acres needs to be considered.

Kerr-McGee believes that it is neither necessary nor desirable to restore the 75 acres to the condition existing before the plant was built. A developed industrial site with buildings, utility lines, water supply, roads, sewage facilities and possible access to a railroad is more valuable and productive than a small pasture. This subject was discussed with Mr. Bill Lovern, Vice President of the First National Bank of Sallisaw, Oklahoma. Mr. Lovern is knowledgable about commercial real estate in that area and he believed that the site could be sold for industrial purposes and it would be more useful and beneficial as an industrial site than as a pasture. Keeping the site in commercial use would minimize the economic impact on the Eastern Oklahoma area.

The land occupied by chemical storage and processing ponds should be restored. This involves filling the ponds and planting suitable cover over both the filled-in ponds and the fill dirt source.

The fluoride sludge ponds and settling basin would not present any particular problem. Calcium fluoride is a common water-insoluble mineral. Lime, on standing, is converted to calcium carbonate, another common mineral. These sludges can be washed free of soluble materials and buried. The ponds could then be filled in.

It is anticipated that the raffinate ponds will be eliminated while the plant is still in operation. The clean-up process will involve:

1. Recovering radioactive material in a solid form. Laboratory scale experiments have precipitated radioactive materials resulting in a solution containing approximately 3% of the Ra_{226} MPC.
2. Disposi'g of it in an approved manner by an AEC licensed burial contractor.
3. Disposing of the liquid nitrate solution by decomposition or other means.
4. Filling in the ponds.
5. Planting suitable cover on the filled area.

The ammonium nitrate solution may be a useful fertilizer after the radioactivity has been removed. It would be a low concentration fertilizer and could be used on the site or in the general area.

The estimated quantities of materials involved can be obtained from Table X. The quantities used have been obtained from purchases and beginning and first inventories for the 12 month period April, 1971-March, 1972. It can be calculated that annually about 300 short tons of calcium fluoride are stored plus some calcium carbonate and lime. Based on projected production figures, about 20,000 tons of insoluble calcium salts will be produced in 30 years. Assuming an effective bulk density of 60 pounds per cubic foot, the volume would be approximately 700,000 cubic feet or a space 375' x 375' and 5 feet deep. Hence about 3.2 acres would be needed. Since calcium carbonate and calcium fluoride are commonly occurring water-insoluble minerals, disposal by burial on the site should be satisfactory after filling and seeding the cover.

By 1976, the raffinate storage ponds will contain 2413 tons of nitrate nitrogen and 2726 tons of ammonia nitrogen based upon actual and projected production rates. By that time,

a satisfactory process for the disposal of raffinate will be in operation. This will treat both accumulated raffinate and also that produced by current operation.

The sewage stabilization lagoon would be an asset needed by the next commercial user of the site. Depending upon the user's sewage load, it could be necessary for him to add additional treatment facilities.

An estimate of the cost required to fill in ponds and reseed is $1,000 per acre. This is the estimated cost used by others for land restoration in a uranium strip mining operation. For the Sequoyah operations, $75,000 should be conservative. It is acceptable procedure for a company with the resources of Kerr-McGee to treat a $75,000 expenditure as an operating expense incurred in the year that the money was actually spent. The Company would not need to establish a dedicated fund as planned by others.

V. COST-BENEFIT ANALYSIS

A. Benefits

The Sequoyah Facility benefits the commerce and residents of Sequoyah and Muskogee Counties, Oklahoma, as well as the overall nuclear industry.

The nuclear industry will gain the benefit of having a second domestic supplier of conversion service, employing a different process and accommodating a different set of specifications for the mining and milling segment of the nuclear industry. The second supplier provides competition, insures an equitable price structure and assures the continuing availability of this necessary phase of the nuclear fuel cycle.

Of the approximately 100 employees at the Sequoyah site, 90 were hired from the immediate area. A result is an annual payroll of about a million dollars. Since, for every direct factory employee, about three service people are needed, a total boost to the local economy of about four million dollars results.

Sequoyah County activities benefit from the additional taxes paid on an industrial installation as compared to those payed on unimproved land.

B. Costs

Seventy-five acres of low grade pasture have been converted to an industrial site. This land would be worth \$150 an acre in the absence of industrial activity. This land would have supported about 10-20 cows on a year-round basis. Since there is plenty of unused potential pasture in the area, this would not seem serious.

Over the next 30 years, 3.2 acres of land will be permanently converted to a burial ground for calcium carbonate and fluoride solid wastes. A second acre may be permanently converted to a burial ground for insoluble radioactive waste using a barium carrier. Burial of radioactive waste depends upon

development of a suitable process and AEC approval. Once the site is relinquished, this land will require excavation, filling and reseeding to restore it to a condition suitable for agricultural or industrial use. During this period (about one year), the land will be unusable. Again, since there is unused grazing land in the area, this does not seem serious. Poor quality pasture would rent for about $10 per acre per year.

Solid, liquid and gaseous effluents will be released. The nature and quantities of these materials have been discussed in detail in another section of this report. State and governmental agencies regulate the quantities of these materials that can be released. The general philosophy is that no detectable harm shall result. The plant operates within boundaries set by all regulatory agencies and endeavors to hold effluent releases to the lowest practical levels rather than boundary limits allowed. It is believed that no significant cost can be assessed against discharge of effluents.

No irreplacable loss of wildlife, plant life, or air quality has occurred. It is concluded that no cost penalty can be assessed for the effect.

No irreversable or irretrievable commitment of resources have occurred. While the 75 acre plant site area will almost certainly remain in industrial use, this would be a matter of choice rather than necessity. The option of restoring the land to a condition similar to the original one still remains.

C. Conclusion

Based on the above, it is our conclusion that the enhancement of values to the population of Eastern Oklahoma by a viable industrial site far outweighs in benefits the negligible impact on the environment.

APPENDIX I

PERMITS AND LICENSES

1. Oklahoma Water Resources Board-Permit to Appropriate Surface Water No. P67-765
2. U.S. Army Corps of Engineers-Contract No. DACW 56-70-C-0083
3. Oklahoma Water Resources Board-Waste Disposal Permit No. IW-70-011
4. Oklahoma Water Resources Board-Certification for Waste Discharges
5. AEC Radioactive Source Material License No. SUB-1010, Docket No. 40-8027 and Amendment No. 1
6. Oklahoma State Department of Health-Sanitary Waste Treatment Permit
7. Engineer's Report on Waste Treatment Plant
8. Technical Assessment by Dr. R. H. Ramsey, "Domestic Waste Disposal Procedures"
9. Oklahoma Air Pollution Control Division-Open Pit Incinerator Application
10. Oklahoma State Department of Health-Open Pit Incinerator Evaluation Test
11. Waste Disposal Technical Provisions and Specifications

SEQUOYAH AVERAGE CONDITIONS

V_s = 475 ft. min^{-1} = 7.9 ft. sec^{-1} (8' diam) 48.0 ft. sec^{-1} (3.25' diam) or 14.6 meters sec^{-1}

d = 3.25' = 1.0 meters
u = ~7mph = 3.0 meters sec^{-1}
P = ~960 mb
Ts = ~320° F = 146° C = 419° k
Ta = ~ 68° F = 20° C = 293° k
h = 150' = 45.72 meters

Then - under average Sequoyah operating conditions:

$$\Delta H = \frac{Vsd}{U}\left(1.5 + 2.68 \times 10^{-3} p \frac{Ts - Ta}{Ts} d\right)$$

$$\Delta H = \frac{14.6(1)}{3}\left[1.5 + 2.68 \times 10^{-3} (920) \frac{419 - 293}{419} (1)\right]$$

$$\Delta H = \frac{14.6}{3}\left[1.5 + 2.68(.92)\ .30\ (1)\right]$$

$$\Delta H = 4.87\left[1.5 + (2.47)(.30)\right]$$

$$\Delta H = 4.87\ (1.5 + .74)$$

$$\Delta H = 4.87\ (2.24) = \underline{10.9}$$

The effective height of emission under average conditions is then:

$$h + \Delta H = 45.72 \text{ meters} + 10.91 \text{ meters}$$

$$H_{(eH)} = \underline{56.6 \text{ meters}}$$

Effective stack height as a function of wind speed
The maximum ground level concentration occurs at some intermediate wind speed, at which a balance is reached between the dilution due to wind speed and the effect of height of emission.

$$\Delta H = \frac{14.6}{U}\ (1.5 + .74)$$

$$\Delta H = \frac{14.6}{U}\ (2.24)$$

$$\Delta H = \frac{32.7}{U}$$

THEN:

	WHEN U= M Sec^{-1}	ΔH= Meters	+ h	H_{eff}
	.5	65.4	45.7	111.1
A-B	1	32.7		78.4
	1.5	21.8		67.5
	2	16.4		62.1
B	2.5	13.0		58.7
	3	10.9		56.6
	3.5	9.3		55.0
	4	8.2		53.9
B-C	4.5	7.2		52.9
	5	6.5		52.2
C D	5.5	5.9		51.6
	6	5.5		51.2
	6.5	5.0		50.7
D	7	4.7		50.4
	9.5	3.3		50.0

Calculation of maximum downwind concentration from Sequoyah stack:

Stability category F — U = ~2.5 M sec^{-1} (assumed); H = 60 M (calculated)

Stability category C — U = ~4 M sec^{-1} (assumed); H = 55 M (calculated)

Stability category D — U = ~7 M sec^{-1} (assumed); H = 50 M (calculated)

THEN

Stability category F (from graphs)

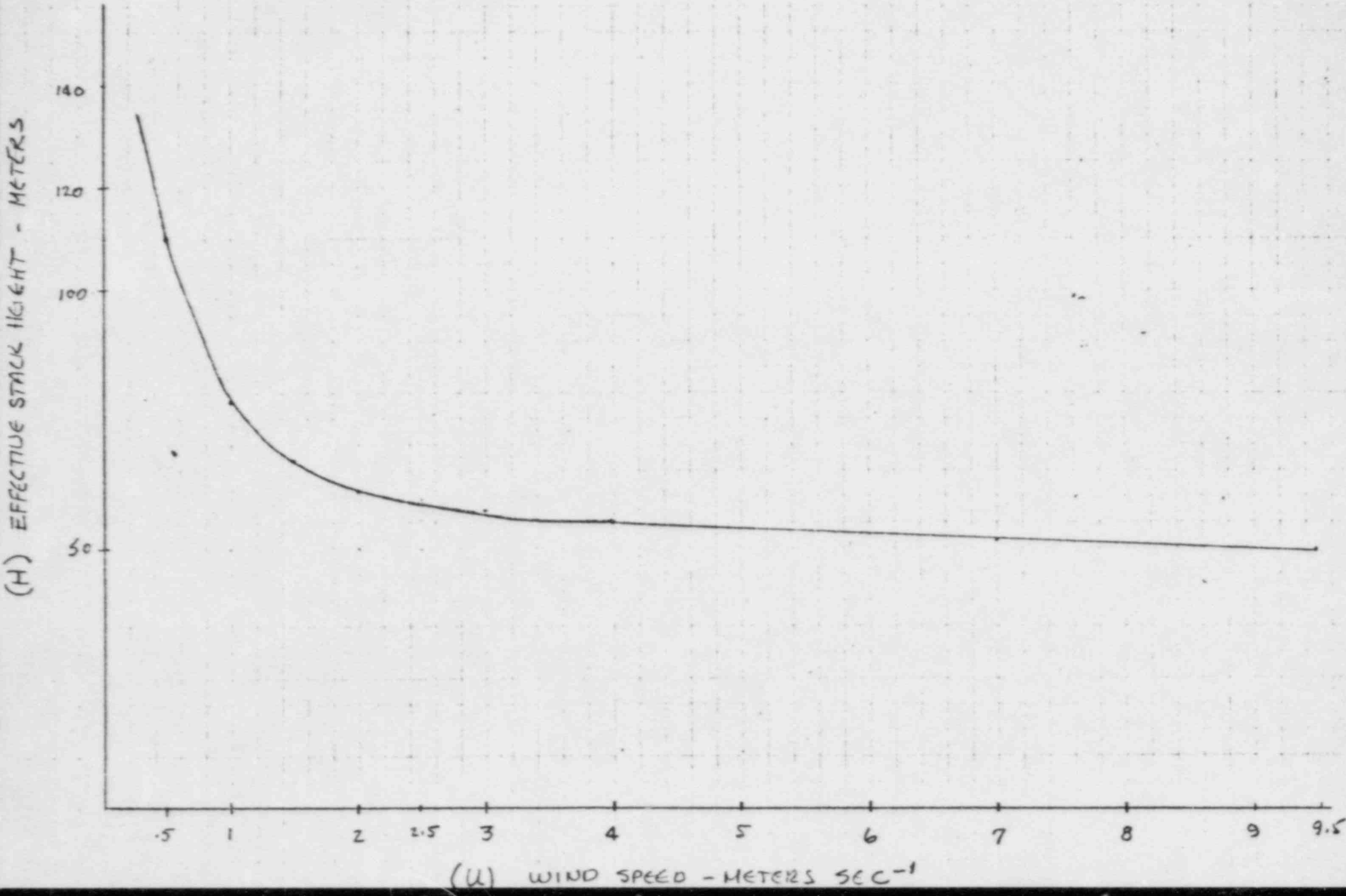
Distance = 5.0 Km

$$\frac{XU}{Q} = 1.45 \times 10^{-5}\ M^{-2}$$

SEQUOYAH FACILITY

EFFECTIVE STACK HEIGHT AS A FUNCTION OF WIND SP[EED]

$H = h + \Delta H \qquad h = 45.7$ meters



Stability category C (from graphs)

Distance = .64 Km

$\frac{XU}{Q} = 4.5 \times 10^{-5}\ M^{-2}$

Stability category D (from graphs)

Distance = 1.1 Km

$\frac{XU}{Q} = 4.4 \times 10^{-5}\ M^{-2}$

Maximum downwind concentrations - Figure 3-9 graph

Stability F = 60 M = XU/Q max m^{-2} = 1.5×10^{-5} x max (Km) = 4 Km

Stability C = 55 = XU/Q max m^{-2} = 4.6×10^{-5} .6 Km

Stability D = 50 = XU/Q max m^{-2} = 4.4×10^{-5} 1 Km

	Conc.	Dist.
1/3 Stability F	$.3 \times 10^{-5}$	1.3 Km
1/3 Stability C	1.5×10^{-5}	.2 Km
1/3 Stability D	1.5×10^{-5}	.33 Km
Max. downwind conc. =	$3.3 \times 10^{-5} x$	$x = \frac{Q}{U}$
Max. downwind distance =		1.83 Km

∴ At 1830 meters (6000 ft) downwind the maximum ground level concentration occurs.
The ground level concentration will be 3.35×10^{-5} times the emission rate of the pollutant in curies or grams divided by the wind speed in M sec^{-1}.

Calculation of Roof Top Emission From Sequoyah Facility

Assuming a 15 meter effective stack height and the following stability categories

1/3 Stability class F	4.5×10^{-4}	.50 Km
1/3 Stability class D	4.5×10^{-4}	.24 Km
1/3 Stability class C	6.0×10^{-4}	.15 Km
	$15.0 \div 3$	$.89 \div 3$
	5.0×10^{-4}	.29

∴ Roof top release at 45 ft would have a max. downwind concentration of 5.0×10^{-4} Q/U at .290 Km or 951 ft.

DAMES & MOORE

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May 26, 1972

Kerr-McGee Corporation
Kerr-McGee Building
Oklahoma City, Oklahoma 73102

Attention: Mr. A. Valentine

Gentlemen:

Enclosed is one copy of our draft report regarding the calculation of potential impact of releases from the Sequoyah UF_6 facility.

I am looking forward to hearing your comments.

Yours very truly,

DAMES & MOORE

Irwin Spickler
Associate

IS:swb

Enclosure

DRAFT REPORT
CALCULATION OF POTENTIAL IMPACT
OF RELEASES
SEQUOYAH UF_6 FACILITY
KERR-McGEE CORPORATION

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The purpose of this report is to quantify the near-ground level atmospheric concentrations of the routine chemical and radioactive gaseous effluents that are released from the Sequoyah UF_6 Facility.

This plant is located in the vicinity of Gore, Oklahoma, which has similar topographic and climatologic characteristics as the closest first-order weather data station, Fort Smith, Arkansas.

The method of analysis was a series of mathematical computer models that assessed the combined effects of atmospheric dilution, multiple source release rates and population distributions.

The mathematical model assumptions are deemed conservation and are in compliance with the current Atomic Energy Commission standards.

A recapitulation of the scope of work is as follows:

Task A - Obtain from the first-order weather station an annual joint frequency occurrence of wind speed, wind direction, and atmospheric stability. Also, obtain the annual wind direction frequency.

Task B - Using the annual joint frequency distribution obtained in Task A, calculate the annual average dilution versus distance and direction from the Uranium Hexafluoride Sequoyah Facility for both 150-foot and ground level releases.

Task ^ - Using gaseous effluent release data, i.e., total NO_x, fluorides, and uranium released during the year, calculate the annual average downwind concentrations of NO_x and fluorides and the lung and bone doses for the insoluble and soluble uranium quantities released versus distance and direction out to a distance of ten miles.

Task D - Using population distribution versus distance and direction and the bone dose distribution calculated in Task C, calculate the total man-rem that could potentially result from the estimated yearly uranium releases.

Task E - Provide a report which documents all analyses performed and presents the results of the analyses performed.

SUMMARY

Both the routine annual calculated doses and concentrations of radioactive and chemical gaseous pollutants may be considered relatively small. The low routine release rates of effluents coupled with the low population density indicates that there will not be any deleterious environmental impact due to the Sequoyah plant operations.

DATA INPUT

Meteorology

The distribution of Pasquill atmospheric stability categories by wind direction was obtained from Fort Smith, Arkansas, for the period of record January 1960 to December 1964 (43847 hourly observations).(1) The stability classification was based on the Pasquill-Turner method.(2) Table I summarizes the annual percent distribution of wind direction versus stability and the average wind speed in meters per second. This summary provided the basis for calculating both the annual average elevated and ground release atmospheric dilution factors. These factors are called relative concentrations or "x/Q" values.

Table II(3) presents an annual percentage frequency occurrence of wind direction distribution by speed groups (knots) for Fort Smith, Arkansas, March 1953 through February 1963.

Population

Table III(4) depicts the population distribution within a 10-mile radius of the Sequoyah plant. The represented polar coordinate population matrix is identical to meteorological wind rose with the 16 cardinal directions

bisecting the lateral sectors. The 1970 U. S. Census provided the average household resident population per county. These multiplicative values were applied to the number of homes that were identified in each polar coordinate segment.

Gaseous Effluent Release Data

A summary of the gaseous effluent rates that are released on a routine annual basis from the Sequoyah plant are listed below. These rates are referred to as "Q" values.

Summary of
Gaseous Effluent Release Data (4)

Radioactive Pollutants

Release Height	Release Rate (Ci/sec) Soluble U	Insoluble U
Ground Level	0.5×10^{-10}	7.2×10^{-10}
150-foot Stack	3.0×10^{-10}	0.1×10^{-10}

Non-radioactive Pollutants

Release Height	Release Rate (g/sec) Fluoride	SO_2	NO_x
Ground Level	0.004	-	-
150-foot Stack	0.12	0.26	1.98

ANALYSIS AND RESULTS

Glossary

The following glossary of symbols reflects a partial list of parameter notations and units applied to the equations.

Symbol	Description	Units
U	Wind speed	Meters per second
h	Height	Meters
H	Stack height (150 feet)	45.7 meters
χ/Q	Relative concentration	sec./M^3

Symbol	Description	Units
f	Fractional annual occurrence of wind direction	Probability
SZ	Sigma-Z, vertical dispersion coefficient	Meters
D	Distance	Meters
Q	Source release rate	Units/sec.
E	A power of ten	10^E
Matrix Location		
I	Wind direction	22-1/2 degrees
K	Distance	Meters
P	Pasquill Stability Classes	A through G
Constant		
2.032	Constant incorporating geometric sector spread of 22-1/2 degrees and ground reflection	Radians

Wind Height Adjustment

The wind speed data was collected at Fort Smith at the 10-meter height. It was required to extrapolate the wind speeds to the stack height level of 150 feet (45.7 meters) for the elevated release model. The following equation was used:

$$U_{45\ meters} = U_{10\ meters} \left(\frac{h_{45}}{h_{10}}\right)^n \quad (5)$$

where:

n is 0.25 for Pasquill A, B, C, D

or 0.50 for Pasquill E, F, G

Ground Release

Average annual ground release relative concentrations (atmospheric dilution factors) were determined by the following equation:

$$\text{Ground } \frac{x}{Q}_{(I,K)} = \sum_{P=A}^{G} \frac{2.032\, f_{(I,P)}}{U_{10(I,P)}\, SZ_{(K,P)}\, D_{(K)}} \qquad (6)$$

Table IV summarizes these relative concentration values by geographic sector and distance in meters from the plant site. The metric distances represent the midpoint value of the statute miles; e.g., 805 meters = 1/2 mile, 2414 meters = 1-1/2 miles, etc.

Elevated Release

Average annual elevated release relative concentrations were determined by the following equation:

$$\text{Elevated } \frac{x}{Q}_{(I,K)} = \sum_{P=A}^{G} \frac{2.032\, f_{(I,P)}}{U_{45(I,P)}\, SZ_{(K,P)}\, D_{(K)}}\, \text{EXP}\left(-\frac{H^2}{2SZ^2_{(K,P)}}\right) \qquad (6)$$

The following assumptions were incorporated:

1. Flat terrain.
2. Ground reflection of the elevated plume.
3. A maximum vertical mixing depth of 1000 meters, i.e., SZ did not exceed 1000 meters.
4. Credit was not taken for any stack plume buoyancy, i.e., effective stack height = 150 feet.

Table V summarizes these values of relative concentration by geographic sector and distance in meters from the plant site.

Radioactive Dose

Dose values were computed based on ground and elevated gaseous effluent release rates and ground and elevated relative concentrations. For radioactive pollutants the generating dose equations are:

$$Dose_{Kidney} = BR\ (DF)\ Time\ \left(\frac{x}{Q}_{(Elevated)}\ Q_{(Elevated)} + \frac{x}{Q}_{(Ground)}\ Q_{(Ground)} \right)$$

where:

$Dose_{Kidney}$ = Annual kidney dose from soluble uranium

BR = Breathing rate of 2.32E-4 M^3/sec.

DF = Dose factor for uranium affecting the kidney (80 rem/μc inhaled).(7)

Time = 3.154E+7 seconds/year

and, Q values for uranium are from the Summary Table.

$$Dose_{Lung} = BR\ (DF)\ Time\ \left(\frac{x}{Q}_{(Elevated)}\ Q_{(Elevated)} + \frac{x}{Q}_{(Ground)}\ Q_{(Ground)} \right)$$

where:

$Dose_{Lung}$ = Annual lung dose from insoluble uranium

DF = Dose factor for uranium affecting the lungs (110 rem/μc inhaled).(7)

and, all other terms remain the same.

$$Dose_{Bone} = BR\ (DF)\ Time\ \left(\frac{x}{Q}_{(Elevated)}\ Q_{(Elevated)} + \frac{x}{Q}_{(Ground)}\ Q_{(Ground)} \right)$$

where:

$Dose_{Bone}$ = Annual bone dose from soluble uranium

DF = Dose factor for uranium affecting the bones (20 rem/μc inhaled).(7)

Table VI, VII and VIII summarizes the kidney, lung and bone dose in millirem, respectively. The highest dose calculated for the kidney (0.62 millirem), lung (11.2 millirem) and bone (0.155 millirem) was southwest of the plant at 1/2 mile (805 meters).

Chemical Pollutants

The ground level concentrations of chemical (non-radioactive) pollutants were determined by the following equation:

$$\text{Concentrations} = \left(\frac{x}{Q}_{(\text{Elevated})} Q_{(\text{Elevated})} + \frac{x}{Q}_{(\text{Ground})} Q_{(\text{Ground})} \right) 1.0E+6$$

where:

Concentrations are in micro-grams per cubic meter.

Q values are from the summary table for fluoride, sulfur dioxide and nitrous oxides.

and, neglible quantities of sulfur dioxide and nitrous oxides are released at ground level and therefore no ground level annual concentration analyses were performed for these pollutants.

Table IX, X, and XI summarize the ground level concentrations of fluoride, sulfur dioxide and nitrogen oxides, respectively. The highest concentration values were found at the distance of 1/2 mile (805 meters) for the following:

Pollutant	Direction	Value (μg/M^3)
Fluoride	SW	0.115
Sulfur dioxide	WSW	0.130
Nitrogen oxides	WSW	0.991

Man-Rem

The cumulative total annual man-rem for lung, kidney, and bone dose, based upon the annual radioactivity releases from the Sequoyah plant, were determined by the following equation:

$$\text{Annual Man-rem}_{(\text{Organ})} = \Sigma[\text{Annual Dose}_{(\text{Organ})(I,K)} \text{Population}_{(I,K)}] \; 1.0E-3$$

where:

Dose is in millirem from Tables VI, VII and VIII for each distance, K, and direction, I.

Population distribution is from Table III for each distance, K, and direction, I.

Tables XI, XII, and XIII summarize annual man-rem for kidney, lung, and bone, respectively, as a function of distance and direction from the plant site. Totals per each direction and each distance as well as cumulative distance totals are also provided. The cumulative total annual man-rem in a 0-10 mile radial from the plant site for kidney, lung and bone dose is 0.056, 0.612 and 0.014, respectively.

ACCIDENT ANALYSIS

The following hypothetical accident is postulated:

Accidental 4800 lb. UF_6 release at ground level
Release time - 400 minutes
Pollutants released
Soluble uranium - 3200 lb. = 39.6 μc/sec.
Fluorides - 1600 lb. = 7.27 x 1.0E+5g = 30.3g/sec.

Meteorological assumption during accident[8] Pasquill F at 1.0 mps for 6.67-hour duration with a constant centerline wind direction.

The following equations generated the accident doses:

$$\frac{X}{Q}_{\substack{\text{Ground}\\ \text{Accident}}} = \frac{1.0}{U\ (\Pi\ SZ(K)\ SY(K) + CA)}$$

where:

SY(K) is the horizontal dispersion coefficient as a function of distance

CA is one-half the minimum cross sectional area of the containment building = 334.5 M^2

and all other terms as previously defined.

$$\text{Soluble Uranium Dose} = \frac{x}{Q}_{\substack{\text{Ground}\\ \text{Accident}}} (Q)\ BR\ (DF)\ \text{Time}$$

where:

Dose is in rem to the kidney for the accident time of 6.67 hours

Q = 39.6 μc/sec.

Time = 2.4E+4 seconds during accident

DF = Dose factor to kidney (80 rem/μc inhaled)

BR = 3.47E-4 M^3/sec.

and all other terms as previously defined.

$$\text{Fluoride} = \frac{x}{Q}_{\substack{\text{Ground}\\ \text{Accident}}} (Q)\ 1.0E+6$$

where:

Fluoride concentration is in micro-grams per cubic meter

Q = 30.3 g/sec.

The table below summarizes accident dose and fluoride concentrations (μg/M^3) as a function of distance. The nearest residential home is 2500 feet (.474 miles or 762 meters) northwest of the plant. Calculated accident dose and fluoride concentrations were 20.1 rem to the kidney and 23000 μg/M^3, respectively. The potential bone dose at 2500 feet is approximately 5.0 rem. The dose calculations are based upon exposure for the 400 minute course of the accident.

Miles	Meters	Kidney Rem	Fluoride (μg/M^3)
.125	200	6.14E+01	7.03E+04
.250	400	3.96E+01	4.53E+04
.474	762	2.01E+01	2.30E+04
.500	805	1.89E+01	2.16E+04
.621	1000	1.38E+01	1.50E+04
1.500	2414	4.29E+00	[illegible].91E+03
[illegible]	[illegible]	2.33E+00	2.66E+03
[illegible]	[illegible]	1.47E+00	1.6[illegible]+03
4.500	7242	1.01E+00	1.16E+03

TABLE 1

DIFFUSION METEOROLOGY, WIND DIRECTION VS. PASQUILL STABILITY

Based on Fort Smith, Arkansas Weather Data
Period of Record: January 1960 through December 1964
43,847 Hourly Observations

Annual Percent Distribution

Wind Direction	Pasquill Stability A	B	C	D*	D**	E	F	G
N	0.03	0.27	0.37	0.85	1.03	0.69	0.70	0.47
NNE	0.04	0.35	0.37	0.63	0.68	0.84	1.70	1.14
NE	0.09	0.82	1.30	1.28	1.57	1.86	4.08	2.60
ENE	0.10	0.97	2.46	3.14	3.62	2.07	2.73	1.53
E	0.07	0.55	1.21	2.37	2.55	1.07	1.00	0.80
ESE	0.05	0.38	0.71	1.09	0.76	0.51	0.55	0.42
SE	0.09	0.46	0.72	0.97	0.73	0.47	0.65	0.59
SSE	0.05	0.30	0.49	0.66	0.46	0.29	0.36	0.26
S	0.06	0.49	0.68	1.06	0.57	0.42	0.72	0.39
SSW	0.06	0.45	0.99	1.51	0.63	0.38	0.51	0.37
SW	0.09	0.57	1.17	1.68	0.54	0.52	0.87	0.79
WSW	0.08	0.49	0.93	1.05	0.57	0.55	1.18	0.66
W	0.05	0.30	0.72	1.25	1.21	0.94	0.71	0.29
WNW	0.05	0.27	0.57	1.32	1.32	0.49	0.32	0.10
NW	0.06	0.25	0.43	0.99	1.03	0.44	0.33	0.19
NNW	0.03	0.19	0.37	0.90	0.92	0.38	0.30	0.15

Average Wind Speed (m.p.s.)

Wind Direction	Pasquill Stability A	B	C	D*	D**	E	F	G
N	1.84	2.44	3.63	5.70	4.92	3.65	2.14	0.67
NNE	1.71	2.41	3.39	4.59	3.54	2.83	2.01	0.68
NE	1.72	2.51	3.10	3.44	2.91	2.74	2.10	0.68
ENE	1.89	2.69	3.55	4.23	3.73	3.05	2.16	0.69
E	1.81	2.60	3.78	4.72	4.34	3.17	2.12	0.67
ESE	1.93	2.60	3.83	4.54	3.71	2.95	2.02	0.68
SE	1.82	2.65	3.72	4.07	3.50	2.79	1.99	0.68
SSE	1.84	2.80	4.04	4.38	3.73	2.79	1.97	0.66
S	1.77	2.77	3.94	4.79	4.02	3.00	2.09	0.70
SSW	1.84	3.02	4.45	5.53	4.91	3.14	2.01	0.67
SW	1.90	2.80	4.42	5.63	4.10	3.40	2.14	0.68
WSW	1.94	2.80	3.88	4.92	3.62	3.36	2.24	0.68
W	1.88	2.83	4.00	5.51	4.94	3.89	2.33	0.67
WNW	1.89	2.92	4.11	6.35	5.75	3.97	2.30	0.67
NW	1.85	2.51	3.97	5.58	4.98	3.97	2.28	0.64
NNW	1.87	2.52	4.20	5.52	5.28	3.96	2.26	0.65

*Day
**Night

TABLE II

ANNUAL PERCENTAGE FREQUENCY OF OCCURRENCE WIND DIRECTIONS BY SPEED GROUPS

Fort Smith, Arkansas Municipal Airport
Period of Record: March 1953 through February 1963

Direction	Speed Groups (Knots) 1-3	4-10	11-21	22-27	28-40	41+	Total No. of Observations %	Obs.	Mean Wind Speed
N	.3	2.4	.8	.0			3.5	3063	8.0
NNE	.5	2.4	.4				3.3	2883	6.6
NE	2.2	12.7	.4	.0	.0		15.3	13381	5.5
ENE	1.6	14.5	1.5	.0			17.6	15426	6.8
E	.9	6.9	1.8	.0			9.6	8423	7.7
ESE	.3	2.1	.3				2.7	2327	6.8
SE	.4	2.3	.3				3.0	2648	6.6
SSE	.2	1.4	.3	.0			1.9	1696	7.1
S	.4	2.6	.8	.0	.0		3.7	3273	7.7
SSW	.3	2.6	1.5	.0			4.4	3865	9.1
SW	.6	3.6	1.9	.0	.0	.0	6.1	5324	8.8
WSW	.4	3.1	.8	.0	.0		4.3	3736	7.6
W	.6	4.9	1.3	.0	.0		6.8	5992	7.9
WNW	.2	2.8	1.3	.0			4.3	3780	9.0
NW	.3	2.6	1.0	.0			3.8	3364	8.4
NNW	.1	1.9	.6	.0			2.7	2322	8.4
Calm							7.0	6105	
TOTALS	9.4	68.6	14.9	.2	.0	.0	100.0	87608	6.8

TABLE III

POPULATION DISTRIBUTION WITHIN A 10-MILE RADIUS OF THE KERR McGEE SEQUOYAH PLANT

Based on 1970 U. S. Census

Direction	Distance in Miles 0-1	1-2	2-3	3-4	4-5	5-10	Totals
N	3	9	3	12	42	303	372
NNE	3	6	21	9	6	143	188
NE	9	3	0	6	3	309	330
ENE	12	15	3	15	6	190	241
E	3	27	33	24	53	1422	1562
ESE	0	15	36	50	3	241	345
SE	0	6	3	48	15	53	125
SSE	6	9	6	0	0	33	54
S	3	12	0	0	12	12	39
SSW	0	3	0	3	30	119	155
SW	3	0	0	12	6	160	181
WSW	3	0	6	9	3	122	143
W	0	0	24	202	27	176	429
WNW	3	0	170	164	5	70	412
NW	3	18	489	46	27	103	686
NNW	3	3	14	49	19	122	210
Totals	54	126	808	649	257	3578	5472
Cumulative Totals	54	180	988	1637	1894	5472	

TABLE IV

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

METEOROLOGICAL DATA IS FROM FORT SMITH, ARKANSAS
FOR THE PERIOD OF RECORD; JANUARY 1960 THROUGH DECEMBER 1964
WITH A COMPOSITE OF 43847 HOURLY OBSERVATIONS

AVERAGE ANNUAL GROUND RELEASE RELATIVE
CONCENTRATIONS IN SECONDS PER CUBIC METER

PER DISTANCE IN METERS AND GEOGRAPHIC DIRECTION FROM PLANT SITE

METERS

DIRECTION	805	2414	4023	5633	7242
N	3.31E-06	5.37E-07	2.58E-07	1.55E-07	1.04E-07
NNE	3.12E-06	5.06E-07	2.43E-07	1.46E-07	9.73E-08
NE	5.63E-06	9.22E-07	4.45E-07	2.68E-07	1.79E-07
ENE	5.18E-06	8.48E-07	4.10E-07	2.46E-07	1.65E-07
E	3.02E-06	4.90E-07	2.34E-07	1.40E-07	9.34E-08
ESE	1.48E-06	2.36E-07	1.11E-07	6.60E-08	4.39E-08
SE	1.91E-06	3.09E-07	1.48E-07	8.83E-08	5.89E-08
SSE	1.58E-06	2.56E-07	1.22E-07	7.28E-08	4.85E-08
S	3.77E-06	6.17E-07	2.98E-07	1.79E-07	1.20E-07
SSW	8.35E-06	1.38E-06	6.68E-07	4.03E-07	2.70E-07
SW	1.93E-05	3.18E-06	1.54E-06	9.29E-07	6.23E-07
WSW	1.32E-05	2.16E-06	1.04E-06	6.22E-07	4.16E-07
W	6.77E-06	1.10E-06	5.29E-07	3.17E-07	2.12E-07
WNW	3.47E-06	5.65E-07	2.71E-07	1.63E-07	1.09E-07
NW	4.45E-06	7.27E-07	3.50E-07	2.11E-07	1.41E-07
NNW	2.22E-06	3.61E-07	1.74E-07	1.04E-07	6.96E-08

METERS

DIRECTION	12070	24140	40233	56326	72419
N	4.97E-08	1.95E-08	9.80E-09	6.30E-09	4.56E-09
NNE	4.65E-08	1.82E-08	9.13E-09	5.87E-09	4.25E-09
NE	8.61E-08	3.39E-08	1.71E-08	1.10E-08	7.95E-09
ENE	7.92E-08	3.12E-08	1.57E-08	1.01E-06	7.32E-09
E	4.46E-08	1.74E-08	8.69E-09	5.57E-09	4.03E-09
ESE	2.08E-08	7.94E-09	3.93E-09	2.[illegible]1E-09	1.81E-09
SE	2.81E-08	1.09E-08	5.44E-09	3.48E-09	2.52E-09
SSE	2.31E-08	8.96E-09	4.47E-09	2.86E-09	2.06E-09
S	5.74E-08	2.26E-08	1.14E-08	7.29E-09	5.28E-09
SSW	1.30E-07	5.15E-08	2.60E-08	1.67E-08	1.21E-08
SW	2.99E-07	1.18E-07	5.97E-08	3.84E-08	2.78E-08
WSW	1.99E-07	7.78E-08	3.90E-08	2.50E-08	1.81E-08
W	1.01E-07	3.94E-08	1.97E-08	1.26E-08	9.14E-09
WNW	5.20E-08	2.04E-08	1.02E-08	6.56E-09	4.75E-09
NW	6.75E-08	2.65E-08	1.33E-08	8.57E-09	6.21E-09
NNW	3.33E-08	1.31E-08	6.55E-09	4.21E-09	3.05E-09

TABLE V

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

METEOROLOGICAL DATA IS FROM FORT SMITH,ARKANSAS
FOR THE PERIOD OF RECORD;JANUARY 1960 THROUGH DECEMBER 1964
WITH A COMPOSITE OF 43847 HOURLY OBSERVATIONS

AVERAGE ANNUAL ELEVATED RELEASE RELATIVE
CONCENTRATIONS IN SECONDS PER CUBIC METER

PER DISTANCE IN METERS AND GEOGRAPHIC DIRECTION FROM PLANT SITE

METERS

DIRECTION	805	2414	4023	5633	7242
N	1.29E-07	5.21E-08	3.28E-08	2.50E-08	2.04E-08
NNE	1.41E-07	5.34E-08	3.23E-08	2.40E-08	1.94E-08
NE	1.65E-07	6.45E-08	4.22E-08	3.39E-08	2.93E-08
ENE	1.46E-07	6.21E-08	4.15E-08	3.33E-08	2.85E-08
E	1.39E-07	6.36E-08	3.83E-08	2.77E-08	2.17E-08
ESE	1.18E-07	4.85E-08	2.72E-08	1.83E-08	1.35E-08
SE	1.04E-07	4.34E-08	2.53E-08	1.79E-08	1.39E-08
SSE	8.74E-08	3.76E-08	2.19E-08	1.54E-08	1.19E-08
S	1.03E-07	5.07E-08	3.31E-08	2.59E-08	2.16E-08
SSW	1.10E-07	6.99E-08	5.30E-08	4.60E-08	4.12E-08
SW	3.12E-07	1.78E-07	1.30E-07	1.11E-07	9.78E-08
WSW	5.01E-07	2.27E-07	1.41E-07	1.05E-07	8.48E-08
W	2.85E-07	1.26E-07	7.56E-08	5.52E-08	4.40E-08
WNW	1.40E-07	5.83E-08	3.57E-08	2.66E-08	2.16E-08
NW	1.48E-07	6.08E-08	3.86E-08	2.99E-08	2.51E-08
NNW	9.12E-08	3.67E-08	2.25E-08	1.69E-08	1.37E-08

METERS

DIRECTION	12070	24140	40233	56326	72419
N	1.27E-08	6.11E-09	3.45E-09	2.34E-09	1.75E-09
NNE	1.20E-08	5.70E-09	3.21E-09	2.18E-09	1.63E-09
NE	1.94E-08	9.78E-09	5.65E-09	3.88E-09	2.92E-09
ENE	1.86E-08	9.24E-09	5.30E-09	3.63E-09	2.73E-09
E	1.28E-08	5.84E-09	3.22E-09	2.16E-09	1.61E-09
ESE	7.37E-09	3.11E-09	1.64E-09	1.08E-09	7.94E-10
SE	8.14E-09	3.69E-09	2.03E-09	1.36E-09	1.01E-09
SSE	6.90E-09	3.10E-09	1.69E-09	1.13E-09	8.38E-10
S	1.39E-08	6.80E-09	3.87E-09	2.64E-09	1.98E-09
SSW	2.83E-08	1.45E-08	8.46E-09	5.82E-09	4.38E-09
SW	6.62E-08	3.38E-08	1.96E-08	1.35E-08	1.01E-08
WSW	5.21E-08	2.46E-08	1.38E-08	9.34E-09	6.98E-09
W	2.68E-08	1.26E-08	7.02E-09	4.74E-09	3.54E-09
WNW	1.34E-08	6.37E-09	3.58E-09	2.43E-09	1.82E-09
NW	1.61E-08	7.92E-09	4.53E-09	3.09E-09	2.32E-09
NNW	8.53E-09	4.08E-09	2.30E-09	1.56E-09	1.17E-09

TABLE VI

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

KIDNEY DOSE IS IN MILLI REM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES				
DIRECTION	0-1	1-2	2-3	3-4	4-5
N	1.19E-01	2.49E-02	1.33E-02	8.92E-03	6.63E-03
NNE	1.16E-01	2.42E-02	1.28E-02	8.47E-03	6.26E-03
NE	1.94E-01	3.83E-02	2.04E-02	1.38E-02	1.04E-02
ENE	1.77E-01	3.57E-02	1.93E-02	1.31E-02	9.83E-03
E	1.13E-01	2.55E-02	1.36E-02	8.95E-03	6.54E-03
ESE	6.40E-02	1.54E-02	8.03E-03	5.15E-03	3.66E-03
SE	7.43E-02	1.67E-02	8.76E-03	5.73E-03	4.16E-03
SSE	6.16E-02	1.41E-02	7.42E-03	4.84E-03	3.51E-03
S	1.28E-01	2.70E-02	1.45E-02	9.77E-03	7.30E-03
SSW	2.64E-01	5.26E-02	2.89E-02	1.99E-02	1.51E-02
SW	6.20E-01	1.24E-01	6.80E-02	4.66E-02	3.54E-02
WSW	4.75E-01	1.03E-01	5.51E-02	3.66E-02	2.70E-02
W	2.48E-01	5.45E-02	2.88E-02	1.90E-02	1.39E-02
WNW	1.26E-01	2.68E-02	1.42E-02	9.44E-03	6.97E-03
NW	1.56E-01	3.20E-02	1.70E-02	1.14E-02	8.52E-03
NNW	8.11E-02	1.70E-02	9.04E-03	6.01E-03	4.45E-03

	MILES				
DIRECTION	5-10	10-20	20-30	30-40	40-50
N	3.69E-03	1.64E-03	8.92E-04	5.95E-04	4.41E-04
NNE	3.47E-03	1.53E-03	8.31E-04	5.55E-04	4.11E-04
NE	5.93E-03	2.71E-03	1.49E-03	1.00E-03	7.46E-04
ENE	5.58E-03	2.54E-03	1.39E-03	9.33E-04	6.93E-04
E	3.55E-03	1.53E-03	8.19E-04	5.42E-04	4.00E-04
ESE	1.90E-03	7.78E-04	4.03E-04	2.63E-04	1.92E-04
SE	2.25E-03	9.68E-04	5.15E-04	3.41E-04	2.51E-04
SSE	1.89E-03	8.06E-04	4.27E-04	2.82E-04	2.08E-04
S	4.12E-03	1.85E-03	1.01E-03	6.77E-04	5.02E-04
SSW	8.77E-03	4.06E-03	2.24E-03	1.51E-03	1.12E-03
SW	2.04E-02	9.40E-03	5.18E-03	3.49E-03	2.59E-03
WSW	1.50E-02	6.60E-03	3.56E-03	2.37E-03	1.76E-03
W	7.67E-03	3.36E-03	1.81E-03	1.20E-03	8.89E-04
WNW	3.87E-03	1.71E-03	9.28E-04	6.19E-04	4.59E-04
NW	4.81E-03	2.17E-03	1.19E-03	7.94E-04	5.90E-04
NNW	2.47E-03	1.10E-03	5.95E-04	3.97E-04	2.94E-04

TABLE VII

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

LUNG DOSE IS IN MILLI REM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

MILES

DIRECTION	0-1	1-2	2-3	3-4	4-5
N	1.92E+00	3.12E-01	1.50E-01	9.01E-02	6.03E-02
NNE	1.81E+00	2.94E-01	1.41E-01	8.46E-02	5.66E-02
NE	3.27E+00	5.35E-01	2.58E-01	1.55E-01	1.04E-01
ENE	3.00E+00	4.92E-01	2.38E-01	1.43E-01	9.59E-02
E	1.75E+00	2.84E-01	1.36E-01	8.13E-02	5.43E-02
ESE	8.56E-01	1.37E-01	6.47E-02	3.84E-02	2.55E-02
SE	1.11E+00	1.80E-01	8.58E-02	5.13E-02	3.42E-02
SSE	9.17E-01	1.48E-01	7.08E-02	4.23E-02	2.82E-02
S	2.18E+00	3.58E-01	1.73E-01	1.04E-01	6.96E-02
SSW	4.84E+00	7.99E-01	3.88E-01	2.34E-01	1.57E-01
SW	1.12E+01	1.84E+00	8.95E-01	5.39E-01	3.62E-01
WSW	7.68E+00	1.25E+00	6.02E-01	3.61E-01	2.41E-01
W	3.93E+00	6.41E-01	3.07E-01	1.84E-01	1.23E-01
WNW	2.01E+00	3.28E-01	1.58E-01	9.45E-02	6.32E-02
NW	2.58E+00	4.22E-01	2.03E-01	1.22E-01	8.18E-02
NNW	1.29E+00	2.10E-01	1.01E-01	6.05E-02	4.04E-02

MILES

DIRECTION	5-10	10-20	20-30	30-40	40-50
N	2.89E-02	1.14E-02	5.71E-03	3.67E-03	2.66E-03
NNE	2.71E-02	1.06E-02	5.32E-03	3.42E-03	2.47E-03
NE	5.00E-02	1.[illegible]7E-02	9.94E-03	6.40E-03	4.63E-03
ENE	4.60E-02	1.82E-02	9.15E-03	5.89E-03	4.27E-03
E	2.59E-02	1.01E-02	5.06E-03	3.25E-03	2.35E-03
ESE	1.21E-02	4.63E-03	2.29E-03	1.46E-03	1.05E-03
SE	1.63E-02	6.34E-03	3.17E-03	2.03E-03	1.47E-03
SSE	1.35E-02	5.22E-03	2.60E-03	1.66E-03	1.20E-03
S	3.34E-02	1.31E-02	6.61E-03	4.25E-03	3.07E-03
SSW	7.55E-02	2.99E-02	1.51E-02	9.73E-03	7.05E-03
SW	1.74E-01	6.89E-02	3.47E-02	2.24E-02	1.62E-02
WSW	1.16E-01	4.53E-02	2.27E-02	1.46E-02	1.05E-02
W	5.88E-02	2.29E-02	1.15E-02	7.36E-03	5.32E-03
WNW	3.03E-02	1.19E-02	5.95E-03	3.82E-03	2.76E-03
NW	3.93E-02	1.54E-02	7.77E-03	4.99E-03	3.62E-03
NNW	1.94E-02	7.60E-03	3.82E-03	2.45E-03	1.77E-03

TABLE VIII

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

BONE DOSE IS IN MILLI REM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES				
DIRECTION	0-1	1-2	2-3	3-4	4-5
N	2.98E-02	6.22E-03	3.33E-03	2.23E-03	1.66E-03
NNE	2.90E-02	6.04E-03	3.19E-03	2.12E-03	1.56E-03
NE	4.85E-02	9.58E-03	5.11E-03	3.45E-03	2.60E-03
ENE	4.43E-02	8.93E-03	4.82E-03	3.27E-03	2.46E-03
E	2.82E-02	6.37E-03	3.39E-03	2.24E-03	1.63E-03
ESE	1.60E-02	3.85E-03	2.01E-03	1.29E-03	9.14E-04
SE	1.86E-02	4.17E-03	2.19E-03	1.43E-03	1.04E-03
SSE	1.54E-02	3.52E-03	1.85E-03	1.21E-03	8.77E-04
S	3.21E-02	6.74E-03	3.63E-03	2.44E-03	1.83E-03
SSW	6.59E-02	1.31E-02	7.22E-03	4.97E-03	3.79E-03
SW	1.55E-01	3.11E-02	1.70E-02	1.16E-02	8.85E-03
WSW	1.19E-01	2.58E-02	1.38E-02	9.16E-03	6.76E-03
W	6.21E-02	1.36E-02	7.19E-03	4.74E-03	3.48E-03
WNW	3.16E-02	6.69E-03	3.55E-03	2.36E-03	1.74E-03
NW	3.91E-02	7.99E-03	4.26E-03	2.85E-03	2.13E-03
NNW	2.03E-02	4.25E-03	2.26E-03	1.50E-03	1.11E-03

	MILES				
DIRECTION	5-10	10-20	20-30	30-40	40-50
N	9.23E-04	4.11E-04	2.23E-04	1.49E-04	1.10E-04
NNE	8.67E-04	3.84E-04	2.08E-04	1.39E-04	1.03E-04
NE	1.48E-03	6.78E-04	3.73E-04	2.51E-04	1.87E-04
ENE	1.39E-03	6.34E-04	3.48E-04	2.33E-04	1.73E-04
E	8.87E-04	3.83E-04	2.05E-04	1.36E-04	1.00E-04
ESE	4.76E-04	1.95E-04	1.01E-04	6.56E-05	4.81E-05
SE	5.63E-04	2.42E-04	1.29E-04	8.51E-05	6.28E-05
SSE	4.72E-04	2.01E-04	1.07E-04	7.04E-05	5.19E-05
S	1.03E-03	4.64E-04	2.53E-04	1.69E-04	1.26E-04
SSW	2.19E-03	1.02E-03	5.61E-04	3.78E-04	2.81E-04
SW	5.10E-03	2.35E-03	1.30E-03	8.72E-04	6.48E-04
WSW	3.74E-03	1.65E-03	8.91E-04	5.93E-04	4.39E-04
W	1.92E-03	8.40E-04	4.52E-04	3.00E-04	2.22E-04
WNW	9.67E-04	4.28E-04	2.32E-04	1.55E-04	1.15E-04
NW	1.20E-03	5.42E-04	2.96E-04	1.98E-04	1.47E-04
NNW	6.18E-04	2.74E-04	1.49E-04	9.93E-05	7.36E-05

TABLE IX

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

AVERAGE ANNUAL FLUORIDE CONCENTRATIONS
IN MICRO-GRAMS PER CUBIC METER FROM BOTH AN
ELEVATED AND GROUND ROUTINE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES				
DIRECTION	0-1	1-2	2-3	3-4	4-5
N	2.87E-02	8.40E-03	4.97E-03	3.62E-03	2.87E-03
NNE	2.94E-02	8.43E-03	4.85E-03	3.46E-03	2.72E-03
NE	4.24E-02	1.14E-02	6.85E-03	5.14E-03	4.23E-03
ENE	3.83E-02	1.08E-02	6.62E-03	4.98E-03	4.07E-03
E	2.87E-02	9.59E-03	5.54E-03	3.88E-03	2.97E-03
ESE	2.01E-02	6.77E-03	3.71E-03	2.47E-03	1.80E-03
SE	2.02E-02	6.44E-03	3.62E-03	2.50E-03	1.90E-03
SSE	1.68E-02	5.54E-03	3.12E-03	2.15E-03	1.62E-03
S	2.74E-02	8.55E-03	5.16E-03	3.82E-03	3.08E-03
SSW	4.66E-02	1.39E-02	9.04E-03	7.13E-03	6.03E-03
SW	1.15E-01	3.41E-02	2.18E-02	1.70E-02	1.42E-02
WSW	1.13E-01	3.59E-02	2.10E-02	1.51E-02	1.18E-02
W	6.14E-02	1.95E-02	1.12E-02	7.90E-03	6.13E-03
WNW	3.07E-02	9.25E-03	5.37E-03	3.85E-03	3.02E-03
NW	3.56E-02	1.02E-02	6.03E-03	4.43E-03	3.57E-03
NNW	1.98E-02	5.84E-03	3.40E-03	2.44E-03	1.93E-03

	MILES				
DIRECTION	5-10	10-20	20-30	30-40	40-50
N	1.73E-03	8.11E-04	4.53E-04	3.06E-04	2.29E-04
NNE	1.62E-03	7.57E-04	4.22E-04	2.85E-04	2.13E-04
NE	2.67E-03	1.31E-03	7.46E-04	5.10E-04	3.83E-04
ENE	2.55E-03	1.23E-03	6.99E-04	4.76E-04	3.56E-04
E	1.71E-03	7.70E-04	4.21E-04	2.81E-04	2.09E-04
ESE	9.67E-04	4.05E-04	2.13E-04	1.39E-04	1.03E-04
SE	1.09E-03	4.87E-04	2.65E-04	1.77E-04	1.31E-04
SSE	9.20E-04	4.07E-04	2.21E-04	1.47E-04	1.09E-04
S	1.89E-03	9.06E-04	5.10E-04	3.46E-04	2.59E-04
SSW	3.91E-03	1.95E-03	1.12E-03	7.65E-04	5.75E-04
SW	9.14E-03	4.53E-03	2.59E-03	1.77E-03	1.33E-03
WSW	7.04E-03	3.27E-03	1.81E-03	1.22E-03	9.10E-04
W	3.62E-03	1.67E-03	9.21E-04	6.19E-04	4.61E-04
WNW	1.81E-03	8.45E-04	4.71E-04	3.18E-04	2.37E-04
NW	2.20E-03	1.06E-03	5.97E-04	4.05E-04	3.04E-04
NNW	1.16E-03	5.41E-04	3.02E-04	2.04E-04	1.52E-04

TABLE X

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

AVERAGE ANNUAL SULFUR DIOXIDE CONCENTRATIONS IN
MICRO-GRAMS PER CUBIC METER FROM AN ELEVATED ROUTINE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

MILES

DIRECTION	0-1	1-2	2-3	3-4	4-5
N	3.36E-02	1.35E-02	8.53E-03	6.49E-03	5.32E-03
NNE	3.66E-02	1.39E-02	8.39E-03	6.24E-03	5.05E-03
NE	4.30E-02	1.68E-02	1.10E-02	8.82E-03	7.61E-03
ENE	3.80E-02	1.61E-02	1.08E-02	8.66E-03	7.40E-03
E	3.61E-02	1.65E-02	9.97E-03	7.19E-03	5.63E-03
ESE	3.07E-02	1.26E-02	7.07E-03	4.77E-03	3.52E-03
SE	2.71E-02	1.13E-02	6.57E-03	4.66E-03	3.61E-03
SSE	2.27E-02	9.78E-03	5.70E-03	4.02E-03	3.09E-03
S	2.67E-02	1.32E-02	8.60E-03	6.72E-03	5.63E-03
SSW	2.85E-02	1.82E-02	1.38E-02	1.20E-02	1.07E-02
SW	8.11E-02	4.64E-02	3.39E-02	2.87E-02	2.54E-02
WSW	1.30E-01	5.91E-02	3.66E-02	2.73E-02	2.20E-02
W	7.42E-02	3.28E-02	1.97E-02	1.44E-02	1.15E-02
WNW	3.64E-02	1.52E-02	9.28E-03	6.92E-03	5.61E-03
NW	3.84E-02	1.58E-02	1.00E-02	7.78E-03	6.51E-03
NNW	2.37E-02	9.53E-03	5.86E-03	4.39E-03	3.57E-03

MILES

DIRECTION	5-10	10-20	20-30	30-40	40-50
N	3.31E-03	1.59E-03	8.96E-04	6.08E-04	4.56E-04
NNE	3.12E-03	1.48E-03	8.35E-04	5.67E-04	4.25E-04
NE	5.05E-03	2.54E-03	1.47E-03	1.01E-03	7.60E-04
ENE	4.83E-03	2.40E-03	1.38E-03	9.43E-04	7.09E-04
E	3.32E-03	1.52E-03	8.36E-04	5.62E-04	4.18E-04
ESE	1.92E-03	8.08E-04	4.27E-04	2.80E-04	2.06E-04
SE	2.12E-03	9.60E-04	5.28E-04	3.53E-04	2.63E-04
SSE	1.79E-03	8.05E-04	4.39E-04	2.93E-04	2.18E-04
S	3.61E-03	1.77E-03	1.01E-03	6.86E-04	5.15E-04
SSW	7.35E-03	3.78E-03	2.20E-03	1.51E-03	1.14E-03
SW	1.72E-02	8.78E-03	5.09E-03	3.50E-03	2.63E-03
WSW	1.35E-02	6.40E-03	3.59E-03	2.43E-03	1.81E-03
W	6.97E-03	3.27E-03	1.82E-03	1.23E-03	9.20E-04
WNW	3.47E-03	1.66E-03	9.32E-04	6.32E-04	4.73E-04
NW	4.19E-03	2.06E-03	1.18E-03	8.04E-04	6.04E-04
NNW	2.22E-03	1.06E-03	5.97E-04	4.06E-04	3.04E-04

TABLE XI

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

AVERAGE ANNUAL NITROGEN OXIDES CONCENTRATIONS IN
MICRO-GRAMS PER CUBIC METER FROM AN ELEVATED ROUTINE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES				
DIRECTION	0-1	1-2	2-3	3-4	4-5
N	2.56E-01	1.03E-01	6.50E-02	4.94E-02	4.05E-02
NNE	2.79E-01	1.06E-01	6.39E-02	4.75E-02	3.84E-02
NE	3.27E-01	1.28E-01	8.36E-02	6.72E-02	5.79E-02
ENE	2.90E-01	1.23E-01	8.22E-02	6.60E-02	5.63E-02
E	2.75E-01	1.26E-01	7.59E-02	5.48E-02	4.29E-02
ESE	2.34E-01	9.61E-02	5.39E-02	3.63E-02	2.68E-02
SE	2.07E-01	8.58E-02	5.01E-02	3.55E-02	2.75E-02
SSE	1.73E-01	7.45E-02	4.34E-02	3.06E-02	2.35E-02
S	2.03E-01	1.00E-01	6.55E-02	5.12E-02	4.29E-02
SSW	2.17E-01	1.38E-01	1.05E-01	9.11E-02	8.16E-02
SW	6.18E-01	3.53E-01	2.58E-01	2.19E-01	1.94E-01
WSW	9.91E-01	4.50E-01	2.79E-01	2.08E-01	1.68E-01
W	5.65E-01	2.50E-01	1.50E-01	1.09E-01	8.72E-02
WNW	2.78E-01	1.15E-01	7.06E-02	5.27E-02	4.27E-02
NW	2.93E-01	1.20E-01	7.64E-02	5.92E-02	4.96E-02
NNW	1.81E-01	7.26E-02	4.46E-02	3.34E-02	2.72E-02

	MILES				
DIRECTION	5-10	10-20	20-30	30-40	40-50
N	2.52E-02	1.21E-02	6.82E-03	4.63E-03	3.47E-03
NNE	2.37E-02	1.13E-02	6.36E-03	4.32E-03	3.23E-03
NE	3.85E-02	1.94E-02	1.12E-02	7.68E-03	5.79E-03
ENE	3.68E-02	1.83E-02	1.05E-02	7.18E-03	5.40E-03
E	2.53E-02	1.16E-02	6.37E-03	4.26E-03	3.18E-03
ESE	1.46E-02	6.15E-03	3.25E-03	2.13E-03	1.57E-03
SE	1.61E-02	7.31E-03	4.02E-03	2.69E-03	2.00E-03
SSE	1.37E-02	6.13E-03	3.35E-03	2.23E-03	1.66E-03
S	2.75E-02	1.35E-02	7.67E-03	5.22E-03	3.92E-03
SSW	5.60E-02	2.88E-02	1.67E-02	1.15E-02	8.68E-03
SW	1.31E-01	6.69E-02	3.88E-02	2.66E-02	2.01E-02
WSW	1.03E-01	4.88E-02	2.73E-02	1.85E-02	1.38E-02
W	5.31E-02	2.49E-02	1.39E-02	9.38E-03	7.01E-03
WNW	2.64E-02	1.26E-02	7.10E-03	4.81E-03	3.60E-03
NW	3.19E-02	1.57E-02	8.96E-03	6.12E-03	4.60E-03
NNW	1.69E-02	8.07E-03	4.55E-03	3.09E-03	2.31E-03

TABLE XII

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

KIDNEY DOSE IS IN MANREM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

MILES

DIRECTION	0-1	1-2	2-3	3-4	4-5	5-10	TOTALS
N	3.58E-04	2.24E-04	4.00E-05	1.07E-04	2.78E-04	1.12E-03	2.13E-03
NNE	3.48E-04	1.45E-04	2.68E-04	7.63E-05	3.75E-05	4.96E-04	1.37E-03
NE	1.75E-03	1.15E-04	0.	8.28E-05	3.12E-05	1.83E-03	3.81E-03
ENE	2.13E-03	5.36E-04	5.78E-05	1.96E-04	5.90E-05	1.06E-03	4.04E-03
E	3.38E-04	6.88E-04	4.48E-04	2.15E-04	3.46E-04	5.04E-03	7.08E-03
ESE	0.	2.31E-04	2.89E-04	2.58E-04	1.10E-05	4.58E-04	1.25E-03
SE	0.	1.00E-04	2.63E-05	2.75E-04	6.24E-05	1.19E-04	5.83E-04
SSE	3.70E-04	1.27E-04	4.45E-05	0.	0.	6.23E-05	6.03E-04
S	3.85E-04	3.24E-04	0.	0.	8.76E-05	4.94E-05	8.46E-04
SSW	0.	1.58E-04	0.	5.96E-05	4.54E-04	1.04E-03	1.71E-03
SW	1.86E-03	0.	0.	5.59E-04	2.12E-04	3.26E-03	5.89E-03
WSW	1.43E-03	0.	3.30E-04	3.30E-04	8.11E-05	1.82E-03	3.99E-03
W	0.	0.	6.90E-04	3.83E-03	3.76E-04	1.35E-03	6.25E-03
WNW	3.79E-04	0.	2.42E-03	1.55E-03	3.49E-05	2.71E-04	4.65E-03
NW	4.69E-04	5.75E-04	8.33E-03	5.25E-04	2.30E-04	4.95E-04	1.06E-02
NNW	2.43E-04	5.10E-05	1.27E-04	2.95E-04	8.45E-05	3.02E-04	1.10E-03
TOTALS	1.00E-02	3.27E-03	1.31E-02	8.36E-03	2.39E-03	1.88E-02	5.59E-02
CUMULATIVE TOTALS	1.00E-02	1.33E-02	2.64E-02	3.47E-02	3.71E-02	5.59E-02	

TABLE XIII

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

LUNG DOSE IS IN MANREM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES						
DIRECTION	0-1	1-2	2-3	3-4	4-5	5-10	TOTALS
N	5.75E-03	2.80E-03	4.50E-04	1.08E-03	2.53E-03	8.76E-03	2.14E-02
NNE	5.42E-03	1.76E-03	2.96E-03	7.61E-04	3.39E-04	3.87E-03	1.51E-02
NE	2.94E-02	1.60E-03	0.	9.33E-04	3.13E-04	1.55E-02	4.77E-02
ENE	3.60E-02	7.38E-03	7.13E-04	2.15E-03	5.75E-04	8.75E-03	5.56E-02
E	5.25E-03	7.67E-03	4.49E-03	1.95E-03	2.88E-03	3.69E-02	5.91E-02
ESE	0.	2.05E-03	2.33E-03	1.92E-03	7.66E-05	2.92E-03	9.30E-03
SE	0.	1.08E-03	2.57E-04	2.46E-03	5.13E-04	8.66E-04	5.18E-03
SSE	5.50E-03	1.34E-03	4.25E-04	0.	0.	4.44E-04	7.71E-03
S	6.55E-03	4.30E-03	0.	0.	8.35E-04	4.01E-04	1.21E-02
SSW	0.	2.40E-03	0.	7.01E-04	4.71E-03	8.98E-03	1.68E-02
SW	3.36E-02	0.	0.	6.47E-03	2.17E-03	2.78E-02	7.00E-02
WSW	2.30E-02	0.	3.61E-03	3.25E-03	7.24E-04	1.41E-02	4.47E-02
W	0.	0.	7.37E-03	3.72E-02	3.32E-03	1.04E-02	5.82E-02
WNW	6.04E-03	0.	2.68E-02	1.55E-02	3.16E-04	2.12E-03	5.07E-02
NW	7.74E-03	7.59E-03	9.94E-02	5.62E-03	2.21E-03	4.04E-03	1.27E-01
NNW	3.87E-03	6.29E-04	1.41E-03	2.96E-03	7.69E-04	2.36E-03	1.20E-02
TOTALS	1.68E-01	4.06E-02	1.50E-01	8.29E-02	2.23E-02	1.48E-01	6.12E-01
CUMULATIVE TOTALS	1.68E-01	2.09E-01	3.59E-01	4.42E-01	4.64E-01	6.12E-01	

TABLE XIV

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

BONE DOSE IS IN MANREM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES						
DIRECTION	0-1	1-2	2-3	3-4	4-5	5-10	TOTALS
N	8.95E-05	5.59E-05	9.99E-06	2.68E-05	6.96E-05	2.80E-04	5.32E-04
NNE	8.70E-05	3.63E-05	6.71E-05	1.91E-05	9.38E-06	1.24E-04	3.43E-04
NE	4.36E-04	2.37E-05	0.	2.07E-05	7.79E-06	4.58E-04	9.52E-04
ENE	5.32E-04	1.34E-04	1.45E-05	4.90E-05	1.47E-05	2.65E-04	1.01E-03
E	8.45E-05	1.72E-04	1.12E-04	5.37E-05	8.66E-05	1.26E-03	1.77E-03
ESE	0.	5.78E-05	7.23E-05	6.44E-05	2.74E-06	1.15E-04	3.12E-04
SE	0.	2.50E-05	6.57E-06	6.88E-05	1.56E-05	2.98E-05	1.46E-04
SSE	9.24E-05	3.17E-05	1.11E-05	0.	0.	1.56E-05	1.51E-04
S	9.62E-05	8.09E-05	0.	0.	2.19E-05	1.24E-05	2.11E-04
SSW	0.	3.94E-05	0.	1.49E-05	1.14E-04	2.61E-04	4.29E-04
SW	4.65E-04	0.	0.	1.40E-04	5.31E-05	8.15E-04	1.47E-03
WSW	3.56E-04	0.	8.26E-05	8.24E-05	2.03E-05	4.56E-04	9.98E-04
W	0.	0.	1.73E-04	9.58E-04	9.40E-05	3.37E-04	1.56E-03
WNW	9.47E-05	0.	6.04E-04	3.87E-04	8.71E-06	6.77E-05	1.16E-03
NW	1.17E-04	1.44E-04	2.08E-03	1.31E-04	5.75E-05	1.24E-04	2.66E-03
NNW	6.08E-05	1.28E-05	3.16E-05	7.37E-05	2.11E-05	7.54E-05	2.75E-04
TOTALS	2.51E-03	8.18E-04	3.27E-03	2.09E-03	5.97E-04	4.70E-03	1.40E-02
CUMULATIVE TOTALS	2.51E-03	3.33E-03	6.60E-03	8.69E-03	9.28E-03	1.40E-02	

REFERENCES

(1) Wind Distribution by Pasquill Stability Classes (S and L Program); Fort Smith, Arkansas, Job Number 13520; U. S. Department of Commerce, NOAA, EDS; May 12, 1972.

(2) Conversion of Hourly Wind Data to Pasquill Classes; D. B. Turner; U. S. Public Health Service; 1962, unpublished.

(3) Uniform Summary of Surface Weather Observations, Part A, Fort Smith, Arkansas Municipal Airport, Data Processing Division Climatic Center USAF; August 1963.

(4) Written Correspondence between Mr. I. Spickler of Dames & Moore and Mr. A. Valentine of Kerr-McGee; May 1972.

(5) Recommended Guide for the Prediction of the Dispersion of Airborne Effluents, American Society of Mechanical Engineers; May 1968.

(6) Meteorology and Atomic Energy 1968, U. S. Atomic Energy Commission.

(7) D. F. Bunch, Dose to Various Body Organs from Inhalation or Ingestion of Soluble Radionuclides, IDO-12054.

(8) Safety Guide Number 4 - Assumptions Used for Evaluating the Potential Consequences of a Loss of Coolant Accident for Pressurized Water Reactors, USAEC; November 2, 1970.

M & M Protection Consultants
A Service of Marsh & McLennan Incorporated
231 South La Salle Street, Chicago, Illinois 60604 312/346-1400

MARSH & McLENNAN

APPENDIX V

INS. DEPT.
JAN 7 1972

January 5, 1972

Mr. Charles E. Hughes
Suite 1000
Leonhardt Building
228 Robert S. Kerr Avenue
Oklahoma City, Oklahoma 73102

Dear Charlie: SEQUOYAH FACILITY

Enclosed is a copy of a letter from the Factory Insurance Association to Automatic Sprinkler Corporation of America indicating that recent tests of the foam water system at the captioned plant meet the design criteria and is acceptable to the FIA.

Yours very truly,

C. V. Frisbie
Fire Protection Consultant

CVF/gh

cc: Mr. R. L. Slaughter
Mr. C. W. Dugan

Encl.

FORM 527 10M 11-71

FACTORY INSURANCE ASSOCIATION

WESTERN REGIONAL OFFICE
CHICAGO, ILL. 60606

COPY

cc: R. L. Knop - Marsh & McLennan, Chicago
Kansas City Office

December 27, 1971

Automatic Sprinkler Corporation
of America
835 Touhy Avenue
Park Ridge, Illinois

Attention: Mr. Hal Thompson

Re: Kerr-McGee Corporation
Sequoyah Facility
Near Vian, Oklahoma
FIA File No. W-49620-W

Dear Hal:

Please accept this letter as evidence that the recent changes to the foam-water system at subject location and full flow test of equipment meets the design criteria and is acceptable to this Association. We fully appreciate your efforts put forth to make this needed protection operate in a satisfactory manner. The full flow test results from the equipment, copies of which we have, speak for themselves.

Should you have any questions and/or comments on any of the above, do not hesitate to advise.

Yours very truly,

FACTORY INSURANCE ASSOCIATION

G. E. Vandarakis
Chemical Engineer

GEV:eg

DEC 2 [illegible]

SEQUOYAH FACILITY STANDARD OPERATING INSTRUCTIONS

Number E-008
Rev. 0

Subject EMERGENCY PROCEDURE FOR UF_6 RELEASE

INTRODUCTION

This procedure outlines the necessary steps and safety precautions to be taken in the event of a major UF_6 release. A major UF_6 release is characterized by dense clouds of heavy white smoke and for this procedure is defined as a release of UF_6 from a system or a vessel which is pressured above atmospheric.

SAFETY PRECAUTIONS

1. Dress with the proper safety equipment.
2. A fresh air mask or Chemox mask and an impermeable suit with a special hood should be used in major releases.
3. A gas mask is not adequate protection in a major release because of the high (above 2% by volume) concentration of UF_6 and the formation of HF.
4. Secure medical attention as soon as possible for any personnel exposed to the release without proper safety equipment. Personnel exposed to the release without proper safety equipment should flush affected parts with large quantities of water for at least fifteen minutes. If respiration is affected, oxygen should be administered until medical attention is secured. Any skin contact warrants first aid and medical attention.
5. Rope off the contaminated areas until decontamination is accomplished.
6. Use care not to direct water on the electrical lines or equipment when attempting to cool a cylinder with water.
7. When area decontamination is completed, personnel should shower and protective clothing should be changed.

PROCEDURE

I. Immediate action.

A. The shift supervisor is responsible for emergency actions.

B. Evacuate all personnel from the area of the release, including neighboring buildings, if necessary.

C. Isolate the system from which the release is occurr ng if it may be done quickly and safely.

D. Start any emergency ventilation available.

II. General action.

A. Put on the proper safety equipment.

B. Determine the location and cause of the release.

C. If possible, isolate the source of release by bordering valves.

D. Reduce the system or vessel pressure below atmospheric if possible.

E. Stop the leak, if at all possible, by physical means such as plug, tape, etc.

F. Clear the atmosphere in the release area as soon as possible.

G. Determine as nearly as possible the amount of inventory lost and inform the Production Manager.

III. Specific action.

A. If the release is from a cold trap:

1. Determine the source of the leak.

2. Cool the trap (per normal procedure) if the trap or associated valving is leaking.

3. Isolate the leak if possible.

4. Evacuate the leaking trap to any standby trap or any trap below atmospheric pressure.

5. Start all ventilating fans.

6. Repair the source of the leak as soon as possible.

B. If the release is from a drain station, pigtail or cylinder:

1. Follow the general procedure.

2. Evacuate the pigtail or cylinder via the drain line to a standby cold trap or, if necessary, to the onstream trap. Evacuation to an onstream trap will probably require shutdown of UF_6 production.

3. Cool the area near the leak with liquid nitrogen. Water may also be used. Water with UF_6 forms HF. Avoid getting the solution on the skin.

4. Make repairs as soon as practical.

C. If the release is from a ruptured cylinder:

1. Assemble the emergency equipment and personnel at a convenient point upwind of the cylinder involved.

2. Apply water to the cylinder for cooling. Water is to be applied quickly and in large quantities.

3. Determine the source of the leak and contain the leak by physical means such as wooden plug, tape, etc.

4. If the leak is too large to stop with wooden plugs or tape, consideration must be given to one of the following means:

    a. Apply liquid nitrogen to the cylinder.

    b. Cover the crack with liquid nitrogen.

    c. Apply and secure a patch over the crack or hole.

    d. Construct as needed a plywood fence or box to be used to hold cooling media (ice, etc.) against the cylinder.

    e. A tarpaulin may be helpful in holding the coolant close to the cylinder.

5. Decontaminate the area after the release is brought under control.

APPROVED: B. E. Brown DATE: January 23, 1970.

APPENDIX VII

KERR-McGEE CORPORATION
Driver or Carrier Instruction

TO ACCOMPANY VEHICLE FROM POINT OF ORIGIN TO DESTINATION
Your cargo is uranium hexafluoride.
If necessary to gain access to load for any reason, call B. E. Brown, Manager Sequoyah Facility, Kerr-McGee Corporation, Gore, Oklahoma, Telephone 918-489-5511 before breaking seal.

This Material: 1. Is not explosive. 2. Will not burn.
3. Should not be breathed. 4. Should not be swallowed or put in mouth.
5. Should not come in contact with skin or clothing.

IN THE EVENT OF ACCIDENT: As soon as possible take preliminary precautions indicated below. Display these instructions as necessary to local authorities on the scene to obtain their help.

1. Evaluate the situation by answering all questions on attached sheet.
2. Call (or have local authority call for you) B. E. Brown, Kerr-McGee Corporation, Gore, Oklahoma 918-489-5511, collect, and report all answers to questions on attached sheet.
3. Make no other statements or phone calls except on instruction from your dispatcher or Kerr-McGee Corporation.

IF CONTAINERS ARE NOT LEAKING, AND ARE NOT SERIOUSLY DAMAGED, THE FOLLOWING ACTION SHOULD BE TAKEN:

1. Caution people not to tamper with the containers. Use civil authorities to help you if necessary.
2. It is not necessary to have a specific distance between humans and the container or truck, but for ease of controlling the situation, ask people to stay back 10-15 feet.
3. If closed containers are lying on the road, obtain assistance from whatever civil authority is available to move containers to the side of the road.
4. Assure local authorities that there is no danger in handling closed containers.

IF CONTAINERS ARE LEAKING OR DAMAGED TOO SERIOUSLY TO BE MOVED, FUMES WILL BE A DEEP WHITE VAPOR:

1. Caution humans to stay away from the material. Keep them at a distance of at least 25 feet. Use civil authorities for help if necessary.
2. Approach containers from the up-wind side.
3. Assure local authorities that there is no danger from radiation but that people should avoid breathing any of the material.
4. Material will vaporize. Obtain help from local civil authorities if necessary to re-route traffic around the spill area.

FIRE INVOLVING VEHICLE OR IN IMMEDIATE VICINITY OF VEHICLE.

1. Obtain fire fighting help from local groups.
2. The material you are hauling will not burn.
3. Fight the fire from up-wind, attack at maximum range, using solid streams of water from a point far enough back that the stream of water breaks up into a shower.
4. Use respirator to avoid breathing smoke from any fire involving your cargo.
5. Every effort should be made to get the fire under control and keep the gas cylinders cooled down so that expansion of the contents will not cause a rupture of the safety disc and release of the contents.

IN CASE OF CONTACT WITH THE SKIN:

1. Flush the area thoroughly with water.
2. Treat as for an HF or other acid burn by packing the burned area with ice to retard action. See local physician.

EVALUATION QUESTIONNAIRE

Name of Individual in Charge of Train or Truck

Carrier

Bill of Lading Number Destination

Time and Place of Accident

Describe Preliminary Precautions You Have Taken:

Describe Any Spillage, Leaking, or Damaged Containers:

Name of Any Law Officer or Civil Authority on the Scene:

Are You Under Any Arrest, Restraint, or Instructions from Local Authorities?

Is Car or Truck Roadworthy?

Can You Proceed to Destination?

Where Can You Be Reached By Phone?

ADDITIONAL REMARKS:

☆U. S. GOVERNMENT PRINTING OFFICE: 1972 – 461-842

FROM:	DATE OF DOCUMENT	DATE RECEIVED	NO.:
Kerr-McGee Corporation Oklahoma City, OK 73102 Parker S. Dunn	Jan 18, 1973	Feb 16, 1973	1124

LTR.	MEMO:	REPORT:	OTHER:
x			x

TO:	ORIG.:	CC:	OTHER:
Mr. Rothfleisch	x		x

ACTION NECESSARY ☐ NO ACTION NECESSARY ☐ CONCURRENCE ☐ COMMENT ☐ DATE ANSWERED: BY:

CLASSIF: UNCLAS POST OFFICE REG. NO:

FILE CODE: DOCKET NO: 40-8027

DESCRIPTION: (Must Be Unclassified)

Ltr transmitting Environmental Supplemental #2, dtd December 1972

ENCLOSURES:

Environmental Supplement #2

195 cys. rec'd 2-16-73

*Denotes: Advance Copy provided to Rothfeisch

REMARKS:

DO NOT REMOVE

REFERRED TO	DATE	RECEIVED BY	DATE
Malaro w/2 cys for ACTION*	2/16	ACKNOWLEDGED	
DISTRIBUTION:			
1-Reg. file cy			
1-PDR			
1-Local PDR			
2-RO			
4-Rouse			
1-J. Shafer			
1-R. Cunningham			
1-S. Smiley			
1-NSIC			
1-DTIE			
1-C. Miles			

U.S. ATOMIC ENERGY COMMISSION **MAIL CONTROL FORM** FORM AEC-326S (8-60)

DOCKET NO. 40-8027

KERR-McGEE CORPORATION

KERR-McGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73102

January 18, 1973

RECEIVED FEB 16 1973 U.S. ATOMIC ENERGY COMMISSION Regulatory Mail Section

U.S. Atomic Energy Commission
ATTN: Mr. J. E. Rothfleisch
Materials Branch
Directorate of Licensing
Washington, D. C. 20545

Dear Mr. Rothfleisch:

Please refer to your letter of December 6 raising certain questions or requesting additional information in regard to our Revised Environmental Report of November 1971 and our Supplemental Environmental Report of June 1972.

The questions raised have been answered and additional detailed data or explanation furnished in the attached Environmental Report-Supplemental #2 dated December 1972. In accordance with our discussion, the report is answered in the order of your questions and additional information included immediately thereafter where appropriate. In some cases your questions have coincided with those of others who have examined these reports and, if one answer covers both subjects, appropriate reference will be made.

In accordance with our previous arrangement, I have included five copies of the report and am shipping to you separately the balance of 195 copies for your distribution. We would be pleased to discuss all or part of this report at your convenience.

Sincerely,

Parker S. Dunn

Parker S. Dunn
Group Vice President
Nuclear Operations

PSD:WJS:srj
Enclosures

DOCKETED USAEC FEB 16 1973 REGULATORY MAIL SECTION DOCKET CLERK

Dupe of 8510220363

dupe ~~8510010363~~ XA   96pp.   previous incomplete rept.

1124

KERR-McGEE CORPORATION

APPLICANTS ENVIRONMENTAL REPORT

USAEC

DOCKET NO. 40-8027

URANIUM HEXAFLUORIDE PLANT

DECEMBER 1972

SUPPLEMENTAL #2

ENVIRONMENTAL REPORT

SEQUOYAH FACILITY

KERR-McGEE CORPORATION

SUPPLEMENTAL #2

(1) Current and projected plant capacity is not clearly stated. We assume that license is for 5,000 TPY operation, yet 10,000 TPY rate is discussed in text. Please clarify.

Design and current plant capacity is 5000 tons per year (4536 MTU) and operation will eventually reach that level. The wet end of the plant was built for a capacity of 10,000 tons per year and the dry end of the plant from boildown through fluorination was designed for 5000 tpy with sufficient space for addition of another module of equipment to raise the total to 10,000 tpy. In earlier exchanges, the AEC requested that we discuss 10,000 tpy, especially in regard to possible effluent effects in terms of the life of the plant. Therefore, this discussion is included where appropriate.

(2) Maps provided (Figure 1 in particular) are not very clear. Suggest substituting following 8 x 10 1/2" drawings:

(a) General map of State of Oklahoma pointing out plant site (scale about 50 miles per inch),

(b) Second map showing general area details i.e., towns, roads, rivers, etc. (scale about 10 miles per inch)

(c) Third map similar to insert in present Figure 1. (scale about 4 miles per inch)

(d) Plant area map (scale about 1500 feet per inch) up-dated to show all existing ponds, monitoring points, residences, etc. alone with distances from air-borne effluent release point to possible critical exposure points; e.g., school, homes, roads.

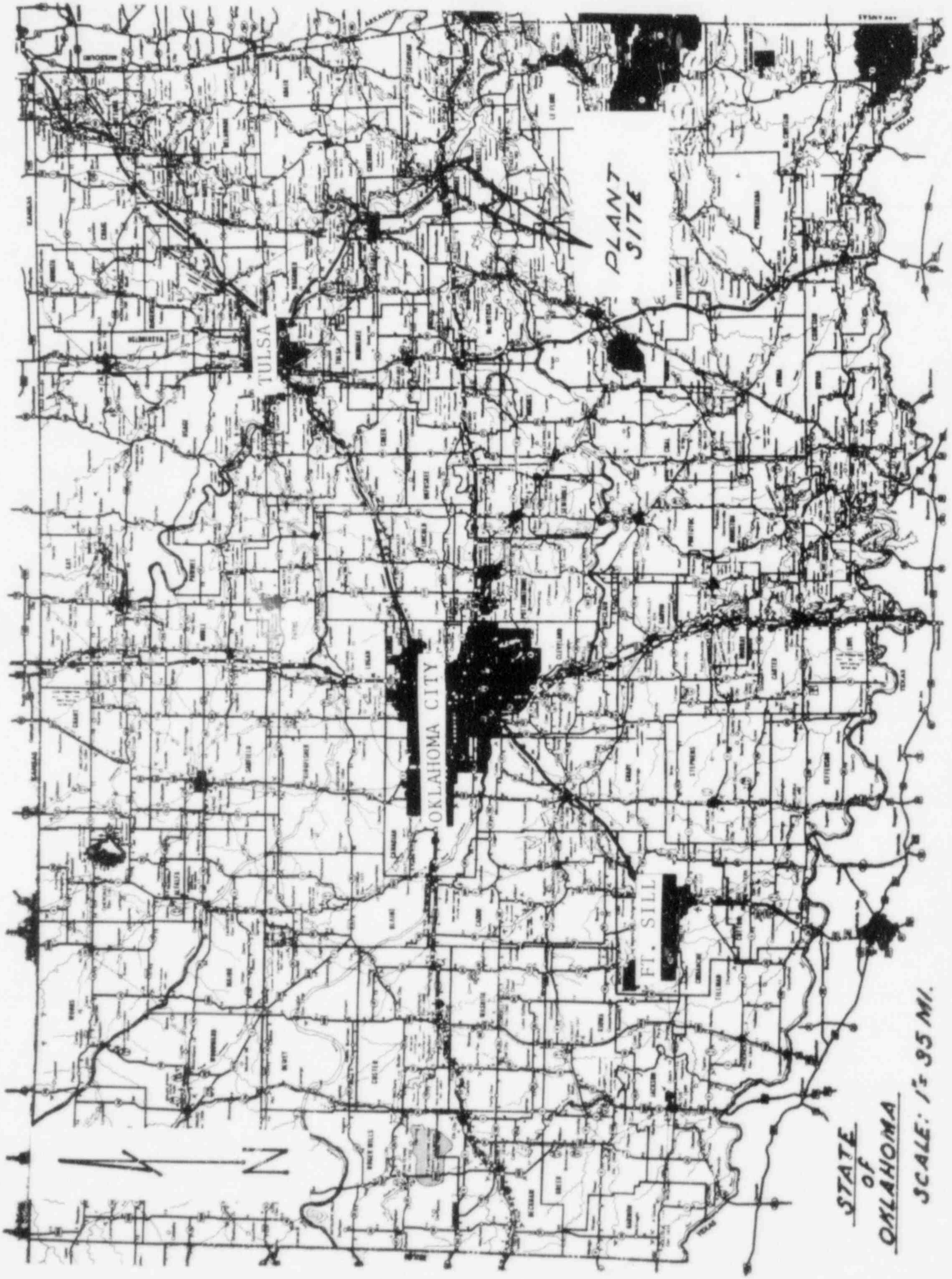
The maps requested are enclosed. We feel, however, that this request, if such fixed criteria for such reports exists, should be included in the guidelines for such reports. Figure 1 is a reduction of Drawing 110-C-151 included with the Revised Environmental Report. The location of the houses and school are circled and the distances tabulated.

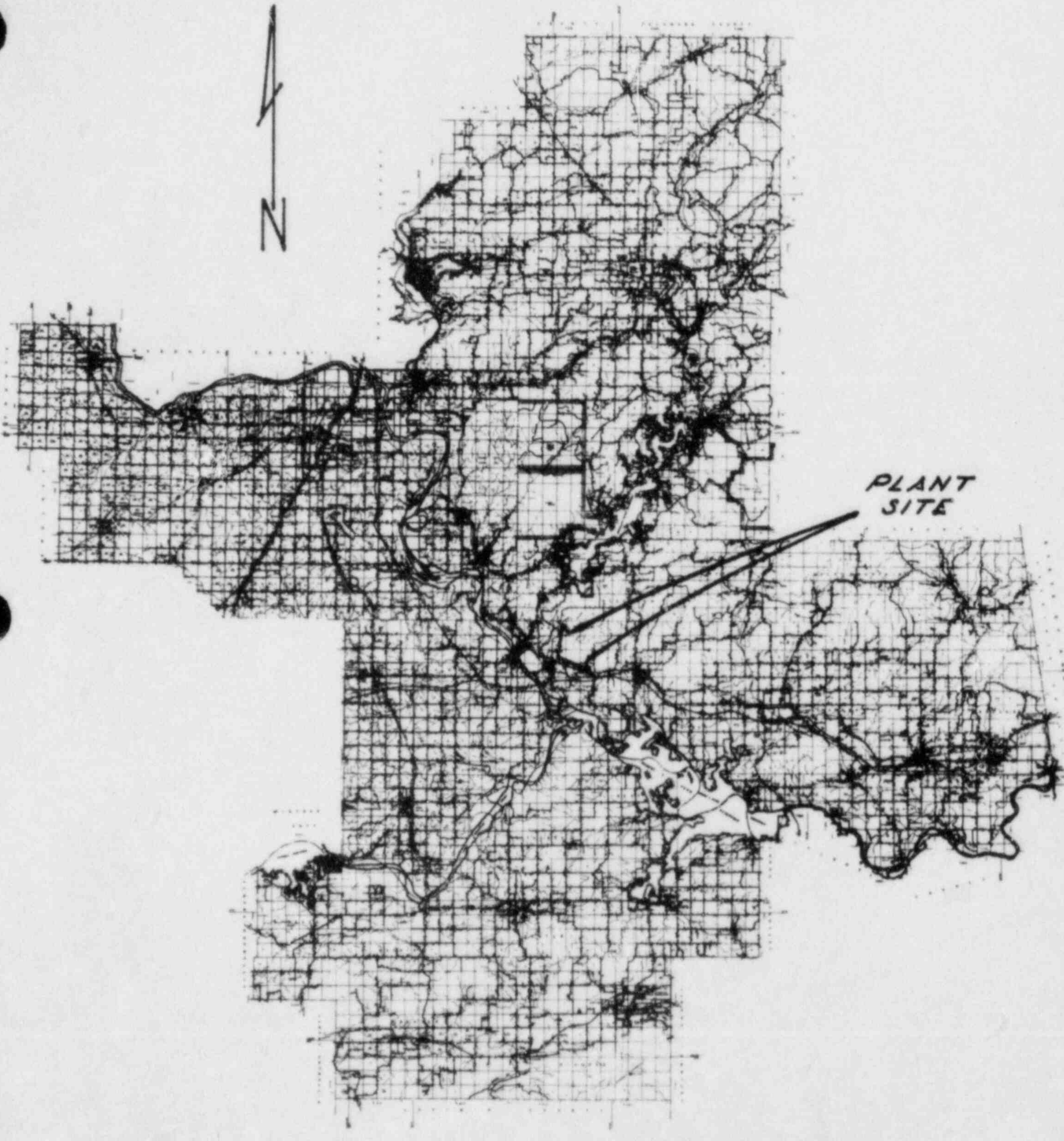
(3) Page S-45. Process description covers disposal of sodium hydroxide solution used to wash lean organic. What is done with the ammonium sulfate solution used in the first stage lean organic wash?

The ammonium sulfate solution used in the first stage of organic washing is returned to the pumper decanters and the aqueous solution combined with the raffinate for discard at that point. We are currently developing the use of this ammoinium sulfate solution to provide sulfation of the UNH instead of using sulfuric acid. Initial results appear favorable.

(4) Page S-45. Claim is made that raffinate stream is neutralized with ammonia and impounded for permanent storage while Revised Environmental Report (November 1971), page R-5, states that raffinate stream is neutralized with lime slurry precipitating U and daughter products, Th-230, Th-234 and Ra-226 along with heavy metals. Which procedure is used?

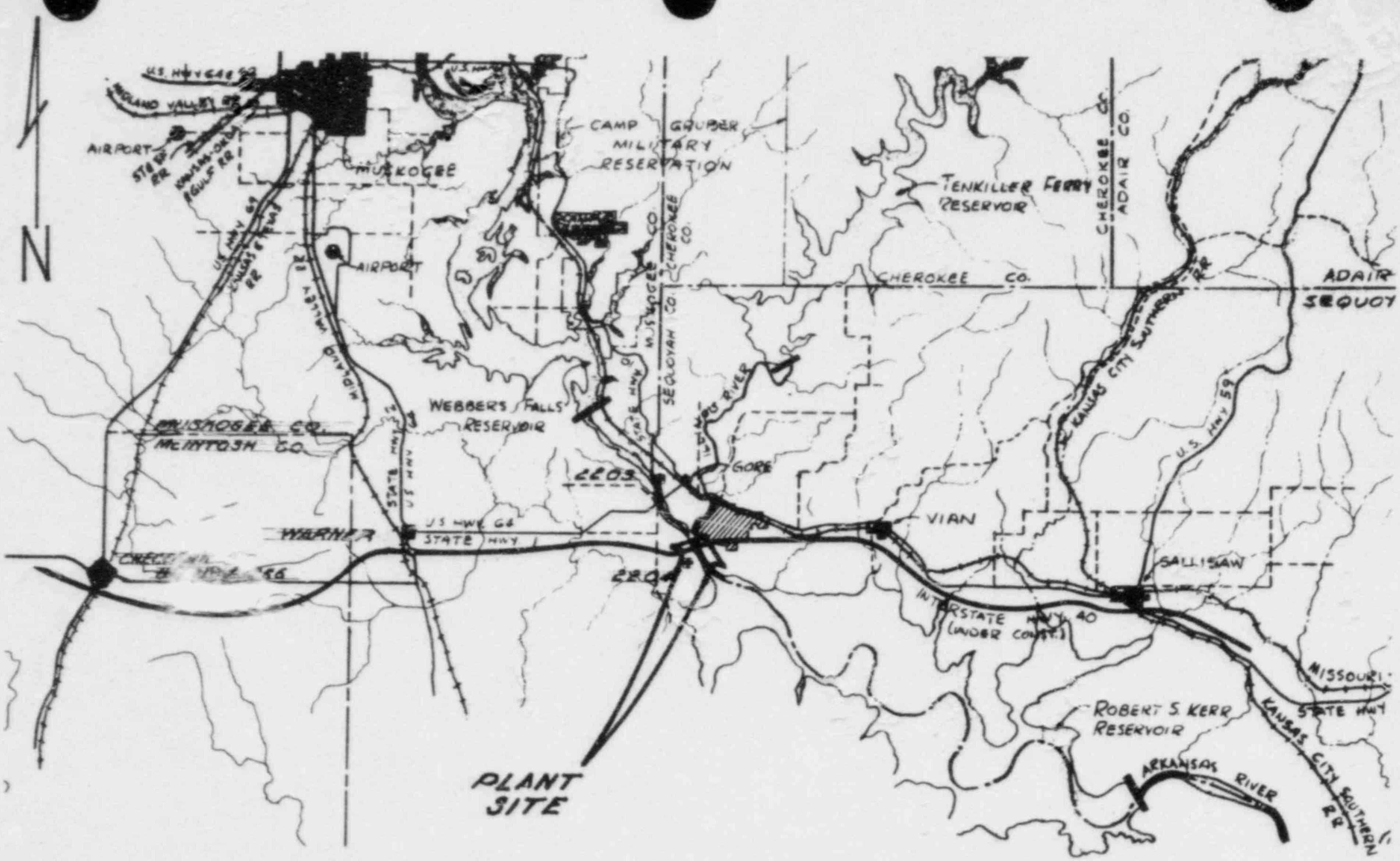
Initially, the raffinate stream was neutralized with lime slurry as described in the Revised Environmental Report and subsequently changed to ammonia in December 1971 in order to take advantage of the ammonia economics, more nearly stoichiometric neutralization, and to prevent filling the pond prematurely with solid calcium hydroxide. Pond No. 1 was essentially all neutralized with lime slurry while Pond No. 2 has only been neutralized with ammonia solution.


PLANT SITE
TULSA
OKLAHOMA CITY
FT. SILL
N
STATE of OKLAHOMA
SCALE: 1"= 35 MI.



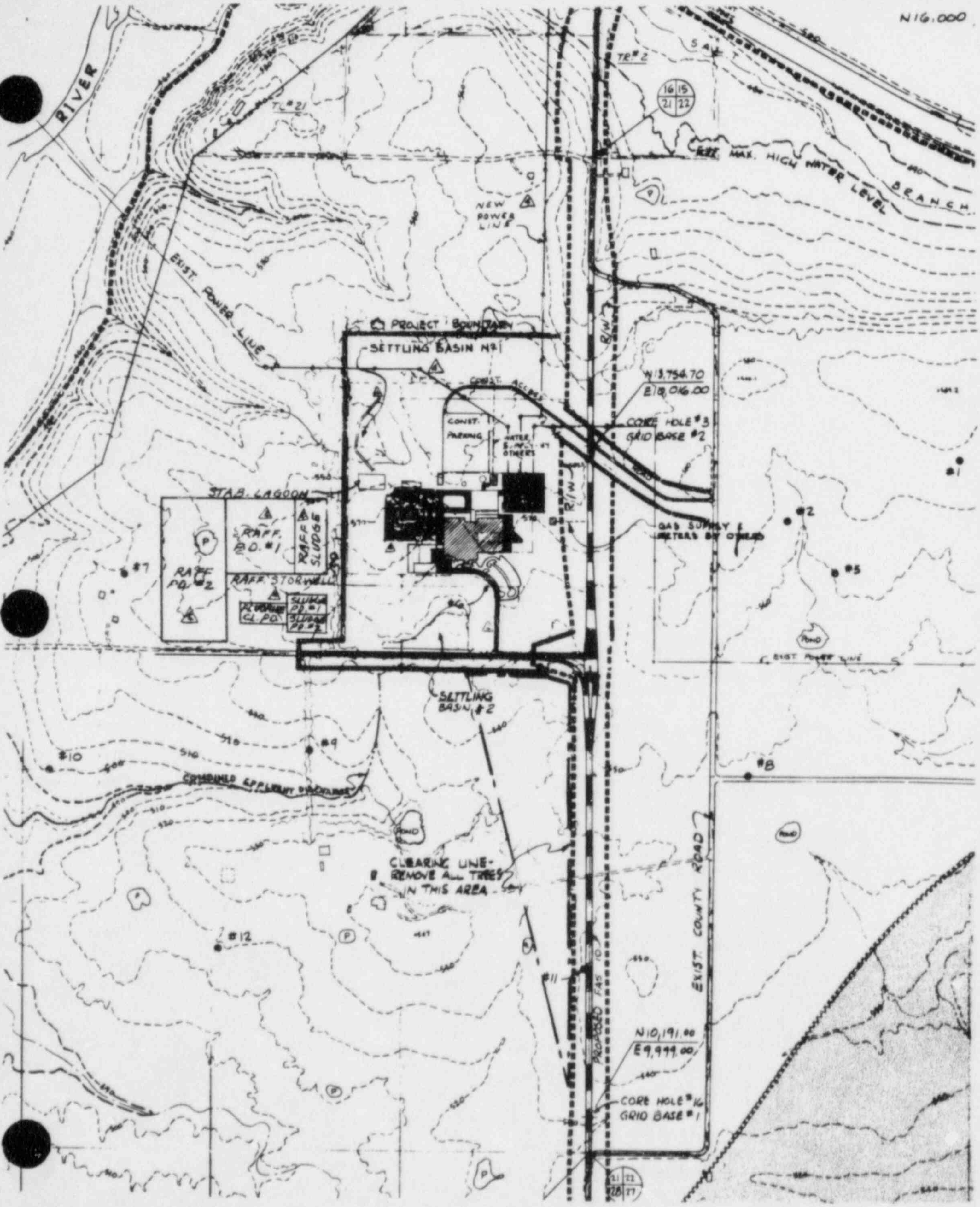
MAP of SEQUOYAH, CHEROKEE, MUSKOGEE and HASKELL COUNTIES

SCALE: 1" = 10 MI.

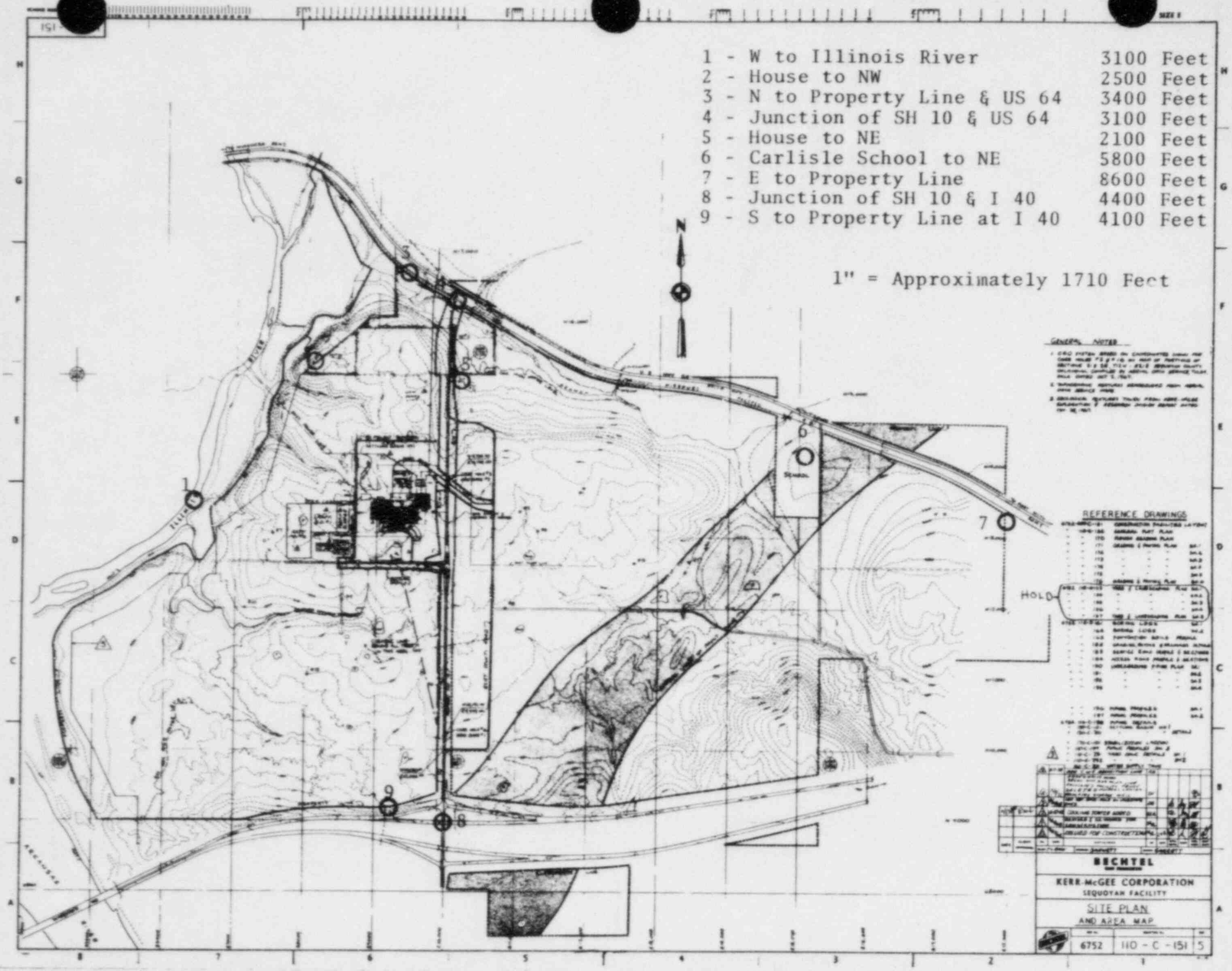


AREA MAP

SCALE: 1" = 4 MI.



ENLARGEMENT OF PLANT AREA 1" = Approx. 670 Ft.


1 - W to Illinois River 3100 Feet
2 - House to NW 2500 Feet
3 - N to Property Line & US 64 3400 Feet
4 - Junction of SH 10 & US 64 3100 Feet
5 - House to NE 2100 Feet
6 - Carlisle School to NE 5800 Feet
7 - E to Property Line 8600 Feet
8 - Junction of SH 10 & I 40 4400 Feet
9 - S to Property Line at I 40 4100 Feet
1" = Approximately 1710 Feet
N
GENERAL NOTES
REFERENCE DRAWINGS
HOLD
BECHTEL
KERR-McGEE CORPORATION
SEQUOYAH FACILITY
SITE PLAN
AND AREA MAP
6752
110 - C - 151
5

(5) Page S-47.

(a) Equation (iii) is not balanced; needs 3 U_3O_8.

(b) Equation is not balanced; insufficient oxygen and no hydrogen on right-hand side of equation. Expression "8 NO_3 not understood.

(Table IV) - Totals from ore digesters do not appear compatible with previous data, i.e., 5280 lb/day release rate of NO_2 for 2 shift operation processing 1717 lb/hr U does not appear to equate to 8350 lb/day release for 3 shift operation at 2686 lb/hr rate. Please clarify.

As you noted, (a) equation (iii) omitted 3 in front of U_3O_8. The corrected equation is given below:

$$3U_3O_8 + 20HNO_3 \rightarrow 9UO_2(NO_3)_2 + 2NO + 10H_2O$$

(b) Equation is not balanced. The corrected equation is given below:

$$UF_4 + 4Al(NO_3)_3 \rightarrow UO_2(NO_3)_2 + 4AlF(NO_3)_2 + 2NO_2$$

The rate of uranium throughput does not orrelate with the rate of uranium digestion. As noted on Table IV, NO_2 rate is 660 lbs/hour (600 in error) because ore addition rate is 5150 lbs U/hour. The daily rate for 5000 TPY operation would require 8 digestions (200 days/year) while 12.5 digestions would be required for 10,000 TPY (310 days/year). Therefore, 8 x 660 = 5280 lbs NO_2/day. Similarly, 8250 lbs/NO_2 day for 12.5 (8350 in error).

(6) Page S-48, Paragraph 2. At 0.2 to 1.2% losses, the amount of NO_2 lost would range from ∿ 36 to 216 lb per day at the 5,000 TPY rate and from ∿ 68 to 406 lb per day at the 10,000 TPY rate based on values given in Table IV. Should specify 9 lb/hr loss is at 5,000 TPY rate. Letter WJS to CRB 1/21/72 indicates loss of 24.1 lb/hr NO_2. Please report measured or best estimate of NO_2 release at 5,000 TPY rate.

NO_2 released from the stack varies with several plant activities. Rate of generation is controlled by the rate of digestion and composition of feed material and the rate of denitration. The degree of absorption is controlled by the efficiency of the

absorber at any given instant. In our total material balance, we show 4.6 metric tons released per month at 5000 tons per year or a rate of 14 pounds per hour which is our current best estimate. The measurements reported to Mr. Buchanan have not been redone though we now have a sampler in the stack which has measured from 100 to 300 ppm NO_2 in the stack effluent. This exact concentration, of course, may vary by the steam demand of the boilers. Nitrogen effluent on Table VII should be 1.4 MT/Mo.

(7) Page S-55, Paragraph 2. Claim is made that plant site is a licensed burial ground. We do not find this authorization in the license, license application or environmental reports. Please clarify.

Burial of plant generated solid waste material on the site is done in accordance with 10 CFR 20.304 which provides a general license for such disposal. Describing the plant site as a "licensed burial ground" should be eliminated. As stated, cumulative burials through November 1 have totalled 304 Kgs of natural uranium. In 1971, Mr. J. Hyder of Region IV Compliance Office answered certain questions as a routine part of his inspection, a copy of which is enclosed for your information.

(8) Pages S-61 and S-62. Tables X and XI should indicate that quantities are in metric tons <u>per month</u>. Please clarify method used to scale up losses.

Tables X and XI show quantities in metric tons per month. Losses were scaled up on an item by item basis since the higher production rate of 378.8 metric tons per month of uranium would permit higher efficiencies in handling of certain off-gas streams. Generally, plants designed for continuous operation produce their best efficiencies at the design rate rather than approximately 50% of design rate. The earlier exchange of information, however, emphasized that these data should be based upon measured experienced quantities and expanded with the best

QUESTIONNAIRE

BURIAL OF WASTE PURSUANT TO § 20.304

I. Licensee Name Kerr McGee
Address

Sequoyah Facility

License No. SUB - 1010
Date of Inspection 9/20-22/71

II. Does licensee generate radioactive waste during normal operations? Yes ✓ No __

III. Does licensee bury waste pursuant to § 20.304? Yes ✓ No __

If No, disregard rest of questionnaire.

IV. What were the principal types of waste buried?

Chemical laboratory waste ____

Animal carcasses ____

Contaminated equipment & scrap ✓

Other (describe briefly) ____

V. What were the principal isotopes and estimated amount of activity buried during 1970?

Nat U 3960 u ci in 22.0 lb (12,000 gm U Nat)

VI. What alternative disposal methods were considered?

Transfer to a commercial disposal firm ____

Incineration ____

Storage for decay ____

Other (describe briefly) None

VII. What were the bases for choosing burial pursuant to § 20.304?

Economics ✓ Convenience ✓

Other (describe briefly) ____

VIII. In the licensee's opinion, would deletion of § 20.304 present a hardship?

Yes ✓ No __

J. Hyder CO IV
Inspector
A.E.C.

engineering estimates which was the procedure followed. As mentioned, October 1972 provided one month of operation at slightly in excess of rated capacity. Additional measurements of effluents were made and Table XI has been reconstituted based upon these measurements. Table XI Revised is attached immediately following.

(9) **Page S-65, Table XII. Design criteria used for a number of constituents appear substantially higher than EPA ambient air quality standards.**

Constituent	Design Value Maximum Ground Level Beyond Site Fence	EPA Air Ambient Quality Standard (40 CFR 50)
Hexane	500 ppm	0.023 ppm (Hydrocarbon) maximum 3-hour concentration
SO_2	0.2 ppm	Primary Standard: (a) 0.03 ppm annual arithmetic mean. Secondary Standard (a) 0.02 ppm annual arithmetic mean.
NO_x	2 ppm	0.05 ppm nitrogen dioxide - annual arithmetic mean
Particulates	0.3 grain/ft^3 at point of release (equivalent to 6.87×10^5 μg/m^3)	Primary Standard: (a) 75μg/m^3 annual geometric mean Secondary Standard: (a) 60μg/m^3 annual geometric mean

$$\frac{687 \times 10^3}{75} = 9160$$ minimum dilution required before reaching site boundary.

UF^4 concentration of 0.006 mg/m^3 (∿ 1.15×10^{-12}μCi/ml) and UF_6 concentration of 0.009 mg/m^3 (∿ 2.03×10^{-12}μCi/ml) appear to be slightly below the 10 CFR 20 allowable limits in unrestricted areas of 2×10^{-12}μCi/ml and 3×10^{-12} μCi/ml for insoluble and soluble natural uranium respectively.

While not stated in the report, the data given on Table XII was design criteria targets compiled from applicable standards at the time these criteria were set, July 1968, so as to provide the goal for the design contractor to perform calculations and select optimal processing methods. These criteria were generated (1968) well before the establishment of EPA ambient air quality standards. Effluent air quality is being monitored continuously to seek control methods to insure that offsite emissions never exceed air quality standards.

TABLE XI REVISED
ACTUAL, OCTOBER 1972
METRIC TONS OF EFFLUENTS IN ALL PROCESS STREAMS AT A PRODUCTION RATE OF 387.8 METRIC TONS PER MONTH OF URANIUM CONTENT AS URANIUM HEXAFLUORIDE[a]

	Stored					A	B	Air Stream					C	
	Neutralized Raffinate	Fluoride Retention Basin	Fluoride Cell Sludge	Emergency Basin No. 1	Burial	TOTAL STORED	Aqueous Combination Stream	Absorber Tail Gas	Reduction Off-Gas to Plant Stack	HF Scrubber	F_2 Cell Hood Rework Exhaust	Miscellaneous	TOTAL AIR STREAM	TOTAL LOSSES A+B+C
Uranium	0.05	0.05		.04	.004	0.14	.43			$2x10^{-4}$		.006	.006	.58
Hexane												8.8	8.8	8.8
Nitrate	180.1					180.1	.54							180.6
Water[b]	397.2	180				577.2	186,000	276	91	62			429	188,000
Ammonia	43.3					43.3								43.3
Fluoride	0.6	13.6	.06			14.3	.20			.006	.030	.047	.083	14.8
Hydrofluoride			.43			.43								.43
Nitrogen Oxide								4.6					4.6	4.6
Sulfur Dioxide									1.51				1.51	1.51
Fluorine												.048		.048
Nitrogen[b]								543.5	1690	3741				
Oxygen[b]								164.2	472	1104				
TOTAL						1815	186,000							

a. Matter such as sodium, potassium and calcium that is present in small amounts and is relatively innocuous has been left off this table.
b. These are diluents that serve to dilute pollutants.
c. 46 million cubic feet (930 metric tons) of natural gas are assumed to be burned in stoichimetric air, yielding 2557 metric tons of CO_2, 1278 metric tons of H_2O and 7958 metric tons of nitrogen. This is not a process stream but it contributes to dilution at the stack.
d. This effluent results from air exhausts from sample preparation, hexane vents, fluorine emergency vents, and roof vents.

(10) Page S-69, Table XIII

Combination stream at plant, average for last 12 months indicates:

$$
\begin{array}{rl}
 & 18.6 \times 10^{-7}\ \mu Ci/ml\ \alpha \\
 & \underline{12.6 \times 10^{-7}\ \mu Ci/ml\ \beta} \\
\Sigma\ \alpha + \beta = & 31.2 \times 10^{-7} = 3.12 \times 10^{-6}\ \mu Ci/ml
\end{array}
$$

Maximum allowable concentration for unidentified radioactive material (10 CFR 20, Appendix B, Note 3C, Table II, Column 2 (unrestricted) is given as 3×10^{-6} µCi/ml indicating 12 month average was in excess of MPC with monthly values of 4.48×10^{-6} for 4/71; 7.38×10^{-6} for 5/71; 4.80×10^{-6} for 10/71 and 5.10×10^{-6} µCi/ml for 11/71 all above MPC.

The observation made as to the data on Table XIII is correct. However, the interpretation of the use of 10 CFR 20, Appendix B, Note 3C, Table II, Column 2, is not in accordance with our understanding. Note 3C is only used for unidientified radioactive material not containing $Radium_{226}$ which is separately recorded on Table XIII. The uranium component of this stream is also measured and is tabulated in the data submitted in answer to paragraph 11 below.

(11) Page S-71, Table XV and following tables:

While well Nos. 1, 2 and 3 do not show any significant trend in α and β levels with time, the Gross α in well Nos. 5 and 6 appears to have taken a sharp rise in the last two months reported. This trend is not seen in fluoride and nitrate analyses reported for these wells in Table XVI.

Page S-73, Table XVII indicates a significant increase in gross α and β in the Fault Well and Residence Well 1 while Table XVIII shows a rise in F and N concentrations in the Fault Well and a jump in fluoride in both the Carlisle School well as well as Residence Well 1.

In addition, as pointed out by Dr. Warner, the average nitrate concentrations and radioactivity in the six monitor wells appear to be substantially higher than in the four background wells indicating possible contamination of the ground water.

In view of these apparent anomalies, we are most interested in seeing more recent analyses for all of these wells and for monitor wells Nos. 10 through 15 if these data are available. Please resubmit data furnished on 11/20/72 in a form and using units that will permit direct comparison with analytical results provided in Tables XIII thru XXII of the Supplemental Environmental Report.

The additional data requested is attached. Additional information as to the construction, subsurface structure, analysis and conclusions as to the integrity of the storage ponds will be covered in detail later in this report.

It should be noted that in January 1972 we changed independent analysts from Controls for Environmental Pollution, Albuquerque, New Mexico, to U.S. Testing Company, Richland, Washington, on the basis that analytical control data could be furnished by UST thereby providing statistically sound results at these extremely low levels. However, these data have not been furnished and we currently plan to use the analysis of the Sequoyah Laboratory and the Kerr-McGee Technical Center upon certification by the Oklahoma Water Resources Board as an environmental laboratory. This certification is now being processed.

(12) Page S-71, Table XV. Well No. 1 on several occasions indicated Radium-226 concentrations of $3 \times 10^{-8} \mu Ci/ml$ and once (July 1971) showed $4 \times 10^{-8} \mu Ci/ml$. MPC (unrestricted) 10 CFR 20 value is $3 \times 10^{-8} \mu Ci/ml$.

It should be noted that this analysis has varied widely. In addition, Well No. 1 is not an unrestricted area and application of 4×10^{-7} $\mu Ci/ml$ is considered the appropriate 10 CFR 20 limit.

(13) Page S-72, Table XVI. Well No. 1 NO_3 as N avg. last 12 months reported as 14.0 ppm with 6 of 12 values exceeding recommended maximum of 10 ppm quoted in Table XXV Page S-84.

While Well No. 1 shows an average value of 14 ppm N as nitrate, you can see it is primarily due to high levels in April, May and June of 1971 and March of 1972. The data supplied under paragraph 11 again shows high levels from March through July. You will note that these levels are not correlatable with uranium levels. Well No. 15, which is down slope from No. 1, shows the same pattern. Again, we believe that these wells should not be considered available for public access and certainly not sources of drinking water to which the standard on Table XXV applies.

1972 ENVIRONMENTAL WATER SAMPLES
SURFACE
UNITED STATES TESTING RESULTS
RADIOACTIVE UNITS-μCi/mlx10^{-8}
CHEMICAL UNITS-ppm[1]

LOCATION	ANALYSIS	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
2201	Nitrate	.1	< .1	.1	.3	.1	1.0	.3	.1	.2	< .1
	Fluoride	.4	.5	.6	.5	.8	.3	< .1	1.0	.6	1.1
Ill. River	Gross α	1.06	.41	1.67	.66	.38	.49	.41	.23	< .23	< .23
Upstream	Gross β	.87	.57	.92	.84	1.18	.51	.65	5.47	1.71	.53
	Uranium	.31	.32	.80	.26	.72	.84	.50	< .17	< .17	.50
	^{226}Ra			< .02			< .02			< .02	
2202	Nitrate	.2	.1	.4	< .1	.4	.5	.2	.1	.3	< .1
	Fluoride	.6	.5	.6	.4	1.0	.7	.2	1.1	.7	2.4**
Ill. River	Gross α	2.08	11.20	7.40	3.63	1.81	1.10	1.15	3.60	5.39	1.94
Downstream	Gross β	1.99	4.58	4.76	2.39	1.74	.97	.56	1.30	3.60	1.57
	Uranium	1.76	6.22	3.25	2.13	.72	1.13	.75	2.72	6.03	3.72
	^{226}Ra			< .02			< .02			< .02	
2203	Nitrate	.7	< .1	.1	.1	.1	.8	.3	.1	.4	< .1
	Fluoride	.6	.6	.7	.7	1.0	.6	.4	1.2	.9	1.4
Ark. River	Gross α	.30	.42	.34	.48	.48	.32	.74	.26	< .23	< .23
Upstream	Gross β	1.51	1.62	.53	2.30	2.46	1.30	1.52	.71	3.43	1.14
	Uranium	.14	.27	.11	.31	1.29	.54	.02	< .17	< .17	< .17
	^{226}Ra			< .02			< .02			< .02	
2204	Nitrate	.1	< .1	.3	< .1	.4	.4	.1	.1	.1	< .1
	Fluoride	.5	.8	.8	.6	1.0	1.0	.3	1.1	.9	1.0
Ark. River	Gross α	< .19	.60	.34	.96	.98		< .23	< .23	< .23	.39
Downstream	Gross β	.81	5.40	1.03	1.05	1.54	.55	.50	.41	4.18	.68
	Uranium	.19	.60	.13	.45	.67	.64	.54	.37	.91	1.93
	^{226}Ra			< .02			< .02			< .02	
2205	Nitrate	.1	< .1	.1	< .1	.1	1.1	1.2	.3	.5	.4
	Fluoride	.4	.5	.8	.6	.8	.6	.3	.8	1.0	1.0
Farm Pond	Gross α	.50	1.06	.64	1.45	.33	.28	< .23	< .23	< .23	.33
East	Gross β	1.67	2.93	1.90	2.91	1.46	1.26	1.32	1.86	4.64	2.29
	Uranium	.18	1.01	.20	.65	.43	.39	.18	< .17	.31	< .17
	^{226}Ra			< .02			< .02			< .02	

SURFACE-CONTINUED

LOCATION	ANALYSIS	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT	OCT.
2206	Nitrate	.2	.3	.1	< .1	.1	.8	.2	.3	.3	.4
	Fluoride	.7	.7	1.0	.8	1.0	1.1	.6	1.0	1.0	1.3
Farm Pond	Gross α	3.94	2.87	8.17	4.07	2.00	2.58	1.39	.23	.37	.26
South	Gross β	6.21	6.64	5.83	2.41	2.92	1.76	1.69	1.68	2.66	1.18
	Uranium	3.39	3.57	2.72	2.00	3.57	.24	.04	.05	.32	.02
	^{226}Ra			< .02			< .02			< .02	
2207	Nitrate	.1	< .1	3.1	1.0	.9	2.4	.8	1.0	1.9	2.3
	Fluoride	1.1	1.1	.4	17.6*	.6	1.1	.4	.7	.7	.7
Facility	Gross α	130.92	186.57	173.17	69.01	22.44	115.72	90.96	100.42	101.03	123.24
Effluent	Gross β	80.05	115.27	90.97	84.63	83.02	58.09	22.57	11.52	18.36	14.37
	Uranium	70.88	164.29	30.62	61.15	94.54	102.38	86.71	63.62	92.15	72.90
	^{226}Ra			< .02			< .02			.05	
2208	Nitrate	.8	< .1	.3	.3	.6	1.1	.4	.1	.2	< .1
	Fluoride	.5	.6	.7	.5	.5	.6	.1	.7	.6	2.3**
Tenkiller	Gross α	15.02	.68	.71	1.07	.54	< .23	.46	.28	.83	< .23
Raw Water	Gross β	15.39	.62	.49	1.57	.75	.31	< .23	< .23	2.04	2.41
	Uranium	15.65	.46	.19	1.49	1.07	.22	.17	.28	.53	.58
	^{226}Ra			< .02			< .02			< .02	
2209	Nitrate	.1	< .1	.1	< .1	.2	.9	.7	.1	.2	< .1
	Fluoride	.2	.5	.6	.6	.5	.8	.2	.9	.8	2.2**
Salt Fork	Gross α	< .09	.70	< .15	1.17	.43	.65	.44	8.54	< .23	< .23
River	Gross β	1.24	1.49	1.06	1.59	.89	1.68	1.52	1.14	2.81	.96
	Uranium	.18	< .12	< .07	3.51	.85	.53	< .17	< .17	.89	< .17
	^{226}Ra			< .02			< .02			< .02	

*This sample was the composite of a continuous sampler for the month analyzed by U. S. Testing. Grab samples are taken each shift and analyzed by the Sequoyah lab. The average for the month was 1.4 ppm. On April 25, one high sample of 32 ppm was recorded when the acid addition system went out of control resulting in a pH of 5.5 for the same sample.

**These results are determined by U. S. Testing. Aliquots measured by Sequoyah lab tested < .1 ppm. Apparently, an example of sample contamination at some stage of handling.

[1]Nitrate reported as nitrogen on all tables.

1972 ENVIRONMENTAL WATER SAMPLES
SEEPAGE WELLS
UNITED STATES TESTING RESULTS
RADIOACTIVE UNITS-μCi/mlx10^{-8}
CHEMICAL UNITS-ppm[1]

LOCATION	ANALYSIS	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
2301	Nitrate	.2	.1	24.0	212.0	273	200.0	180.0	15.5	14.0	66.0
	Fluoride	1.2	1.0	1.0	7.0	2.0	1.3	1.3	4.5	3.1	1.4
Basin No. 1	Gross α	1.34	14.04	13.85	21.61	51.61	65.84	6.86	166.27	5.26	4.05
North	Gross β	9.24	5.20	5.28	17.26	26.17	.15	9.18	25.57	8.50	6.98
	Uranium	8.38	.17	3.09	4.42	134.21	39.44	38.25	109.40	6.79	2.17
	^{226}Ra			< .02			< .02			< .02	
2302	Nitrate	< .1	1.0	.3	.7	.6	1.3	3.7	4.8	6.5	5.5
	Fluoride	1.0	1.1	1.2	6.8	1.3	1.1	.8	.7	.6	.6
Basin No. 1	Gross α	5.10	10.52	4.89	17.19	5.22	12.84	9.55	5.21	2.00	2.00
South	Gross β	4.29	4.54	2.66	13.19	3.55	3.61	2.36	1.38	1.78	[illegible].37
	Uranium	4.36	5.86	.65	3.95	5.94	4.80	5.91	2.18	2.04	.86
	^{226}Ra			< .02			< .02			< .02	
2303	Nitrate	.1	< .1	.9	1.0	.1	.6	.6	2.3	1.1	5.1
	Fluoride	.9	.9	1.1	1.1	2.0	.9	.7	.8	.5	.5
Raffinate	Gross α	4.11	8.25	12.10	26.78	4.95	52.14	6.05	6.58	2.09	1.64
Pond No. 1	Gross β	.66	6.62	1.22	21.67	5.30	17.49	4.18	2.05	2.96	11.44
North	Uranium	3.64	6.49	3.37	8.61	7.44	9.97	3.93	3.04	1.52	.78
	^{226}Ra			< .02			< .02			< .02	
2305	Nitrate	.6	1.1	1.0	.9	.7	.8	.9	5.5	5.9	2.4
	Fluoride	1.2	.7	.8	1.4	1.1	1.0	1.1	.8	.5	.2
Raffinate	Gross α	3.34	10.18	13.95	21.02	6.86	10.46	9.47	9.43	1.07	.89
Pond No. 1	Gross β	.30	6.13	6.34	22.80	3.11	9.38	3.24	2.10	2.53	5.42
South	Uranium	3.37	3.97	2.33	4.52	5.22	17.10	3.88	1.41	.56	.51
	^{226}Ra			< .02			< .02				

SEEPAGE WELLS-Continued

LOCATION	ANALYSIS	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
2306	Nitrate	.2	< .1	.2	.5	0.2	< .1	.3	.1	< .1	.1
	Fluoride	1.0	.7	.5	2.6	1.2	.5	.3	.3	.2	< .1
Carlisle F.	Gross α	1.50	11.56	14.57	13.40	.87	1.36	3.02	5.67	1.96	1.51
Pond South	Gross β	9.44	6.25	2.24	3.88	1.21	1.49	.49	.89	1.40	5.07
	Uranium	7.25	5.88	3.61	5.16	1.59	2.12	.59	1.37	5.94	.90
	^{226}Ra			< .02			< .02			< .02	
2307	Nitrate	.9	.5	.5	< .1	.4	.5	.6	.3	.3	.3
	Fluoride	4.0	4.2	4.2	4.0	5.4	6.2	4.6	2.7	3.3	4.0
Fault Well	Gross α	3.27	7.08	4.15	5.39	4.18	< .23	3.21	3.25	2.74	< .23
	Gross β	.53	6.79	4.04	5.29	5.71	4.48	2.04	2.05	4.35	14.70
	Uranium	.23	.21	.12	1.18	.59	.38	.20	.18	.22	.21
	^{226}Ra			< .02			< .02			< .02	
2308	Nitrate	< .1	< .1	.1	< .1	< .1	.1	.1	.1	< .1	< .1
	Fluoride	1.1	.7	1.0	.8	1.1	.7	.4	.5	.4	.4
Residence	Gross α	2.09	4.23	3.83	4.76	1.34	1.38	2.51	.34	2.38	.72
Well	Gross β	1.46	1.84	2.97	4.50	1.21	1.25	.90	.34	2.56	.67
	Uranium	.62	1.48	1.52	.38	1.16	1.12	.62	.22	< .17	.36
	^{226}Ra			< .02			< .02			< .02	
2309	Nitrate	< .1	< .1	.3	.1	1.3	1.8	.7	.2	.1	< .1
	Fluoride	.9	.5	.6	.5	1.0	.6	.2	.2	.2	.2
Carlisle	Gross α	.09	.24	.17	< .23	.43	< .23	.23	< .23	.23	< .23
School Well	Gross β	1.24	.81	.96	.74	.89	.62	.65	.73	3.13	.91
	Uranium	.18	.12	< .06	3.51	.49	.12	< .17	< .17	< .17	< .17
	^{226}Ra			< .02			< .02			< .02	
2310	Nitrate	.1	1.1	2.4	1.3	.4	.8	1.2	.2	.2	.1
	Fluoride	1.3	1.0	1.1	1.2	2.0	1.1	1.0	.2	.8	.9
Raffinate	Gross α	3.11	2.06	11.98	9.11	3.31	6.93	2.58	< .23	2.52	.84
Pond No. 2	Gross β	4.26	5.06	6.05	4.81	1.62	2.17	.60	.67	1.70	.59
	Uranium	2.68	3.93	4.30	3.33	2.11	4.32	1.22	< .17	2.46	1.11
	^{226}Ra			< .02			< .02			< .02	
2311	Nitrate	.5	3.5	4.7	3.4	.1	1.3	.4	.3	.2	< .1
	Fluoride	1.0	.6	1.0	.9	2.2	.8	.5	.6	.5	.5
Raffinate	Gross α	4.01	4.49	4.82	13.24	4.99	3.06	7.05	3.24	3.05	3.39
Pond No. 2	Gross β	1.37	.15	3.87	10.03	2.47	3.53	1.69	1.25	1.32	1.22
	Uranium	3.37	2.95	3.46	6.52	6.83	4.52	3.30	1.16	2.10	1.75
	^{226}Ra			< .02			< .02			< .02	

SEEPAGE WELLS-Continued

LOCATION	ANALYSIS	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
2312	Nitrate	< .1	.3	.1	.8	1.0	1.2	1.8	.5	.7	.5
	Fluoride	1.0	.8	1.0	.7	1.0	.4	.4	.8	.3	.4
Raffinate	Gross α	7.34	1.79	6.45	17.77	2.45	5.24	2.43	10.67	2.53	3.80
Pond No. 2	Gross β	3.67	.24	5.81	11.15	2.34	1.21	.47	1.60	1.10	.74
	Uranium	3.37	1.95	2.74	4.58	8.74	2.39	.72	1.96	1.28	1.55
	^{226}Ra			< .02			< .02			< .02	
2313	Nitrate	.3	< .1	.1	.1	.2	.7	.4	4.5		.1
	Fluoride	.9	.6	1.1	.9	1.0	.6	.5	.6		.5
Raffinate	Gross α	1.89	.35	22.97	111.18	6.96	18.61	6.27	6.09		4.58
Pond No. 2	Gross β	2.09	2.09	10.67	116.12	5.52	3.17	1.22	1.79		1.33
	Uranium	.85	.98	3.93	52.69	3.93	7.10	2.88	2.32		1.78
	^{226}Ra			< .02			< .02				
2314	Nitrate	.3	1.6	1.9	.4	.3	10.4	.3	1.0	.2	< .1
	Fluoride	1.0	.9	.9	4.1	2.0	.7	.7	.7	.6	.6
Raffinate	Gross α	1.92	12.79	12.57	34.32	4.74	12.67	8.15	5.22	4.01	16.58
Pond No. 2	Gross β	2.23	6.60	5.83	21.26	4.74	4.19	1.80	.87	1.70	2.13
	Uranium	2.04	6.83	4.23	1.16	7.85	8.09	4.73	3.27	6.08	2.38
	^{226}Ra			< .02			< .02		.02		
2315	Nitrate	.1	16.0	48.0	97	.5	91.0	42.0	15.5	42.0	15.5
	Fluoride	.9	.7	.8	.3	2.4	.2	.2	.2	.3	.2
Raffinate	Gross α	1.23	1.63	1.44	9.85	1.90	1.64	6.66	2.40	.30	.61
Pond No. 2	Gross β	.89	1.74	1.92	2.43	1.89	.33	1.96	.82	1.73	< .23
	Uranium	1.01	.90	1.29	4.62	2.90	1.40	.79	.44	< .17	.34
	^{226}Ra			< .02			< .02			< .02	

[1]Nitrate reported as Nitrogen on all tables.

1972 ENVIRONMENTAL VEGETATION SAMPLES

UNITED STATES TESTING RESULTS

ALL UNITS-ppm

LOCATION	ANALYSIS	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
2501	Uranium			2025.0		69.2					
South	Fluoride			43.3	70.0*						
Security Fence	Nitrate			700.0	< 1.0*						
2502	Uranium			141.3		33.4					
North	Fluoride			11.9	90.7*						
Security Fence	Nitrate			200.0	< 1.0*						
2503	Uranium			33.21		51.27	< 5.0		< 5.0	22.13	< 5.0
South	Fluoride			11.7	19.5*	13.0	28.0	20.0	10.1	11.8	19.0
1000 Feet	Nitrate			700.0	< 1.0*	100.0	< 10.0	100.0	30.0	1200.0	475.0
2504	Uranium			607.8		7.0	< 5.0		< 5.0	18.3	5.0
West	Fluoride			326.0	147.0*	58.0	95.7	103.0	96.0	61.7	33.0
1000 Feet	Nitrate			400.0	60.0*	520.0	100.0	50.0	100.0	1200.0	515.0
2505	Uranium			13.1		5.2	< 5.0		< 5.0	4.0	209.0
North	Fluoride			11.2	20.9*	11.0	44.3	17.4	18.9	3.5	8.0
1000 Feet	Nitrate			500.0	< 1.0*	40.0	< 10.0	< 25.0	25.0	100.0	5.0
2506	Uranium			13.7		< 5.0	< 5.0		< 5.0	3.4	< 5.0
East	Fluoride			6.7	20.0*	7.0	30.5	11.8	19.1	12.7	6.0
1000 Feet	Nitrate			400.0	30.0*	180.0	< 10.0	< 25.0	25.0	300.0	5.0
2507	Uranium					5.5	< 5.0		< 5.0	6.6	< 5.0
South	Fluoride				8.9*	177.0	30.9	7.3	11.0	8.7	13.0
6000 Feet	Nitrate				10.0*	40.0	50.0	< 25.0	40.0	300.0	15.0
2508	Uranium					< 5.0	< 5.0		< 5.0	9.4	< 5.0
West	Fluoride				15.1*	13.1	11.5	14.4	10.4	17.9	9.0
6000 Feet	Nitrate				10.0*	100.0	< 10.0	< 25.0	80.0	800.0	7.0

1972 ENVIRONMENTAL VEGETATION SAMPLES-Cont.

LOCATION	ANALYSIS	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
2509	Uranium					< 5.0	< 5.0		< 5.0	2.9	< 5.0
North	Fluoride				10.7*	22.4	35.7	24.5	20.8	26.7	14.0
6000 Feet	Nitrate				30.0*	40.0	< 10.0	< 25.0	30.0	100.0	30.0
2510	Uranium					< 5.0	< 5.0		< 5.0	4.6	< 5.0
East	Fluoride				15.4*	19.0	32.5	21.0	15.9	38.1	15.0
6000 Feet	Nitrate				10.0*	40.0	< 10.0	< 25.0	25.0	400.0	40.0

*Samples were taken on May 5 and May 9, 1972

1972 ENVIRONMENTAL SOIL SAMPLES

UNITED STATES TESTING RESULTS
ALL UNITS-ppm

LOCATION	ANALYSIS	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
2401	Uranium			16.6							
South Security	Fluoride			280.0							
Fence	Nitrate			57.0							
2402	Uranium			23.8							
North Security	Fluoride			224.0							
Fence	Nitrate			20.0							
2403	Uranium			< 1.2			7.2			3.8	
South	Fluoride			116.0			96.0			44.0	
1000 Feet	Nitrate			8.0			35.0			45.0	
2404	Uranium			20.0			39.6			43.4	
West	Fluoride			160.0			91.0			73.0	
1000 Feet	Nitrate			3.0			55.0			8.5	
2405	Uranium			< 2.6			11.9			6.1	
North	Fluoride			176.0			71.0			96.0	
1000 Feet	Nitrate			5.0			4.0			1.0	
2406	Uranium			< 2.7			8.7			3.3	
East	Fluoride			100.0			70.0			86.0	
1000 Feet	Nitrate			2.0			6.0			16.5	

(14) Pages S-78 and S-78A, Table XXII. Analytical results reported indicate erratic control of fluoride emissions with a number of values at the security fence exceeding recommended maximum concentration of vegetation of 40 ppm. Please provide more recent data. (See Comment (11))

More recent data is supplied under question 11. From our examination of this data, we conclude that in the sample taken 1000 feet west of the plant there appears to be a single incident resulting in contamination which has gradually decreased until the October sample which is within recommended levels. All other samples appear to be within the normal limits of variability of this sampling and analysis procedure. As noted on Page S-78, no cattle are grazed north of the Port Facility Road nor west of State Highway 10.

(15) Page S-79 - Effective stack height is reported as 170 feet (~ 51.8 meters) while calculated value shown in Appendix IV, Page 3 is 56.6 meters. Calculation shown in Appendix IV fails to clarify whether stack diameter is 8 feet or 3.25 feet. Calculation is also unclear as to whether barometric pressure is 960 mb or 920 mb.

Effective stack heighth is 54.82 meters based upon recent calculations of rate of discharge and using 960 for the pressure in milibars. The number on Page S-79 should be corrected. The confusion on stack diameter is due to the fact that the OD of the stack is 8 feet. However, it has a liner that restricts the effective diameter to 7 feet and also has a restriction at the discharge to 3.25 feet.

(16) Appendix IV, Page 3 indicates 475 ft/minute velocity out of 8 ft diam. stack for total flow of $(.785)(8)^2(475) = 2.38 \times 10^4$cfm. License application 9/3/69 Page V-11 indicates stack discharge volume of 1.9×10^5 cfm (normal) and 8.85×10^4 cfm during low loads. Letter, W. J. Shelley to C. R. Buchanan dated 1/31/72 estimates flow with two boilers operating at 25,000 cfm.

The measurement of 475 feet per minute should, of course, be used in conjunction with the 7 foot effective diameter resulting in a flow of 18,270 cubic feet per minute. The license application discharge volume was made based upon estimates during the design of the plant. The data supplied to Mr. Buchanan on 1/31/72 was based upon the gas consumption of the boilers as of January 1972.

Recent data calculated from gas consuption during an extended period and temperature measurements in the stack result in a calculated discharge of 24,200 cubic feet per minute.

(17) Page S-80, Table XXIII. Data presented are not clear or consistent with Figure 3.9 of "Workbook" Page 29. Table headings are confusing.

Table XXIII is mislabeled. All columns should be labeled "Maximum XU/Q".

(18) Page S-81, Table XXIV. Off-site concentrations presented do not appear to be consistent with dilution of 10.4 Values indicate dilution of 10 rather than 10,000. Headings on right should read ppb. Also, see comment (25) below:

Observation is accurate that the off-site levels assuming 10^4 dilution should be in ppb.

(19) Page S-84, Table XXV. Footnotes b and c are not shown in body of table. You compare concentrations in rivers with recommended maximum concentrations. Please note that 10 CFR Part 20.106 limits concentration of radioactive materials in the effluent stream and requires considerable additional information if Appendix B, Table II limits are to be exceeded.

Footnotes b and c apply to recommended maximum levels of fluoride and nitrate. We understand the application of 10 CFR 20.106 limits to effluent streams and do not intend to request exception to Appendix B, Table 2, limits.

(20) Page S-85, Paragraph 1. Dilution factor implies process water flow of 240,000/150 or 1600 gpm. Table VII indicates process water of 345,000 gal/metric ton of U. With production of 5,000 short tons/year (4.55×10^2 metric tons/year), total water used = $3.45 \times 10^5 \times 4.55 \times 10^3 = 15.7 \times 10^8$ gallons per year. This is equivalent to 2990 gpm. Please explain.

1600 gpm is the design capacity of the process water system. Actual flow varies from 1100 to 1450 gpm due to variations of the level of water in the lake, i.e. the static head on the pipe withdrawal system located in the dam penstock; the condition of the pipeline, i.e. scale or algae present; and the resistance of flow through the receiving station valves and meter. The amount of water received from the lake is metered and fed into a stilling and treatment basin shown on Figure 11, Page 54. At

this point, water needed for the processing is withdrawn in three streams. The first is an emergency cooling water stream which feeds certain sensitive cooling needs in order to protect the plant equipment. This emergency cooling water flow is then fed to the cooling tower feed basin and a secondary cooling water system is used for less critical service and returned directly to the cooling tower. The second stream is a bypass stream which is excess to the needs of the plant and joins discard from the cooling water system and flows to the point of discharge into the natural drainage channel. The third stream is potable water which is treated by settling, filtering and chlorination. The quantity of water discharged from the plant does not vary significantly with processing rates.

(21) **Page S-86, Paragraph 2. Ra-226 level of 1 x 10^{-8}µCi/ml is 33% of MPC which still provides some leeway but not a great deal. Also, 14 ppm nitrate level is in excess of recommended maximum per Table XXV, Page S-84.**

Please see the answer to question 13 on nitrate level in Monitor Well No. 1. While $Radium_{226}$ is 33% of the MPC, it can be recognized from Table XV that this level is approximately the level of detection and reliable values would only be seen above this level.

(22) **Page S-86, Paragraph 3. Should refer to Table XVIII rather than XVII. Also fluoride level in Carlisle School well has also "increased slightly."**

Your correction is noted. Paragraph 3 on Page S-86 should refer to Table XVIII instead of XVII. Fluoride analysis in these

wells has shown very erratic data, especially between the two laboratories. We hope that with the certification program of the Oklahoma Water Resources Board this erratic variation will decrease.

(23) Page S-86, Last Paragraph. Please explain more fully how the data obtained establishes the potential path of pond seepage.

A complete description of the pond construction, the monitoring wells and the strata in the immediate area follows at the end of the questions.

(24) (deleted)

(25) Page S-97, Table XXVI - The data presented in this table represent releases to the atmosphere during plant operation at throughputs significantly below those expected at the normal production rate of 5000 tons per year. To permit an assessment of the environmental impact of the Sequoyah facility under normal operating conditions, the release data must be scaled up (with the bases for the calculations clearly shown) and as a minimum requirement, the annual average significant organ doses to individuals exposed to radioactive pollutants at the off-site point of maximum ground level concentration must be estimated. In addition, organ doses and chemical pollutant concentrations should be estimated for each of the following off-site locations: (a) Residence northwest of plant site. (b) Residence northeast of plant site. (c) Carlisle School. (d) Points of maximum ground level concentration on Oklahoma Highway 10, U. S. Highway 64, Interstate Highway 40, and the Missouri Pacific railroad, and (e) Other nearby points of permanent and transient habitation.

Total dosages attributable to radioactive effluents out to a distance of ten miles from the site should be estimated for both the transient as well as the permanent population.

During October, data shown in Table XXVI, Page S-97, was measured for the month of October 1972 wherein the production rate was 387.8 metric tons/month (5119 tons U/Yr). Air sampling and counting systems are those commonly employed

throughout the nuclear industry for low specific activity material and have been inspected by the Division of Regulatory Operations, Region IV, for adequacy and accepted. Revised release data is shown on the attached table as compared to the measured and estimated releases shown originally. These new data were supplied to Dames & Moore who incorporated these data into the exposure computer program with the resulting data shown in their answer. As can be seen, radiological organ dose estimates in milirem/year are insignificant compared to natural background. As with the earlier calculations, the dose values are conservative since no allowance was made in the calculations for fallout between the release point and downwind locations.

Dames & Moore answer to question 25 appears after Table XXVI - Revised.

TABLE XXVI - REVISED

ATMOSPHERIC RELEASES
Uranium - gm/sec

	Supplement - Page 97		October 1972	
	Insoluble	Soluble	Insoluble	Soluble
150 Foot Stack				
1. HF Scrubber		.00047		.000066
7. Incinerator	.0000175		.0000175	
Ground Level Stacks				
1. Sampling Plant Dust Collector	.00034		.00064	
2. Plant Vacuum System	.000084	.0000092	.0000037	.00000046
3. UO_3 Dust Collector		.00000062		.0000005
4. Sample Preparation Hoods	.000007		.0000037	
5. Roof Vents	.00066	.000073	.00057	.00007
6. Lab Hoods		.000001		.000001
	.001109	.0005538	.001235	.0001380
$\mu Ci/sec \times 10^{-4}$	3.66	1.83	4.08	.46
μCi/month	947.9	474	1057	119
*μCi/month/acre	.471	.236	.526	.059
*$\mu Ci/month/M^2 \times 10^{-6}$	116	58.3	130	14.6

*Assume all effluent evenly deposited on circle one mile in diameter - 2010 acres or 8.13×10^6 M^2.

A.E.C. Question 25

Page S-97, Table XXVI - The data presented in this table represent releases to the atmosphere during plant operations at throughputs significantly below those expected at the normal production rate of 5000 tons per year. To permit an assessment of the environmental impact of the Sequoyah facility under normal operating conditions, the release data must be scaled up (with the bases for the calculations clearly shown) and as a minimum requirement, the annual average significant organ doses to individuals exposed to radioactive pollutants at the off-site point of maximum ground level concentration must be estimated. In addition, organ doses and chemical pollutant concentrations should be estimated for each of the following off-site locations: (a) Residence northwest of plant site. (b) Residence northeast of plant site. (c) Carlisle School. (d) Points of maximum ground level concentration on Oklahoma Highway 10, U. S. Highway 64, Interstate Highway 40, and the Missouri Pacific railroad, and (e) Other nearby points of permanent and transient habitation.

Total dosages attributable to radioactive effluents out to a distance of ten miles from the site should be estimated for both the transient as well as the permanent population.

Response:

Data collected on Uranium release in October 1972, during which the Sequoyal facility operated at a rate of 5119 TPY (387.8 metric tons) is tabulated below:

Summary of
Gaseous Effluent Release Data

Radioactive Pollutants

Release Height	Release Rate (Ci/sec) Soluble U	Release Rate (Ci/sec) Insoluble U
Ground Level	2.4×10^{-11}	4.1×10^{-10}
150-foot Stack	2.2×10^{-11}	5.8×10^{-12}

Non-radioactive Pollutants

Release Height	Release Rate (g/sec) Fluoride
150-foot Stack	.0496

The values of the October operating releases are utilized in calculating the doses associated with these release levels. Tables IVa,

Va, VIa, VIIa, VIIIa, IXa, Xa, XIa, XIIa, XIIIa, and XIVa represent the October operating data.

Specific radiological organ dose estimates (in mRem/yr) of primary interest locations are as follows:

	Bone	Lung	Kidney
25. (a) Residence NW (.5 miles)	1.57×10^{-2}	1.47	6.44×10^{-2}
(b) Residence NE (.5 miles)	1.98×10^{-2}	1.86	8.13×10^{-2}
(c) Carlisle School (NE 1 mile)	6.23×10^{-3}	5.73×10^{-1}	2.56×10^{-2}
(d) Highway Maximums			
1) I-40 (SW 1.5miles)	1.15×10^{-2}	1.05	4.70×10^{-2}
2) US-64/RR (NE.5 miles)	1.98×10^{-2}	1.86	8.13×10^{-2}
(e) Points of Interest			
1) Vian (E 4 miles)	4.63×10^{-4}	3.74×10^{-2}	1.90×10^{-3}
2) Gore (NW 2 miles)	1.81×10^{-3}	1.61×10^{-1}	7.43×10^{-3}
3) Weber Falls (W 3 mi.)	1.58×10^{-3}	1.33×10^{-1}	6.46×10^{-3}
4) [MAX] (SW.5 miles)	6.71×10^{-2}	6.37	2.75×10^{-1}

To evaluate the consequences of radiological releases upon transient population groups, population estimates by Dr. R. V. Garner were evaluated for two specific areas: I-40 and recreational doses. The US-64/RR dose (man-rem) is considered insignificant when compared to the high volume of the Interstate.

The transient I-40 population is given by Dr. Garner as 2.2 million cars per year. Each car is assumed to have two occupants and is exposed to the releases for five minutes. Assuming a maximum exposure distance selection of one mile NE for deposition and dose calculation, the annual lung dose to transient I-40 population groups is .044 man-rem/year.

The transient recreational population is given by Dr. Garner as 4 million visitors to the various reservoirs located on the ten-mile radius perimeter. Each visitor is assumed to stay 24 hours per visit and exposed to the ten-mile maximum dose. The annual lung dose to transient recreational population groups is .825 man-rem/year.

The radiological dose calculations have been tabulated for distances of 0-10 miles. Dose estimates have been evaluated for distances up to 50 miles. However, the 10-50 mile dose calculations are not included as the resultant doses are insignificant when compared to allowable dose levels.

TABLE IVA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

METEOROLOGICAL DATA IS FROM FORT SMITH,ARKANSAS
FOR THE PERIOD OF RECORD;JANUARY 1960 THROUGH DECEMBER 1964
WITH A COMPOSITE OF 43847 HOURLY OBSERVATIONS

AVERAGE ANNUAL GROUND RELEASE RELATIVE
CONCENTRATIONS IN SECONDS PER CUBIC METER

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES				
DIRECTION	0.5	1.0	1.5	2.0	2.5
N	3.31E-06	1.01E-06	5.37E-07	3.59E-07	2.58E-07
NNE	3.12E-06	9.56E-07	5.06E-07	3.37E-07	2.43E-07
NE	5.63E-06	1.73E-06	9.22E-07	6.17E-07	4.45E-07
ENE	5.18E-06	1.59E-06	8.48E-07	5.67E-07	4.10E-07
E	3.02E-06	9.25E-07	4.90E-07	3.26E-07	2.34E-07
ESE	1.48E-06	4.49E-07	2.36E-07	1.56E-07	1.11E-07
SE	1.91E-06	5.86E-07	3.09E-07	2.06E-07	1.48E-07
SSE	1.58E-06	4.84E-07	2.56E-07	1.70E-07	1.22E-07
S	3.77E-06	1.16E-06	6.17E-07	4.13E-07	2.98E-07
SSW	8.35E-06	2.58E-06	1.38E-06	9.24E-07	6.68E-07
SW	1.93E-05	5.96E-06	3.18E-06	2.13E-06	1.54E-06
WSW	1.32E-05	4.07E-06	2.16E-06	1.44E-06	1.04E-06
W	6.77E-06	2.08E-06	1.10E-06	7.36E-07	5.29E-07
WNW	3.47E-06	1.07E-06	5.65E-07	3.77E-07	2.71E-07
NW	4.45E-06	1.37E-06	7.27E-07	4.86E-07	3.50E-07
NNW	2.22E-06	6.82E-07	3.61E-07	2.41E-07	1.74E-07

	MILES				
DIRECTION	3.0	4.0	5.0	7.5	10.0
N	1.96E-07	1.25E-07	8.72E-08	5.43E-08	3.76E-08
NNE	1.85E-07	1.18E-07	8.17E-08	5.08E-08	3.51E-08
NE	3.39E-07	2.17E-07	1.51E-07	9.41E-08	6.52E-08
ENE	3.12E-07	1.99E-07	1.39E-07	8.65E-08	6.00E-08
E	1.78E-07	1.13E-07	7.83E-08	4.86E-08	3.36E-08
ESE	8.41E-08	5.31E-08	3.66E-08	2.26E-08	1.55E-08
SE	1.12E-07	7.12E-08	4.93E-08	3.06E-08	2.11E-08
SSE	9.25E-08	5.87E-08	4.06E-08	2.52E-08	1.74E-08
S	2.26E-07	1.45E-07	1.01E-07	6.27E-08	4.35E-08
SSW	5.09E-07	3.26E-07	2.27E-07	1.42E-07	9.88E-08
SW	1.17E-06	7.52E-07	5.24E-07	3.27E-07	2.27E-07
WSW	7.88E-07	5.02E-07	3.49E-07	2.17E-07	1.50E-07
W	4.02E-07	2.56E-07	1.77E-07	1.10E-07	7.62E-08
WNW	2.06E-07	1.31E-07	9.13E-08	5.68E-08	3.93E-08
NW	2.66E-07	1.70E-07	1.18E-07	7.38E-08	5.11E-08
NNW	1.32E-07	8.41E-08	5.84E-08	3.64E-08	2.52E-08

TABLE VA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

METEOROLOGICAL DATA IS FROM FORT SMITH,ARKANSAS
FOR THE PERIOD OF RECORD;JANUARY 1960 THROUGH DECEMBER 1964
WITH A COMPOSITE OF 43847 HOURLY OBSERVATIONS

AVERAGE ANNUAL ELEVATED RELEASE RELATIVE
CONCENTRATIONS IN SECONDS PER CUBIC METER

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

MILES

DIRECTION	0.5	1.0	1.5	2.0	2.5
N	1.29E-07	7.59E-08	5.21E-08	3.99E-08	3.28E-08
NNE	1.41E-07	8.05E-08	5.34E-08	4.00E-08	3.23E-08
NE	1.65E-07	9.38E-08	6.45E-08	5.01E-08	4.22E-08
ENE	1.46E-07	8.67E-08	6.21E-08	4.89E-08	4.15E-08
E	1.39E-07	9.24E-08	6.36E-08	4.78E-08	3.83E-08
ESE	1.18E-07	7.44E-08	4.85E-08	3.52E-08	2.72E-08
SE	1.04E-07	6.55E-08	4.34E-08	3.20E-08	2.53E-08
SSE	8.74E-08	5.65E-08	3.76E-08	2.78E-08	2.19E-08
S	1.03E-07	7.05E-08	5.07E-08	3.96E-08	3.31E-08
SSW	1.10E-07	8.48E-08	6.99E-08	5.91E-08	5.30E-08
SW	3.12E-07	2.25E-07	1.78E-07	1.48E-07	1.30E-07
WSW	5.01E-07	3.27E-07	2.27E-07	1.73E-07	1.41E-07
W	2.85E-07	1.87E-07	1.26E-07	9.43E-08	7.56E-08
WNW	1.40E-07	8.61E-08	5.83E-08	4.40E-08	3.57E-08
NW	1.48E-07	8.88E-08	6.08E-08	4.66E-08	3.86E-08
NNW	9.12E-08	5.43E-08	3.67E-08	2.77E-08	2.25E-08

MILES

DIRECTION	3.0	4.0	5.0	7.5	10.0
N	2.83E-08	2.24E-08	1.87E-08	1.25E-08	9.35E-09
NNE	2.74E-08	2.14E-08	1.76E-08	1.17E-08	8.75E-09
NE	3.74E-08	3.13E-08	2.73E-08	1.86E-08	1.42E-08
ENE	3.68E-08	3.06E-08	2.64E-08	1.79E-08	1.37E-08
E	3.21E-08	2.42E-08	1.94E-08	1.27E-08	9.35E-09
ESE	2.20E-08	1.56E-08	1.18E-08	7.50E-09	5.34E-09
SE	2.10E-08	1.56E-08	1.24E-08	8.09E-09	5.92E-09
SSE	1.81E-08	1.34E-08	1.06E-08	6.88E-09	5.02E-09
S	2.89E-08	2.35E-08	1.99E-08	1.35E-08	1.02E-08
SSW	4.91E-08	4.34E-08	3.90E-08	2.69E-08	2.09E-08
SW	1.19F-07	1.04E-07	9.20E-08	6.33E-08	4.89E-08
WSW	1.20E-07	9.35E-08	7.69E-08	5.11E-08	3.81E-08
W	6.37E-08	4.88E-08	3.97E-08	2.63E-08	1.95E-08
WNW	3.04E-08	2.38E-08	1.96E-08	1.31E-08	9.77E-09
NW	3.35E-08	2.72E-08	2.31E-08	1.56E-08	1.18E-08
NNW	1.92E-08	1.51E-08	1.25E-08	8.33E-09	6.24E-09

TABLE VIA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

KIDNEY DOSE IS IN MILLI REM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

MILES

DIRECTION	0.5	1.0	1.5	2.0	2.5
N	4.81E-02	1.52E-02	8.21E-03	5.55E-03	4.05E-03
NNE	4.56E-02	1.45E-02	7.79E-03	5.25E-03	3.83E-03
NE	8.13E-02	2.56E-02	1.38E-02	9.31E-03	6.80E-03
ENE	7.47E-02	2.35E-02	1.27E-02	8.60E-03	6.29E-03
E	4.42E-02	1.42E-02	7.70E-03	5.19E-03	3.78E-03
ESE	2.23E-02	7.27E-03	3.94E-03	2.64E-03	1.91E-03
SE	2.82E-02	9.08E-03	4.90E-03	3.30E-03	2.40E-03
SSE	2.33E-02	7.53E-03	4.08E-03	2.75E-03	1.99E-03
S	5.43E-02	1.72E-02	9.33E-03	6.31E-03	4.61E-03
SSW	1.19E-01	3.73E-02	2.03E-02	1.37E-02	1.01E-02
SW	2.75E-01	8.67E-02	4.70E-02	3.19E-02	2.33E-02
WSW	1.92E-01	6.14E-02	3.33E-02	2.25E-02	1.64E-02
W	9.88E-02	3.17E-02	1.71E-02	1.16E-02	8.41E-03
WNW	5.06E-02	1.61E-02	8.69E-03	5.86E-03	4.27E-03
NW	6.44E-02	2.04E-02	1.10E-02	7.43E-03	5.42E-03
NNW	3.24E-02	1.03E-02	5.55E-03	3.74E-03	2.73E-03

MILES

DIRECTION	3.0	4.0	5.0	7.5	10.0
N	3.12E-03	2.05E-03	1.46E-03	9.23E-04	6.49E-04
NNE	2.94E-03	1.93E-03	1.37E-03	8.65E-04	6.06E-04
NE	5.24E-03	3.45E-03	2.47E-03	1.56E-03	1.10E-03
ENE	4.85E-03	3.20E-03	2.29E-03	1.45E-03	1.02E-03
E	2.91E-03	1.90E-03	1.35E-03	8.47E-04	5.93E-04
ESE	1.47E-03	9.47E-04	6.65E-04	4.14E-04	2.86E-04
SE	1.84E-03	1.20E-03	8.52E-04	5.34E-04	3.73E-04
SSE	1.53E-03	9.98E-04	7.06E-04	4.43E-04	3.09E-04
S	3.55E-03	2.33E-03	1.67E-03	1.05E-03	7.42E-04
SSW	7.78E-03	5.14E-03	3.69E-03	2.34E-03	1.66E-03
SW	1.80E-02	1.19E-02	8.54E-03	5.41E-03	3.82E-03
WSW	1.26E-02	8.26E-03	5.89E-03	3.71E-03	2.60E-03
W	6.46E-03	4.22E-03	3.00E-03	1.89E-03	1.32E-03
WNW	3.29E-03	2.15E-03	1.53E-03	9.66E-04	6.78E-04
NW	4.17E-03	2.74E-03	1.96E-03	1.24E-03	8.70E-04
NNW	2.10E-03	1.38E-03	9.82E-04	6.18E-04	4.34E-04

TABLE VIIA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

LUNG DOSE IS IN MILLI REM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES				
DIRECTION	0.5	1.0	1.5	2.0	2.5
N	1.09E+00	3.35E-01	1.77E-01	1.19E-01	8.54E-02
NNE	1.03E+00	3.16E-01	1.67E-01	1.12E-01	8.03E-02
NE	1.86E+00	5.73E-01	3.04E-01	2.04E-01	1.47E-01
ENE	1.71E+00	5.26E-01	2.80E-01	1.87E-01	1.35E-01
E	9.96E-01	3.06E-01	1.62E-01	1.08E-01	7.74E-02
ESE	4.88E-01	1.49E-01	7.80E-02	5.16E-02	3.68E-02
SE	6.32E-01	1.94E-01	1.02E-01	6.80E-02	4.88E-02
SSE	5.22E-01	1.60E-01	8.45E-02	5.62E-02	4.03E-02
S	1.24E+00	3.83E-01	2.04E-01	1.36E-01	9.84E-02
SSW	2.76E+00	8.52E-01	4.55E-01	3.05E-01	2.21E-01
SW	6.37E+00	1.97E+00	1.05E+00	7.04E-01	5.09E-01
WSW	4.37E+00	1.34E+00	7.14E-01	4.76E-01	3.43E-01
W	2.24E+00	6.88E-01	3.65E-01	2.43E-01	1.75E-01
WNW	1.15E+00	3.52E-01	1.87E-01	1.25E-01	8.97E-02
NW	1.47E+00	4.52E-01	2.40E-01	1.61E-01	1.16E-01
NNW	7.34E-01	2.25E-01	1.19E-01	7.97E-02	5.74E-02

	MILES				
DIRECTION	3.0	4.0	5.0	7.5	10.0
N	6.50E-02	4.15E-02	2.88E-02	1.80E-02	1.24E-02
NNE	6.10E-02	3.89E-02	2.70E-02	1.68E-02	1.16E-02
NE	1.12E-01	7.17E-02	4.99E-02	3.11E-02	2.16E-02
ENE	1.03E-01	6.59E-02	4.59E-02	2.86E-02	1.99E-02
E	5.88E-02	3.74E-02	2.59E-02	1.61E-02	1.11E-02
ESE	2.79E-02	1.76E-02	1.21E-02	7.49E-03	5.14E-03
SE	3.71E-02	2.36E-02	1.63E-02	1.01E-02	6.99E-03
SSE	3.06E-02	1.94E-02	1.35E-02	8.35E-03	5.76E-03
S	7.49E-02	4.78E-02	3.33E-02	2.08E-02	1.44E-02
SSW	1.68E-01	1.08E-01	7.52E-02	4.70E-02	3.27E-02
SW	3.88E-01	2.49E-01	1.73E-01	1.08E-01	7.53E-02
WSW	2.61E-01	1.66E-01	1.15E-01	7.18E-02	4.97E-02
W	1.33E-01	8.47E-02	5.87E-02	3.65E-02	2.52E-02
WNW	6.82E-02	4.35E-02	3.02E-02	1.88E-02	1.30E-02
NW	8.81E-02	5.63E-02	3.92E-02	2.44E-02	1.69E-02
NNW	4.36E-02	2.78E-02	1.93E-02	1.20E-02	8.34E-03

TABLE VIIIA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

BONE DOSE IS IN MILLI REM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES				
DIRECTION	0.5	1.0	1.5	2.0	2.5
N	1.17E-02	3.71E-03	2.00E-03	1.35E-03	9.88E-04
NNE	1.11E-02	3.53E-03	1.90E-03	1.28E-03	9.33E-04
NE	1.98E-02	6.23E-03	3.36E-03	2.27E-03	1.66E-03
ENE	1.82E-02	5.73E-03	3.10E-03	2.10E-03	1.53E-03
E	1.08E-02	3.46E-03	1.88E-03	1.27E-03	9.22E-04
ESE	5.42E-03	1.77E-03	9.59E-04	6.44E-04	4.66E-04
SE	6.88E-03	2.21E-03	1.20E-03	8.05E-04	5.85E-04
SSE	5.69E-03	1.84E-03	9.94E-04	6.69E-04	4.86E-04
S	1.32E-02	4.20E-03	2.27E-03	1.54E-03	1.12E-03
SSW	2.89E-02	9.10E-03	4.94E-03	3.35E-03	2.46E-03
SW	6.71E-02	2.11E-02	1.15E-02	7.77E-03	5.69E-03
WSW	4.69E-02	1.50E-02	8.11E-03	5.48E-03	3.99E-03
W	2.41E-02	7.72E-03	4.18E-03	2.82E-03	2.05E-03
WNW	1.23E-02	3.92E-03	2.12E-03	1.43E-03	1.04E-03
NW	1.57E-02	4.97E-03	2.68E-03	1.81E-03	1.32E-03
NNW	7.90E-03	2.51E-03	1.35E-03	9.12E-04	6.65E-04

	MILES				
DIRECTION	3.0	4.0	5.0	7.5	10.0
N	7.61E-04	5.00E-04	3.57E-04	2.25E-04	1.58E-04
NNE	7.18E-04	4.70E-04	3.35E-04	2.11E-04	1.48E-04
NE	1.28E-03	8.40E-04	6.02E-04	3.80E-04	2.68E-04
ENE	1.18E-03	7.79E-04	5.58E-04	3.53E-04	2.48E-04
E	7.09E-04	4.63E-04	3.29E-04	2.06E-04	1.44E-04
ESE	3.57E-04	2.31E-04	1.62E-04	1.01E-04	6.98E-05
SE	4.49E-04	2.93E-04	2.08E-04	1.30E-04	9.08E-05
SSE	3.74E-04	2.43E-04	1.72E-04	1.08E-04	7.52E-05
S	8.66E-04	5.69E-04	4.07E-04	2.57E-04	1.81E-04
SSW	1.90E-03	1.25E-03	9.01E-04	5.71E-04	4.04E-04
SW	4.39E-03	2.90E-03	2.08E-03	1.32E-03	9.32E-04
WSW	3.08E-03	2.01E-03	1.44E-03	9.03E-04	6.34E-04
W	1.58E-03	1.03E-03	7.32E-04	4.60E-04	3.22E-04
WNW	8.01E-04	5.25E-04	3.74E-04	2.35E-04	1.65E-04
NW	1.02E-03	6.68E-04	4.78E-04	3.01E-04	2.12E-04
NNW	5.12E-04	3.36E-04	2.39E-04	1.51E-04	1.06E-04

TABLE XIA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

AVERAGE ANNUAL NITROGEN OXIDES CONCENTRATIONS IN
MICRO-GRAMS PER CUBIC METER FROM AN ELEVATED ROUTINE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES				
DIRECTION	0.5	1.0	1.5	2.0	2.5
N	2.56E-01	1.50E-01	1.03E-01	7.89E-02	6.50E-02
NNE	2.79E-01	1.59E-01	1.06E-01	7.91E-02	6.39E-02
NE	3.27E-01	1.86E-01	1.28E-01	9.92E-02	8.36E-02
ENE	2.90E-01	1.72E-01	1.23E-01	9.68E-02	8.22E-02
E	2.75E-01	1.83E-01	1.26E-01	9.47E-02	7.59E-02
ESE	2.34E-01	1.47E-01	9.61E-02	6.98E-02	5.39E-02
SE	2.07E-01	1.30E-01	8.58E-02	6.34E-02	5.01E-02
SSE	1.73E-01	1.12E-01	7.45E-02	5.50E-02	4.34E-02
S	2.03E-01	1.40E-01	1.00E-01	7.84E-02	6.55E-02
SSW	2.17E-01	1.68E-01	1.38E-01	1.17E-01	1.05E-01
SW	6.18E-01	4.46E-01	3.53E-01	2.92E-01	2.58E-01
WSW	9.91E-01	6.48E-01	4.50E-01	3.42E-01	2.79E-01
W	5.65E-01	3.70E-01	2.50E-01	1.87E-01	1.50E-01
WNW	2.78E-01	1.71E-01	1.15E-01	8.71E-02	7.06E-02
NW	2.93E-01	1.76E-01	1.20E-01	9.23E-02	7.64E-02
NNW	1.81E-01	1.08E-01	7.26E-02	5.49E-02	4.46E-02

	MILES				
DIRECTION	3.0	4.0	5.0	7.5	10.0
N	5.60E-02	4.44E-02	3.69E-02	2.47E-02	1.85E-02
NNE	5.43E-02	4.24E-02	3.49E-02	2.32E-02	1.73E-02
NE	7.41E-02	6.20E-02	5.40E-02	3.68E-02	2.82E-02
ENE	7.29E-02	6.06E-02	5.23E-02	3.55E-02	2.71E-02
E	6.36E-02	4.80E-02	3.83E-02	2.52E-02	1.85E-02
ESE	4.36E-02	3.08E-02	2.33E-02	1.48E-02	1.06E-02
SE	4.15E-02	3.09E-02	2.45E-02	1.60E-02	1.17E-02
SSE	3.59E-02	2.66E-02	2.09E-02	1.36E-02	9.93E-03
S	5.73E-02	4.65E-02	3.94E-02	2.66E-02	2.02E-02
SSW	9.73E-02	8.60E-02	7.71E-02	5.33E-02	4.14E-02
SW	2.36E-01	2.05E-01	1.82E-01	1.25E-01	9.68E-02
WSW	2.37E-01	1.85E-01	1.52E-01	1.01E-01	7.55E-02
W	1.26E-01	9.67E-02	7.87E-02	5.21E-02	3.87E-02
WNW	6.02E-02	4.70E-02	3.88E-02	2.59E-02	1.93E-02
NW	6.64E-02	5.38E-02	4.57E-02	3.08E-02	2.34E-02
NNW	3.81E-02	2.99E-02	2.47E-02	1.65E-02	1.24E-02

TABLE XA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

AVERAGE ANNUAL SULFUR DIOXIDE CONCENTRATIONS IN
MICRO-GRAMS PER CUBIC METER FROM AN ELEVATED ROUTINE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

MILES

DIRECTION	0.5	1.0	1.5	2.0	2.5
N	3.36E-02	1.97E-02	1.35E-02	1.04E-02	8.53E-03
NNE	3.66E-02	2.09E-02	1.39E-02	1.04E-02	8.39E-03
NE	4.30E-02	2.44E-02	1.68E-02	1.30E-02	1.10E-02
ENE	3.80E-02	2.26E-02	1.61E-02	1.27E-02	1.08E-02
E	3.61E-02	2.40E-02	1.65E-02	1.24E-02	9.97E-03
ESE	3.07E-02	1.93E-02	1.26E-02	9.16E-03	7.07E-03
SE	2.71E-02	1.70E-02	1.13E-02	8.32E-03	6.57E-03
SSE	2.27E-02	1.47E-02	9.78E-03	7.23E-03	5.70E-03
S	2.67E-02	1.83E-02	1.32E-02	1.03E-02	8.60E-03
SSW	2.85E-02	2.21E-02	1.82E-02	1.54E-02	1.38E-02
SW	8.11E-02	5.86E-02	4.64E-02	3.84E-02	3.39E-02
WSW	1.30E-01	8.51E-02	5.91E-02	4.50E-02	3.66E-02
W	7.42E-02	4.85E-02	3.28E-02	2.45E-02	1.97E-02
WNW	3.64E-02	2.24E-02	1.52E-02	1.14E-02	9.28E-03
NW	3.84E-02	2.31E-02	1.58E-02	1.21E-02	1.00E-02
NNW	2.37E-02	1.41E-02	9.53E-03	7.20E-03	5.86E-03

MILES

DIRECTION	3.0	4.0	5.0	7.5	10.0
N	7.35E-03	5.83E-03	4.85E-03	3.24E-03	2.43E-03
NNE	7.13E-03	5.56E-03	4.58E-03	3.05E-03	2.28E-03
NE	9.73E-03	8.15E-03	7.09E-03	4.83E-03	3.70E-03
ENE	9.57E-03	7.96E-03	6.87E-03	4.66E-03	3.55E-03
E	8.36E-03	6.30E-03	5.03E-03	3.31E-03	2.43E-03
ESE	5.72E-03	4.05E-03	3.06E-03	1.95E-03	1.39E-03
SE	5.45E-03	4.06E-03	3.22E-03	2.10E-03	1.54E-03
SSE	4.72E-03	3.49E-03	2.74E-03	1.79E-03	1.30E-03
S	7.52E-03	6.11E-03	5.18E-03	3.50E-03	2.65E-03
SSW	1.28E-02	1.13E-02	1.01E-02	7.00E-03	5.43E-03
SW	3.10E-02	2.69E-02	2.39E-02	1.64E-02	1.27E-02
WSW	3.12E-02	2.43E-02	2.00E-02	1.33E-02	9.91E-03
W	1.66E-02	1.27E-02	1.03E-02	6.84E-03	5.08E-03
WNW	7.90E-03	6.18E-03	5.10E-03	3.40E-03	2.54E-03
NW	8.72E-03	7.07E-03	6.00E-03	4.05E-03	3.07E-03
NNW	5.00E-03	3.93E-03	3.25E-03	2.17E-03	1.62E-03

TABLE IXA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

AVERAGE ANNUAL FLUORIDE CONCENTRATIONS
IN MICRO-GRAMS PER CUBIC METER FROM BOTH
AN ELEVATED AND GROUND ROUTINE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

MILES

DIRECTION	0.5	1.0	1.5	2.0	2.5
N	1.97E-02	7.85E-03	4.75E-03	3.43E-03	2.67E-03
NNE	1.95E-02	7.85E-03	4.69E-03	3.35E-03	2.59E-03
NE	3.08E-02	1.16E-02	6.91E-03	4.97E-03	3.89E-03
ENE	2.80E-02	1.07E-02	6.49E-03	4.72E-03	3.71E-03
E	1.90E-02	8.32E-03	5.14E-03	3.70E-03	2.85E-03
ESE	1.18E-02	5.52E-03	3.37E-03	2.38E-03	1.81E-03
SE	1.29E-02	5.62E-03	3.41E-03	2.42E-03	1.85E-03
SSE	1.07E-02	4.76E-03	2.90E-03	2.07E-03	1.58E-03
S	2.02E-02	8.17E-03	5.00E-03	3.63E-03	2.85E-03
SSW	3.89E-02	1.46E-02	9.01E-03	6.65E-03	5.33E-03
SW	9.28E-02	3.51E-02	2.16E-02	1.59E-02	1.27E-02
WSW	7.80E-02	3.27E-02	2.00E-02	1.44E-02	1.12E-02
W	4.14E-02	1.77E-02	1.07E-02	7.66E-03	5.90E-03
WNW	2.09E-02	8.57E-03	5.17E-03	3.71E-03	2.87E-03
NW	2.52E-02	9.92E-03	5.95E-03	4.27E-03	3.33E-03
NNW	1.35E-02	5.45E-03	3.28E-03	2.35E-03	1.82E-03

MILES

DIRECTION	3.0	4.0	5.0	7.5	10.0
N	2.20E-03	1.62E-03	1.28E-03	8.40E-04	6.18E-04
NNE	2.11E-03	1.54E-03	1.21E-03	7.89E-04	5.78E-04
NE	3.23E-03	2.43E-03	1.97E-03	1.31E-03	9.73E-04
ENE	3.09E-03	2.33E-03	1.88E-03	1.24E-03	9.23E-04
E	2.32E-03	1.66E-03	1.28E-03	8.30E-04	6.02E-04
ESE	1.44E-03	9.91E-04	7.34E-04	4.65E-04	3.29E-04
SE	1.50E-03	1.07E-03	8.16E-04	5.27E-04	3.81E-04
SSE	1.28E-03	9.05E-04	6.90E-04	4.45E-04	3.20E-04
S	2.35E-03	1.75E-03	1.40E-03	9.24E-04	6.84E-04
SSW	4.49E-03	3.48E-03	2.86E-03	1.91E-03	1.44E-03
SW	1.07E-02	8.19E-03	6.69E-03	4.47E-03	3.35E-03
WSW	9.15E-03	6.69E-03	5.24E-03	3.42E-03	2.51E-03
W	4.79E-03	3.47E-03	2.70E-03	1.76E-03	1.28E-03
WNW	2.34E-03	1.71E-03	1.35E-03	8.80E-04	6.46E-04
NW	2.74E-03	2.04E-03	1.63E-03	1.07E-03	7.95E-04
NNW	1.49E-03	1.09E-03	8.59E-04	5.62E-04	4.13E-04

TABLE XIIA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

KIDNEY DOSE IS IN MANREM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES						
DIRECTION	0-1	1-2	2-3	3-4	4-5	5-10	TOTALS
N	1.44E-04	7.39E-05	1.22E-05	3.00E-05	7.23E-05	2.61E-04	5.94E-04
NNE	1.37E-04	4.68E-05	8.04E-05	2.12E-05	9.70E-06	1.16E-04	4.10E-04
NE	7.31E-04	4.13E-05	0.	2.52E-05	8.69E-06	4.51E-04	1.26E-03
ENE	8.96E-04	1.91E-04	1.89E-05	5.83E-05	1.61E-05	2.57E-04	1.44E-03
E	1.32E-04	2.08E-04	1.25E-04	5.57E-05	8.43E-05	1.12E-03	1.73E-03
ESE	0.	5.90E-05	6.88E-05	5.82E-05	2.37E-06	9.33E-05	2.82E-04
SE	0.	2.94E-05	7.20E-06	7.06E-05	1.51E-05	2.65E-05	1.49E-04
SSE	1.40E-04	3.67E-05	1.20E-05	0.	0.	1.37E-05	2.02E-04
S	1.63E-04	1.12E-04	0.	0.	2.35E-05	1.18E-05	3.10E-04
SSW	0.	6.08E-05	0.	1.87E-05	1.30E-04	2.60E-04	4.70E-04
SW	8.26E-04	0.	0.	1.74E-04	6.00E-05	8.09E-04	1.87E-03
WSW	5.77E-04	0.	9.83E-05	9.08E-05	2.08E-05	4.22E-04	1.21E-03
W	0.	0.	2.02E-04	1.04E-03	9.56E-05	3.11E-04	1.65E-03
WNW	1.52E-04	0.	7.26E-04	4.31E-04	9.03E-06	6.32E-05	1.38E-03
NW	1.93E-04	1.98E-04	2.65E-03	1.54E-04	6.21E-05	1.19E-04	3.38E-03
NNW	9.72E-05	1.66E-05	3.82E-05	8.23E-05	2.19E-05	7.05E-05	3.27E-04
TOTALS	4.19E-03	1.07E-03	4.04E-03	2.31E-03	6.31E-04	4.41E-03	1.67E-02
CUMULATIVE TOTALS	4.19E-03	5.26E-03	9.30E-03	1.16E-02	1.22E-02	1.67E-02	

TABLE XIIIA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

LUNG DOSE IS IN MANREM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES						
DIRECTION	0-1	1-2	2-3	3-4	4-5	5-10	TOTALS
N	3.27E-03	1.60E-03	2.56E-04	6.16E-04	1.44E-03	4.99E-03	1.22E-02
NNE	3.09E-03	1.00E-03	1.69E-03	4.33E-04	1.93E-04	2.20E-03	8.61E-03
NE	1.67E-02	9.13E-04	0.	5.31E-04	1.78E-04	8.80E-03	2.72E-02
ENE	2.05E-02	4.20E-03	4.06E-04	1.22E-03	3.28E-04	4.98E-03	3.17E-02
E	2.99E-03	4.37E-03	2.55E-03	1.11E-03	1.64E-03	2.10E-02	3.37E-02
ESE	0.	1.17E-03	1.33E-03	1.09E-03	4.36E-05	1.66E-03	5.29E-03
SE	0.	6.14E-04	1.47E-04	1.40E-03	2.92E-04	4.93E-04	2.95E-03
SSE	3.13E-03	7.61E-04	2.42E-04	0.	0.	2.53E-04	4.39E-03
S	3.73E-03	2.45E-03	0.	0.	4.75E-04	2.28E-04	6.88E-03
SSW	0.	1.36E-03	0.	3.99E-04	2.68E-03	5.12E-03	9.56E-03
SW	1.91E-02	0.	0.	3.68E-03	1.24E-03	1.58E-02	3.99E-02
WSW	1.31E-02	0.	2.06E-03	1.85E-03	4.13E-04	8.03E-03	2.55E-02
W	0.	0.	4.20E-03	2.12E-02	1.89E-03	5.89E-03	3.32E-02
WNW	3.44E-03	0.	1.52E-02	8.83E-03	1.80E-04	1.21E-03	2.89E-02
NW	4.41E-03	4.32E-03	5.66E-02	3.20E-03	1.26E-03	2.30E-03	7.21E-02
NNW	2.20E-03	3.58E-04	8.03E-04	1.69E-03	4.38E-04	1.35E-03	6.83E-03
TOTALS	9.58E-02	2.31E-02	8.56E-02	4.72E-02	1.27E-02	8.44E-02	3.49E-01
CUMULATIVE TOTALS	9.58E-02	1.19E-01	2.04E-01	2.52E-01	2.64E-01	3.49E-01	

TABLE XIVA

KERR MCGEE

SEQUOYAH UF6 FACILITY NEAR GORE OKLAHOMA

BONE DOSE IS IN MANREM PER YEAR FROM BOTH
AN ELEVATED AND GROUND ROUTINE ANNUAL AVERAGE RELEASE

PER DISTANCE IN MILES AND GEOGRAPHIC DIRECTION FROM PLANT SITE

	MILES						
DIRECTION	0-1	1-2	2-3	3-4	4-5	5-10	TOTALS
N	3.52E-05	1.80E-05	2.96E-06	7.31E-06	1.76E-05	6.37E-05	1.45E-04
NNE	3.33E-05	1.14E-05	1.96E-05	5.17E-06	2.36E-06	2.82E-05	1.00E-04
NE	1.78E-04	1.01E-05	0.	6.14E-06	2.12E-06	1.10E-04	3.06E-04
ENE	2.18E-04	4.65E-05	4.60E-06	1.42E-05	3.93E-06	6.26E-05	3.50E-04
E	3.23E-05	5.07E-05	3.04E-05	1.36E-05	2.05E-05	2.74E-04	4.22E-04
ESE	0.	1.44E-05	1.68E-05	1.42E-05	5.78E-07	2.27E-05	6.87E-05
SE	0.	7.17E-06	1.75E-06	1.72E-05	3.68E-06	6.45E-06	3.63E-05
SSE	3.41E-05	8.94E-06	2.92E-06	0.	0.	3.33E-06	4.93E-05
S	3.97E-05	2.73E-05	0.	0.	5.73E-06	2.88E-06	7.56E-05
SSW	0.	1.48E-05	0.	4.57E-06	3.16E-05	6.35E-05	1.14E-04
SW	2.01E-04	0.	0.	4.23E-05	1.46E-05	1.97E-04	4.55E-04
WSW	1.41E-04	0.	2.40E-05	2.21E-05	5.07E-06	1.03E-04	2.95E-04
W	0.	0.	4.92E-05	2.54E-04	2.33E-05	7.58E-05	4.02E-04
WNW	3.70E-05	0.	1.77E-04	1.05E-04	2.20E-06	1.54E-05	3.37E-04
NW	4.71E-05	4.82E-05	6.46E-04	3.75E-05	1.51E-05	2.90E-05	8.23E-04
NNW	2.37E-05	4.06E-06	9.31E-06	2.01E-05	5.35E-06	1.72E-05	7.97E-05
TOTALS	1.02E-03	2.62E-04	9.84E-04	5.64E-04	1.54E-04	1.07E-03	4.06E-03
CUMULATIVE TOTALS	1.02E-03	1.28E-03	2.27E-03	2.83E-03	2.98E-03	4.06E-03	

(26) Page S-104. a. Estimated Uranium Uptakes and Effects - Checking calculations: Steer ingests total forage on one acre. Forage contains 16.6 μCi natural uranium. Fraction retained by kidney = 1.1×10^{-3} (ICRP #6 not ICRP #2 cited as reference 30). Total retained by steer kidney: $(16.6)(1.1 \times 10^{-3}) = 18.3 \times 10^{-3}$ μCi. Man ingests 1/2 kidney per year or 9.15×10^{-3} μCi and retains $(1.1 \times 10^{-3})(9.15 \times 10^{-3}) = 10.05 \times 10^{-6}$ μCi versus 1.2×10^{-6} μCi reported.

Organ Dose Calculations: Ref. Page 277 "Handbook of Laboratory Safety" 1967; 92.238 organ dose = 1.59×10^{8} rem/Ci.

$$\frac{1.5 \times 10^{8}\ \text{rem}}{\text{Ci}} \times \frac{10^{3}\ \text{mrem}}{\text{rem}} \times \frac{\text{Ci}}{10^{6}\mu\text{Ci}} = 1.59 \times 10^{5}\ \frac{\text{mrem}}{\mu\text{Ci}}$$

Using reported retention, kidney dose would be 1.2×10^{-6} μCi $\times 1.59 \times 10^{5}\ \frac{\text{mrem}}{\mu\text{Ci}}$ = 0.191 mrem versus < 0.02 mrem reported.

At 10.05×10^{-6} μCi retained, kidney dose would be 1.59 mrem.

Estimated Uranium Uptake. Several errors were found in the calculations included on Page S-104 and data recalculated for effluent quantities shown on Page 29 (S-97) and quantities measured in October 1972.

The following assumptions were made for exposure from the food chain:

a. All effluent evenly deposited on circle one mile in diameter.
b. A steer ingests total forage on one acre each month.
c. Forage receives .471 μCi insoluble and .236 μCi soluble (October - .526 μCi insoluble and .059 μCi soluble). Uranium content of steer kidney results only from intake of soluble portion since insoluble uranium is excreted without uptake.

d. Total uranium retained by steer kidney is
$9 \times .236 \times 1.1 \times 10^{-3} = 2.34 \times 10^{-3}$ μCi
(October - $.585 \times 10^{-3}$ μCi).

e. Man ingests 1/2 kidney per year or
$2.34 \times 10^{-3} \times .5 \times 1.1 \times 10^{-3} = 1.28 \times 10^{-6}$ μCi
(October - $.322 \times 10^{-6}$ μCi).

f. Organ dose - Page 277 of "Handbook of Laboratory Safety", 1967:
1.59×10^{8} rem/Ci = 1.59×10^{5} mRem/μCi
$1.28 \times 10^{-6} \times 1.59 \times 10^{5} = .203$ mRem
(October - .051 mRem)

Kidney dose is consequently a negligible fraction of background dose.

(27) Page S-104. b. External Exposure from Uranium Deposited on the Soil: At 16.6 μCi/acre deposited and emission of 7.57×10^{4} d/s/μCi natural uranium, Σ Emission = $7.57 \times 10^{4} \times 16.6 \times 60 = 7.54 \times 10^{7}$ d/m/acre

Reported Value = 7.4×10^{7} d/m/acre

$$\frac{7.4 \times 10^{7}\ \text{d}}{\text{min - acre}} \times \frac{\text{acre}}{4047\text{m}^2} = 1.83 \times 10^{4}\ \text{d/min/m}^2$$

Reported Value = 1.8×10^{4} d/min/m^2

$$\frac{1.8 \times 10^{4}\ \text{d}}{\text{min - m}^2} \times \frac{\text{M}^2}{10^{4}\text{cm}^2} = 1.8\ \text{d/min/cm}^2$$

or 180 d/min/100 cm^2 vs 1P1/m/100 cm^2 reported

Cannot determine calculation method employed to arrive at quoted dose rate of .0032 mrem/yr. Please clarify.

We have recalculated external exposure in accordance with Table XXVI-Rev. and the correct level should be .924 (October - .76) disintegrations/minute/100 square centimeters. The method of calculation for dose rate is shown below:

Based on the data shown on Revised Table XXVI (Page S-97), total deposition = 174.3×10^{-4} μCi/Mo/M^2 = 2.09×10^{-3} μCi/yr/M^2 (October -

144.6×10^{-6} µCi/M^2 or 1.73×10^{-3} µCi/yr/M^2).

From "Radiological Health Handbook", Page 32:

Exposure rate from a point source-assuming dose is from all uranium in a 1 M^2 area:

$I_r = .156\ n\ E(10^5\ \mu a)$

where:

I_r = mR/hr at 1 meter/mCi

n = gamma quanta per disintegration = 1.0

E = energy of gamma quanta in MeV = .185

μa = energy absorption coefficient for gamma in air (S.T.P.) in cm^{-1} = 3.2×10^{-5} cm^{-1}

then:

$I_r = .156(1.0)(.185)(3.2 \times 10^{-5})(10^5)$

$I_r = .156(.592) = .09$ mR/hr/mCi @ 1 meter

External exposure:

$.09 \times 2.1 \times 10^{-6}$ mCi/yr/M^2 =

1.89×10^{-7} mR/hr/M^2

$1.89 \times 10^{-7} \times 8760 = 1.65 \times 10^{-3}$ or

.0016 mR/yr/M^2

(28) Page S-105, Paragraph 1. Cannot follow calculation for uranium buildup in the soil (.096 mrem/yr)or runoff by rainwater (.001 MPC). Please clarify.

Buildup in uranium in soil would equal 30 times the buildup calculated, .0016 mRem/yr x 30 = .048 mRem/yr dose rate after 30 years of operation.

Runoff of uranium by rainwater is calculated on the basis that 8.36 µCi/acre/yr is deposited with an assumed runoff of 50%, resulting in the following calculations:

$$\frac{8.36\ \mu Ci/acre \times .5}{43{,}560\ Ft^2/acre \times \frac{40''\ rain/yr}{12''/Ft} \times 28.32 \times 10^3\ ml/Ft^3} =$$

$1.02 \times 10^{-9}\ \mu Ci/ml$

or .00005 MPC for natural uranium (October - 7.02 µCi/acre/yr or approximately the same runoff).

(29) Page S-112, Table XXXIII. MPC values used in calculations for Th-230 soluble and insoluble, and for Ra-226 soluble are not taken from 10 CFR 20. Apparently values used were 1×10^{-8} µCi/ml for Ra-226 (sol) instead of 3×10^{-8} µCi/ml and 1×10^{-6} µCi/ml for Th-230 soluble and insoluble instead of 2×10^{-6} µCi/ml for soluble Th-230 and 3×10^{-5} µCi/ml for insoluble Th-230. Use of proper MPC values would not appear to change the overall conclusion but would require considerably less dilution to attain MPC level than is indicated in paragraph one, page S-113. Reasoning behind adding dilution needed to reach Ra-226 MPC to that needed to reach Th-230 and U-Nat MPC appears to be in error since providing the required dilution for the Ra-226 would more than take care of that needed for the Th-230 and U-Nat. Table and text should be corrected. Values shown in table for raffinate sludge pond are all in error as are most of values reported for natural uranium.

Table XXXIII. Calculations on this table have been checked and a revised table is attached. As noted, the incorrect MPC value for $Radium_{226}$ was used in the calculation of the required dilution volume. This calculation has been redone as follows:

Total Volume: 14.2×10^6 gallons x 35.6 =
5.05×10^8 gallons required for dilution

At 540 cps, the Illinois River would supply 3.49×10^8 gallons daily or 1.4 days would be required to dilute the entire soluble contents of the retention ponds to 1 MPC. Observations as to the probable effect of chemical concentrations on fish life in the reservoir do not change.

TABLE XXXIII

RADIOACTIVITY - WASTE RETENTION PONDS

	Raffinate Pond #1	Raffinate Pond #2	Raffinate Sludge Pond
Volume-mℓ	2.27×10^{10} (8 Million Gallons)	1.32×10^{10} (3.5 Million Gallons)	$.757 \times 10^{10}$ (2.7 Million Gallons)
Ra-226 Activity-µCi/mℓ			
Soluble	107×10^{-8}	106×10^{-8}	1.07×10^{-6}
MPC	35.6	35.0	35.6
Insoluble	$.356 \times 10^{-5}$	4.59×10^{-6}	3.5×10^{-6}
MPC	0.12	0.15	0.12
Total Th Activity-µCi/mℓ			
Soluble	1.1×10^{-8}	1.1×10^{-8}	1.1×10^{-8}
MPC	.01	.01	.01
Insoluble	1.94×10^{-6}	1.1×10^{-6}	2.0×10^{-6}
MPC	.19	0.11	.20
Natural Uranium Activity-µCi/mℓ			
Soluble	1.2×10^{-6}	1.2×10^{-6}	1.0×10^{-6}
MPC	0.06	0.06	0.06
Insoluble	5.9×10^{-5}	5.77×10^{-5}	5.76×10^{-5}
MPC	3.0	2.88	2.88

(30) Page S-115. Analysis of HF tank rupture indicates that limestone provided is more than adequate if the HF doesn't vaporize. With a boiling point of 19.4°C, it appears that more of the HF would probably vaporize than would react with the limestone. Need new analysis considering atmospheric pollution effect of HF release.

Acid Tank Rupture. While the capability of the limestone contained in the curbed area under the HF tanks was calculated to demonstrate its capability for neutralizing HF in the event of a tank rupture, it seems unlikely that such an accident would happen.

The acid tanks are 3/4" carbon steel tanks mounted on scales with no bottom opening. Acid is charged to the tank and removed through the top. The tank is pressurized to 30 psig in order to discharge acid through a dipleg reaching to within 6" of the bottom. The tank is equipped with two rupture discs. The first, set at 55 psi, discharging into the scrubber system; the second, set at 75 psi, discharging into the atmosphere. The tanks are inspected each three years at the welds, heads and circumferentially with an audiogauge to determine the thickness. The most probable accident would be the accidental rupture of a discharge line or valve containing liquid HF. By quickly venting the tank to the scrubber system to reduce the pressure and localized absorption with water sprays and neutralizing lime for liquid spillage, such line or valve ruptures have been contained with very little loss of HF and no measurable escape from the plant site.

Rupture discs installed are subject to occasional rupture due to gradual fatigue of the discs. Such accidental releases have occurred but have been quickly controlled by venting the tank to the scrubber and replacing the disc.

The worst accident of this nature known of by Kerr-McGee was the loss of a flange while unloading an acid tank car at the AEC's Weldon Springs site where approximately 11,000 pounds of HF were lost before the tank car pressure could be reduced and flow valved off. In this instance, the plume rose almost vertically and drifted past a building whose ventilation system pulled the HF into the building forcing its evacuation. The bulk of the plume continued to rise and drifted approximately 1000 feet before disappearing due to atmospheric dilution. No ground level exposure occurred. Trees in the immediate path were defoliated as would be expected but recovered during the next growing season.

In examining the remote probability of a complete tank rupture, several simplifying assumptions had to be made in order to calculate the size of the plume. The assumptions were as follows:

1. Temperature - 100°F. Atmospheric Pressure - 29.5" mercury.
2. Sufficient limestone available to neutralize the entire tank and reaction of HF with limestone instantaneously.
3. No atmospheric effect influences the diffusion and dispersion of the vaporized HF.
4. The HF tank contains the normal working inventory of 60,000 pounds.
5. The tank contents empty instantaneously onto the area of the limestone contained within the curb.
6. The ratio of HF vaporized to HF reacted is equal to the ratio of the heat of reaction to the heat of vaporization.

   Heat of reaction = 12,384 BTU/lb mol

   Heat of vaporization = 3,950 BTU/lb mol

   Ratio = 3, i.e. 25% of the HF reacts and 75% vaporizes

7. The HF diffuses uniformly into the shape of a half sphere from the point of release.
8. An acceptable concentration of HF for temporary exposure is 100 mg/M^3 or 6.239×10^{-6} lbs HF/Ft^3.

With these assumptions, we can calculate as follows:

$.75 \times 60{,}000$ lbs = 45,000 lbs vaporized
$45{,}000/6.24 \times 10^{-6} = 7.2 \times 10^9$ Ft^3
Radius = $(3 \times \text{Volume}/8\pi)^{1/3}$. The radius, therefore, equals 1500 feet.

Therefore, we conclude that under these assumptions, breathing zone tolerable levels are reached 1500 feet from the location of the storage tank while localized defoliation would occur and immediate onsite air concentrations would exceed the tolerable levels. We believe that, in view of the procedural and equipment precautions, excessive airborne exposure would not be a credible accident from the unlikely event of an HF tank rupture.

(31) Page S-117. Burning of uranium loaded organic should result in dispersing particulates in the resulting smoke. An assessment of the amount of airborne uranium and dispersion to off-site areas should be made.

We have not been able to locate or generate a thorough technical assessment of the result of burning uranium-loaded organic solutions. Four experiments were made in the laboratory with plant solutions of hexane-TBP solvent. Upon ignition, these solutions burned until all hexane disappeared. Combustion of the loaded TBP, however, was dependent on conducting the test in a thin aluminum shallow pan providing maximum temperature generation and conduction of heat to the TBP residual. Under this circumstance, a residual tar remained containing some

uranium. When the TBP-hexane mixture was burned in a heavy nickel crucible or a glass beaker, combustion ceased with complete removal of the hexane. We conclude that, in order to burn uranium-loaded TBP, a special consideration for the maximum conduction of heat to the TBP must be made. We consider the probability that, in the event of a fire in the solvent extraction plant, such special conditions would not be present, i.e. no large amounts of material to conduct heat to the TBP and containment in concrete (poor heat conducting) curbing. Based upon these tests and conclusions, we do not believe excessive dispersion of uranium in resulting smoke a credible accident.

In the "Environmental Survey of the Nuclear Fuel Cycle", November 1972, published by the Directorate of Licensing, the results of two fires in uranium concentration mills are reported. No "appreciable release of uranium to unrestricted environment" was determined as a result of investigations into these fires.

(32) Page S-117, Paragraph 4. Do not understand meaning of last sentence.

It is calculated that the effective curb volume is 10,564 gallons and the time to fill the curb with foam and water discharge is 14.9 minutes. The quantity of foam available for discharge will only run for 8 minutes. Therefore, the last sentence says, in effect, that the amount of foam and water will only fill the curb area to the extent of 8/15 or approximately 55% with no allowance made for the bulk buildup characteristics of the foam.

(33) Page S-118. Safety factor provided to contain maximum possible Sx tankage spill within curbed area (17091/17000) is extremely small.

While the safety factor provided on the solvent extraction curbing appears to be small by the calculation, note that it is provided that the pulse column and the tankage located in the rework side could conceivably spill into the solvent extraction area. These areas also have curb volumes to protect from tankage collapse or total spillage with adequate safety factors. As noted, this is a maximum but "improbable spill".

(34) Page S-123, Last Paragraph and Page S-125. Cannot follow reasoning that only 2/3 of the fluoride is available because 1/3 is tied up as insoluble UO_2F_2 formed by UF_6 hydrolysis while all of the uranium is considered to be soluble. Please explain.

The consultant's calculations assume that personnel present in the downind plume are exposed to elemental fluorine which is not true. Upon exposure to air, UF_6 hydrolyzes to UO_2F_2 and HF as shown at the bottom of Page 123. Individuals in the plume, therefore, are exposed to gaseous HF and particulate, probably respirable, UO_2F_2. Therefore, we must deal with two separate toxic chemical exposures. The first, HF; the second, UO_2F_2, with its accompanying radiological and toxicological exposure to uranium and accompanying fluoride. The fluoride present in UO_2F_2 is not free fluorine nor HF when solubilized in the lung and proceeds promptly to the blood stream. Therein, if it became an available fluorine contamination for subsequent flurosis of the skeletal bones, an exchange reaction would be required with chloride ions in the blood stream. Based upon the 19.9 (20 rem exposure), total inhalation would be

$$\frac{20 \text{ Rem}}{80 \text{ Rem}/\mu\text{Ci inhaled}} \times .33\mu\text{Ci/g} \times 40/238 =$$

.012 gram fluorine absorbed with the uranium dose

This amount of fluorine is below that causing fatality in animals as reviewed by Dr. Sternhagen in the letter immediately following.

35. Answer by Dames & Moore.

36. Answer by Dames & Moore.

SCHOOL OF MEDICINE | DEPARTMENT OF RADIOLOGY | (505) 265-4411 Ext. 2424

THE UNIVERSITY OF NEW MEXICO | ALBUQUERQUE, NEW MEXICO 87106

13 Dec 72

William J. Shelley
Nuclear Division
Kerr-McGee Corporation
Kerr-McGee Building
Oklahoma City, Oklahoma 73102

Dear Mr. Shelley:

The Following information was requested by you per our phone conversation regarding fluorine toxicology and its effects which we discussed this morning.

Animal experiments (W. F. Machle, et al, J. Ind. Hyg. Toxicol., 16, 129 (1934); and 17, 223 (1935)) showed that rabbits and guinea pigs died within five minutes in air containing hydrogen fluoride 1500 mg/cu. meter. But inhaling air with 1000 mg/cu. meter for 30 minutes caused no fatalities in these animals. 500 mg/cu. meter for 15 minutes caused some signs of ill health; below 100 mg/cu meter no deaths occurred in five hours and 24 mg/cu meter caused no deaths after 41 hours. It is necessary to discuss hydrogen fluoride since this becomes one of the chemical products in the possible exposures of interest due to presence of hydrogen ions in the hydrated alveolar lung tissue or other respiratory epithelial lining areas.

The dose causing fatality of sodium fluoride given orally to rabbits is 200 mg/kg of body weight (C. W. Muehlberger, J. Pharmacol. Exptl. Therap., 39, 346 (1930))and when injected intraperitoneally it is 250 mg/kg (P. Handler, J. Biol. Chem., 161, 55 (1945)). But Na_3AlF_6, cryolite, cannot be given orally to rats in high enough doses to cause deaths because of lower toxicity, secondary to lower solubility (E. J. Largent, J. Ind. Hyg. Toxicol., 30, 92 (1948)). The basic process of fluoride action is as an inhibitor of some intracellular enzymatic processes in anaerobic glucolysis, and the therapy has been published in the work by J. H. Peters, Am. J. Med. Sci., 216, 278 (1948) and is beyond the scope of a toxicology presentation such as this.

In humans, in industrial exposures to fluorine in an aluminum plant (G. H. Agate, et al, Med. Res. Council Brit., Mem. No. 22,1948) it was noted that there were no disabling symptoms even though some had radiographic changes on X-ray Roentgenograms of bones consistent with the diagnosis of skeletal fluorosis. The urinary fluoride mean daily output was 9.03 mg in the most heavily exposed group in that study. It is also now known that very slight

bone changes can be seen in a small number of workers with chronic exposures causing urinary concentrations of six mg/liter (F. F. Heyroth, Am. J. Public Health, 42, 1568 (1952)).

Some industrial physicians regard the maximum permissible exposure as that causing less than 4 mg mean daily urinary output.

If there is any further way I may be of assistance to you in this, please do not hesitate to let me know.

Respectfully,

C. J. Sternhagen, M. D.
Charles J. Sternhagen, M. D.
Asst. Professor of Radiology

CJS/cs

cc. P. A. Puttroff

A.E.C. Question 35

Appendix IV Dames & Moore Report Page 8. Accident doses calculated as follows:

$$\frac{\chi}{Q}\ \text{Ground Accident} = \frac{1.0}{U\ (\Pi\ SZ(K)\ SY(K) + CA)}$$

where $SZ(K) = \sigma_z$; $SY(K) = \sigma_y$

CA = 1/2 minimum cross sectional area of containment building = 334.5 M^2

I question validity of using the "CA" term in the equation and believe that the basic equation for atmospheric diffusion from a ground level point source is applicable here. ie $\frac{\chi}{Q} = \frac{1}{\Pi U \sigma_y \sigma_z}$

Use of the CA term was adopted from Reactor Safety Guide 4 dealing with a PWR accident.

Response:

The utilization of the "CA" term was made to incorporate accepted standard effects caused by "wake entrainment" associated with ground level releases. The omission of the "CA" term causes increased dispersion of the atmospheric ground release. By incorporating the "CA" term, a more realistic and more conservative estimate of the effects of the ground release are made. Even though the CA term is associated with Safety Guide 4's PWR accident it is used to evaluate a ground level release that is influenced by a building wake which is a model used by Safety Guide 4 and its use is not restricted to either pressurized water reactors or accidents per se. An additional reference would be "Atmospheric Dispersion Calculations Using the Generalized Gaussian Plume Model" by F. A. Gifford, Jr. of the Weather Bureau Research Station, Oak Ridge, Tennessee, published in the USAEC quarterly NUCLEAR SAFETY.

AEC Question 35 (continued):

Dosage calculations at nearest residence ie 762 meters northwest of plant:

$$\frac{\chi}{Q}\text{ Ground Accident} = \frac{1.0}{U\ (\Pi\ SZ(K)\ SY(K) + CA)}$$

Where: U = 1.0 mps for 6.67 hour duration (assumed) (stability F)

$SZ(K)$ @ $x = 762m \cong 11.5m$

$SY(K)$ @ $x = 762m \cong 26.5m$

$$\frac{\chi}{QGA} = \frac{1.0}{(1)(3.14)(11.5)(26.5) + 334.3} = \frac{1}{1291.5} = 7.73 \times 10^{-4}$$

Soluble Uranium Dose = $\frac{\chi}{QGA}$ (Q) (BR) (DF) (TIME)

Response:

The values to SZ(K) and SY(K) were obtained from Figures 3.10 and 3.11 in "Meteorology and Atomic Energy 1968," published by the Division of Technical Information, USAEC. Some other references contain copying discrepancies in the use of these tables.

AEC Question 35 (continued):

Where: Dose is in rem to kidney for accident time of 6.67 hr.

Time = 2.4×10^4 seconds

BR = $3.47 \times 10^{-4}\ m^3/sec$ (Safety Guide #4 p. 4.2)

DF = Dose factor to kidney (80 rem/μCi inhaled)

Value indicated in Ref (7), (page 6 of D & M Report) ie IDO-12054 indicates inh. dose for 92.238 to kidney at 4.45×10^6 rad/Ci or 4.45 rad/μCi.

Source of 80 rem/μCi used in calculations is IAEA Safety Series No. 7 (1961) p. 50. Value of 4.45 rem/μCi given in Handbook of Laboratory Safety 1967, p. 277. Calculations of this value was checked from equation given in both IDO-12054 and HLS-1967 as

$$\text{Dose} = \frac{AfET_E}{m} \left(1 - \exp. \frac{-1.26 \times 10^4}{T_E}\right) \times \frac{1.6 \times 10^{-6} \times 3.2 \times 10^{15}}{0.693 \times 10^2}$$

With A = 1.0; f = 0.028; E = 43.0 MeV; T_E = 15.0 days
and m = 300.0 grams, Dose = 4.45×10^6 rem/Ci

D. F. Bunch, author of IDO-12054, claims IAEA value of 80 rem/µCi is incorrect.

Response:

Reference (7) in the Dames & Moore Report is incorrect for that report; it should be IAEA Safety Series No. 7 "Regulations for the Safe Transport of Radioactive Materials: Notes on Certain Aspects of the Regulations," SPI/Pub/32, which is more applicable for this type of an evaluation. The reference also includes chemical toxicity, and although the 80 rem/µCi is not the most rigorous value, it is the more conservative.

AEC Question 35 (continued):

In soluble uranium dose expression, Q is calculated to be:

$$\frac{4800 \text{ lb. } UF_6}{400 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{238 \text{ lb. U}}{352 \text{ lb. } UF_6} \times \frac{454g}{\text{lb.}} = 61.5 \text{ gU/sec.}$$

With D & M using Q = 39.6 µCi/sec, specific activity being used is;

$$\frac{39.6 \text{ µCi/sec}}{61.5 \text{ gU/sec}} = 0.644 \text{ µCi/gU}$$

This does not agree with ∿ 1/3 µCi/gU given for U_{238} on p. 104, Jan. 1970 edition of Radiological Health Handbook or for U-nat. in 10 CFR 20.5(c).

Response:

The value of 1/3 µCi/gU is the commonly-agreed upon value for natural Uranium and therefore was used in the Dames & Moore calculations.

AEC Question 35 (continued):

Using D & M Values, checking arithmetic

Soluble Uranium Dose = $\frac{X}{QGA}$ (Q) (BR) (DF) (TIME)

= (7.73×10^{-4}) (39.6) (3.47×10^{-4}) (80) (2.4×10^{4}) = 20.4 rem

versus 20.1 rem reported.

Using DF of 4.45 rem/µCi and specific activity of 1/3 µCi/gram U, dosage would be:

$20.1 \times \frac{4.45}{80} \times \frac{0.333}{0.644} = 0.58$ rem

indicating D & M calculations to be conservative.

Fluoride concn. = $\frac{X}{Q}$ Ground Accident (Q) $\times 1 \times 10^{6}$

@ 1600 lb F^{-}/400 minute release,

$Q = \frac{1600 \text{ lb}}{400 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{454 \text{ g}}{\text{LB}} \cong 30.3$ g/sec

F^{-} Concn = (7.73×10^{-4}) (30.3) (10^{6}) = 23422 µg/m^{3} checking
23000 µg/m^{3} reported

Response:

The above AEC checks on reported values are in good agreement and it is assumed these checks do not reflect any concern with the analyses reported.

AEC Question 36

Page S-125

Correcting exposures for 4550 LB UF_6 released in 40 minutes vs 4800 lb released in 400 minutes: (using D & M values for DF and specific activity)

$\frac{X}{QGA}$ remains the same @ 7.73×10^{-4}

Soluble U Dose:

$$Q = \frac{4550}{40} \times \frac{1}{60} \times \frac{238}{352} \times 454 \times 0.644 \cong 374\ \mu Ci/sec$$

$$Dose = (7.73 \times 10^{-4})\ (374)\ (3.47 \times 10^{-4})\ (80)\ (2.4 \times 10^{3}) = 19.3\ rem$$

vs. 19.9 rem reported

Fluoride concn (basis 2/3 of total available)

$$Q = \frac{1600\ lb}{40\ min} \times \frac{2}{3} \times \frac{1}{60} \times 454 \cong 201.8\ g/sec$$

$$F^- \text{ Concn} = (7.73 \times 10^{-4})\ (2.018 \times 10^{2})\ (10^{6}) = 15.6 \times 10^{4}\ \mu g/m^3$$

or 156 mg/m^3 checking
153 mg/m^3 reported

Response:

The values obtained by the AEC and D & M are in good close agreement for the Soluble Uranium dose and the Fluoride concentrations, as cited above.

AEC Question 36 (continued):

Method is OK but values questioned based on foregoing discussion.

Checking Ref. 35, ie "Safety Evaluation by DML, USAEC in the Matter of MFRP, Docket No. 50-268, October 6, 1967." The presumed acceptable 75 rem kidney dose appears to have been calculated using the guideline basis described on page 44 of the document where it is stated that "we have used an intake guideline which we believe is equivalent to the whole body exposure guideline of 25 rem set forth in 10 CFR 100. This guideline is that the intake of long-lived radionuclides shall not be greater than 50 times the annual intake by individual members of the general public which could occur under the provisions of 10 CFR 20." The rationale appears to be as follows:

(a) The whole body occupational annual permissible dose is 5 rems.

(b) The whole body annual permissible dose for individuals in the general population is 10 percent of this level or 0.5 rem.

(c) The permissible "other organ" (i.e., kidney) emergency dose (occupational) is 15 rem.

(d) Therefore, the permissible emergency kidney dose for individuals in the general population is 10% of 15 rem or 1.5 rem (50 year integrated dose).

At 50 times the permissible dose an acceptable kidney dose for accidental exposure would appear to be 1.5 x 50 or 75 rem.

While this rationale appears reasonable, it should be pointed out that permissible emergency exposures are covered in ICRP-6, p. 30, rather than 10 CFR 20.

Response:

The acceptance of the rationale by the AEC in the evaluation of Docket No. 50-268 formed the basis for the 75 rem kidney accidental exposure dose. The reference to the ICRP-6, p. 30, was not considered as the USAEC has not expressed the adoption of these levels for emergency exposures. Since the AEC accepted limits for emergency exposures, as developed in Ref. 35, other limits were not considered.

AEC Question 36 (continued):

Checking Reference 37 "Dangerous Properties of Industrial Materials", 1968 edition, page 823, referring to hydrofluoric acid, "Inhalation of the vapor may cause ulcers of the upper respiratory tract. Concentrations at 50 to 250 ppm are dangerous, even for brief exposures" (50 to 250 ppm = 41 to 204 mg/m^3). Statement on page S-125 reads, Sax permits brief exposure to 33 - 165 mg/m^3". Please resolve this apparent discrepancy.

Response:

In reference 36 and the cited reference 37, the term "brief exposures" and "dangerous" provide unfortunate latitude in interpretation. It is apparent from ref. 36 and 37 that a potential lethal hazard exists for HF. It is inferred from Sax reference, however, that a "non-lethal" exposure (33-165 mg/M^3) could be tolerated by an individual for "brief" periods.

36. Kerr-McGee answer.

Reference 37, "Dangerous Properties of Industrial Materials", 1968 Edition, Page 823, is quoted accurately for ppm. Conversion from ppm to mg/M^3 is given as 2/3 on page 13-5, "Industrial Ventilation", Tenth Edition, American Conference of Industrial Hygienists, resulting in the numbers of 33-165 mg/M^3 shown in the report. The difference in calculated concentration in mg/M^3 is probably due to the use of the above reference which is probably not an exact calculation.

Persons in the plume at this concentration would be uncomfortable during the period of exposure. In view of the conservative assumptions used on diffusion calculations and the procedural and equipment precautions, we do not believe even this temporary exposure is a credible accident.

(37) You state (top page S-130) that a satisfactory process will be developed to handle the raffinate storage pond contents. To support this statement, you should provide a detailed status report of investigations underway to cope with this problem. This is particularly important in view of the apparent raffinate pond seepage being experienced.

Three methods exist for the concentration and eventual disposal of raffinate generated by the Sequoyah process:

1. Concentration. The fertilizer industry produces solid ammonium nitrate by reacting ammonia with HNO_3 and subsequently concentrating the solution to approximately 80% NH_4NO_3. This molten salt is then solidified in a prilling tower to an appropriate form for distribution.

   This process can be halted at any appropriate salt concentration and the solution sold for

fertilizer as a solution. This same process could be used on the neutralized raffinate solution to either partially concentrate so as to maintain freeboard in the ponds and overcome the natural dilution of rainwater or concentration be continued and the material allowed to solidify for disposal by burial.

In 1971 and early 1972, tests were made with a submerged combustion evaporator which achieved more concentrated solutions without undue operating difficulty. These tests were run on a batch basis concentrating step-wise to examine operating difficulties and effluent concentrations. From these tests it was concluded that a large unit installed to process raffinate on a once-through basis returning the concentrate to the ponds would meet emission criteria and avoid the construction of additional ponds until resolution of the proposed deep well disposal or the installation of one of the alternate processes described below.

2. Removal of Radionuclides. The radionuclides contained in the raffinate can be removed by chemical treatment as solids resulting in a solution of essentially ammonium nitrate contaminated by trace amounts of metallic impurities.

It has been demonstrated in the laboratory and on a small scale in pilot plant equipment that the radium content can be reduced to approximately $.05 \times 10^{-8}$ μCi/ml or 1/30 of MPC, the thorium to $.4 \times 10^{-8}$ μCi/ml or 1/250 of MPC, and uranium to 1.2×10^{-7} μCi/ml or approximately 6/1000 of MPC. This treatment involves the

neutralization of the raffinate with ammonia which essentially removes all uranium and thorium and then treatment with a soluble barium content to the extent of approximately 2 g/l barium. The barium sulfate forms a precipitate and serves as a carrier for radium sulfate removal. The resulting solution radium concentration reaches the limit of detection for measuring $Radium_{226}$.

Work is planned to determine the feasibility of treating raw raffinate directly by this system so as to produce a more concentrated ammonium nitrate solution which then could be disposed of as fertilizing solution.

The solid precipitated would be separated by settling or filtration and buried in accordance with 10 CFR 20.304 or at a licensed burial ground.

3. Decomposition. The third method of disposal of the raffinate would involve decomposition to stable metallic salts, nitrate and ammonia or nitrogen and water. Two processes have been technically described but, as yet, neither has been tested in the laboratory.

The first involves the neutralization with magnesium oxide with evolution of ammonia and its collection, evaporation of the magnesium nitrate solution, kiln firing of the resultant magnesium nitrate hydrate and fractionation of the evolved nitric and hydrochloric acid vapor

for recycle. The stream of solids consisting of uranium, radium, magnesium oxide and sodium sulfate would be packaged as waste material for burial.

The second process is the neutralization of raffinate with ammonia and subsequent evaporation and solidification of the concentrated ammonium nitrate solution. This solid is then fed to a fluidized bed reactor for decomposition to nitrous oxide and water which is decomposed by a catalytic burner to nitrogen, oxygen and water vapor. Solids recovered from the fluid bed are separated by screening and buried. These solids would contain uranium, thorium, radium oxides and sodium sulfate.

It is planned to commence laboratory evaluation of these processes early in 1973.

(38) Supplemental Environmental Report: Appendix I, Item 11, Waste Disposal System Ponds. While design and installation of both the fluoride and raffinate ponds may meet all requirements of AEC licensing guide, the soluble salts in the raffinate stream may in time destroy the effectiveness of the "impervious" clay liner through ion exchange mechanisms. We suggest a laboratory study be performed to determine resistance of pond clays to attack by raffinate solutions.

Soil permeability tests were performed on samples of the clay liners from Ponds 1 and 2. Fresh water Pond 1 and Pond 2 and raw raffinate was used as the fluid for these tests. After 21 days of testing, no permeability of the clay used as liners

was detected. The test used was that described on Page 63 of "The Mechanics of Engineering Soils" by P. Leonard Capper and W. Fisher Cassie.

(39) Supplemental Environmental Report: Appendix IV, Page 6. Max downwind concns - Fig. 3-9. Stability F, X_{max} occurs @ ~5.2 Km rather than 4 Km. Also under "Conc." 1/3 stability F should be 0.5×10^{-5} making total 3.5×10^{-5} x. Under "Dist." 1/3 stability F should read 1.73 making maximum downwind distance 2.26 Km, changing statement in next paragraph. Maximum concentration occurs 2260 meters downwind.

The corrections noted were checked and the last sentence on Page 6 of Appendix 4 should read: "At 2260 meters downwind, the maximum ground level concentration, 3.5×10^{-5} x the stack level concentration, would occur."

(40) Supplemental Environmental Report: Appendix IV, Page 7. Small errors in picking values off Figure 3-9 of "Workbook" result in final sentence change to read "maximum downwind concentration of 5.5×10^{-4} $\frac{Q}{\upsilon}$ at .340 Km or 1114 ft.

Table is labeled incorrectly and should read:

	$\frac{X\upsilon}{Q\ Max}\ m^{-2}$	Distance, Km
Stability F	4.5×10^{-4}	0.63
Stability D	5.7×10^{-4}	0.25
Stability C	6.2×10^{-4}	0.15
Σ(F + D + C)	16.4×10^{-4}	1.03
Σ(F + D + C)/3	5.5×10^{-4}	0.34

The questions were noted and the calculations rechecked. The last sentence on Page 7 of Appendix 4 should read: "Roof top release at 45 feet would have a downwind concentration of 5.5×10^{-4} at 340 meters."

41. Answer by Dames & Moore.

42. Answer by Dames & Moore.

AEC Question 41

Supplemental Environmental Report: Appendix IV, Dames & Moore Report, Page 3. Summary Table of gaseous effluent release data should have been obtained from data shown in Table XXVI; Page 97.

ΣF^- (stack) = 0.1152518 g/sec = 0.12 g/sec

ΣF^- (ground level) = 0.0040923 = 0.004

ΣNO_x (stack) = 1.98 g/sec

ΣSO_2 (stack) = 0.26 g/sec

(a) Σ Soluble Uranium (ground level) = .00008382 or 8.382×10^{-5} g/sec

(b) Σ Soluble Uranium (stack) = .00047 or 4.7×10^{-4} g/sec

(c) Σ Insol Uranium (ground level) = .001091 or 1.091×10^{-3} g/sec

(d) Σ Insol Uranium (stack) = .0000175 or 1.75×10^{-5} g/sec

Appendix IV, p. 3, summary table gives uranium release rate in Ci/sec. i.e., Sol U (stack) = 3.0×10^{-10} Ci/sec or 3.0×10^{-4} µCi/sec.

$$\text{Specific Activity} = \frac{3.0 \times 10^{-4}\ \mu\text{Ci/sec}}{4.7 \times 10^{-4}\ \text{g/sec}} = 0.639\ \frac{\mu\text{Ci}}{\text{gram}}$$

This agrees substantially with 0.644 µCi/g value calculated previously in these comments, but does not agree with 1/3 µCi/gU value cited in the literature.

Response:

Reference AEC Question 35.

AEC Question 41 (continued):

However, apparent specific activity used was not constant:

		µCi/gram U Specific Activity
Sol U Stack:	$\frac{3.0 \times 10^{-4}}{4.7 \times 10^{-4}}$ =	0.639
Sol U Ground:	$\frac{5.0 \times 10^{-5}}{8.382 \times 10^{-5}}$ =	0.597

Insol U Stack: $\frac{1.0 \times 10^{-5}}{1.75 \times 10^{-5}}$ = 0.571

Insol U Ground: $\frac{7.2 \times 10^{-4}}{10.91 \times 10^{-4}}$ = 0.659

This would imply that data furnished by K-M to Dames and Moore; Reference (4) written correspondence between I. Spickler of D & M and A. Valentine of K-M; May 1972 may not have been obtained from Table XXVI, page 97. Please clarify this apparent discrepancy. Also see comment (25) above; release data may need revision.

Response:

Reference AEC Question 35.

AEC Question 42

Supplemental Environmental Report: Appendix IV, D & M Report, Page 6.

Dose factor for uranium affecting the kidney in reference (7) "IDO-12054" is listed as 4.45×10^6 rad/Ci = 4.45 rad/µCi for inhaled soluble U-238 versus value of 80 rem/µCi used by D & M.

Response:

Reference AEC Question 35.

AEC Question 42 (contin:ed):

Dose factor for lungs is given as 110 rem/ Ci by D & M quoting IDO-12054. Lung data are not included in this publication.

Response:

Reference should be to revised reference #7.

AEC Question 42 (continued):

Dose factor for bones is given as 20 rem/µCi by D & M. IDO-12054 gives value as 19.5 rad/µCi.

Response:

The revision from 20 rem/µCi to 19.5 rad/µCi was made in the tables under question 25.

(43) Environmental Report (revised), dated November 1941.

Page 23-R: Calculations for discharge data are in error. Basis for conclusions drawn on page 24, §1 not understood.

(a) N as NO_3 shown as 2 ppm with NO_3 shown as 8.4 ppm.

$$\frac{NO_3}{N} = \frac{14 + 48}{14} \times 2 \text{ ppm N} = 8.85 \text{ ppm } NO_3$$

(b) Illinois River: 1462 cfs.

$\Sigma\ NO_3$ @ 2.4 ppm given as 2290 lbs/day

$$\frac{1462 \text{ CF}}{\text{sec}} \times \frac{62.4 \text{ lbs}}{\text{CF}} \times \frac{8.64 \times 10^4 \text{ sec}}{\text{day}} \times \frac{2.4 \text{ Parts } NO_3}{1\text{x}10^6 \text{ Parts } H_2O} = 18900 \frac{\text{lbs}}{\text{day}} NO_3$$

F^- @ 0.1 ppm would be $\frac{18900}{24}$ or 788 $\frac{\text{lbs}}{\text{day}}$ F^-

in place of 95 lbs/day shown

(c) Arkansas River: 19500 cfs

@ NO_3 = 4.8 ppm, Σ = 64000 lbs/day shown

Should be $\frac{19500}{1462} \times \frac{4.8}{2.4}$ (18900) = 505,000 lbs/day

F^- @ 0.3 ppm would be $\frac{50500}{16}$ = 31500 lbs/day

versus 4680 lbs/day shown

The calculational errors noted under this comment should be incorporated in the Environmental Report-Revised dated November 1971.

(44) K-M application dated 9/23/69; Page IV-7 § 3.

UF_6 normal release rate of .00074 lb-mol/hour along with 3.3 lb-mol/hour of inert gases.

$$7.4 \times 10^{-4} \frac{\text{lb-mol } UF_6}{\text{Hour}} \times \frac{352 \text{ lb } UF_6}{\text{lb-mol } UF_6} \times \frac{454\text{g}}{\text{lb}} \times \frac{1000 \text{ mg}}{\text{g}}$$

UF_6 Release = $(7.4 \times 10^{-4})\ (3.52 \times 10^{2})\ (4.54 \times 10^{2})\ (10^{1})$

$= 118 \times 10^{3}$ mg UF_6/hour

Gas flow = $3.3\ \frac{\text{lb-mol}}{\text{hour}} \times \frac{359\ \text{CF}}{\text{lb/mol}}\ (\text{@STP}) \times \frac{1\ M^3}{35.31\ \text{CF}}$

$= 33.6\ M^3$/hour

UF_6 concn = $\frac{118 \times 10^{3}\ \text{mg}\ UF_6/\text{hr}}{33.6\ M^3/\text{hr}} = 3.51 \times 10^{3}\text{mg}/M^3$

versus 0.004 mg/M^3 cited.

$3.51 \times 10^{3}\ \text{mg}/M^3 = 3.51 \times 10^{-6}$ g UF_6/ml or $(\frac{238}{352})\ (3.51 \times 10^{-6}) =$

$2.37 \times 10^{-6}\ \frac{gU}{ml}$

@ specific activity of 1/3 μCi/g, this represents a concentration of 0.79×10^{-6} μCi/ml

At an MPC value of 3×10^{-12} μCi/ml for soluble U-238 per 10 CFR 20, a dilution factor of $\frac{0.79 \times 10^{-6}}{3 \times 10^{-12}}$ or about 2.6×10^{5} is required to meet the permissible site boundary concentration.

The reference to the Kerr-McGee license application dated September 23, 1969, Page IV-7, Paragraph 3, is not complete in that the paragraph states further that this material is released from the cold traps and is further processed by scrubbing prior to release to the atmosphere at the top of the 150-foot stack. In any event, as noted earlier, the dilution factor (corrected) is 3.5×10^{5} (question 39).

45. Answer by Dames & Moore.

AEC Question 45

Supplemental Environmental Report: Appendix IV, Dames and Moore Report, Table I. Please dscribe meteorological conditions corresponding to Pasquill Stability Category "G" along with source of this information.

Response:

The references to Pasquill Stability Category "G" can be obtained from the AEC Safety Guide 23 and IDO-12048 "Climatography of the National Reactor Testing Station" Idaho Operations Office, USAEC.

Answer to comments of Colorado State University Environmental Resources Center

Part 1, No. 1. See attached discussion on storage ponds.

Part 1, No. 2. Monitor wells are described in more detail in the attached discussion.

Part 1, No. 3. Study of the hydrological atlas of Oklahoma, Fort Smith quadrangle, demonstrates that Atoka formations lack a well defined water table or piezometric surface. The residence well northeast of the plant has a water surface of 475 feet, well below current pond levels. The well formerly serving the Carlile homestead, approximately 1000 feet south of the plant, has a natural water level of about 516 feet. This well was not sufficient, according to the former owners, to maintain a flow of water for domestic use. A cistern was relied upon for the domestic water supply.

As can be seen from the elevations shown on the cross section of the storage pond locations, these water depths in the referenced wells are well below the 532 foot elevation of the No. 2 Pond.

Comments by U.S. Department of Commerce

As noted, Kerr-McGee manual calculations are less precise than those made by Dames & Moore in their computer calculations and are 100 times more conservative than the Dames & Moore results.

The wording on Page 29 of the Environmental Report-Revised is not clear when it uses the "100% deposition". The calculations were made assuming 100% deposition of the uranium content of the material inhaled in the lung without an allowance of deposition efficiency.

Comments of Dr. Don L. Warner, Rolla, Missouri

Dr. Warner again raises questions as to the integrity of the raffinate ponds and the apparent contamination of monitoring well water. Please see the attached discussion for more detailed explanation.

No discussion was given of burying solid wastes resulting from raffinate treatment methods because it is still contemplated that the deep disposal well will be approved. All of the alternate methods of raffinate disposal described under question 37 would require burial of a solid. The first alternate would require the burial of solidified raffinate in containers at a commercial burial site. Alternates 2 and 3 would require that solids be buried in accordance with 10 CFR 20.304 or packaged for commercial burial.

RAFFINATE STORAGE PONDS

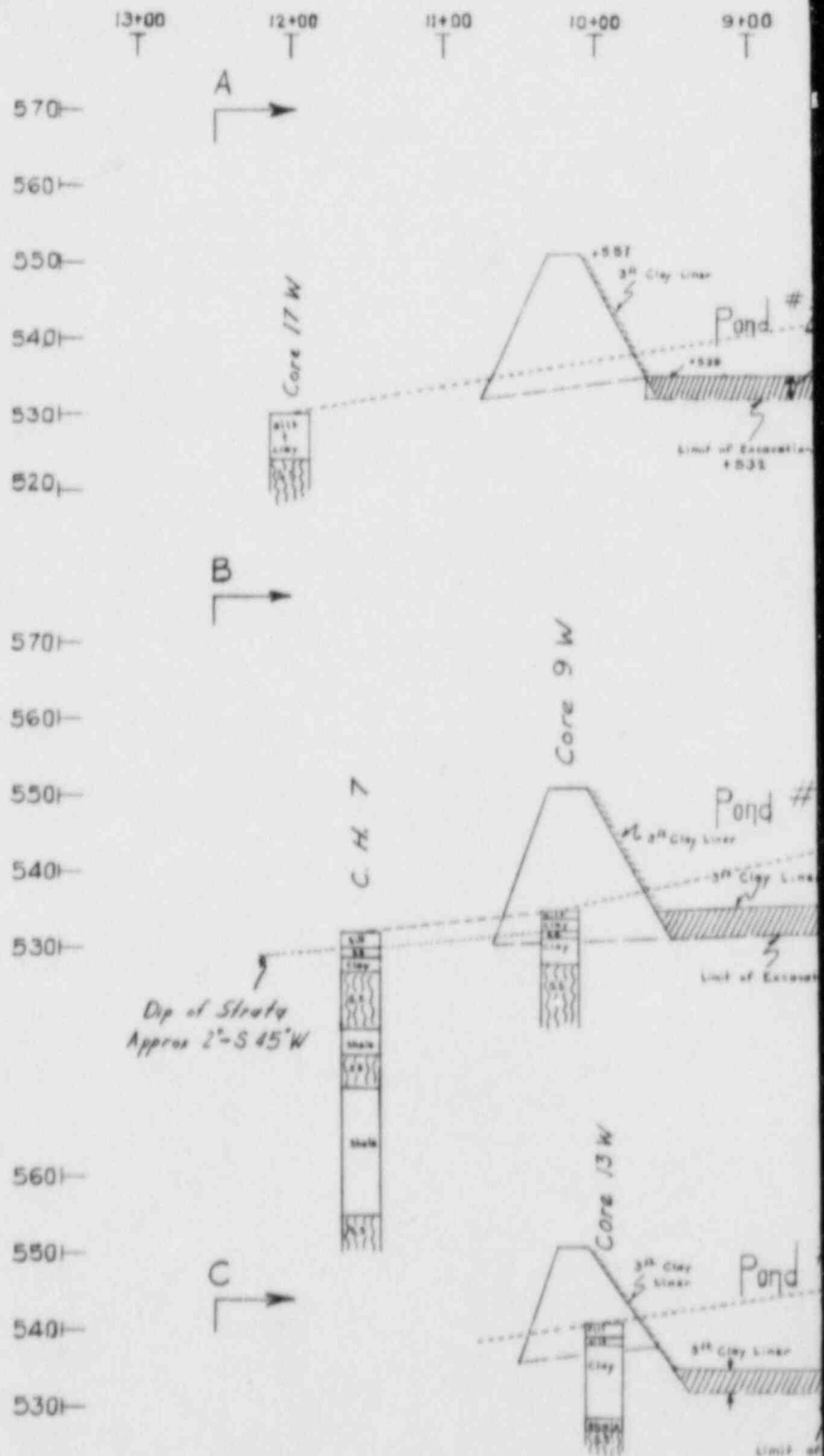
Questions relating to the raffinate pond construction (University of Colorado report) and levels of various analyses in monitoring wells (questions 11, 23, 36, D. L. Warner comments and University of Colorado comments) demonstrate concern that the raffinate storage ponds have leaked chemicals into the nearby monitoring wells.

This discussion describes more fully the examinations made, the construction of the ponds, and the monitoring well analysis so as to provide assurance that these ponds are not leaking contaminated material into the ground.

Pond Construction

The ponds were constructed as described in the Supplementary Environmental Report. All construction was supervised by a well-qualified civil engineer specializing in such construction. Inspection of the placement of the liner and dikes was conducted on a daily basis by an on-site inspector. Density tests of compacted bottom and levy liners were conducted routinely. Areas that did not meet specified compaction requirements were scarified and recompacted. A cross section of the ponds is given on Page 79. The exact layout of the ponds and the location of monitoring wells is shown on Page 80. A site map showing approximate location of monitor wells can be seen on Page 81. As can be seen from the cross section, only on the east wall of Pond No. 2 was the excavation made to the level of a sandstone strata. Subsequent installation of the clay liner provides adequate assurance of no leakage of the pond contents into this sandstone. In view of the demonstrated dip of the strata, location of monitoring wells appears to be appropriate.

As described briefly under question 38, clay linings and dike facings were subjected to permeability tests by standard methods



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12+00
11+00
10+00
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A
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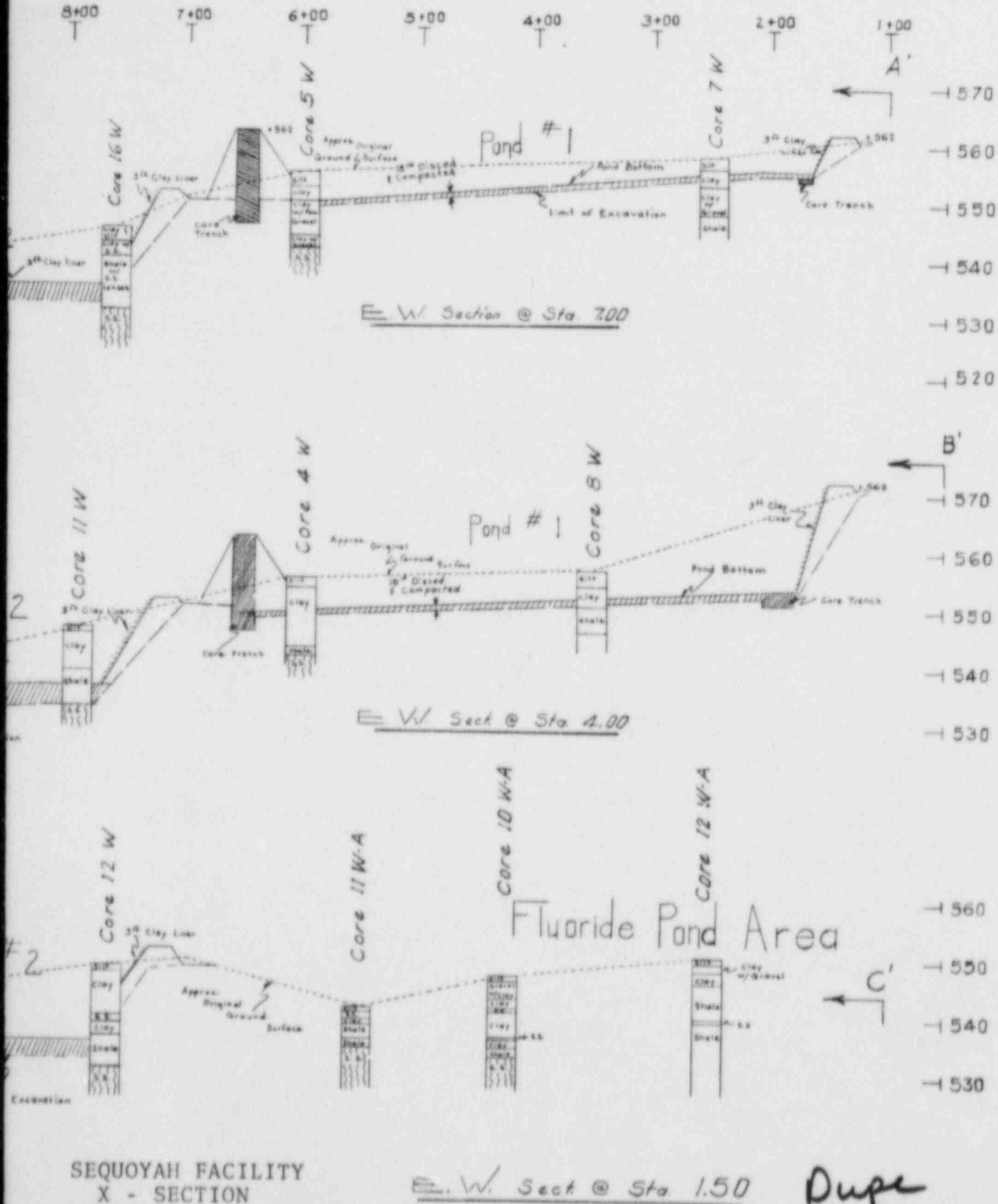
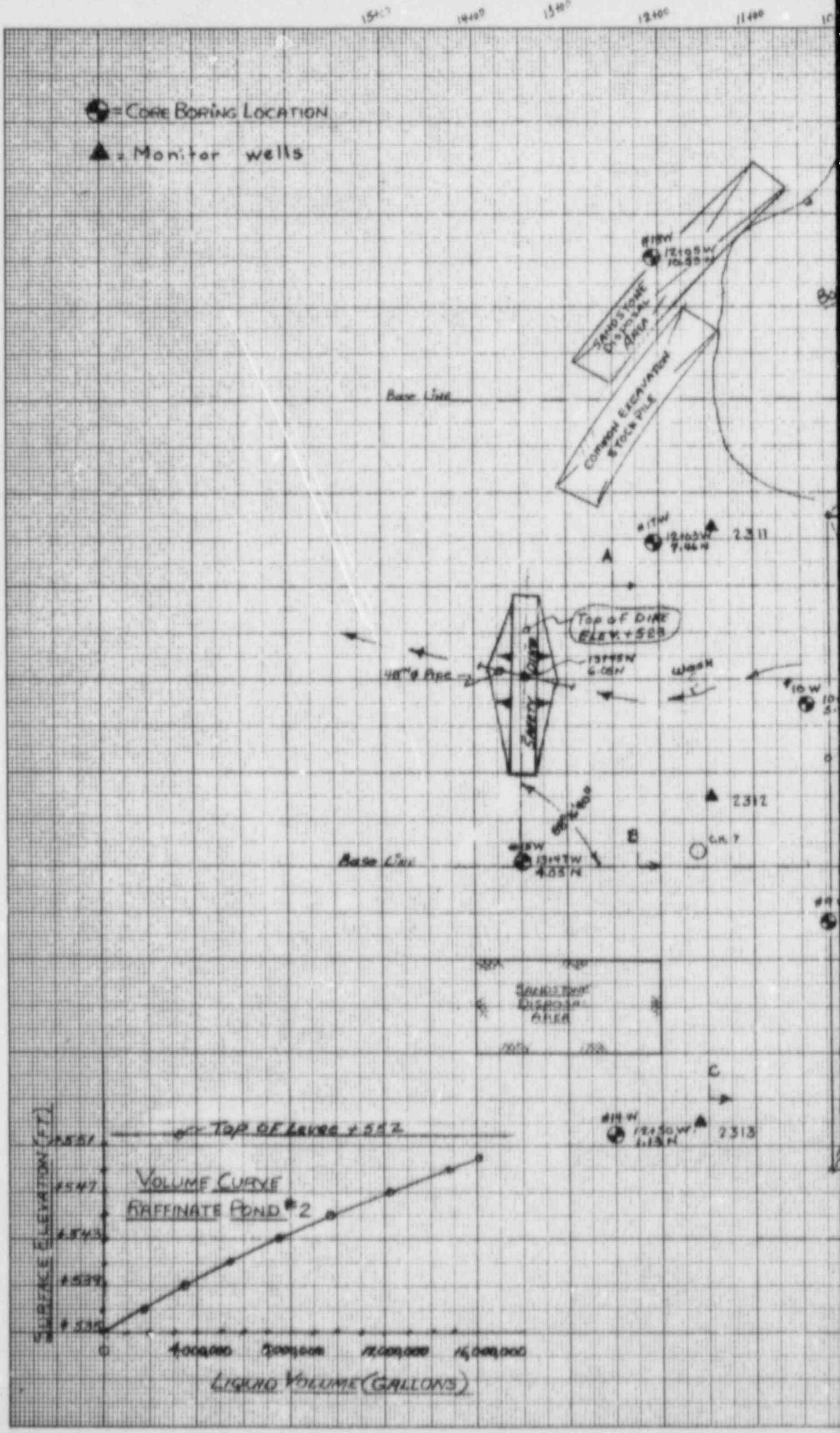
520
Core 17 W
3 ft Clay Liner
Pond #
Limit of Excavation
B
Core 9 W
C. H. 7
Pond #
3 ft Clay Liner
Limit of Excavat
Dip of Strata
Approx 2°-S 45°W
Shale
C
Core 13 W
3 ft Clay Liner
Pond
Clay

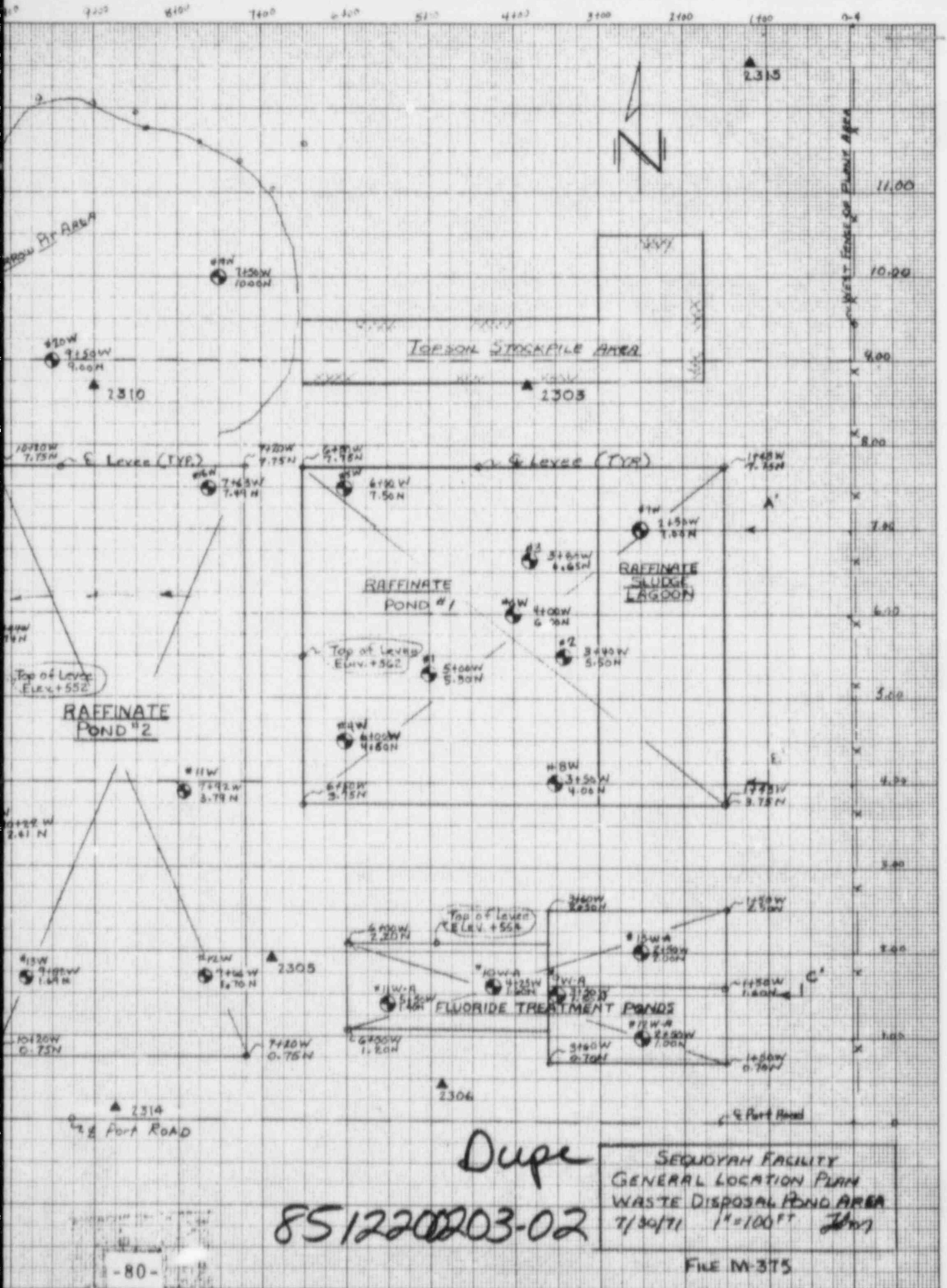


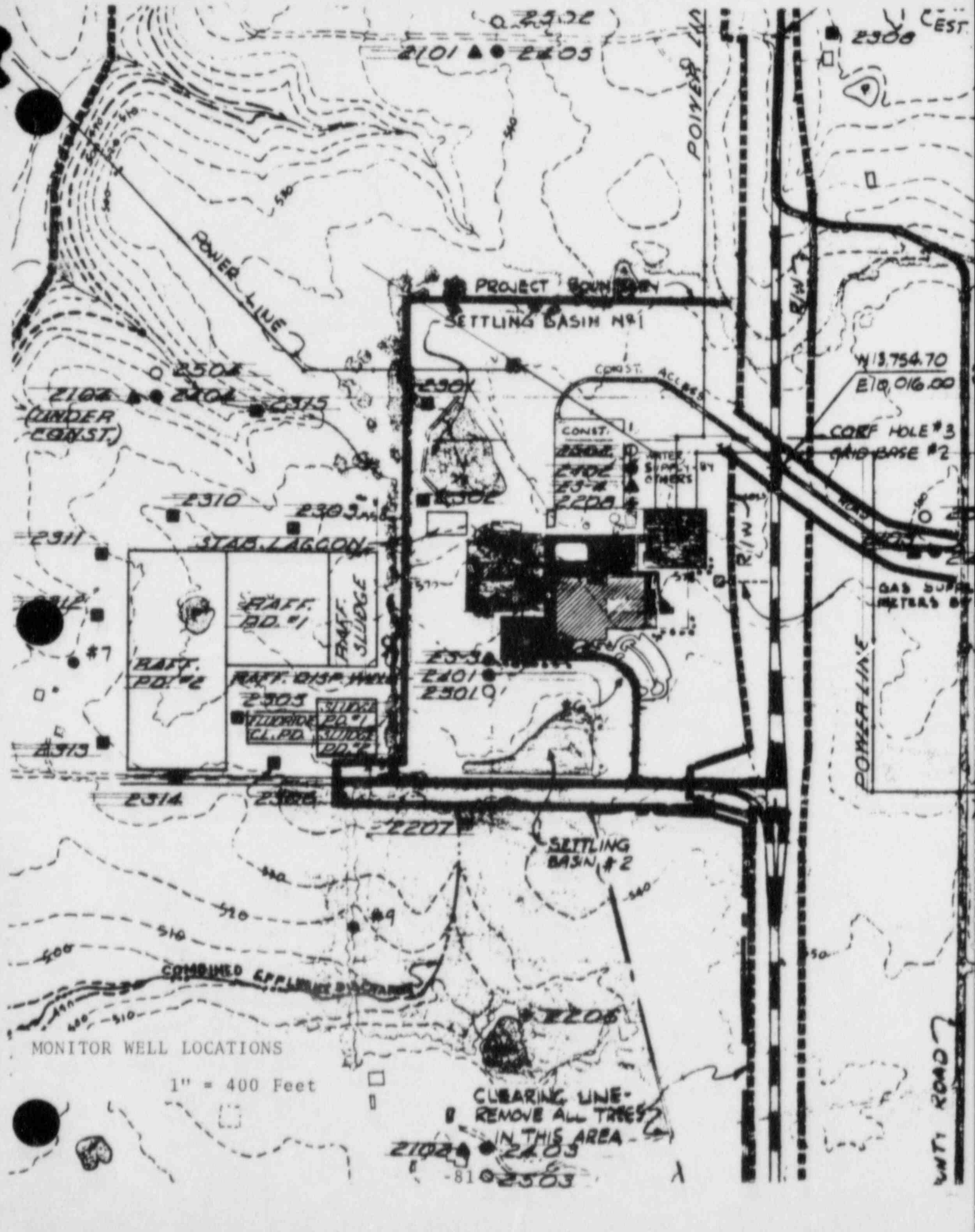
SEQUOYAH FACILITY
X - SECTION
THROUGH HOLDING PONDS
NOTE: VERT.-EXAG. 5:1
12/72

Dupe

8512200203-01


= Core Boring Location
▲ = Monitor wells
Base Line
Common Excavation Stock Pile
Top of Dike Elev. +553
48"Ø Pipe
2311
2312
2313
Base Line
Top of Levee +552
Volume Curve
Raffinate Pond #2
Surface Elevation (FT)
Liquid Volume (Gallons)
4,000,000
8,000,000
12,000,000
16,000,000


Topsoil Stockpile Area
2303
2310
2313
2305
2306
2314
℄ Levee (TYP.)
℄ Levee (TYP.)
Top of Levee Elev. +552
Top of Levee Elev. +562
Top of Levee Elev. +558
RAFFINATE POND #2
RAFFINATE POND #1
RAFFINATE SLUDGE LAGOON
FLUORIDE TREATMENT PONDS
℄ Port Road
℄ Port Road
West Fence of Plant Area
11.00
10.00
9.00
8.00
6.00
5.00
Dupe
SEQUOYAH FACILITY
GENERAL LOCATION PLAN
WASTE DISPOSAL POND AREA
7/30/71 1" = 100 FT
FILE M-375
8512200203-02



MONITOR WELL LOCATIONS

1" = 400 Feet

employed by soil engineers, demonstrating essentially no permeability to raffinate fluids exists as shown on the attached report by Hemphill Drilling Co.

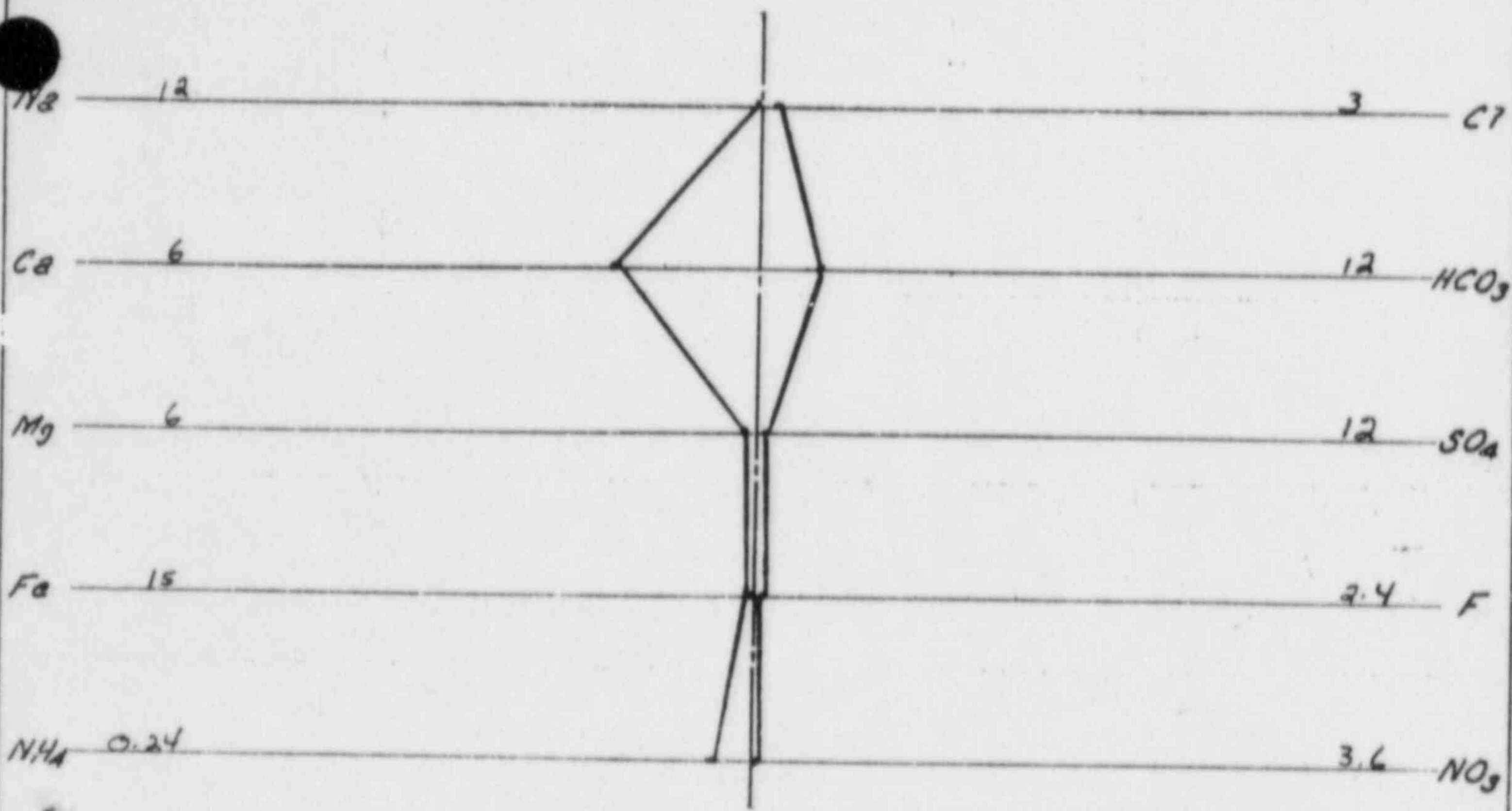
Monitoring Well Analysis

In an effort to determine if raffinate solutions have migrated into ground water entering monitoring wells, a "pattern analysis" was performed of monitoring well and raffinate pond contents. The use of these analyses is described in "The Interpretation of Water Analysis by Means of Patterns", Petroleum Transactions, AIME, Volume 192, 1951. These analyses are shown on the attached graphs*and were made on samples taken in October 1972. The first graph, labeled raw water and combination stream, demonstrates the relation of the two analyses from essentially the same water. It should be noted that the calcium level of the combination stream and the bicarbonate level has increased slightly as has the ammonium and nitrate above incoming raw water. The next graph, labeled 2301 and 2315, is samples taken from the well north of the No. 1 retention basin shown on page 54 of the Supplementary Environmental Report. 2315 is located downslope from that and it is conceivable that ground water would progress from 2301 to 2315. As can be seen by the comparison of the patterns, it is reasonable to conclude that except for additional dilution such migration has occurred. The third graph shows 2308 which is the residence well to the northeast of the plant which may be considered as typical Atoka formation water but may contain a slightly increased amount of sodium chloride than water taken from higher in the structure. Patterns from 2311 through 2314 are prepared from well samples taken immediately around the No. 2 raffinate pond.

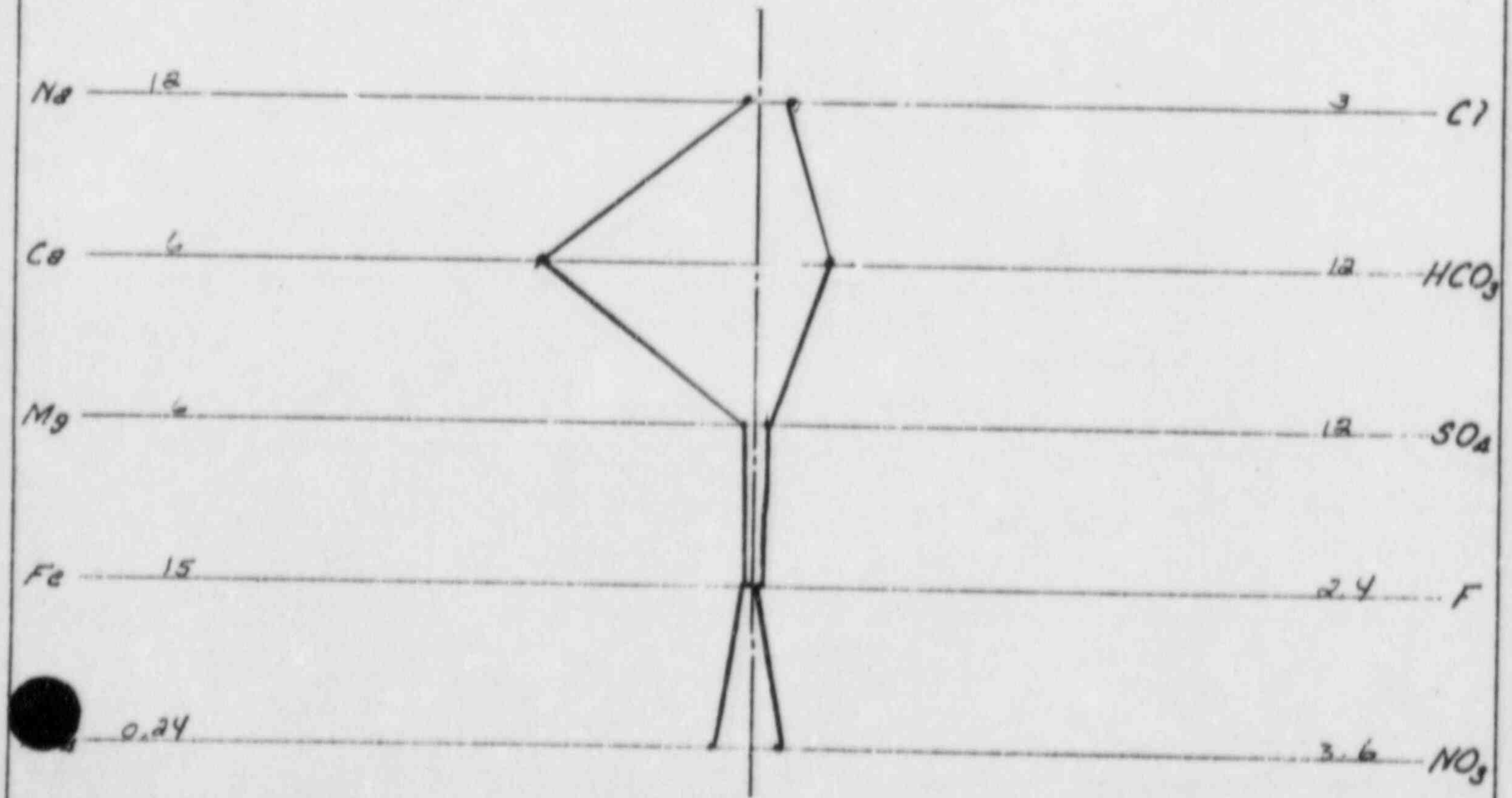
In studying these patterns resulting from these analyses, one is first struck by the relation between calcium and sodium ion as it appears in the wells as contrasted to the relation

*Horizontal axis shows miligram equivalents/liter of ion of interest.

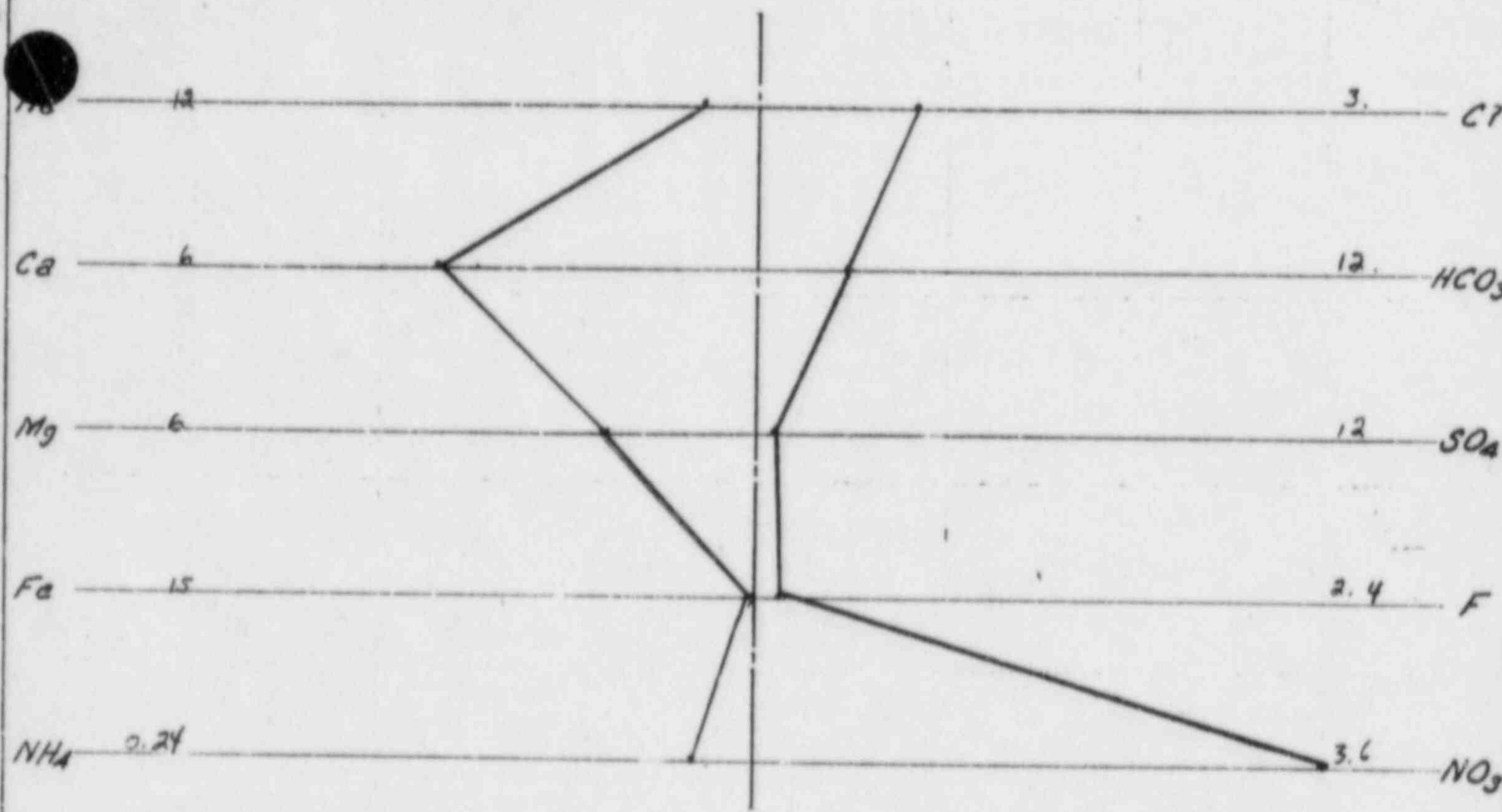
NINE MONTHS RAW WATER



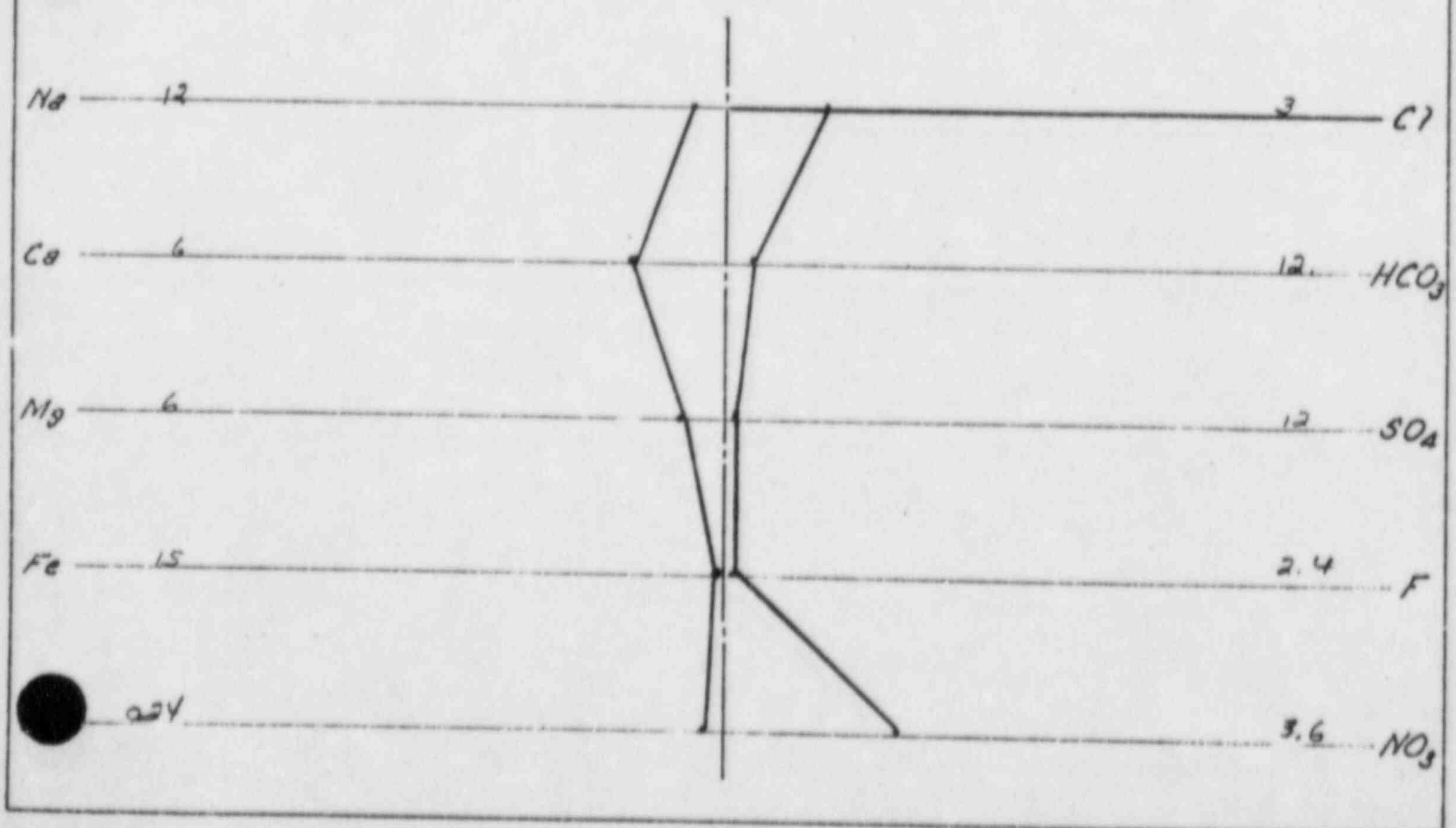
NINE MONTHS COMB. STR.



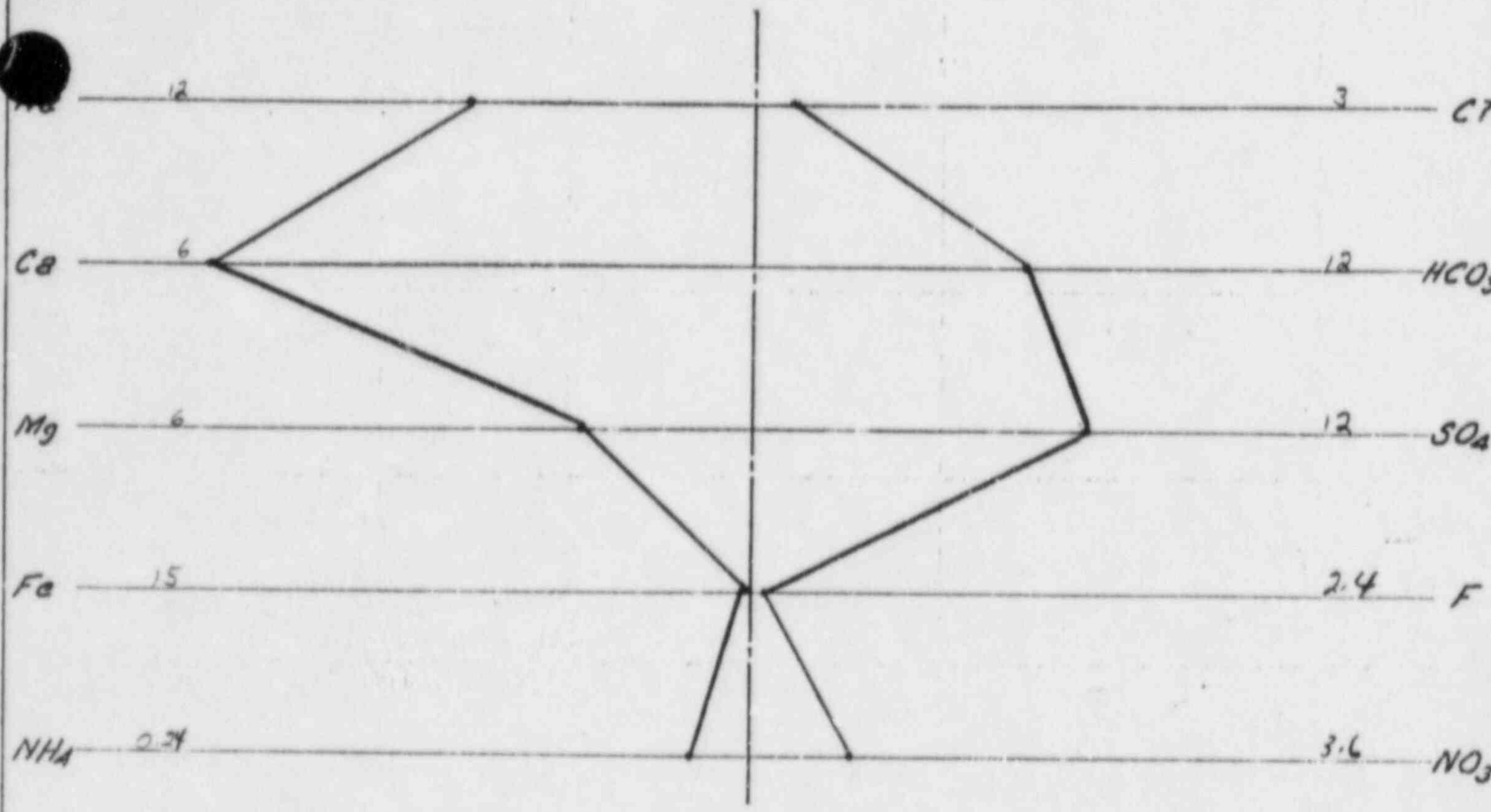
2301


Na 12
Ca 6
Mg 6
Fe 15
NH4 0.24
3. Cl
12. HCO3
12 SO4
2.4 F
3.6 NO3

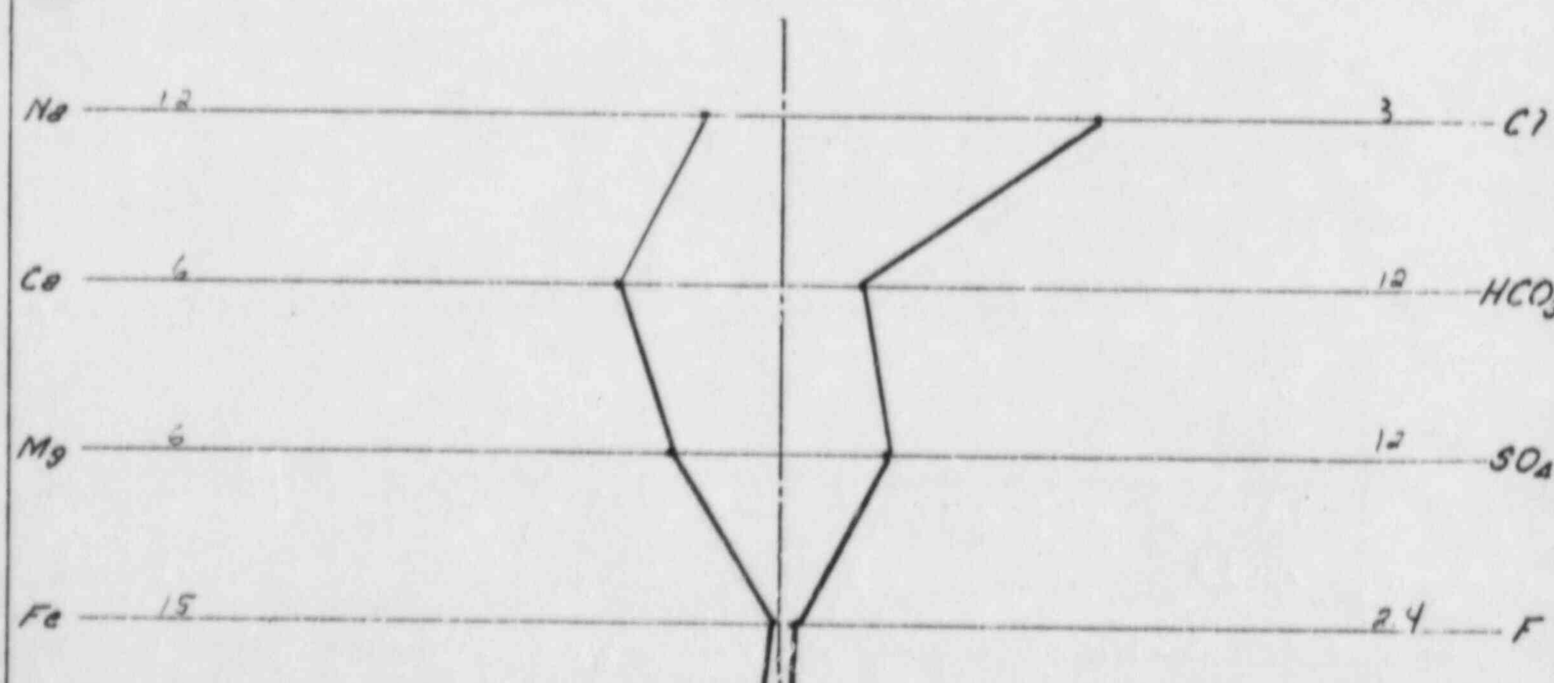
2315


Na 12
Ca 6
Mg 6
Fe 15
0.24
3 Cl
12. HCO3
12 SO4
2.4 F
3.6 NO3

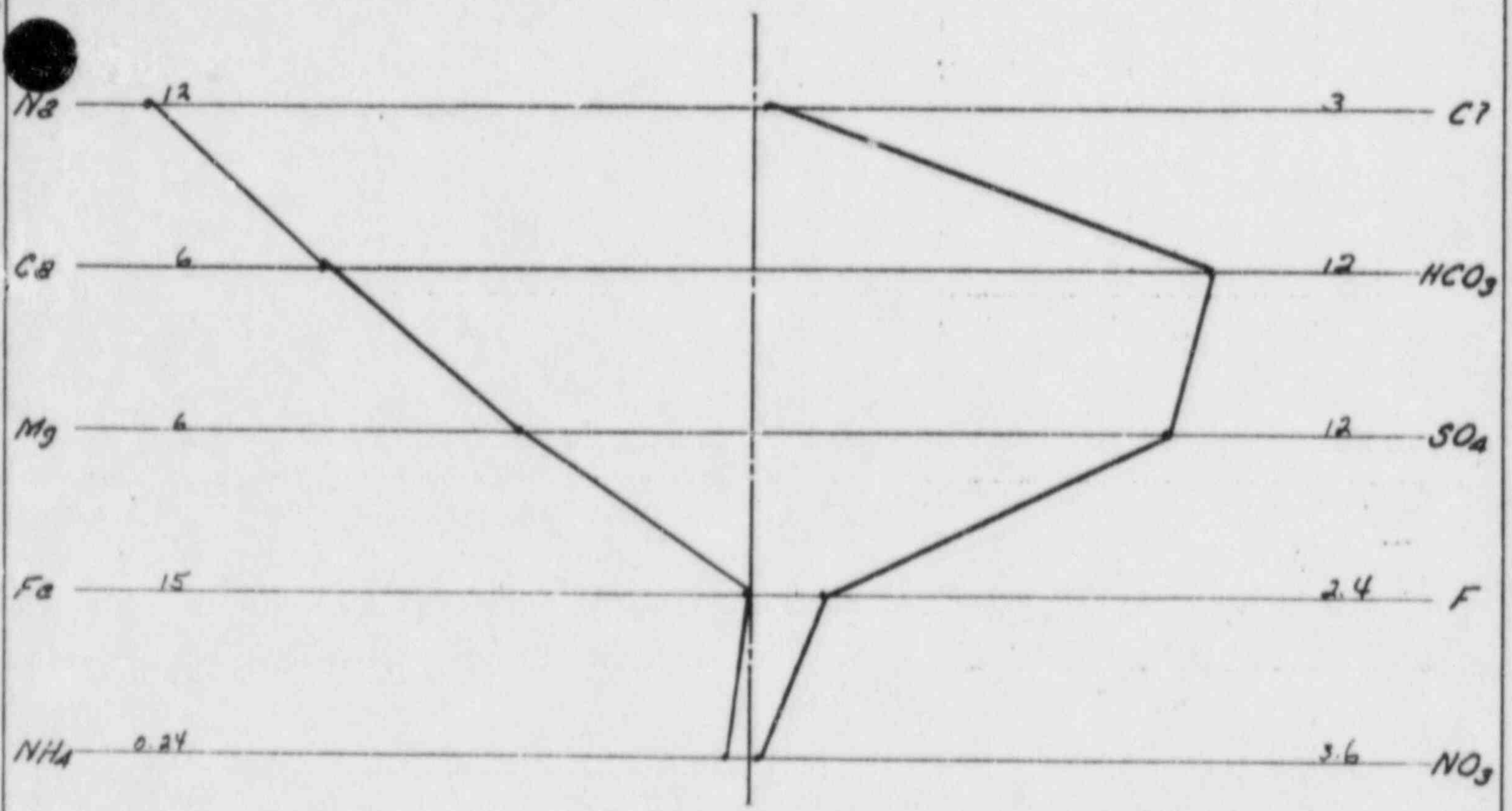
2303


12
3
Cl
Ca
6
12
HCO3
Mg
6
12
SO4
Fe
15
2.4
F
NH4
0.24
3.6
NO3

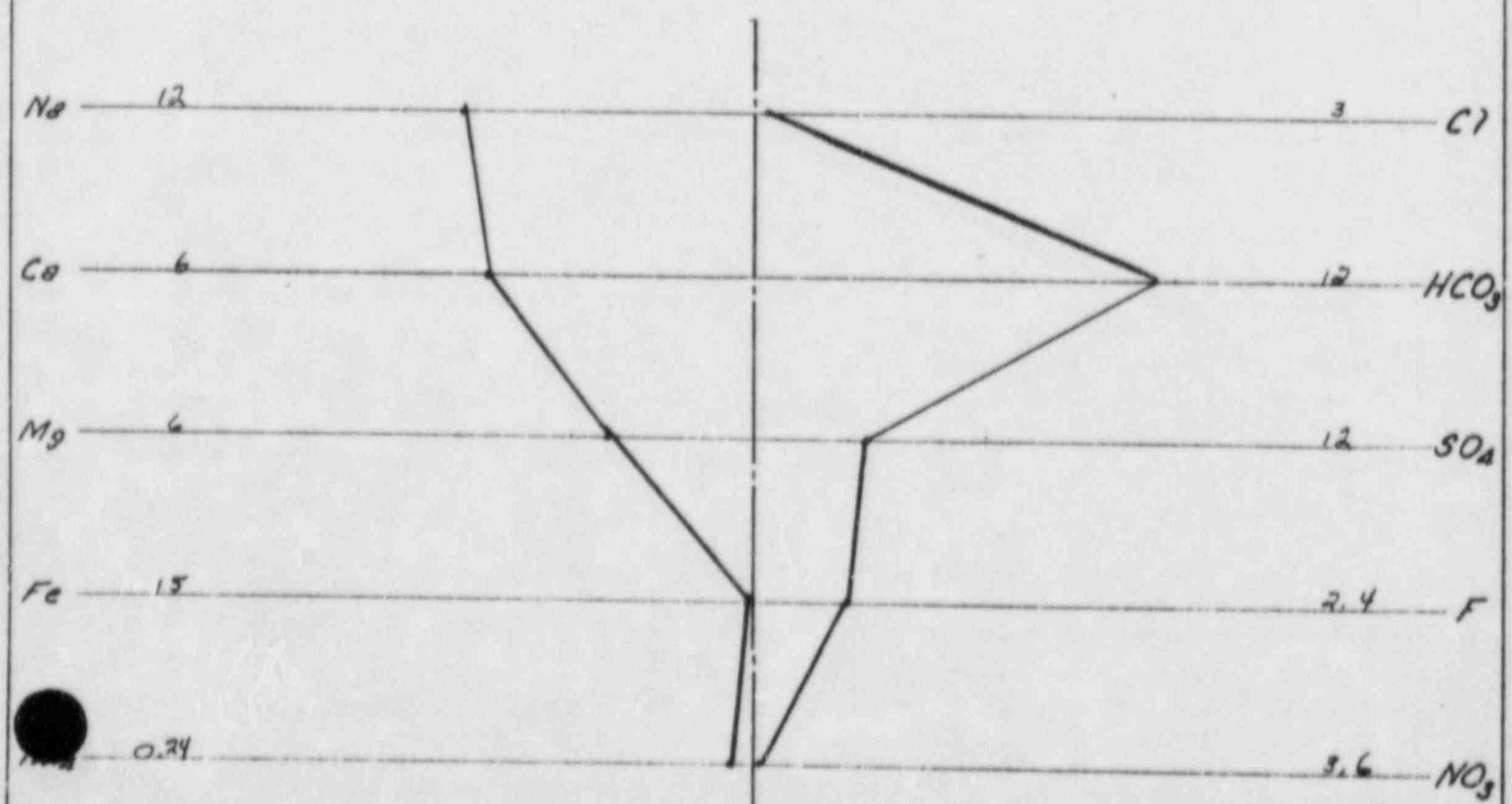
2308

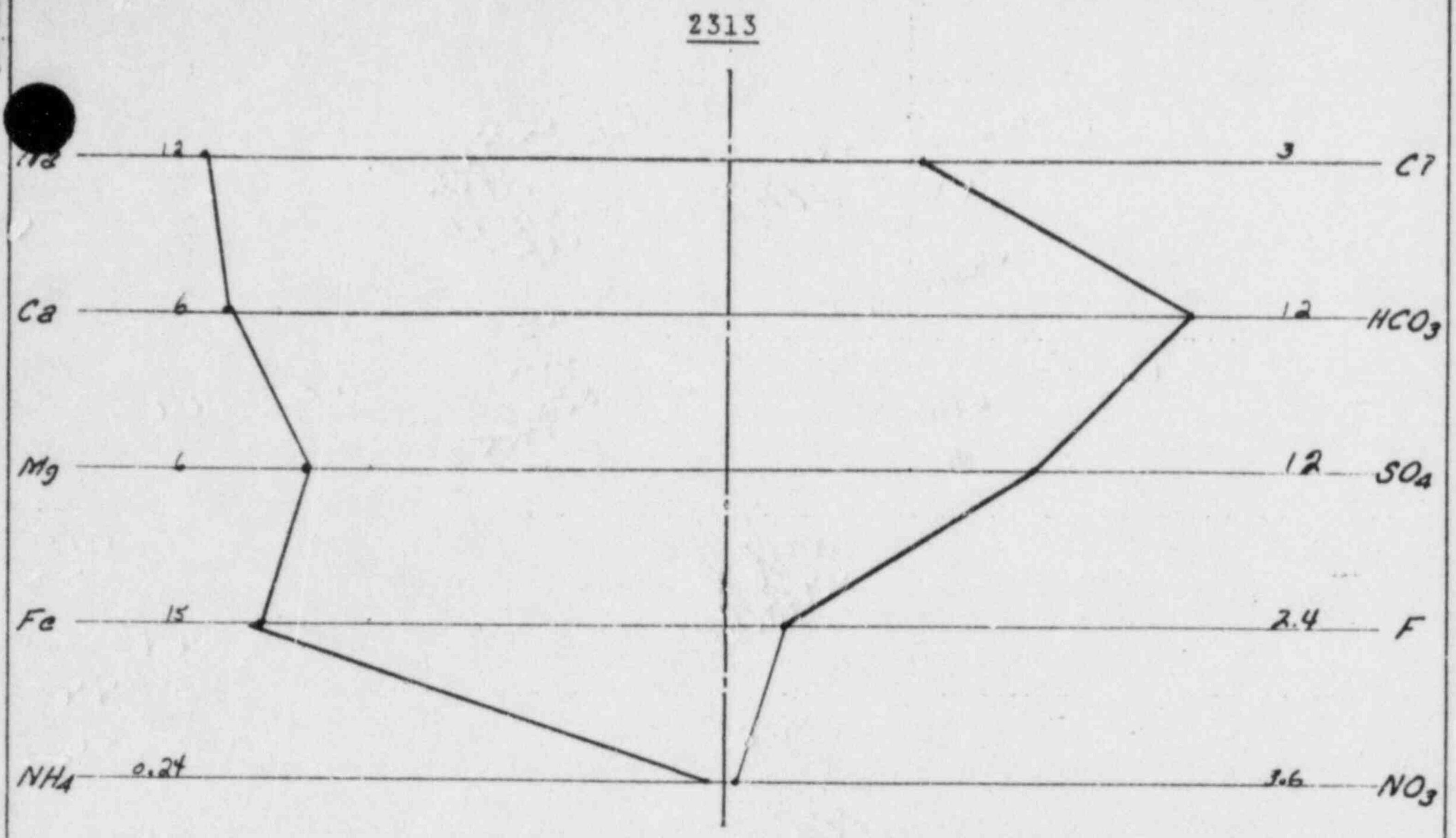

Na
12
3
Cl
Ca
6
12
HCO3
Mg
6
12
SO4
Fe
15
2.4
F
0.24
3.6
NO3

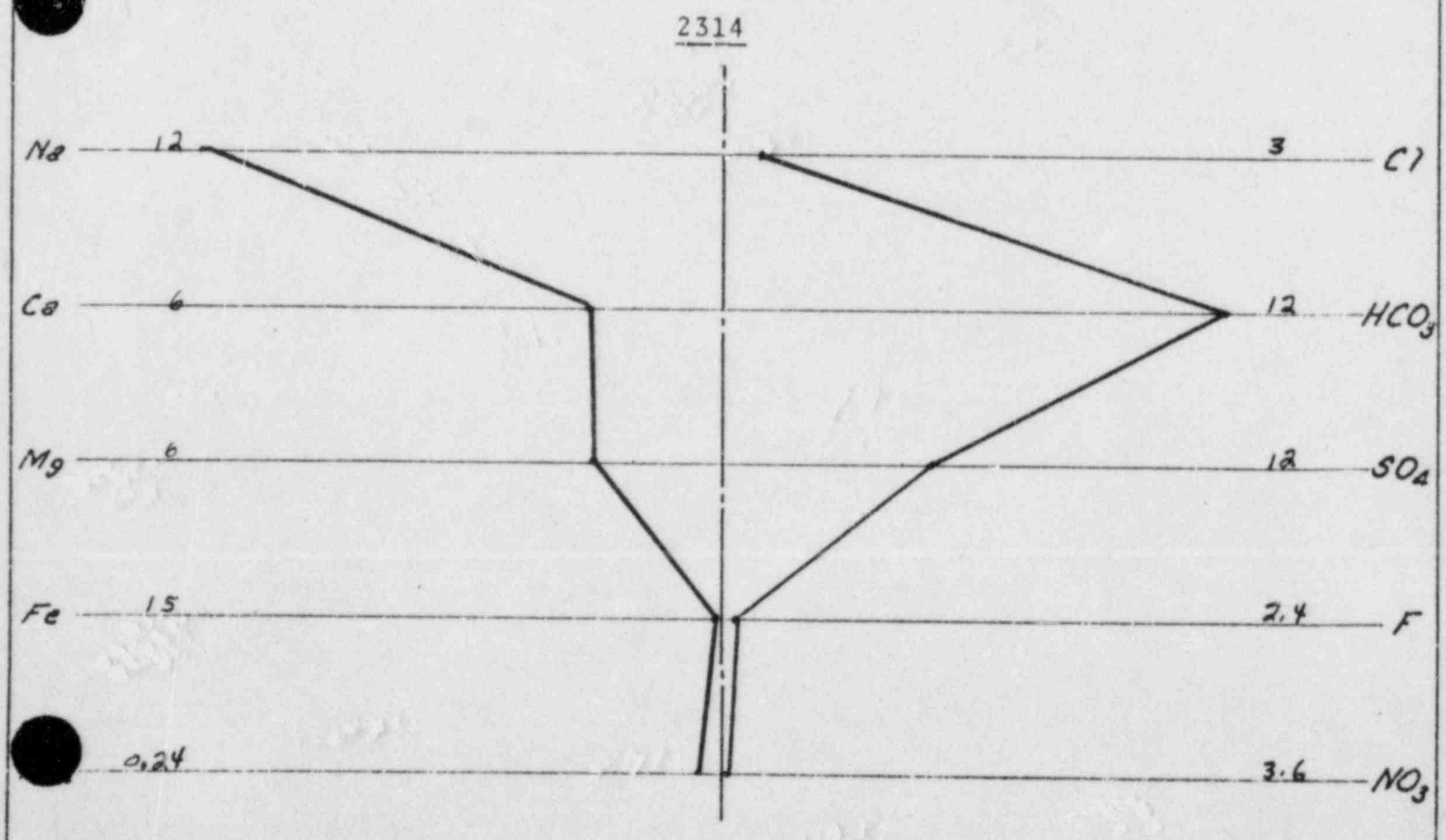
2311


Na 12
Ca 6
Mg 6
Fe 15
NH4 0.24
3 Cl
12 HCO3
12 SO4
2.4 F
3.6 NO3

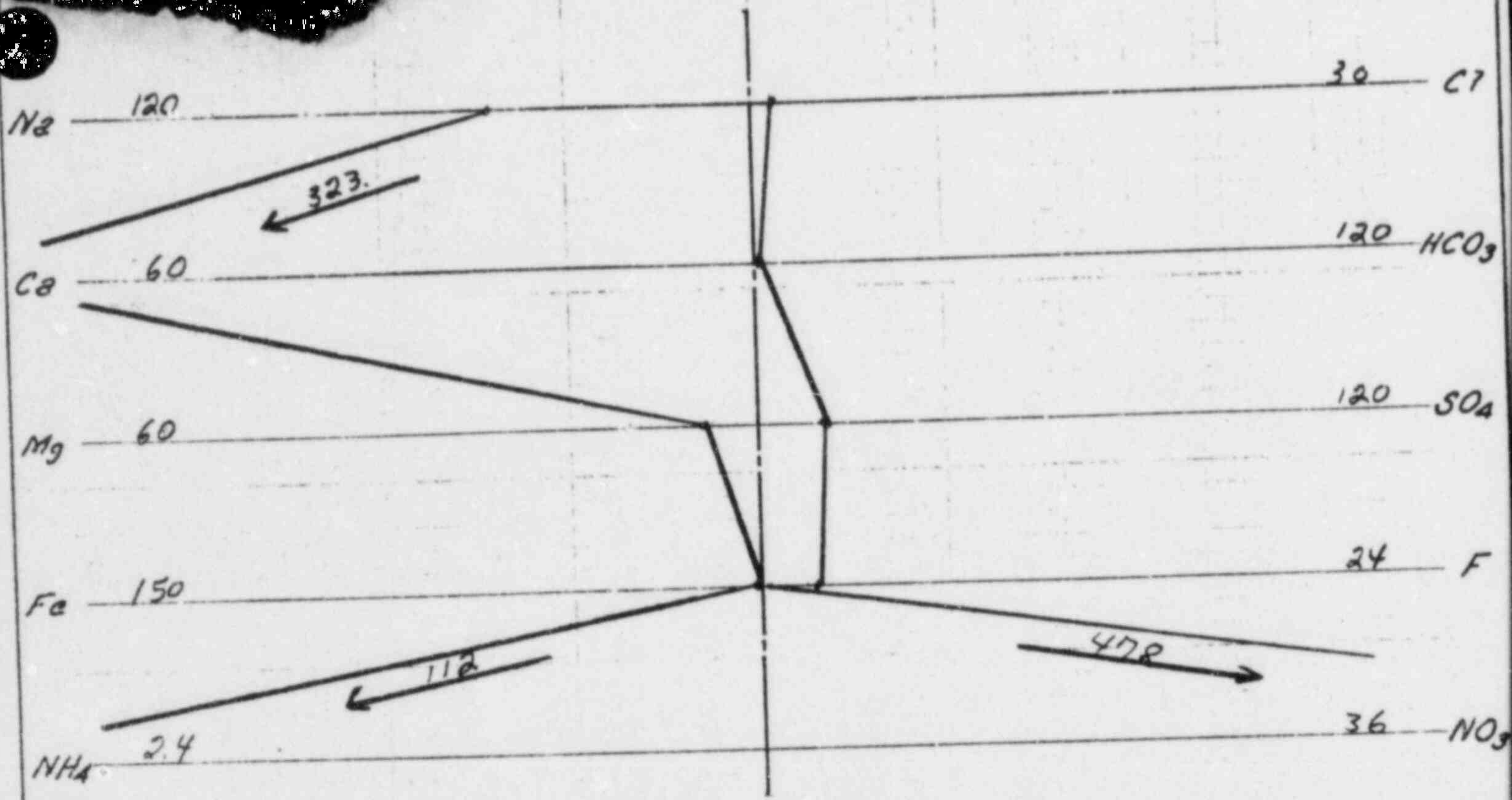
2312


Na 12
Ca 6
Mg 6
Fe 15
0.24
3 Cl
12 HCO3
12 SO4
2.4 F
3.6 NO3

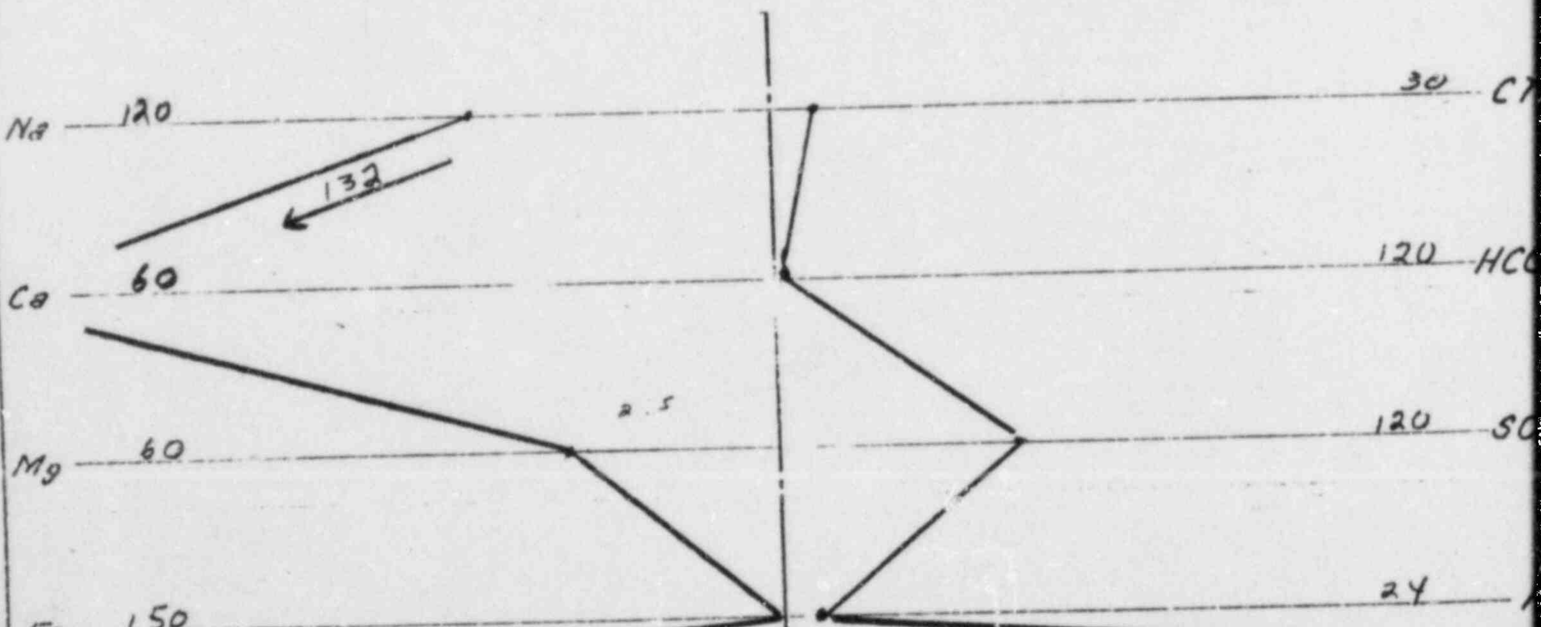

2313
Na 12
Ca 6
Mg 6
Fe 15
NH4 0.24
3 Cl
12 HCO3
12 SO4
2.4 F
3.6 NO3


2314
Na 12
Ca 6
Mg 6
Fe 1.5
0.24
3 Cl
12 HCO3
12 SO4
2.4 F
3.6 NO3

#1 RAFF


Na 120
323.
Ca 60
Mg 60
Fe 150
112
NH4 2.4
30 Cl
120 HCO3
120 SO4
24 F
478
36 NO3

#2 RAFF


Na 120
132
Ca 60
Mg 60
2.5
Fe 150
478
NH4 2.4
30
120
120
24
585
36

appearing in the ponds. In the wells, the ratio of sodium to calcium is approximately 2/1 with the exception of 2304 and 2314 where they appear to be 1/1 and 6/1, respectively, while the raffinate solutions have the reverse ratio of 1/5 and 1/2.

The same anomaly exists in the levels of bicarbonate and sulfate appearing in the well waters as compared to low concentrations in the raffinate pond. Bicarbonate seems to be a major component in the case of the wells with the exception of 2303 while, in the raffinate solutions, it is not present. The most outstanding absence in the wells is the absence of either ammonium ion or nitrate ion which are present in high concentrations in the raffinate solutions. It has been argued by some that ammonium ion absorption would occur in passage through the soils; but, since most nitrates are soluble, it would seem apparent that, if the ammonium ion was trapped, another balancing ion would replace it, such as calcium. From study of these patterns, it is concluded that no contamination of the wells has resulted by seepage of material from the raffinate pits into the ground water.

In the monitor wells, themselves, no single source of ground water is apparent, which is typical of Atoka formation water. Most ground water in such a formation is in pockets and noncommunicating layers rather than any contiguous interconnected field.

In the monitor well results shown under paragraph 11, the most probable ground water contamination occurs in Well No. 1, sample 2301, which is located immediately to the north of settling basin No. 1 shown on page 54 of the Supplementary Environmental Report. Previous and continued contamination of this well led us to examine the probable cause of such contamination.

When the deep disposal well was first disapproved, it was necessary to provide temporary holding capcity for raffinate. This was provided by the use of settling basin No. 1 while the first two raffinate ponds were being constructed. Upon the completion of the raffinate ponds in 1971, holding basin No. 1 was pumped to the raffinate sludge pond which overflows to raffinate pond No. 1. Subsequently, the dike at the east end of the settling pond was constructed so that the settling pond could be used in an emergency and to prevent any washing of sediment intc the watercourse. When the dike was constructed, it was located too far to the west to include the soil covered by the level of liquid reached when the settling pond was originally used. As a consequence, measurable amounts of raffinate materials exist to the east of the new dike. Also, the dike provided a barrier to surface water draining to the west. It has been noticed that surface water collects against the dike and, when reaching a high enough level, flows to the north around the end of the dike and directly into monitoring well No. 1. Upon this discovery, an additional wing was added (August 1972) to the north end of the dike so that this material would be held and, as it collects, it is pumped to the raffinate pond or into the combination stream, as appropriate, depending upon the uranium and nitrate concentrations contained. Subsequent to the installation of this new wing to the dike, September and October analyses demonstrate very low levels of uranium and nitrate content in Well No. 1.

Conclusion

As a result of these detailed examinations, we believe that the integrity of the raffinate ponds has been demonstrated. It is concluded that any contamination appearing in the monitor wells is incidental to surface contamination and, at current low levels of airborne release, a substantial reduction in contamination in all future analyses will be observed.

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CLARENCE A. HEMPHILL
Res. (918) 836-1926

hemphill DRILLING COMPANY

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January 11, 1973

Tom S. Moore
Kerr - McGee Corporation
Kerr - McGee Bldg.
Room 521
Oklahoma City, Okla. 73102

Re: Permeability Tests
Kerr - McGee
Sequoyah Facility
Gore, Oklahoma

Gentlemen:

The soils testing requested by Mr. Tom S. Moore for the subject site has been completed. Five (5) soil samples from two retention ponds were tested for permeability characteristics when exposed to certain solutions from the Gore Plant. All test data is attached.

The permeability test specimens were recompacted to optimum moisture and maximum density as shown in the test results. A pressure of 5 psi was applied to the test specimen as a constant head. The samples tested, material source, and the respective solution used for the test are listed below in Table 1.

TABLE 1

TEST SPECIMEN DATA

SAMPLE NO.	MATERIAL SOURCE	SOLUTION USED
1	Pond 2	Tap Water
2	Pond 2	Raffinate from Pond 2
3	Pond 2	Raffinate (fresh)
4	Pond 1	Raffinate (fresh)
5	Pond 1	Raffinate from Pond 1

The permeability test results are shown in Table 2.

TABLE 2

PERMEABILITY TEST RESULTS

SAMPLE NO.	DEPTH (Inc.)	MATERIAL SOURCE	SOLUTION	PERMEABILITY COEFFICIENT GPD/sq/ft.
1	3-9	Pond 1	Tap Water	Impermeable
2	3-9	Pond 2	Raffinate from Pond 2	Impermeable
3	3-9	Pond 2	Raffinate (fresh)	Impermeable
4	3-9	Pond 1	Raffinate (fresh)	Impermeable
5	3-9	Pond 1	Raffinate from Pond 1	Impermeable

Since all samples tested indicate an impermeable soil, it appears the variation of a fresh or non-fresh solution of Raffinate causes no difference in the permeability of the soils.

If you have any questions please feel free to call.

Very truly yours,

HEMPHILL DRILLING COMPANY

Jerry D. Shepherd

Jerry D. Shepherd, PE
Consulting Engineer

JDS/pjr

cc: 3 Tom S. Moore
1 File