NUREG-1189
Vol. 2

Assessment of the Public Health Impact From the Accidental Release of UF_6 at the Sequoyah Fuels Corporation Facility at Gore, Oklahoma

Docket No. 40-8027
License No. SUB-1010

Appendices

U.S. Nuclear Regulatory Commission

Ad Hoc Interagency Public Health Assessment Task Force

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Manuscript Completed: March 1986
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Ad Hoc Interagency Public Health Assessment Task Force

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ABSTRACT

Following the accidental release of UF_6 from the Sequoyah Fuels Facility on January 4, 1986, an Ad Hoc Interagency Public Health Assessment Task Force was established. The Task Force consists of technical staff members from various agencies who have prepared this assessment of the public health impact associated with the accidental release.

The assessment consists of two volumes and is based on data from the accident available as of February 14, 1986.

Volume 1 of the report describes the effects from the intake of uranium and fluoride and summarizes the findings and recommendations of the Task Force.

Volume 2 of the report contains Appendices which provide more detailed information used in the assessment and support the discussion in Volume 1.

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APPENDIX 2.2

DESCRIPTION OF SFC'S FACILITY OPERATION

APPENDIX 2.2 Description of SFC's Facility Operation

2.2.1 Receiving and sampling

Uranium feed material is delivered to the SFC facility in three forms: dry yellowcake (ore concentrate), wet yellowcake slurry, and wet UF_4 slurry. Processing of wet yellowcake slurry and UF_4 slurry will be discussed in Section 2.2.2.

The dry concentrate (yellowcake) is received from uranium mills in 55-gal steel drums. Each drum has an identifying number so that an accurate record may be maintained of the contents and analysis for purposes of uranium accountability and for billing or payment to customers. The drums are stored four to a pallet and up to three pallets high on an outside storage pad. The drums and pallets are strapped down for storm protection.

After weighing, each drum is emptied through a falling stream sampling unit. This unit consists of two samplers in series, each taking a small cut. The first cut provides an initial sample weight of about 1 percent or less of the contents of a drum. The sample is split down again by a factor of about 50 and is collected in trays. The material collected in the trays is processed to a final sample pulp by the operations of drying, pulverizing, riffling, sieving, and blending as needed.

The remaining ore concentrate from each drum can be fed directly into the two digester feed hoppers or can be redrummed for later use. The hoppers have a combined capacity of about 50 tons, which is one day's output of the sampling system.

All operations in the dry yellowcake sampling area of the main building involving open drums or uncontained yellowcake powders are performed under dust collection hoods.

2.2.2 Dry Yellowcake Digestion

Dry yellowcake digestion is the primary digestion process in the SFC facility. This is a batch process where the concentrate is reacted with preheated nitric acid in one of three 4000-gal digestion tanks to convert the uranium, present in the form of oxides or diuranates, to uranyl nitrate solution.

Initially, about 1400 gal of nitric acid of up to 60 percent concentration is pumped from the tank farm to a digester tank. Steam coils in the digester tank are used to raise the acid temperature to between 190 and 220°F. When the proper temperature is attained, dry concentrate is fed from the digester feed hoppers into the digester tank using screw-type feeders. About 12,000 lb of concentrate is added to the nitric acid. The normal batch volume is about 3100 gal. An agitator is operated continuously to promote both thorough mixing of the concentrate in the acid and thermal equilibrium. The reaction of the concentrate with nitric acid is exothermic, and water-cooled coils are used to remove excess heat to control the solution temperature. The reaction is also accompanied by evolution of nitrogen oxides.

When digestion is complete, the slurry is transferred to an adjustment tank and the digester tank and transfer lines are flushed with water. The adjustment tank provides a holdup period for cooling of the slurry, for adjustment of the chemistry of the slurry to prevent uranium loss as precipitates, and to improve uranium recovery in the subsequent solvent extraction process. Composition adjustment may involve modifying the acidity of the uranyl nitrate slurry or the addition of special feed solutions from other digestion processes discussed below.

Wet yellowcake slurry containing approximately 38 wt percent of water is delivered from some uranium mills in stainless steel cargo tanks. The cargo tank arrives at the plant about 60 percent full. Pumps and piping enable transfer of the slurry to plant receiving tanks and recycle to the cargo tank.

In batch quantities, 60 percent HNO_3 is fed into the cargo tank until the solids in the yellowcake slurry are completely dissolved. This uranyl nitrate solution is then pumped to a receiving tank where the contents are weighed, sampled, and transferred to a 10,000-gal storage tank. Subsequently, this solution is pumped to the uranyl nitrate feed preparation tanks for final adjustment of solution chemistry before entering the solvent extraction operation (Fig. 2.2.1).

Tanks, pumps, and piping for processing the wet yellowcake slurry and the uranyl nitrate solutions are mostly enclosed in a separate building surrounded by curbs that can contain the total volume of the tanks in case of tank rupture. The parking area for the cargo tank is also curbed to contain the entire tank volume.

The UF_4 slurry with about 50 percent water is received in 55-gal drums with polyethylene liners. These drums are stored in a building with a curbed foundation that is adjacent to the west wall of the yellowcake slurry receiving building. The drums are emptied into a 4500-gal digester tank containing an HNO_3-$Al(NO_3)_3$ solution. The resulting uranyl nitrate solution can be stored or pumped to the feed preparation tanks for final adjustment before entering the solvent extraction operation (Fig. 2.2.1). Nitrogen oxide and hydrogen fluoride gases evolve during this digestion process.

A miscellaneous batch digester 1500 gal is used to recover uranium from fluorination ash and dusts collected in dust control systems by dissolution in a HNO_3-$Al(NO_3)_3$ solution. Fluorination ash is derived from the exit filters of the fluorination reactors which are blown down periodically into ash receivers below the filters. Batch weight in the miscellaneous digester is approximately 2000 lb of ash [approximately 750 lb of uranium], and the resulting solution is blended with the primary digestion product from yellowcake digestion and fed to the solvent extraction system. Again, nitrogen oxides and hydrogen fluoride are produced.

The liquids of all digester tanks discussed above are eventually pumped into the solvent extraction system for purification of the uranium. There are no solid wastes from the digestion operations. Off-gases from the digester tanks are cooled with dilute HNO_3 and treated to remove most of the acid fumes, water vapor, and noxious nitrogen oxides. Condensed vapors are returned to the

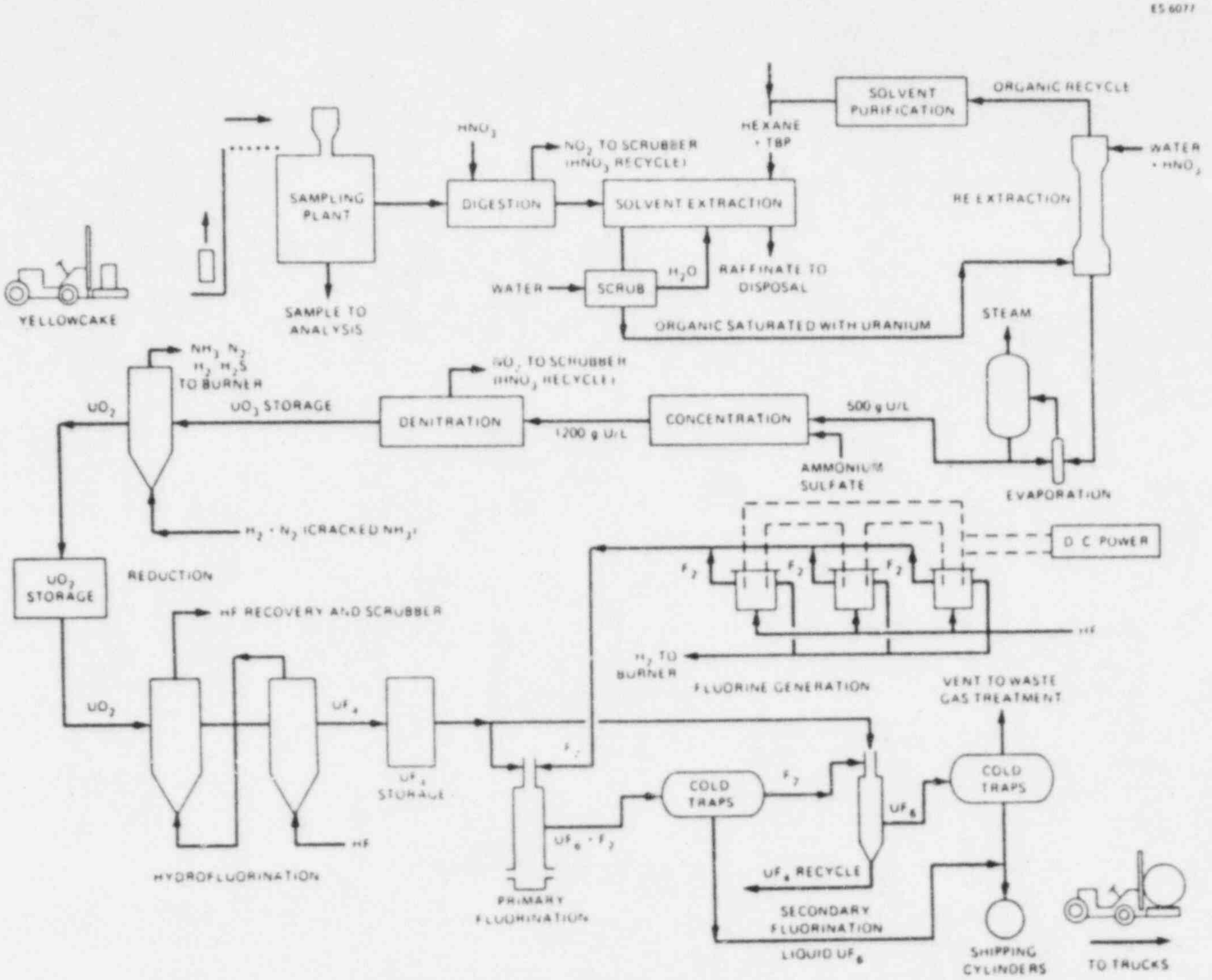

Figure 2.2.1 Process diagram for uranium hexafluoride (UF_6) production from yellowcake (U_3O_8), including process inputs and waste product treatment

digestion tanks, caustic chemical-waste-containing fluoride is collected for disposal, and the remaining off-gases are piped to the HNO_3 recovery plant for recycle of remaining HNO_3 vapors.

The primary and miscellaneous digester tanks have spill curbs to contain any accidental leakage. Drainage from these curbed areas can be pumped into other digester tanks for processing.

2.2.3 Solvent Extraction

The uranyl nitrate slurry is fed from the adjustment tanks to the solvent extraction system. The uranyl nitrate is processed by countercurrent extraction in a series of pumper-decanters using 30 percent vol tributyl phosphate (TBP) in hexane solvent. Two control criteria have been established for the solvent extraction process. First, the digester slurry feed rate is adjusted at constant solvent flow to assure an acceptably low uranium loss in the raffinate waste stream. Second, a high uranium saturation level is maintained in the organic extraction product to obtain satisfactory separation of uranium from the impurities.

There are two liquid streams flowing from the series of pumper-decanters: the raffinate waste stream with very low uranium content and the organic extraction product that includes most of the uranium. The raffinate stream passes from the solvent extraction system to a raffinate decanter vessel where it is washed with hexane. The raffinate is then discharged to one of the four settling basins of clarifier for treatment and disposal.

The organic extraction product containing the uranium is then washed in a two-stage mixer-settler scrub system using 0.01 M HNO_3. The aqueous phase with impurities from the first-stage wash is recycled to the solvent extraction tanks, and the washed organic product is again contacted with 0.01 M HNO_3 in the re-extraction column where the uranium is stripped from the organic phase and transferred to an aqueous solution. The aqueous uranyl nitrate containing 80 to 100 g of uranium per liter is washed with hexane to remove TBP and transferred to the evaporation system feed tank.

The hexane from the raffinate wash, re-extraction column, and the aqueous uranium product wash is processed in the solvent rework system for recycle to the solvent extraction system.

2.2.4 Solvent Rework

The impure hexane solvent waste stream from the solvent extraction system is processed in the solvent rework (purification) system. Most of the residual uranium is recovered by washing the hexane with 25 percent ammonium sulfate. The TBP hydrolysis products, dibutyl phosphate and monobutyl phosphate, and remaining uranium are then removed as sodium salts by scrubbing the hexane with 5 percent sodium hydroxide (NaOH). The purified hexane is then adjusted for recycle to the solvent extraction system by addition of new hexane and/or TBP.

2.2.5 Evaporation and Boildown

From the evaporation system feed tank, the aqueous uranyl nitrate liquor flows through a feed condensate heat exchanger to a combination evaporator-condenser. In this equipment, the uranium concentration is increased to about 500 g/L as water and HNO_3 are evaporated. These vapors are compressed, recycled through the evaporator condenser to assist in the evaporation of the liquor, and condensed. The condensate collects in the recovered acidic condensate tank and is then pumped through the feed condensate heat exchanger to heat the incoming uranyl nitrate liquor. The acidic condensate tank is vented to atmosphere to dispose of small amounts of saturated steam, traces of hexane, and noncondensable gases. The acidic condensate is then stored for reprocessing and recovery of the HNO_3.

The concentrated uranyl nitrate liquor (~500 g/L) is collected in a 2000-gal surge tank and held at 200°F until transferred to the boildown system.

The boildown system consists of three tanks in which batches of product from the evaporation system are heated using steam coils to boil off additional water and nitric acid, which increases the uranium concentration in the aqueous solution to about 1200 g/L. Vapor from the boildown tanks is condensed and the acidic condensate (0.1 M nitric acid) is transferred to a storage tank for subsequent recovery and recycle of the acid. The concentrated uranium product is pumped from the bottom of the boildown tanks into a recirculation piping system that permits feed to the denitration system.

2.2.6 Denitration

The concentrated product, uranyl nitrate hexahydrate (UNH), is bled from the boildown recirculation loop to the denitration system at the rate of 1.1 gpm. The UNH is heated in enclosed denitrator trays to a temperature of about 550°F with a slight negative pressure. The UNH is decomposed according to the following approximate reaction:

$$UO_2\ (NO_3)_2(n\ H_2O)\ \rightarrow UO_3 + NO + NO_2 + O_2 + n\ H_2O.$$

The uranium trioxide (UO_3) produced in the denitrator trays consists of a free flowing, minus 8 mesh material that is discharged over an internal well and through seal legs to an enclosed screw-type system conveyor. The granular material is then ground in a pulverizer to a powder finer than 60 mesh (250 µm) and discharged into the UO_3 storage bin.

The off-gases from the denitrator trays are scrubbed with 40 percent HNO_3 for removal of particulates and a portion of the nitrogen oxides and water vapor. The scrubbing fluid is cooled to 100°F and recirculated to the off-gas scrubbers. Excess nitric and scrubbing fluids are returned to the HNO_3 storage tank.

The conveyor system, pulverizer, and storage bins are vented through a bin vent baghouse. Fine particulates of UO_3 trapped in the baghouse are periodically blown back into the storage bin by reverse air flow.

2.2.7 Reduction

The UO_3 is transferred by screw conveyor to the UO_3 feed bin which is slightly pressurized with nitrogen. The UO_3 is then moved by screw conveyor and charged into a two-stage fluid-bed reactor at about 2000 lb/h. Cracked ammonia (hydrogen and nitrogen) from an ammonia dissociator is introduced at the bottom of both stages. The reduction of UO_3 with hydrogen proceeds according to the following reaction:

$$UO_3 + H_2 \rightarrow UO_2 + H_2O \text{ (vapor)} + \text{heat.}$$

Sufficient cracked ammonia is introduced to assure complete reduction. The thermal energy (heat) released in the reaction is used to help maintain the reaction temperature of 950-1100°F. Electrical furnaces are used to attain initial operation of the reactors and air-cooled coils are used to maintain temperature control.

Excess gas and UO_2 product from the reduction reactors are discharged to a UO_2 filter bin where the UO_2 is filtered from the gas by porous stainless steel filter elements that can remove 98 percent of all particles larger than 0.7 µm. The filters are periodically cleansed by a reverse flow of nitrogen.

Solids collected in the filter bin are discharged to a screw conveyor and subsequently transported to the HF recovery reactor or directly to the UO_2 seal bin for storage.

Exit gases from the filter bin are discharged through another stainless steel filter element to remove final traces of UO_2 product. The filtered off-gases, consisting of ammonia, nitrogen, water vapor, hydrogen, and hydrogen sulfide, are piped to a reduction hydrogen burner before disposal to the atmosphere.

The HF recovery reactor is a screw-type conveyor where contact between UO_2 powder and unreacted HF from the filter bin of the subsequent hydrofluorination stage can reduce loss of fluoride to the environment. The off-gas from the HF recovery reactor is filtered to remove particulates and cooled to condense the HF. The HF condensate and noncondensable gases are routed to the HF scrubber in the gaseous waste disposal system. The UO_2 powder partially reacted with HF is discharged into the UO_2 seal bin.

2.2.8 Hydrofluorination

Uranium dioxide is screw-fed from the UO_2 seal bin to the first stage of the hydrofluorination system where the powder is contacted with a countercurrent flow of HF in a stirred fluid-bed reactor. The reactor wall temperature is maintained at about 400-650°F using electrical heaters and air blowers. A mixture of UO_2, UF_4 product, excess HF, and water vapor are discharged from the first-stage reactor at a temperature of about 600-700°F into the UO_2-UF_4 filter bin where the solids are separated from the gases using porous carbon filter elements. These filters remove 98 percent of all particles larger than 0.7 µm and are periodically cleaned by back-flushing with hot nitrogen gas. Gases discharged from the UO_2-UF_4 filter bin are routed to the HF recovery reactor discussed in the previous section. The solids in the UO_2-UF_4 filter bins are transferred by screw conveyor to the second-stage hydrofluorinator for contact with anhydrous HF vapor heated to about 1000°F. The second-stage reactor is maintained at about 900°F with an electrical furnace and a cooling air blower. The UF_4 product, excess HF vapor, water vapor, and other gases are discharged from the second-stage reactor into the UF_4 seal bin where most of the UF_4 solids are collected and most of the gases and entrained fine particles are piped to the first-stage fluorinator.

The UF_4 powder is transferred from the UF_4 seal bin by screw conveyor to a UF_4 nitrogen lift chamber where gaseous nitrogen is used to purge entrained HF vapor from the UF_4 powder. The UF_4 and all the gases then enter the UF_4 filter seal bin where the gases are separated and piped to the HF scrubber in the gaseous waste disposal system. The UF_4 powders are transferred by screw conveyor to UF_4 storage bins.

2.2.9 Fluorination

The UF_4 is transferred to a two-stage fluorination system by enclosed conveyors. The UF_4, charged into the first stage at a temperature of 100°F, is converted to UF_6 by reaction with elemental fluorine at a temperature of 850°F according to the following reaction:

$$UF_4 + F_2 \rightarrow UF_6 + \text{thermal energy.}$$

Excess reaction heat is removed from the reaction vessels using steam-cooled coils. About 15 percent excess fluorine over the stoichiometric conversion requirement is introduced into the first-stage reactor to maximize conversion of UF_4 to UF_6. Approximately 1 percent of the feed material is collected as unreacted UF_4 or intermediate fluorides in ash containers at the bottom of the first-stage reactors. Each first-stage reactor is periodically shut down, and the ash is ground and returned to the UF_4 storage bin.

The outlet gases from the first-stage fluorination reactors are cooled to about 300°F, and entrained solids are removed in a cyclone separator and by porous Monel filter elements in the F_2 reactor filters. The filters remove 98 percent of all particles greater than 0.7 μm and are periodically cleaned using a backflow of air. The particulates are returned to the miscellaneous digester for reprocessing.

The filtered gas, containing UF_6, F_2, HF, O_2, and N_2, is passed through the primary cold traps at 30°F where approximately 90 percent of the UF_6 is condensed as a solid. The noncondensed gases are heated to 800°F and forced into the second-stage fluorinators (cleanup reactors) for reaction with an excess of the stoichiometric requirement of UF_4 at a temperature above 750°F. About 10 percent of the UF_4 will be unreacted and is removed from the bottom of the cleanup reactor by screw conveyor where the product is cooled to 400°F. The excess UF_4 is subsequently returned to the UF_4 storage bin for feed to the fluorinators. The system is designed, monitored, and controlled so that the excess F_2 from the primary fluorinator will be completely consumed by the reactions with UF_4 and any UO_2 or UO_2F_2 in the feed material.

The gases and entrained solids from the cleanup reactor enter the cleanup reactor filter where 98 percent of the particles greater than 0.7 μm are removed by porous Monel filters (primary and backup). These filters are also periodically cleaned using a backflow of air.

The filtered gas is passed through the secondary cold traps for condensation of UF_6 as a solid at -65 to -75°F. The noncondensable gases are pumped to the HF scrubber in the gaseous waste disposal system. Fluorine is monitored in the noncondensable gas discharge as an element in the process control.

2.2.10 UF_6 handling and shipping

When any primary or secondary cold trap is full, the UF_6 is melted and drained by gravity through porous Monel filters into evacuated 10-ton or 14-ton shipping cylinders where it slowly solidifies at ambient temperature. The piping from the cold traps to the cylinders consists of a 2-in.-diam sloped, steam-traced transfer header. The transfer header and filter are connected to the cylinder valve through a 3/4-in.-diam copper tubing pigtail.

Two transfer headers and filling stations are in use. The headers are manifolded so that each filling station can handle UF_6 from either the primary or the secondary cold traps. The primary cold traps have a nominal capacity of 10 tons. After filling, the cylinders are weighed and transferred to the cylinder storage area in the yard. The cylinders are cooled for a minimum of 5 days before shipment.

APPENDIX 3.1.1

PHOTOS SHOWING THE LOCATION OF THE 14-TON CYLINDER AND THE RUPTURE

PHOTOS FOR APPENDIX 3.1.1

Figure 3.1.1.1A	The Sequoyah Facility's Process Buildings Viewed from the South. The sod has been stripped from the lawn in front of the building. Route 10 is at the upper right.
Figure 3.1.1.2A	The Sequoyah Facility, Viewed from the North-Northwest. The self-propelled crane is preparing to lift away the damaged steam chest from over the ruptured cylinder.
Figure 3.1.1.3A	Removing the Steam Chest from the Ruptured Cylinder. Both the cylinder and the steam chest are in the positions in which they were found after the cylinder ruptured. A temporary cover is in place over the rupture.
Figure 3.1.1.4A	The 52-inch Long Rupture. At its midpoint, the opening is about 8 inches wide. The cylinder wall is 5/8-inch thick steel. Water is draining out after rinsing out the cylinder.

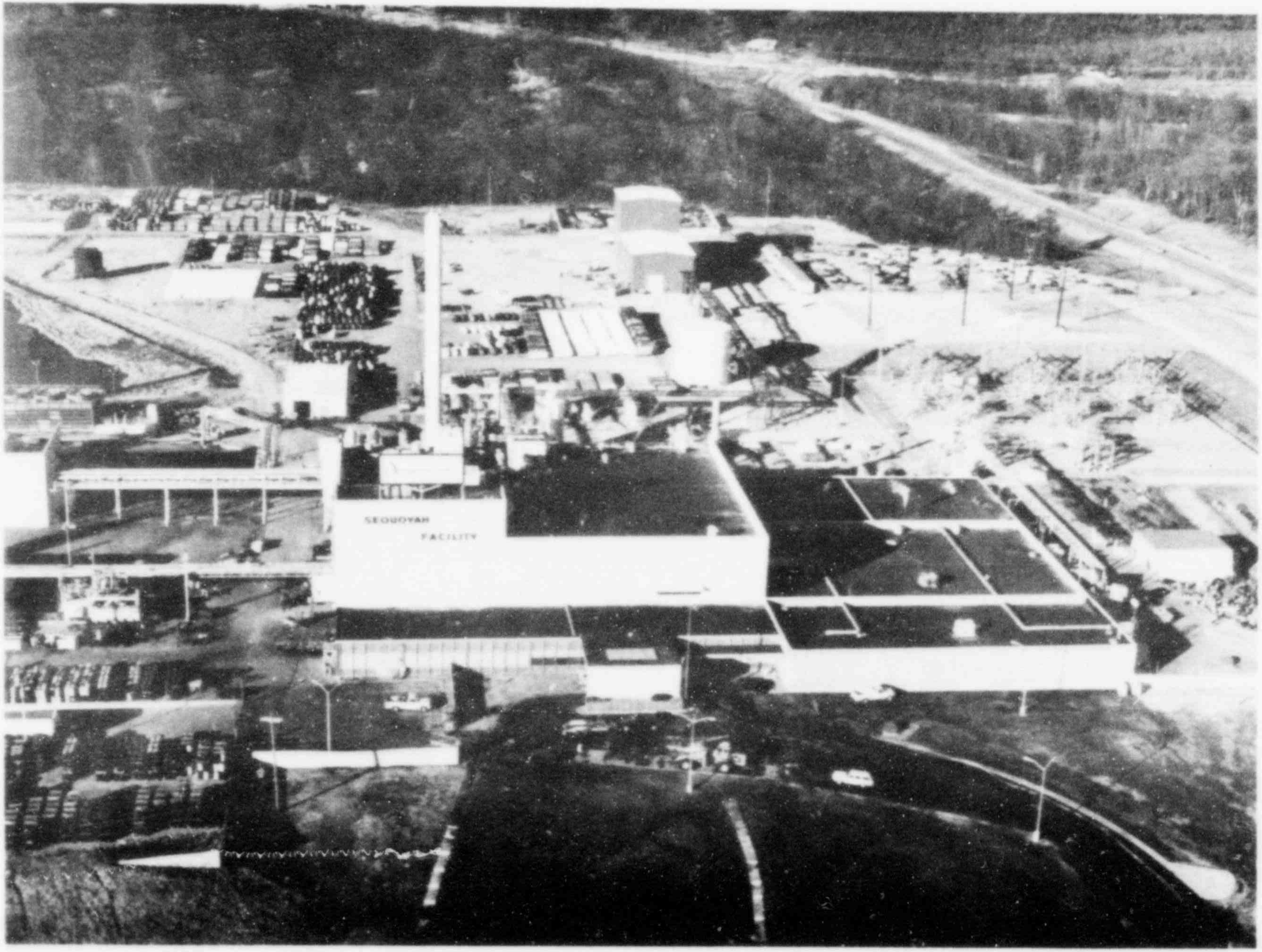

Figure 3.1.1.1A The Sequoyah Facility's Process Buildings Viewed from the South

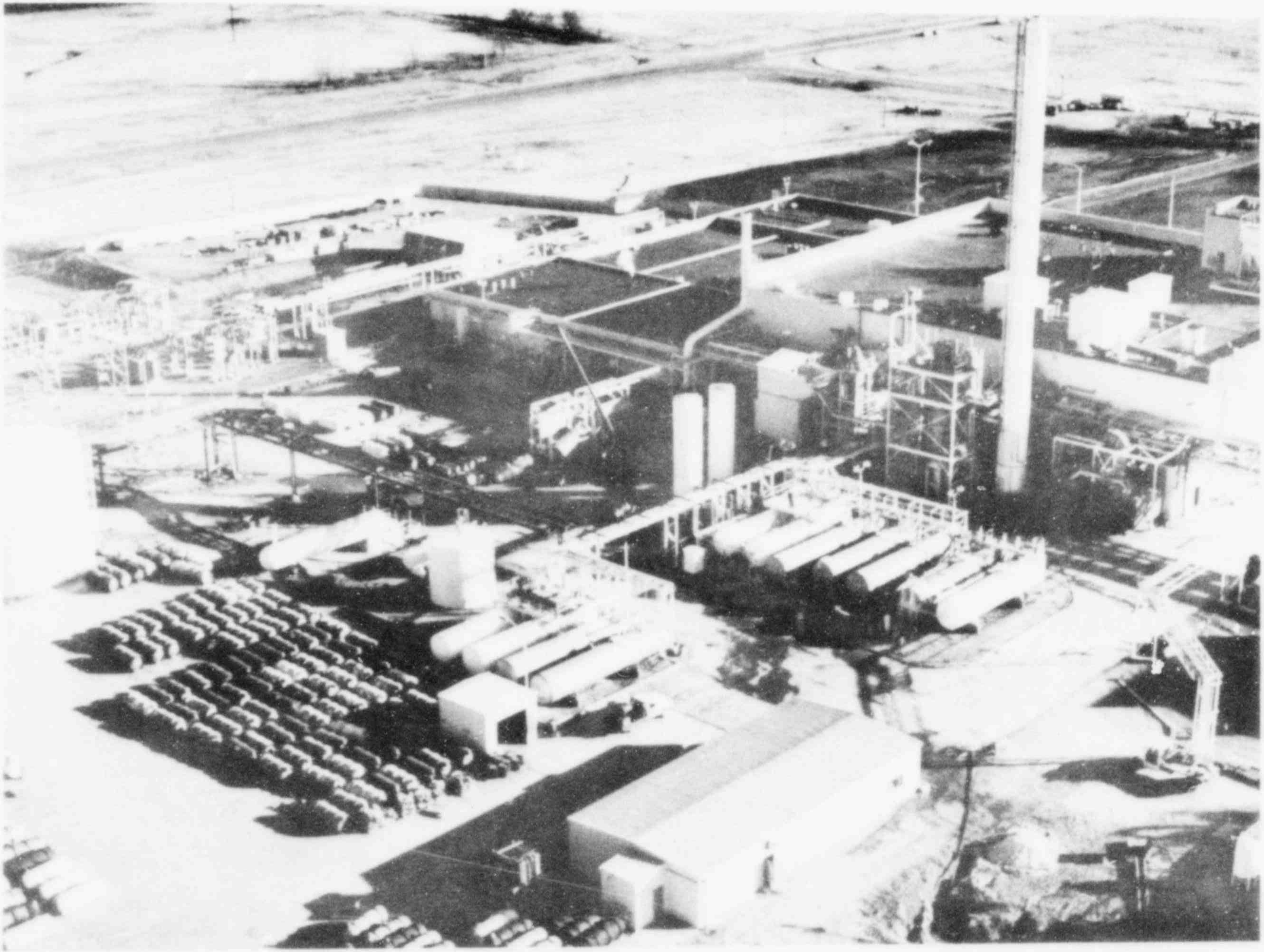

Figure 3.1.1.2A The Sequoyah Facility, Viewed from the North-Northwest

Figure 3.1.1.3A Removing the Steam Chest from the Ruptured Cylinder

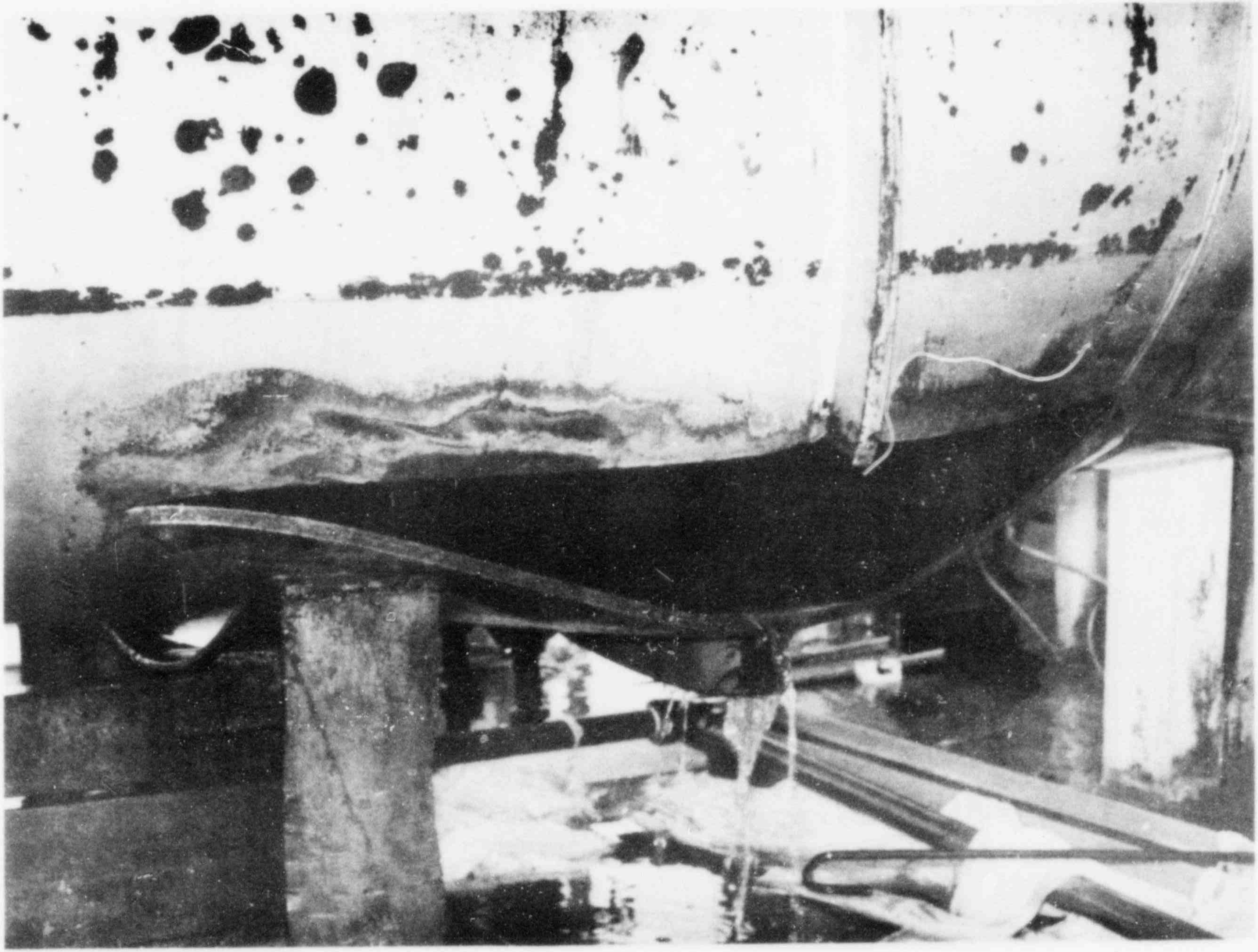

Figure 3.1.1.4A The 52-inch Long Rupture

APPENDIX 3.3.1

NRC'S PRELIMINARY NOTIFICATIONS OF EVENT OR UNUSUAL OCCURRENCE FOLLOWING THE ACCIDENT OCCURRING ON JANUARY 4, 1986

January 5, 1986

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE -- PNO-IV-86-02

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by the Region IV staff on this date.

FACILITY:
Sequoyah Facility
Sequoyah Fuels Corporation
(formerly Kerr-McGee Nuclear Corp.)
Gore, Oklahoma
License No. SUB-1010

Licensee Emergency Classification:
_____ Notification of Unusual Event
_____ Alert
_____ Site Area Emergency
_____ General Emergency
__X__ Not Applicable

SUBJECT: RUPTURED URANIUM HEXAFLUORIDE CYLINDER

At approximately 11:30 a.m. on January 4, 1986, a cylinder containing approximately 29,500 pounds of uranium hexafluoride (UF6) ruptured, releasing its contents into the atmosphere and resulting in the death of one company employee from the inhalation of hydrogen fluoride (HF). As a result of this incident, the NRC has established an emergency response organization at the site to examine the resultant health and environmental impacts and an Augmented Investigation Team (AIT) to investigate the circumstances of the cylinder rupture.

According to statements from company officials, plant employees had overfilled the cylinder (maximum limit is 27,560 pounds) and were in the process of heating the cylinder to facilitate removing the excess uranium hexafluoride when the rupture occurred. An approximate three foot-long split occurred in the wall of the cylinder, allowing the contents of the cylinder to be released to the atmosphere in gaseous form. Company officials estimate that the contents of the cylinder emptied in about 30 to 40 minutes.

Contact with the air resulted in the formation of hydrogen fluoride (HF) and uranyl fluoride. Although it is believed, based on radiation surveys and sample results to date, that most of the uranyl fluoride was deposited in the immediate vicinity of the plant, the hydrogen fluoride, a toxic and corrosive chemical, formed a plume that was visible at more than a mile from the plant site before it was dispersed. Interstate 40, which runs east-west about a mile south of the plant, was closed for a short period of time after the incident by the Oklahoma Highway Patrol.

About 25 people, mostly company employees, were hospitalized as a result of the incident, but only a few were diagnosed as suffering from respiratory problems related to inhalation of hydrogen fluoride. Those exhibiting actual respiratory problems were transferred to a medical facility in Fort Smith, Arkansas, from a hospital in Sallisaw, Oklahoma. One person, a company employee, died enroute to Fort Smith. No additional deaths have been reported. Numerous company employees and local residents have reported to the Sallisaw hospital at the company's urging for initial screening. Many have been asked for urine samples which the company will analyze at its Technical Center in Oklahoma City.

The Company continues to perform radiation surveys at the plant and to perform surveys and take samples from the environment in the areas that the plume is believed to have traversed.

Although the rupture took place in a steam-heating facility outside the main process buildings, contamination was spread through most plant buildings by the building ventilation systems. The company continues to decontaminate those areas needed to manage its recovery activities.

Region IV's emergency response activities are being conducted in parallel with those of the Augmented Investigation Team. Both are headed by Region IV's Director of the Division of Radiation Safety and Safeguards. The complement of NRC personnel presently at the site include six technical staff Region IV (two from the Uranium Recovery Field Office), one each from NMSS and IE, and Region IV's Public Affairs Officer. The team is focusing on the events that led to the cylinder rupture, the resultant health and environmental impacts and the recovery activities that are currently taking place. Region IV's Incident Response Center and the Headquarters Operations Center were activated and staffed promptly after receiving notification of this incident. The company has agreed to leave the equipment and facilities related to this incident untouched and not to resume facility operations without NRC concurrence. The team is making arrangements to interview all plant employees who were at the facility at the time of the incident and to have those interviews transcribed.

Arrangements have been made through the Department of Energy for an aerial radiation survey. Both the state of Oklahoma and the state of Arkansas have been contacted regarding this event. The Oklahoma Department of Health dispatched two individuals to the plant site on Saturday. The NRC's response team has been coordinating its activities with representatives of the state of Oklahoma and the licensee.

National and local news media have run stories on this incident. The company and NRC have been responding to media inquiries since shortly after the incident. The company issued a news announcement at about 2:00 p.m. Saturday. A press conference was arranged by Congressman Mike Synar of Oklahoma and took place at about 2:00 p.m. Sunday in Muskogee. The NRC's response team leader and Oklahoma state officials took part in the press conference. The response team leader also briefed Congressman Synar separately on Sunday morning.

A hearing on a license amendment for this facility that was to have taken place on January 7 and 8 in Fort Smith, Arkansas, has been indefinitely postponed by the presiding Atomic Safety and Licensing Board Judge.

Region IV was notified of this incident at about noon January 4 by the Headquarters Operations Officer. This information is current as of 7:00 a.m. on Monday, January 6. This PN will be updated periodically.

CONTACT: E. F. Bates, FTS: 728-8100

January 7, 1986

LIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE -- PNO-IV-86-02A

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by the Region IV staff on this date.

FACILITY: Sequoyah Facility
Sequoyah Fuels Corporation
(formerly Kerr-McGee Nuclear Corp.)
Gore, Oklahoma
License No. SUB-1010

Licensee Emergency Classification:
____ Notification of Unusual Event
____ Alert
____ Site Area Emergency
____ General Emergency
__X__ Not Applicable

SUBJECT: RUPTURED URANIUM HEXAFLUORIDE CYLINDER (UPDATE)

The NRC's Augmented Investigation Team (AIT) and other response personnel continue to investigate the circumstances of the January 4, 1986, rupture of a cylinder containing approximately 15 tons of uranium hexafluoride (UF6) at the Sequoyah Fuels Corporation UF6 production facility near Gore, Oklahoma. The NRC team is evaluating both the events leading to the rupture and the radiological impact of the incident. The company has agreed not to resume processing operations without NRC concurrence. Nonradiological effluent processing systems are continuing to operate. This is an activity unrelated to the incident.

The investigation team began interviewing plant personnel on Monday, January 6, and has begun compiling a chronology of events. The team believes it is close to identifying the fundamental cause of the cylinder rupture. At a news briefing Tuesday, the company acknowledged that the plant's operating procedures prohibit heating a UF6 cylinder that has been overfilled.

An additional wisp of hydrogen fluoride gas was observed evolving from the residual UF6 in the ruptured cylinder but control measures by plant personnel have been successful in stopping it. No health or safety importance is attached to this release.

The company has formulated plans for cleaning up the processing portions of the facility and has already begun cleanup of the plant property itself, including the removal of sod from the lawn at the south end of the plant. The NRC team is reviewing the company's cleanup plans to ensure adequate protection of workers and ensure that no equipment essential to the investigation is disturbed. The team has asked the company to consider alternative methods of collecting fluids that will result from the washdown operations at the plant, rather than sending them through the plant's normal processing system and to the Illinois River.

Aerial radiation monitoring by EG&G, arranged through the Department of Energy, is expected to begin Wednesday. The survey, which will be conducted using a red, white and blue helicopter flying at an elevation of 150 feet, will cover an approximate

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12-square-mile area surrounding the plant. The company is taking steps to inform the public about the nature and purpose of these flights. The results of the aerial survey will be used to confirm ground survey data that appears to indicate that no significant amounts of uranium were deposited off the plant site. Initial review of environmental data available to the team at this time confirms early prediction that no significant offsite radiological impacts are expected.

The company reported today that all individuals hospitalized as a result of this incident have been released with the exception of one who remains hospitalized for reasons unrelated to the event.

The NRC team, now totaling 15 people at the site, is requesting additional personnel with expertise in instrument maintenance and surveillance, QA/QC and laboratory analytical procedures. These technicians are expected to arrive at the site tomorrow (January 8).

News briefings are being conducted daily in the vicinity of the facility. NRC, the company and the state of Oklahoma are represented at these briefings. The NRC team continues to work in cooperation with the company and the state of Oklahoma and to keep the state of Arkansas informed of the status of the recovery operations.

This information is current as of 1:00 p.m. on Tuesday, January 7, 1986. The team plans to update the information in this PN daily.

CONTACT: J. B. Baird (FTS: 728-8100)

January 8, 1986

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE -- PNO-IV-86-02B

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by the Region IV staff on this date.

FACILITY: Sequoyah Facility
Sequoyah Fuels Corporation
(formerly Kerr-McGee Nuclear Corp.)
Gore, Oklahoma
License No. SUB-1010

Licensee Emergency Classification:
___ Notification of Unusual Event
___ Alert
___ Site Area Emergency
___ General Emergency
_X_ Not Applicable

SUBJECT: RUPTURED URANIUM HEXAFLUORIDE CYLINDER (UPDATE)

The NRC's Augmented Investigation Team (AIT) and response team personnel continued to analyze information and data collected in the aftermath of the January 4, 1986 rupture of a cylinder containing approximately 15 tons of uranium hexafluoride (UF6). The rupture resulted in the death of one Sequoyah Fuels Company (SFC) employee. The AIT has completed interviews with 12 plant personnel but has temporarily discontinued interviewing to permit team members to analyze information gathered to date.

Based on the information obtained to date and visual observation of the ruptured cylinder, the best judgement of the team is that the cylinder failed by hydraulic rupture. The team has found no information which would indicate the cylinder was defective. On the contrary, the extensive deformation experienced by the cylinder before it ruptured indicates that it was subjected to internal pressures far beyond the pressures for which it was designed.

Such large pressures would be produced hydraulically when the liquid contents expanded to a volume greater than the volume of the vessel. The current state of the analysis at the site indicates that this condition occurred.

The company's cleanup of plant buildings and property continues. Decontamination of three areas of the plant process building -- the access areas, the change room and the maintenance shop -- has begun. Removal of contaminated sod from the lawn south of the main plant buildings continues and is expected to be completed soon. The NRC is reviewing the company's plans for disposition of the waste resulting from the cleanup. SFC is analyzing alternatives to discharging cleanup liquids (although expected to be within uranium concentration limits for discharge) to the Illinois River. Regarding contaminated sod, SFC and NRC are examining the possibility of transporting it to a company uranium mill tailings site in New Mexico.

The NRC team has completed a preliminary description of the probable trajectory of the plume. Using data from surveys and sample analysis, efforts are underway to define the extent of fluoride and uranium deposition. The company

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continues to analyze the fluoride impact on animals in the path of the plume, but has seen no observable effects. Some fluoride damage to cedars has been observed by a specialist employed by the company. The NRC plans to produce a detailed report examining the radiological consequences of this incident. There is no data at this time to indicate any significant offsite radiological impacts.

The aerial radiation survey of the area surrounding the plant did not begin today as expected because of an FAA airworthiness directive that kept the helicopter grounded. This issue is expected to be resolved promptly.

The company reports today that all employees were were hospitalized as a result of this incident have been released from the hospital. Medical consultants to the company continue to monitor affected employees for evidence of kidney damage from uranium ingestion. Funeral services for the employee who died as a result of inhaling toxic hydrogen fluoride vapors took place today in Vian, Oklahoma.

News media interest in the incident has remained steady. Another briefing was held at 11:00 a.m. today in Gore, Oklahoma. The NRC team continues to work with the state of Oklahoma representatives at the site and to keep the Arkansas Department of Health informed of the status of the recovery operations. The team continues to brief Congressman Synar's staff daily. NRC, Oklahoma and company representatives have been requested to attend this evening's special meeting of the Gore Public Schools Board of Education to address concerns about location of Carlile School about one mile east of the plant site.

This information is current as of 1:00 p.m. on Wednesday, January 8, 1986.

CONTACT: J. B. Baird (FTS: 728-8100)

January 9, 1986

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE -- PNO-IV-86-02C

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by the Region IV staff on this date.

FACILITY: Sequoyah Facility
Sequoyah Fuels Corporation
(formerly Kerr-McGee Nuclear Corp.)
Gore, Oklahoma
License No. SUB-1010

Licensee Emergency Classification:
____ Notification of Unusual Event
____ Alert
____ Site Area Emergency
____ General Emergency
_X_ Not Applicable

SUBJECT: RUPTURED URANIUM HEXAFLUORIDE CYLINDER (UPDATE)

The NRC's Augmented Investigation Team (AIT) is nearing the completion of its fact-finding activities and continues to evaluate the information that has been gathered to date. The site team leader announced to the press today the AIT's preliminary conclusion on the cause of the UF6 cylinder rupture. It appears that early next week the team can present estimates of the size and concentrations associated with the release and some conclusions at to the health and environmental impact of the incident.

The aerial surveys to monitor the vicinity of the plant for the presence of uranium and for any indication of fluoride damage to vegetation (using infrared photography) began today. The company announced that damage to offsite cedars previously reported to have been caused by fluoride was actually caused by a power company spraying a defoliant beneath its power lines.

The company continues to make progress in cleaning up the process areas and the plant property. Plans have been made to decontaminate the ruptured cylinder prior to its removal to an offsite location for a metallurgical examination. Arrangements are being made to obtain a complete inspection and test of the scale that was to weigh the cylinder.

Plant buildings were evacuated this morning when a fire alarm sounded. The company determined that the alarm was caused by low nitrogen pressure in the automatic fire suppression system in the solvent extraction building. The NRC is assisting the company in making arrangements to obtain necessary nitrogen supplies because the nitrogen must be delivered to an area of the facility that remains contaminated.

Senator Don Nickles (R-Oklahoma) visited the plant site this morning and was briefed by the NRC team leader and company officials. Senator Nickles, the NRC team leader, company and Oklahoma representatives then briefed the news media at an 11:00 a.m. news conference in Gore, Oklahoma. Last night in Gore, the NRC team leader appeared before a special meeting of the Gore Public Schools Board of Education that was called to assess the long-term safety of students in the Carlile elementary school, which is

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located about a mile east of the plant. The school was not in the direction of the plume from this incident and was surveyed in detail to confirm that no radioactivity from the incident had been deposited there. The school board delayed until Monday, January 13, a decision on whether to shut down the Carlile school and move students to other facilities.

This information is current as of 1:00 p.m. on Thursday, January 9, 1986.

CONTACT: J. B. Baird (FTS: 728-8100)

January 10, 1986

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE -- PNO-IV-86-02D

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by the Region IV staff on this date.

FACILITY: Sequoyah Facility
Sequoyah Fuels Corporation
(formerly Kerr-McGee Nuclear Corp.)
Gore, Oklahoma
License No. SUB-1010

Licensee Emergency Classification:
____ Notification of Unusual Event
____ Alert
____ Site Area Emergency
____ General Emergency
__X__ Not Applicable

SUBJECT: RUPTURED URANIUM HEXAFLUORIDE CYLINDER (UPDATE)

The NRC's response team met with company officials this morning to discuss detailed plans for decontamination of the ruptured cylinder and the handling of any residual UF6 as the company prepares the cylinder for eventual transport to the Lawrence Livermore Laboratory for metallurgical examination. The principal concern of the team has been that adequate steps are taken to protect the health and safety of workers and others involved in this activity. These concerns have been satisfactorily addressed. The decontamination is underway.

Sequoyah Fuels Corporation (SFC) employees continue to decontaminate service areas of the plant process building. Removal of contaminated sod from the south lawn of the plant is complete. SFC officials assured the NRC this morning that decontamination activities over the weekend will involve only those portions of the facility for which NRC has already reviewed and approved plans. In addition, SFC plans to contract for additional health physics technician support to more carefully implement contamination control procedures as the cleanup of the plant and site continue. The NRC will maintain a presence at the facility over the weekend to monitor those activities.

The NRC's Augmented Investigation Team (AIT) has completed interviews with plant employees and has developed a preliminary sequence of events. The sequence is attached to this PN. The AIT's activities at the facility are virtually complete. Health physic coverage and environmental assessment activities will continue through the weekend. NRC presence at the site beyond early next week is expected to be limited to radiation protection specialists who will continue to monitor the decontamination of the plant.

Aerial surveys to monitor the vicinity of the plant for the presence of uranium and for any indication of fluoride damage to vegetation continued today. DOE expects the aerial radiation surveys to be completed sometime Saturday.

The Regional Administrator and other NRC staff members will brief the Commissioners on this incident at a public meeting beginning at 1:00 p.m. (EST) today. No news briefings at the plant site are scheduled today or over the weekend.

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The NRC response team continues to work in close cooperation with the state of Oklahoma Department of Health representatives at the plant site and to keep Arkansas Department of Health officials and Congressman Synar's staff informed of the status of recovery activities.

This information is current as of 1:00 p.m. on Friday, January 10, 1986. Additional PNs will be issued as necessary.

ATTACHMENT: Sequence of Events

CONTACT: J. B. Baird (FTS: 728-8100)

Sequoyah Facility, Sequoyah Fuels
Corporation (formerly Kerr-McGee
Nuclear Corp.), Gore, Oklahoma,
License No. SUB-1010

SEQUENCE OF EVENTS

9/20/85	Cylinder No. E-2047 received at Sequoyah facility.
9/27/85	Cylinder passes 20-point quality inspection conducted by site engineer.
1/3/86 (10:00 am)	Cylinder passes second 20-point quality inspection conducted by day shift operator. Cylinder is moved to south filling bay within the plant process building and has begun to be filled with the UF$_6$ product. The operator adjusts the counterweight of the scales on which the cylinder is positioned so that the scale dial is indicating no weight. That is, the counterweight is positioned to counterbalance the tare weight of the empty cylinder so that the scales will directly measure the net weight of the product.
(3:30 pm)	At the end of his shift, the day shift operator records that the cylinder has been loaded with 11,230 pounds of product and is still being filled.
(11:30 pm)	At the end of his shift, the evening shift operator records that the cylinder has been loaded with an additional 12,200 pounds of product. The total weight of product in the cylinder is correctly noted as being 23,430 pounds.
1/4/86 (2:15 am)	Midnight shift operator continues filling of cylinder. Although the targeted net weight of the cylinder is 27,500 pounds of product, the operator is unable to fill it beyond 26,400 pounds. Upon closer investigation, the operator observes that one wheel of the cart holding the cylinder is not fully on the scales which are set to indicate the net weight of the product in the cylinder. After restoring the cart to a position fully on the scales, the scale indicator pegs out at 29,500 pounds. The operator informs the shift supervisor that the cylinder has been overfilled. The supervisor orders the operator to

begin removing product from the cylinder using a vapor evacuation technique.

1/4/86 (6:00 am) The operator moves the counterweight on the scales so that the scale dial indicator will be freed from its pegged position and will indicate the rate at which product is removed from the cylinder.

(6:15 am) Evacuation of product from the cylinder begins. The scale indicates that 150 pounds of product is removed in the succeeding 10 minutes. The operator can hear the flow of material through the cylinder valve.

(7:45 am) At the end of the midnight shift, evacuation of UF_6 from the cylinder is still in progress.

The operator informs the oncoming day shift operator of the problem.

(8:45 am) The day shift operator is unable to draw off any more product from the cylinder, presumably because the UF_6 has begun to solidify. The operator confers with the day shift supervisor who instructs the operator to transfer the cylinder to the southwest steam chest outside and north of the process building. The UF_6 will again be liquified in the steam chest before the cylinder is returned to the filling bay for further product extraction. The supervisor instructs the worker to leave the cylinder in the chest for 6 hours. (Heating an overfilled cylinder is prohibited by company procedures.)

Before transferring the cylinder from the scales, the counterweight is moved to its original position which had been demarked on the slide bar with a pen by the operator on the previous shift. The scale now again indicates 29,500 pounds.

(9:15 am) The operator uses a fork lift truck to transfer the cylinder to the steam chest. Steam heating of the cylinder is begun.

(11:30 am) The cylinder ruptures while in the steam chest. The UF_6 quickly vaporizes forming UO_2F_2 and hydrofluoric acid. The operator in a scrubber building 50 feet from the steam chest sustains lethal injuries caused by the acid fumes. Workers further away sustain less serious injuries. The plant is evacuated of approximately 40 workers.

The vapor release which continues for approximately 40 minutes is carried south by south-east by a gusting 25 mph wind.

January 13, 1986

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE -- PNO-IV-86-02E

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by NRC staff on this date.

FACILITY: Sequoyah Facility
Sequoyah Fuels Corporation
(formerly Kerr-McGee Nuclear Corp.)
Gore, Oklahoma
License No. SUB-1010

Licensee Emergency Classification:
___ Notification of Unusual Event
___ Alert
___ Site Area Emergency
___ General Emergency
_X_ Not Applicable

SUBJECT: RUPTURED URANIUM HEXAFLUORIDE CYLINDER (FINAL UPDATE)

The NRC's response team has begun to receive results of soil and vegetation samples taken from more than 100 locations in a broad area extending as far as 10 miles south of the facility (in the direction of the plume). Samples are being analyzed by the Kerr-McGee Technical Center, the state of Oklahoma Department of Health and the Oak Ridge National Laboratory (on behalf of NRC). Sample results to date indicate no deposition of uranium in detectable quantities beyond property owned by the licensee.

Preliminary results of aerial radiation surveys in a 25-square-mile area confirm the absence of uranium in concentrations above background except in the immediate areas of the facility. NRC and state of Oklahoma officials continue to analyze soil and vegetation samples for uranium and fluorine content. Company medical consultants also continue to analyze the results of uranium analyses done on the urine of both plant employees and members of the public.

The initial decontamination of the ruptured cylinder was completed without incident on Friday, January 10. As expected, a small amount of hydrogen fluoride vapor was released to the air during the operation of flushing residual materials from the UF6 cylinder. As a precaution, the state of Oklahoma Department of Health notified local officials prior to this activity. Other decontamination activities performed over the weekend focused on returning plant office space and the main gate area to normal conditions. The company plans to develop a program to periodically resurvey areas that have been cleaned to ensure that contamination is not spread during cleanup operations.

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With the exception of radiation specialists who will maintain coverage during the decontamination of the facility, the remaining members of the response team plan to complete their onsite activities on Tuesday, January 14, and depart the site that afternoon.

The team plans a final news briefing at 3 p.m. Monday in Gore and a final briefing of U.S. Representative Mike Synar's staff on Tuesday. The team prepared a letter to the president of the Gore school board describing the results of radiation surveys of the Carlile School in preparation for a Monday evening meeting of the board to decide whether to move Carlile students to other facilities. All surveys at the school confirmed that no radiological contamination was present.

This information is current as of 1 p.m. on Monday, January 13, 1986. This is the final PN on this subject.

CONTACT: J. B. Baird (FTS: 728-8100)

APPENDIX 4.1.2

METEOROLOGY AND ATMOSPHERIC DISPERSION

APPENDIX 4.1.2

ATMOSPHERIC DISPERSION AND METEOROLOGY

4.1.2.1 Atmospheric Dispersion Modeling

The atmospheric transport, diffusion, and deposition models used for assessing the impacts of the atmospheric releases are part of the Atmospheric Release Advisory Capability (ARAC) operated by the Lawrence Livermore National Laboratory under the auspices of the Department of Energy. The models[7,8] used were the Mass-Adjusted Three Dimensional Wind Field (MATHEW) model and the Atmospheric Diffusion Particle-In-Cell (ADPIC) model. These models are fully described in References 7 and 8. The regional wind field was developed from information compiled from National Weather Service stations within 200 km, although data from the site dominated the wind field and consequently plume movement close to the faiclity. Data from two other stations affected the movement of the plume well-away from the facility. These stations are located in Fort Smith Arkansas (approximately 70 km east-southeast), and Page, Oklahoma (approximately 100 km south of the facility).

The influence of terrain and airflow trajectory is considered in determining the 3-dimensional wind field, with horizontal resolution of terrain of one-twentieth of the overall grid size and vertical resolution of terrain of 50 meters independent of grid size. Calculations of atmospheric dispersion were performed for three grid sizes: 10 km, 40 km, and 80 km. The total vertical depth modeled was 700 meters. Because of different terrain cell sizes and varying grid cell volumes close to the facility, contours of air concentration and deposition differ slightly in magnitude and location close to the facility for each computational grid used.

The ADPIC Model is based on a particle-in-cell technique with concentration represented by Lagrangian-marker particles inside a fixed Eulerian grid. From observations at the facility during the accident, the initial cloud was assumed to be an ellipsoidal volume 21 meters high (in the vertical direction), 76 meters wide (in the cross-wind direction), and 4 meters long (in the along wind direction). Uranyl fluoride was modeled as particles with a log-normal size distribution, a median diameter of one micron, and a standard geometric deviation of 1.5 microns. A deposition velocity of 1 cm/sec was assumed. Hydrogen fluoride was modeled as a vapor with a deposition velocity of 1 cm/sec. The assumptions regarding the character and behavior of uranyl fluoride and hydrogen fluoride were developed to simplify for modeling purposes the complex chemical transformations and atmospheric processes related to condensation, precipitation, and sublimation. The assumptions appear reasonable given the nature of the release and meteorological conditions at the time of the accident; however, the relatively simple characterization of such complex processes is a major source of uncertainty in the atmospheric dispersion models used for this evaluation.

For example, when the cylinder ruptured in the steam chest, it released UF_6 in three physical states, i.e., some was a gas, some liquid, and some solid. It was reported that small pieces of solid UF_6 were scattered widely around the steam chest area. Some of the UF_6 reacted immediately with the steam and other water in the steam chest and in the surrounding air, but there was not enough water present for an immediately reaction with all 13,400 kg UF_6. The total water requirement would be about 1,370 kg water. Thus, the initial cloud (before hosing down by SFC workers) contained some unreacted UF_6 as well as UO_2F_2 and HF. As the airborne UF_6 was carried downwind, it reacted with the moisture in the air. How far the UF_6 may have been transported before the reaction was essentially complete is not known, but even though the air had a relatively low moisture content, the UF_6 would not have been transported more than a few km downwind before encountering sufficient atmospheric moisture to complete the reaction. If inhaled, the UF_6 would quickly react with moisture in the lungs, bronchial passages, etc., to form UO_2F_2 and HF; the reaction also liberates heat. If deposited on surfaces (e.g., vegetation) the UF_6 would also react there with available moisture within a relatively short time period. The release has been modeled as the reaction products UO_2F_2 and HF; quantities of uranium and fluoride in UF_6 are accurately presented as the sum of the quantities of UO_2F_2 and HF.

Furthermore, the cloud as formed within the first few seconds after cylinder rupture was exceptionally dense. This great density would promote, for example, rapid particle agglomeration and deposition in the vicinity of the plant buildings. No attempt was made to model such circumstances; instead, the dispersion modeling was designed to represent the cloud well when it had traveled a kilometer or more downwind.

However, even though the meteorological conditions were favorable to mathematical modeling of the cloud of released chemicals, the models provide a description based on experience and do not describe in second-by-second detail what actually occurred in the cloud of chemicals. Because the greater part of the chemicals was released in the first few minutes after cylinder rupture, it is possible that especially during this brief time period some small portions of the cloud carried substantially higher concentrations downwind a few kilometers before atmospheric mixing made the cloud more uniform and more dilute.

Based on initial observations of the accident and consideration of the process involved, type of cylinder, and the physical form of the material in the cylinder, 75 percent of the material was assumed to be released in the first 5 minutes following the rupture of the cylinder, with the remaining 25 percent of the material released during the next 40 minutes. Model calculations were performed for a unit release (1 gram) with a uniform release rate of 0.75 gram over 300 seconds (5 minutes) and of the remaining 0.25 gram over 2400 seconds (40 minutes). Use of a release normalized to one gram was chosen by the Ad Hoc Task Force for the dispersion modeling so that modeling results could contribute to the selection of the quantities to be used in the modeled exposure calculations to best represent their judgment of the quantities transported downwind to distances of a kilometer or more.

The dispersion simulation results produced by LLNL-ARAC are provided here in three forms: (1) contours of integrated air concentrations, (2) contours of cumulative deposition concentrations, and (3) instantaneous air concentrations. All three are presented for UO_2F_2 and HF separately; all three are presented normalized to a release of one gram of UO_2F_2 or one gram of HF. Thus to estimate meaningful exposures, these normalized values must be multiplied by the estimated source term, e.g., 5,900 kg UO_2F_2. The contour plots for UO_2F_2 serve to provide an estimate for uranium exposures; to estimate fluoride exposures, some combination of the results for both HF and UO_2F_2 must be used; the Task Force chose to use the sum of 1,500 kg HF and 5,900 kg UO_2F_2. Results in the form of normalized quantities deposited per square meter are also provided; the same considerations apply. Figures 4.1.2.1A through 4.1.2.3A represent (in units of seconds per cubic meter) the ARAC-simulated normalized air concentrations for uranyl fluoride integrated over the total time of passage of the cloud. Figures 4.1.2.4A through 4.1.2.6A present the simulated normalized cumulative deposition (in units of inverse square meter). Figures 4.1.2.7A through 4.1.2.12A represent the same simulations for HF.

Figures 4.1.2.13A through 4.1.2.20A present contours of the simulated instantaneous normalized concentration of hydrogen fluoride at 10 minute intervals; Figure 4.1.2.13A begins the sequence at 11:40 a.m. local time, 10 minutes after the release began. The sequence illustrates the progression of the cloud and its transport and diffusion downwind. Figures 4.1.2.21A through 4.1.2.27A are the corresponding series for uranyl fluoride until the wind has blown the airborne material off the grid.

In addition, LLNL-ARAC has provided numerical results at selected points. Points selected are residences and sample locations near residences in the cloud path, towns downwind, and an array of other points downwind to 72 km. Figures 4.1.2.28A and 4.1.2.29A show the location of these points. The numerical values of the integrated normalized air concentrations and normalized cumulative depositions are presented in Tables 4.1.2.1A and 4.1.2.2A. Table 4.1.2.3A presents normalized air concentrations approximating the peak 10-minute exposure period at selected points in the affected area north of the Robert S. Kerr Reservoir.

4.1.2.2 Meteorology

Meteorological conditions in the vicinity of the site at the time of the accident, with strong, gusty winds generally from the north-northwest and clear skies, reflected the passage of a cold front through the area approximately 6 hours earlier. At the time of the accident, onsite meteorological measurements indicated winds flowing from the north-northwest (resulting in transport to the south-southeast) at about 18 mph with gusts up to about 30 mph. Because of the relatively high wind speeds and somewhat unsteady wind direction, atmospheric stability was considered to be neutral (Pasquill type "D"), which is typical of post-cold-front situations. This is also supported by analysis of the temperature structure in the planetary boundary layer from the nearest atmospheric sounding station at Monett, Missouri. Temperatures in the area were in the upper 40's (°F) and relative humidity was approximately 40 percent.

There is no official National Weather Service station in the immediate plant vicinity. The nearest station having similar topographic and climatological characteristics as the plant site is at Fort Smith, Arkansas, approximately 70 km (40 miles) east-southeast. The Sequoyah Fuels Corporation (SFC) maintains continuously recording wind speed and direction instrumentation at the plant. Although the onsite meteorological measurement system is located atop a sign on the roof of the process building and would likely be affected by airflow over the building and sign, the measurements at the time of the accident are consistent with the synoptic weather pattern and other measurements and observations in the region and, therefore, have been used for the assessments of atmospheric transport, diffusion, and deposition.

The general transport direction away from the site was south-southeast, which is consistent with site and regional meteorological information. Near the facility, plume transport probably was influenced by the presence of buildings and initial release characteristics such as buoyancy and other release energetics.

Figure 4.1.2.30A is the surface weather map for Oklahoma and adjacent regions for 12:00 noon (18Z), Saturday, January 4, 1986, (from the U.S. Department of Commerce, NOAA/NWS/NMC Washington). It shows, among other things, the wind direction in east-central Oklahoma, and the cold front which by then had moved out of Oklahoma. Figure 4.1.2.31A is the 850 millibar weather map of the area at 6:00 a.m. (12Z), Saturday, January 4, 1986.

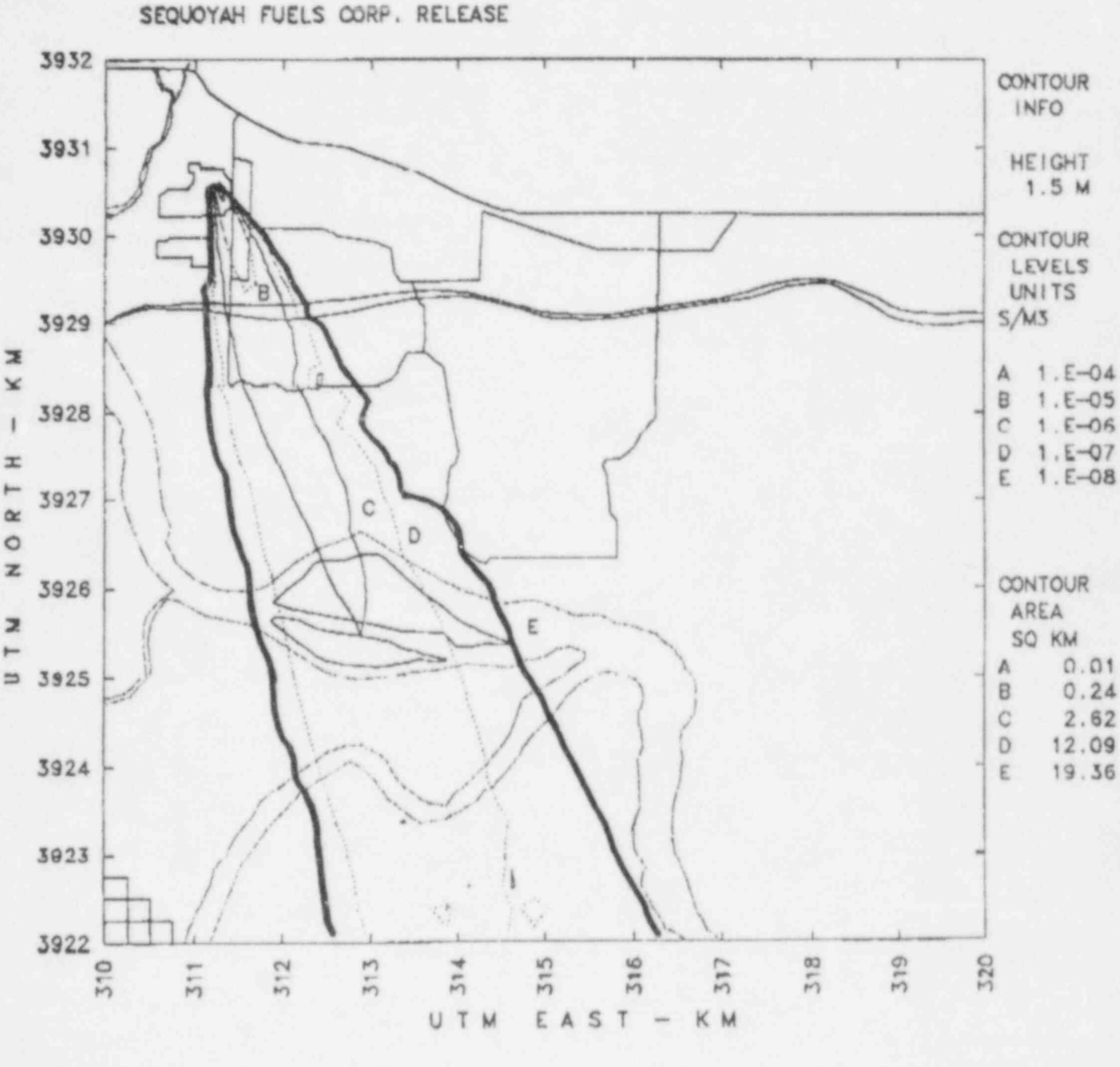


Figure 4.1.2.1A Integrated normalized air concentration of UO_2F_2

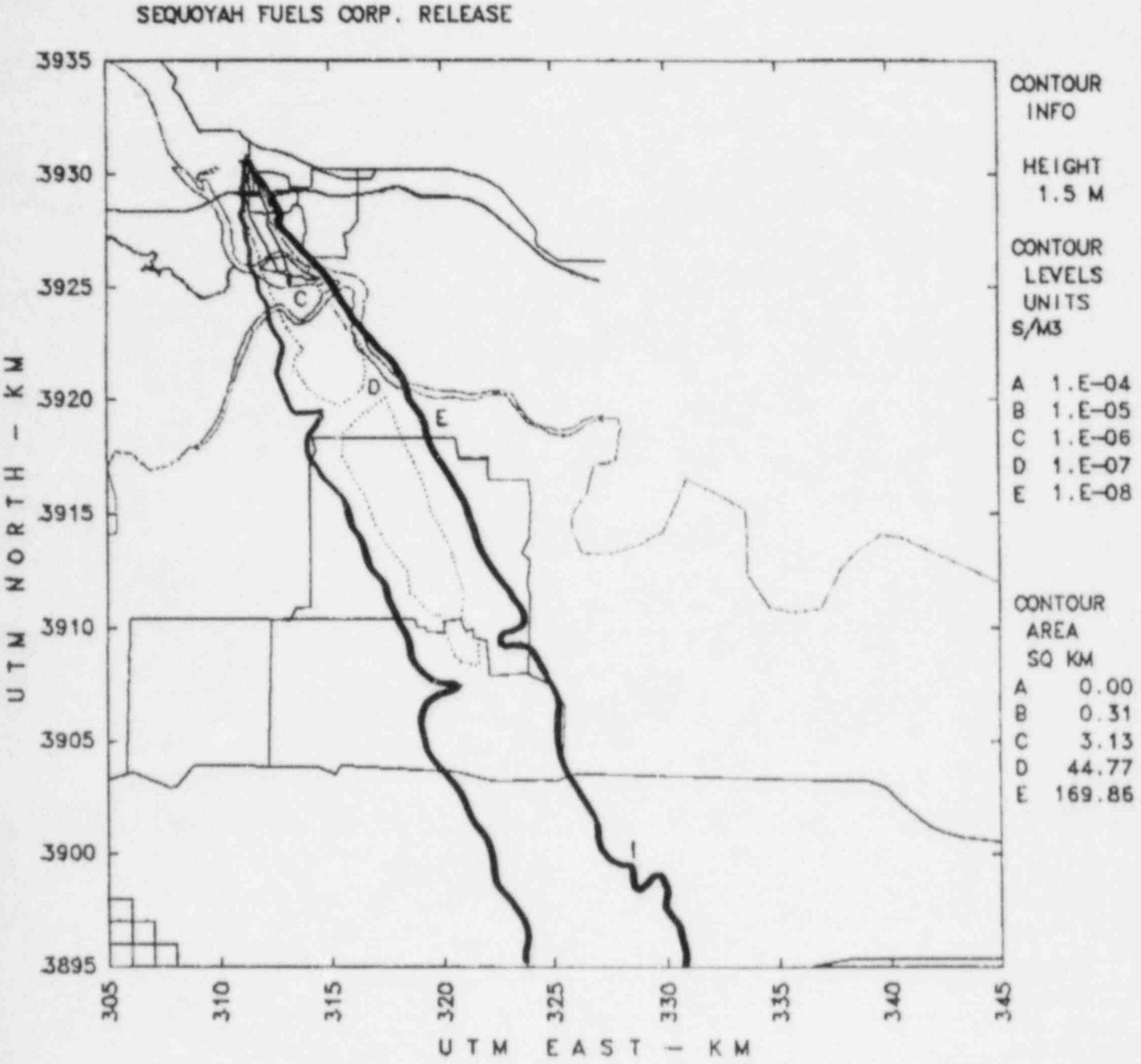


Figure 4.1.2.2A Integrated normalized air concentration of UO_2F_2

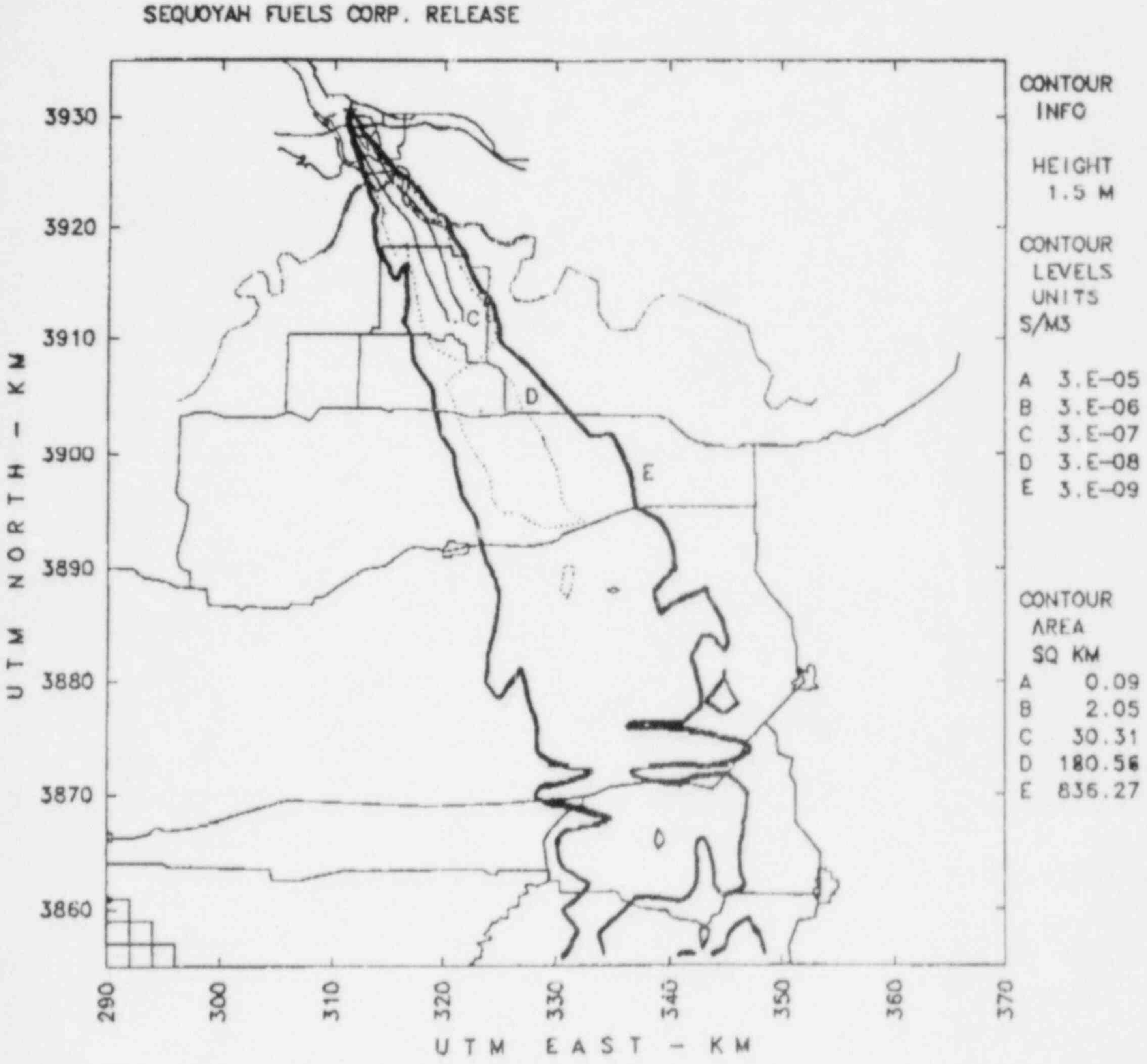


Figure 4.1.2.3A Integrated normalized air concentration of UO_2F_2

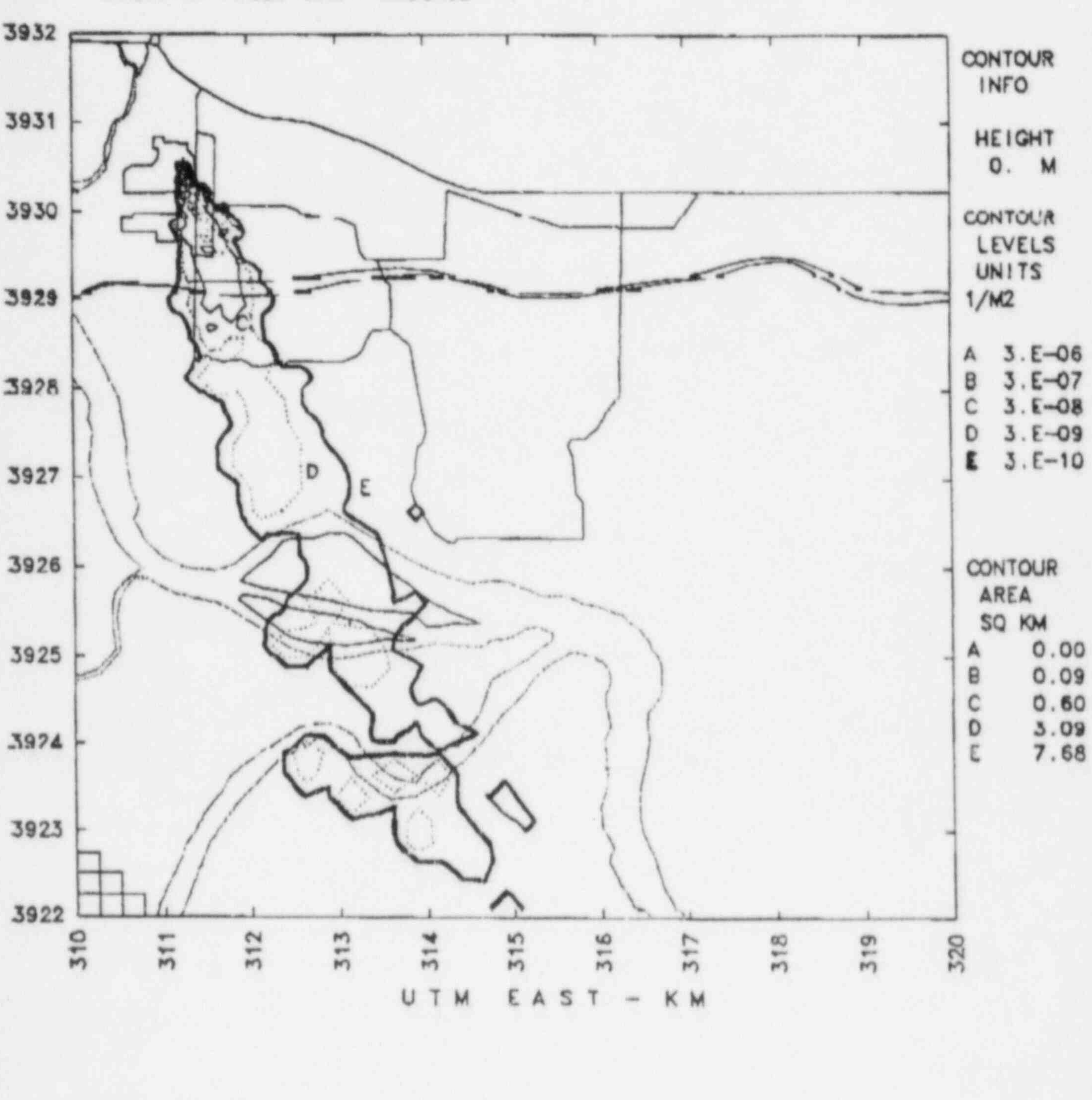


Figure 4.1.2.4A Normalized cumulative deposition of UO_2F_2

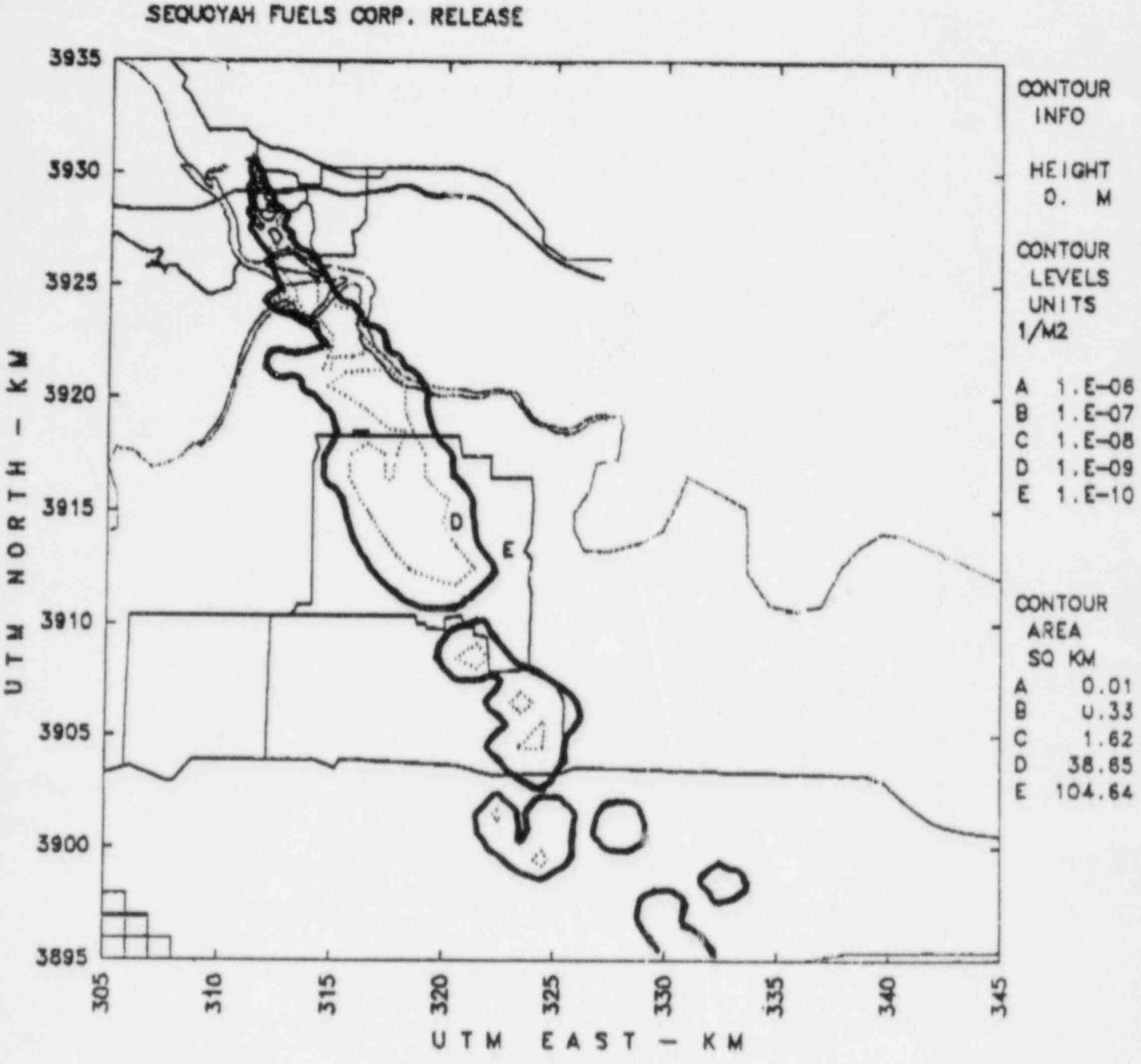


Figure 4.1.2.5A Normalized cumulative deposition of UO_2F_2

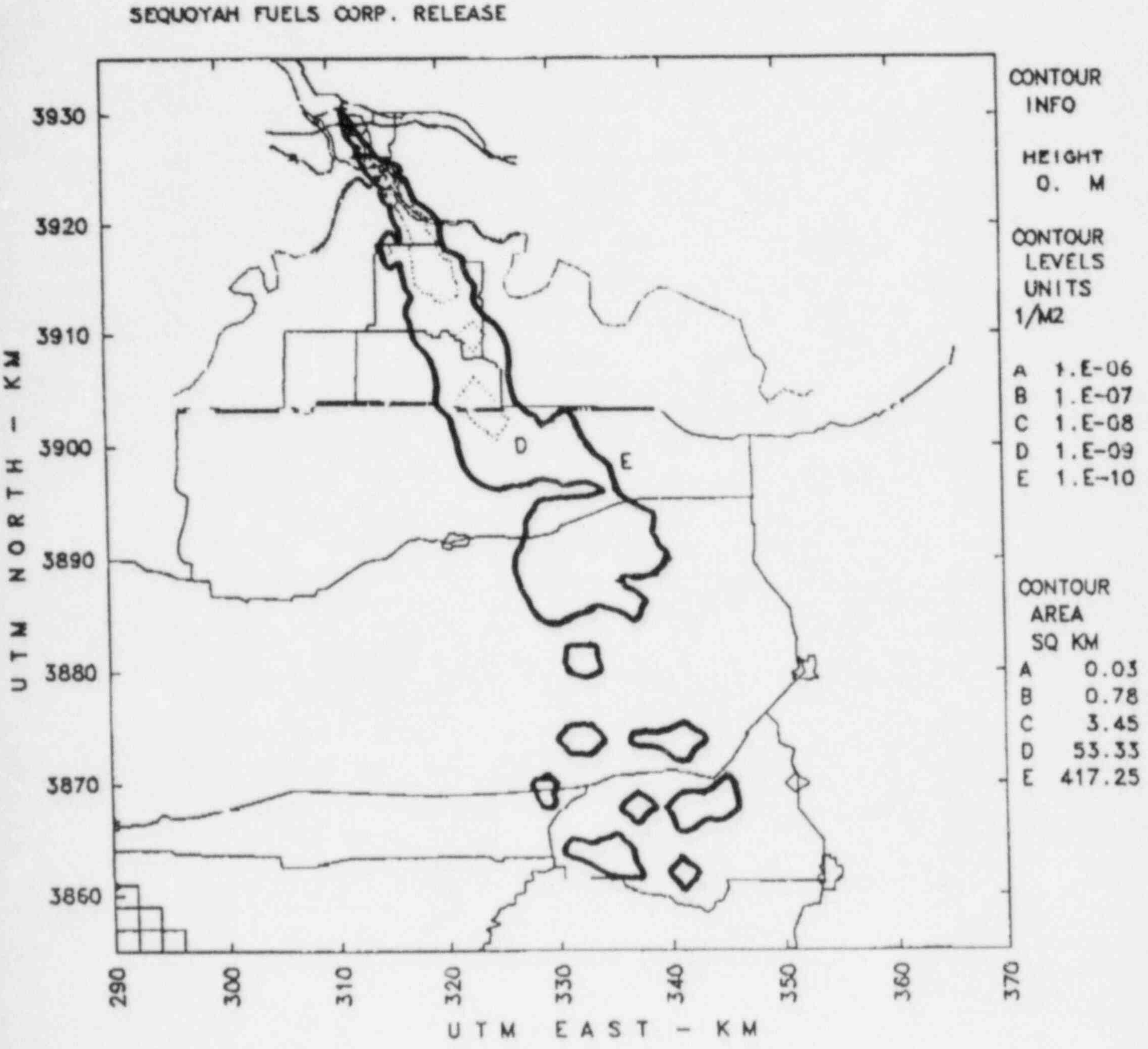


Figure 4.1.2.6A Normalized cumulative deposition of UO_2F_2

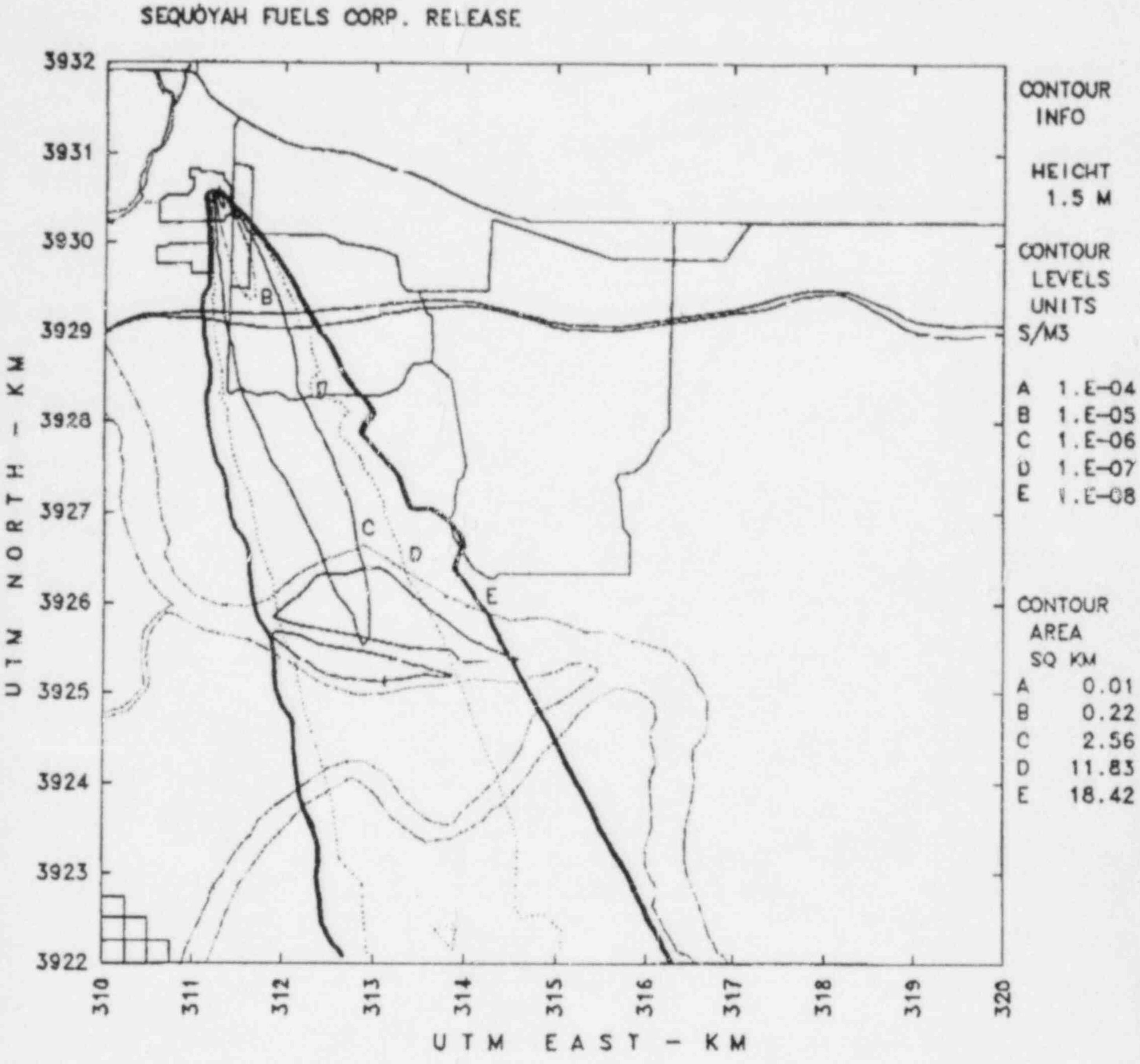


Figure 4.1.2.7A Integrated normalized air concentration of HF

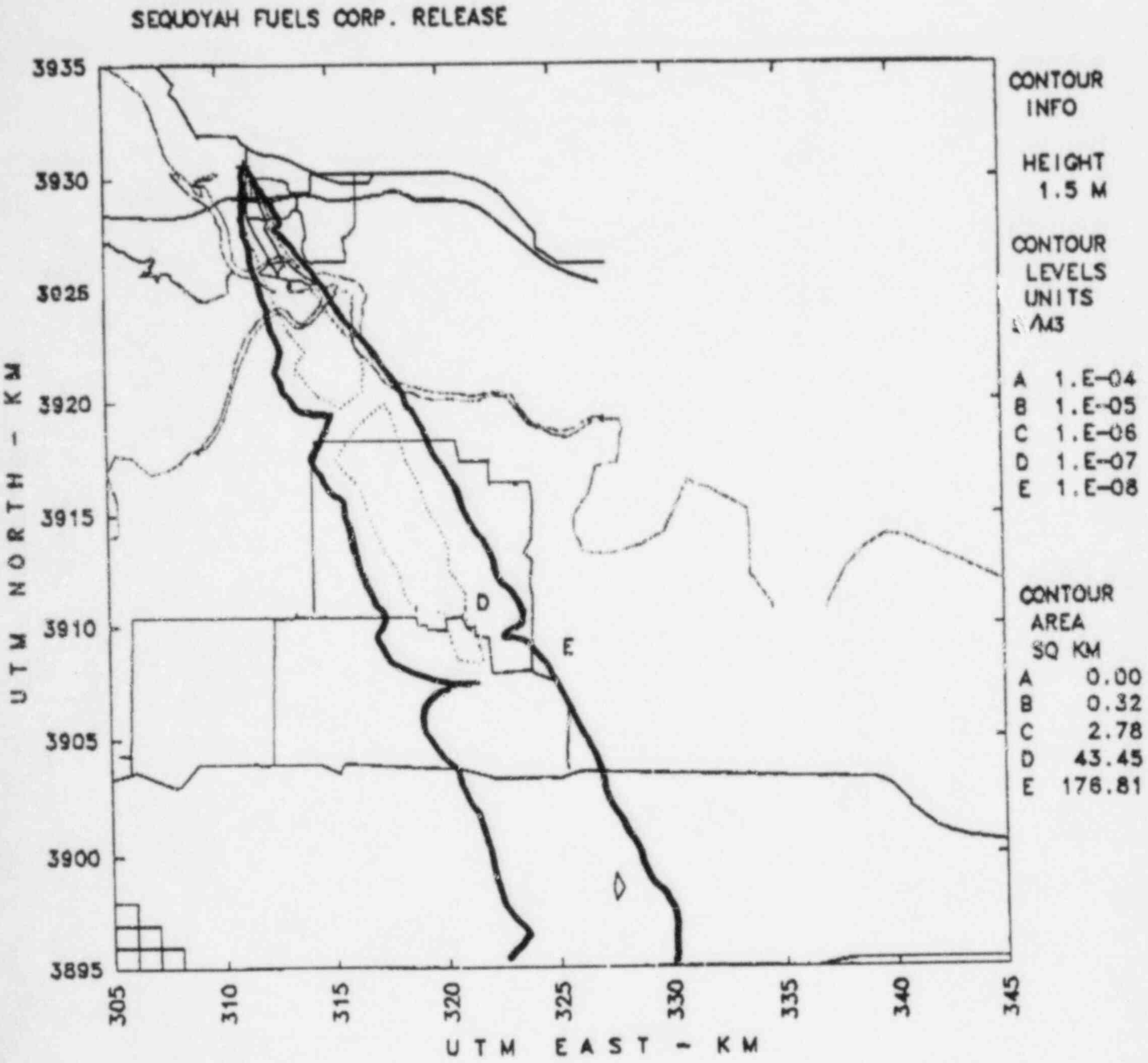


Figure 4.1.2.8A Integrated normalized air concentration of HF

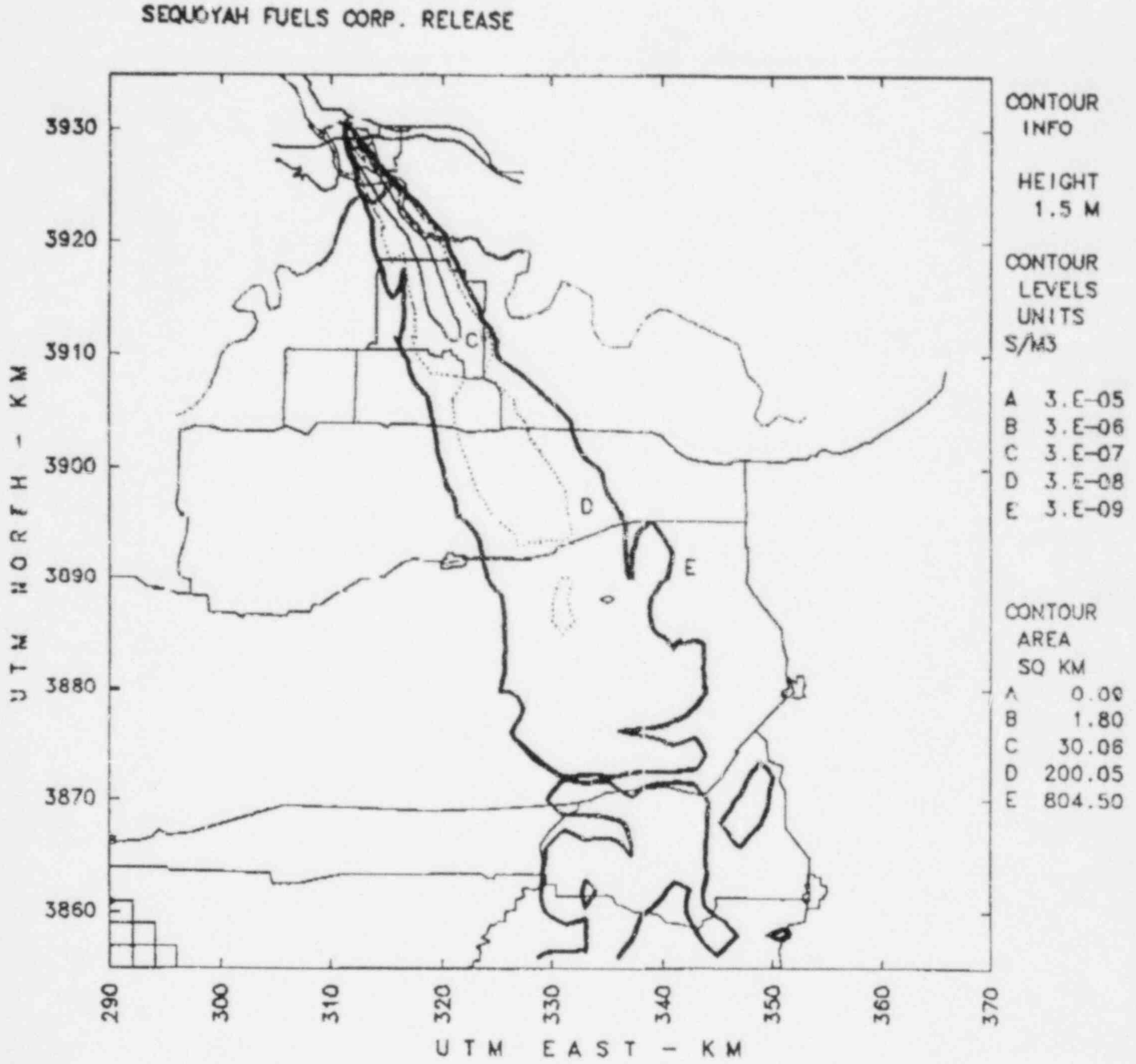


Figure 4.1.2.9A Integrated normalized air concentration of HF

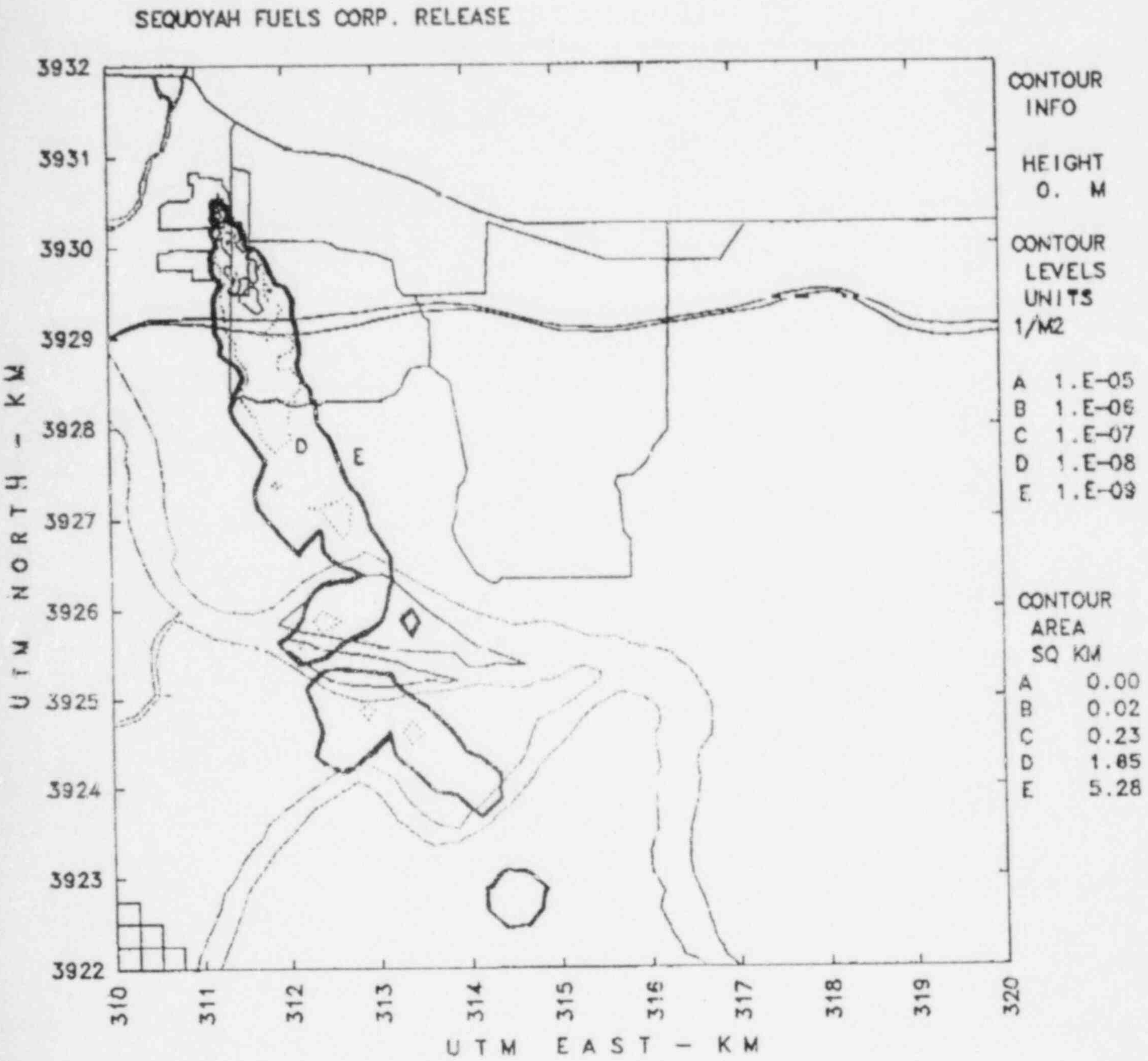


Figure 4.1.2.10A Normalized cumulative deposition of HF

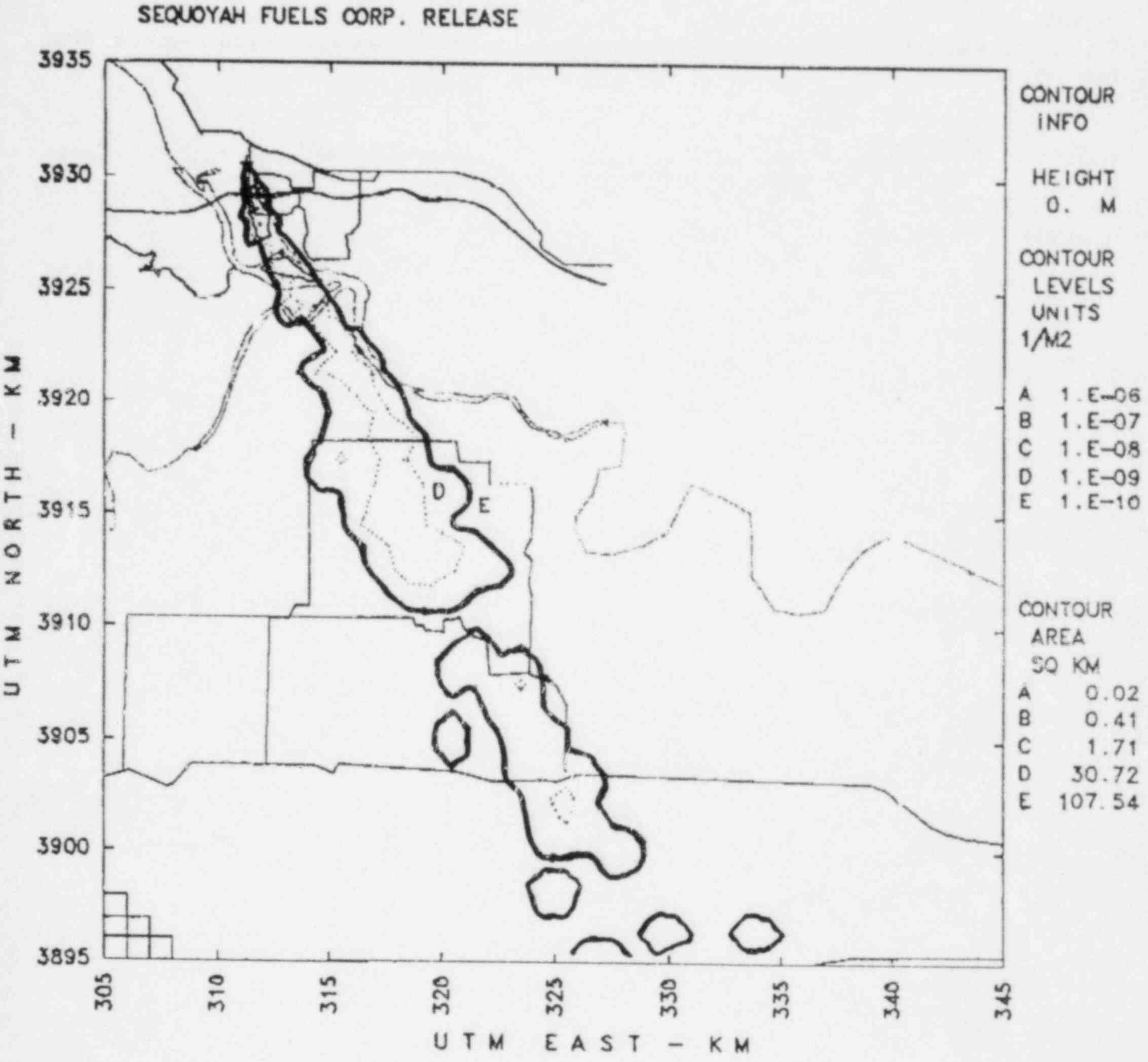


Figure 4.1.2.11A Normalized cumulative deposition of HF

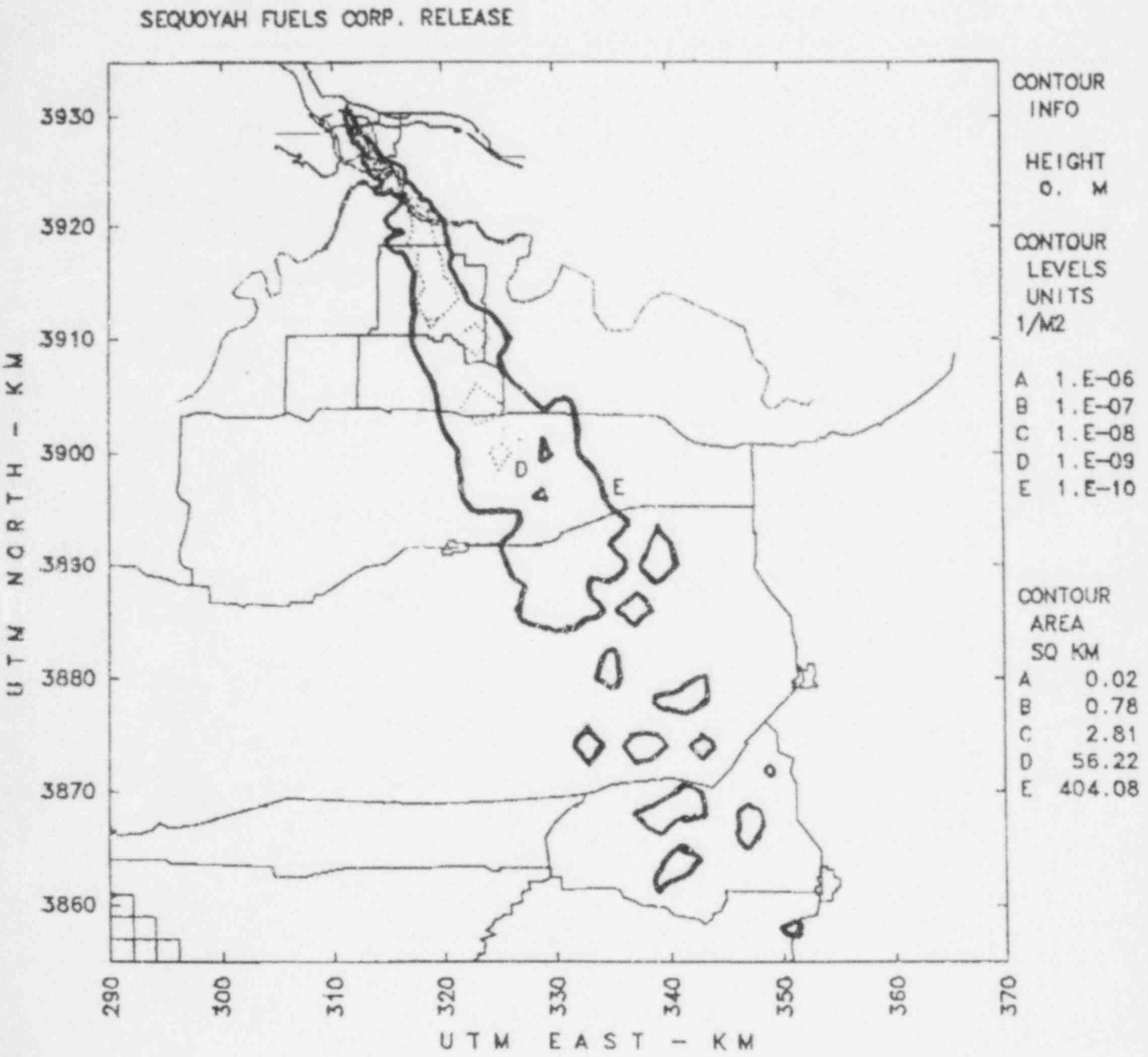


Figure 4.1.2.12A Normalized cumulative deposition of HF

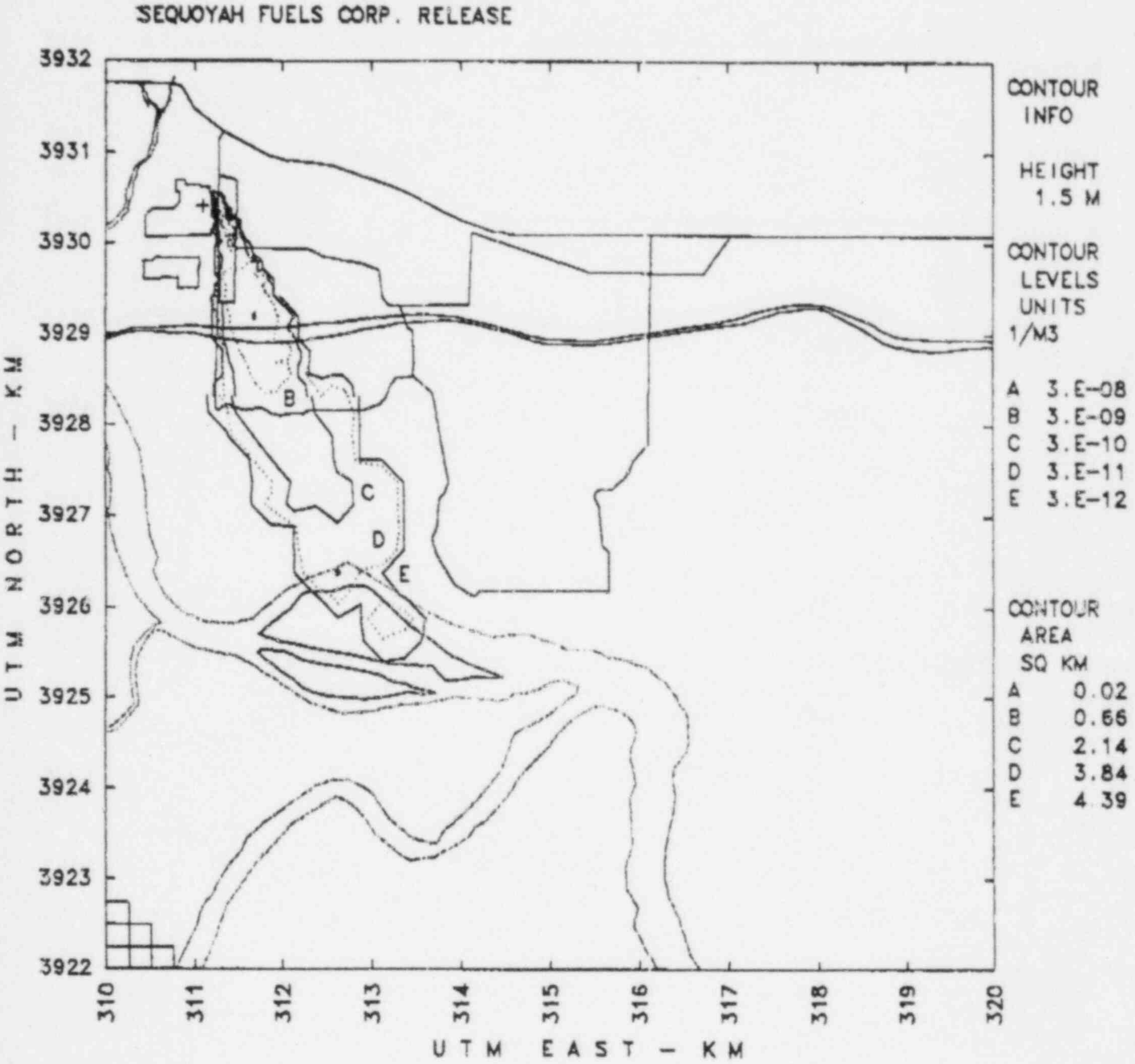


Figure 4.1.2.13A Instantaneous normalized air concentration of HF 10 minutes after cylinder rupture

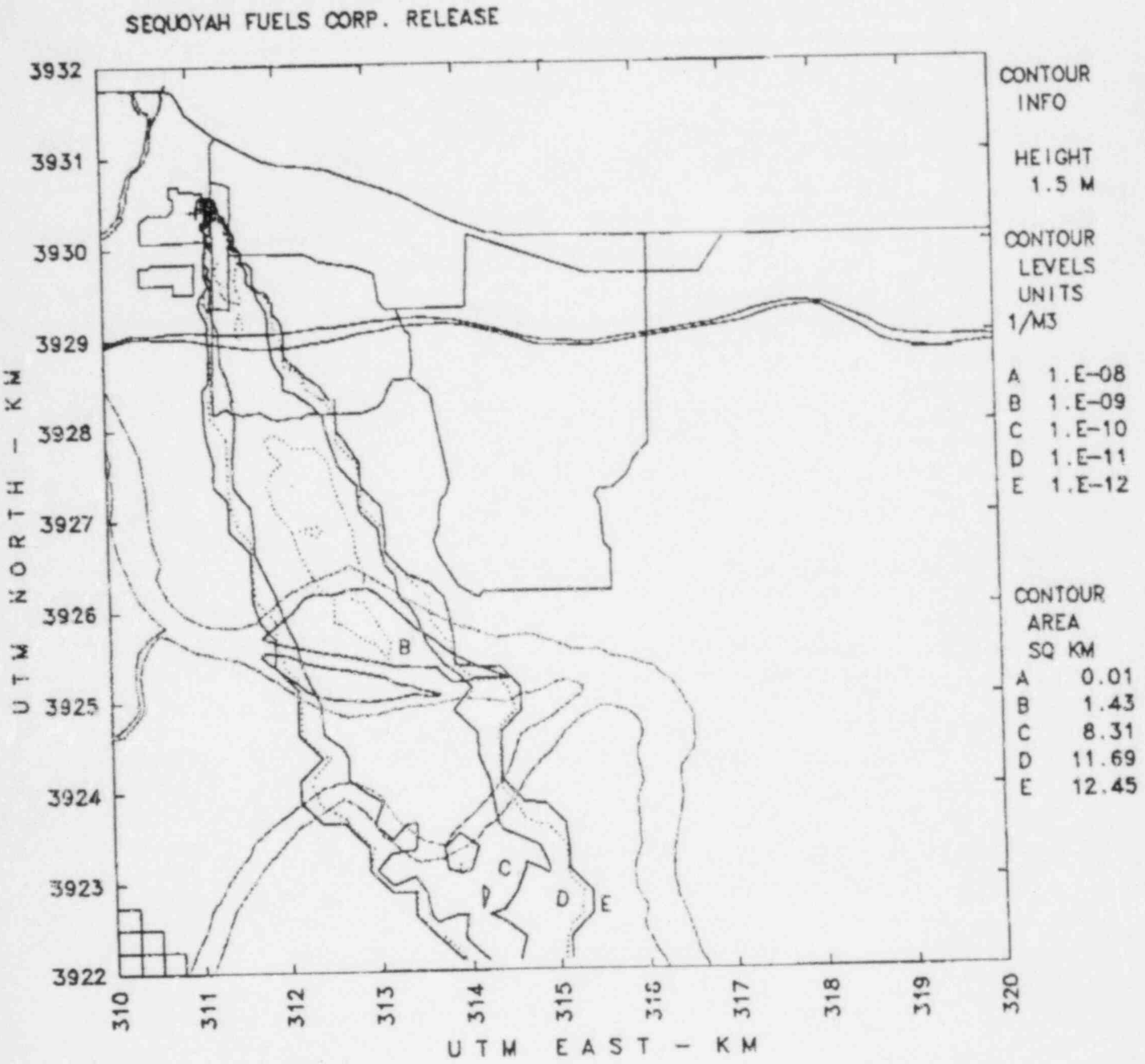


Figure 4.1.2.14A Instantaneous normalized air concentration of HF 20 minutes after cylinder rupture

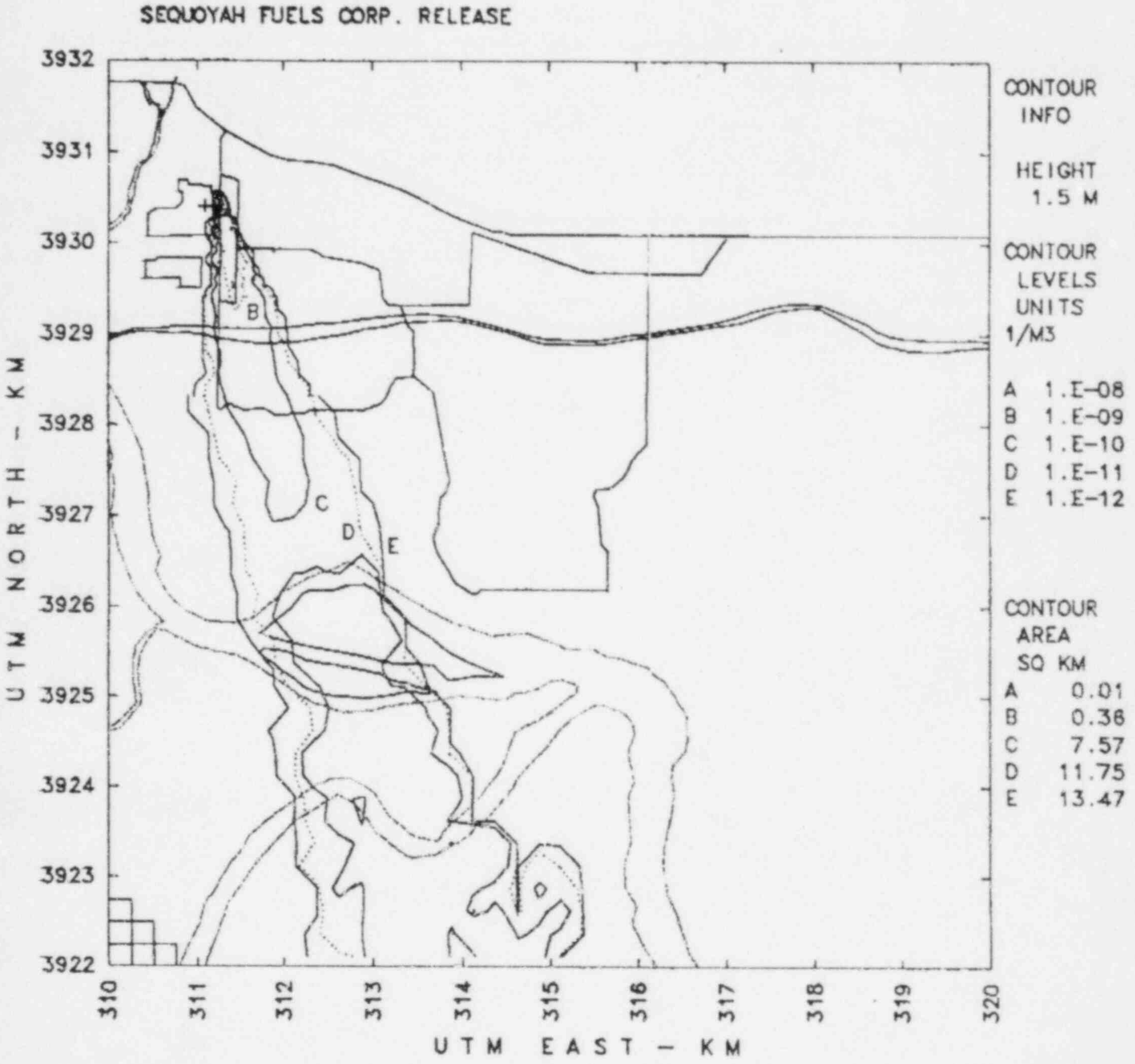


Figure 4.1.2.15A Instantaneous normalized air concentration of HF 30 minutes after cylinder rupture

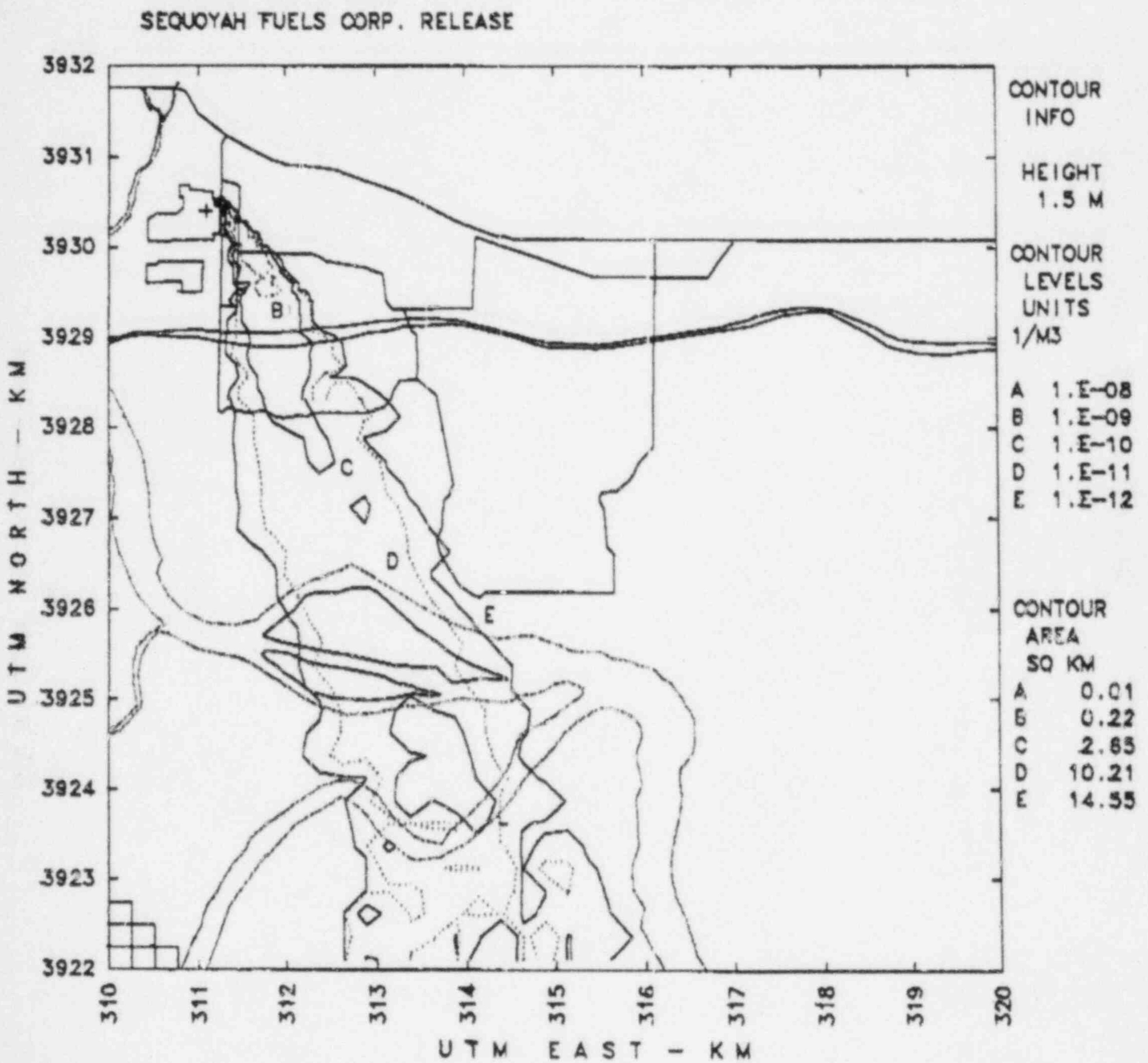


Figure 4.1.2.16A Instantaneous normalized air concentration of HF 40 minutes after cylinder rupture

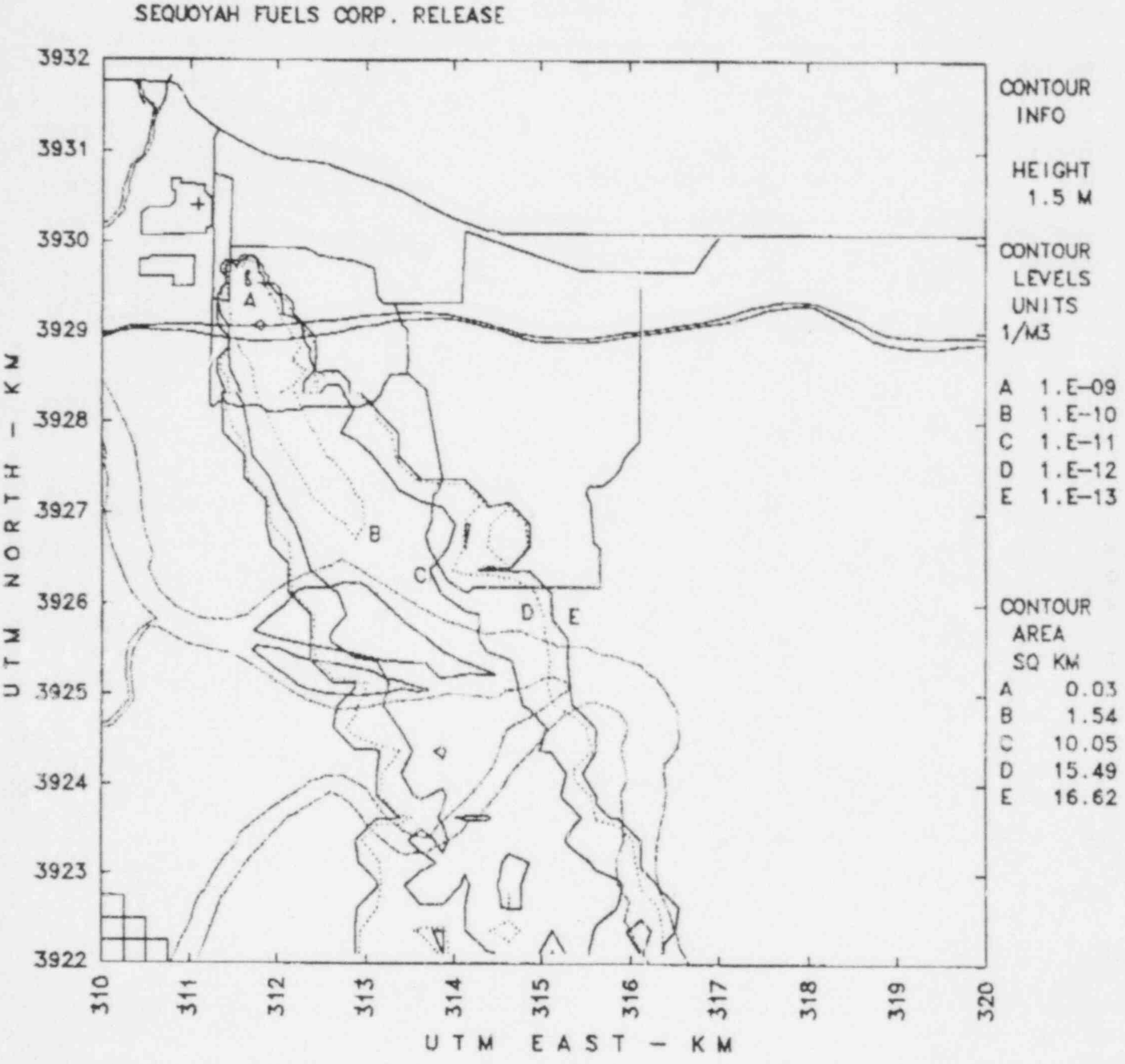


Figure 4.1.2.17A Instantaneous normalized air concentration of HF 50 minutes after cylinder rupture

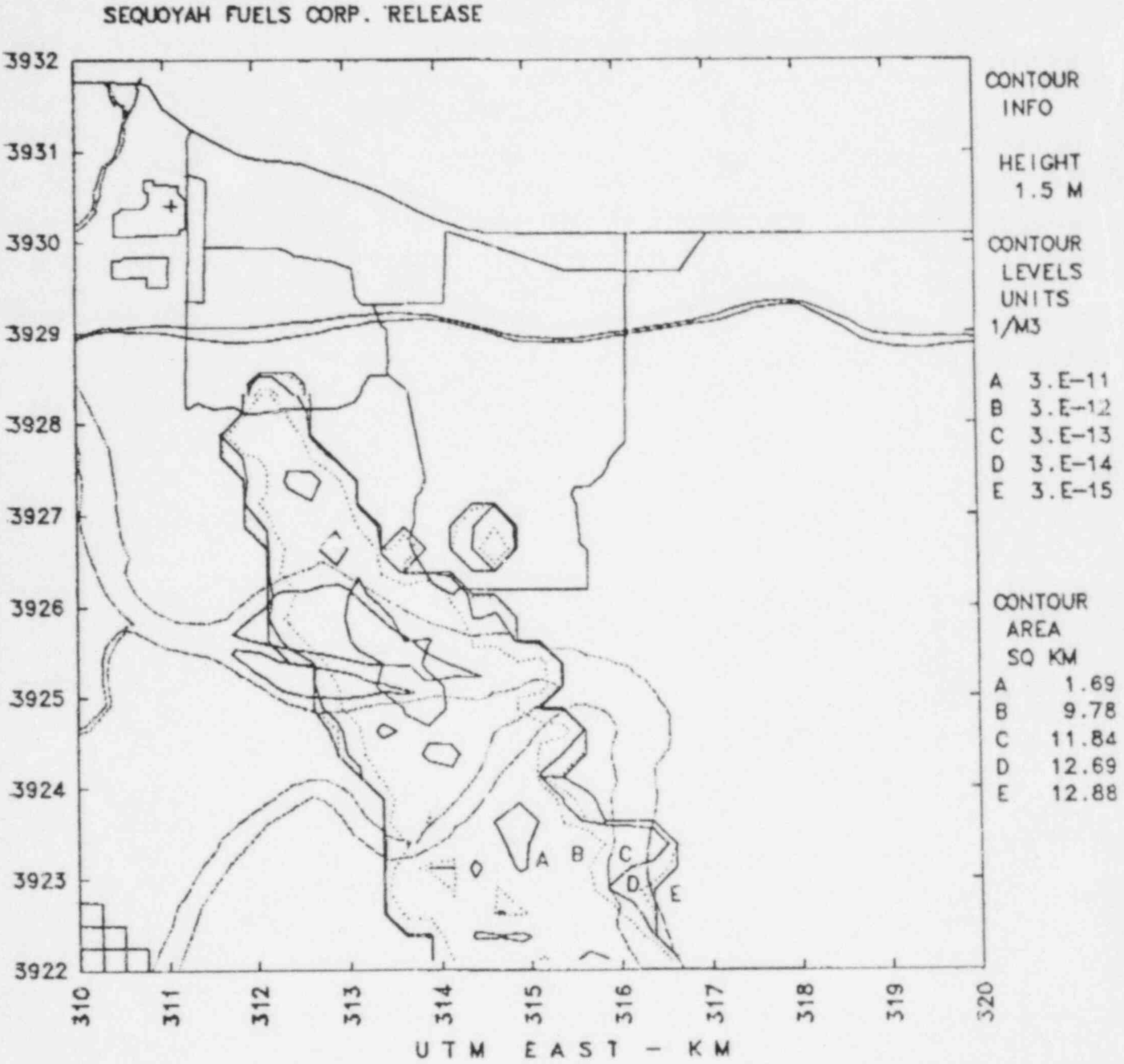


Figure 4.1.2.18A Instantaneous normalized air concentration of HF 60 minutes after cylinder rupture

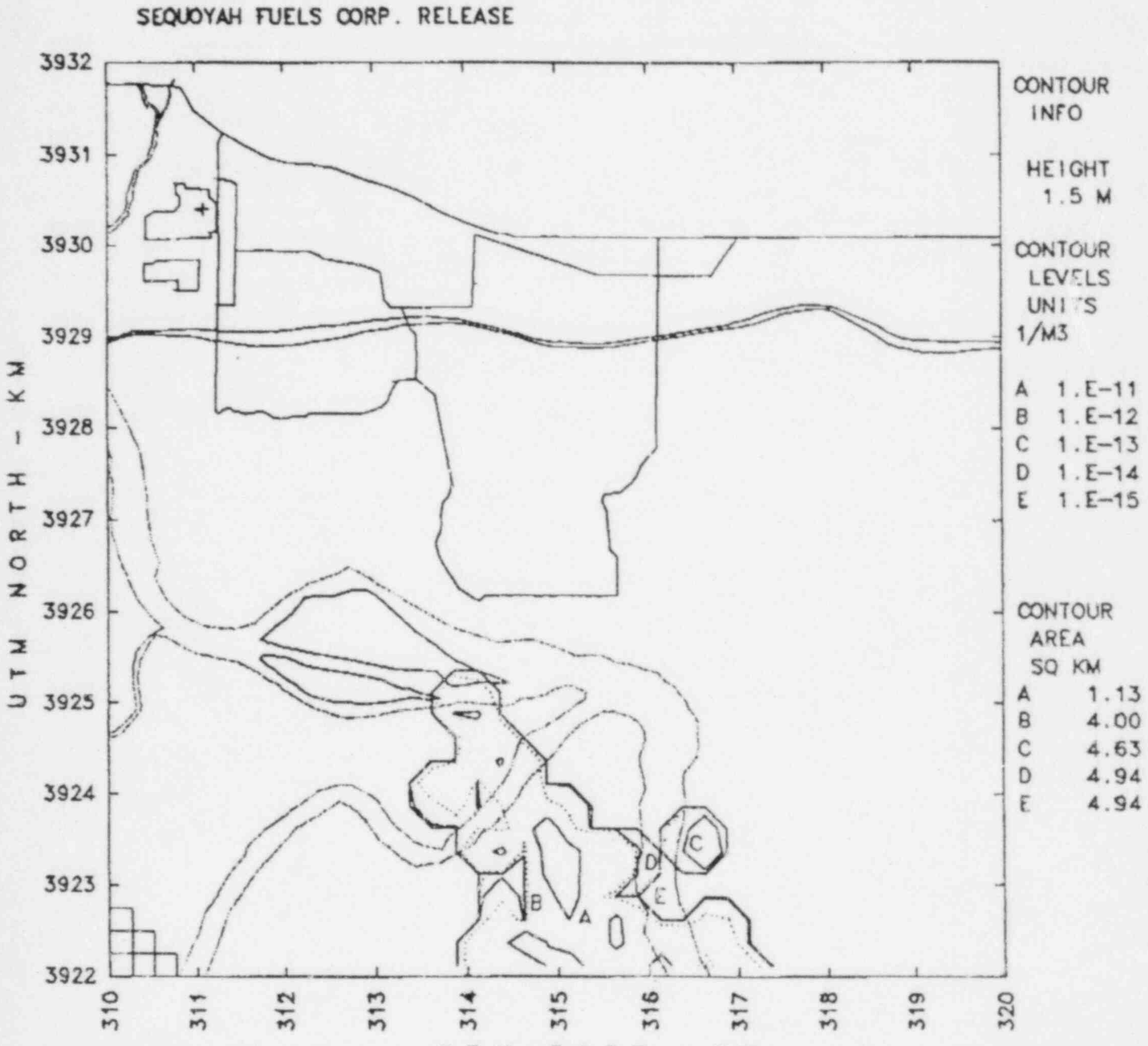


Figure 4.1.2.19A Instantaneous normalized air concentration of HF 70 minutes after cylinder rupture

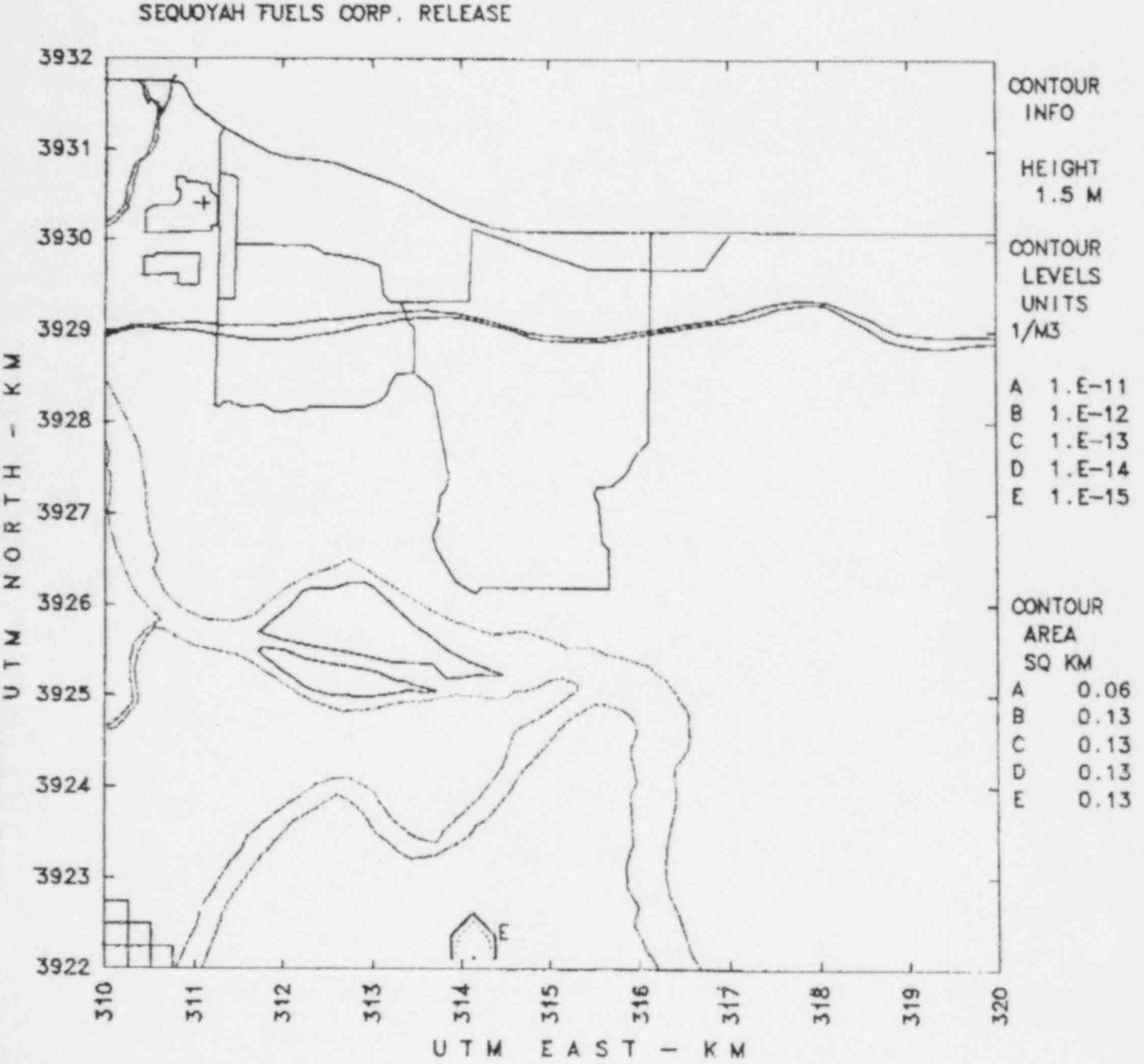


Figure 4.1.2.20A Instantaneous normalized air concentration of HF 80 minutes after cylinder rupture

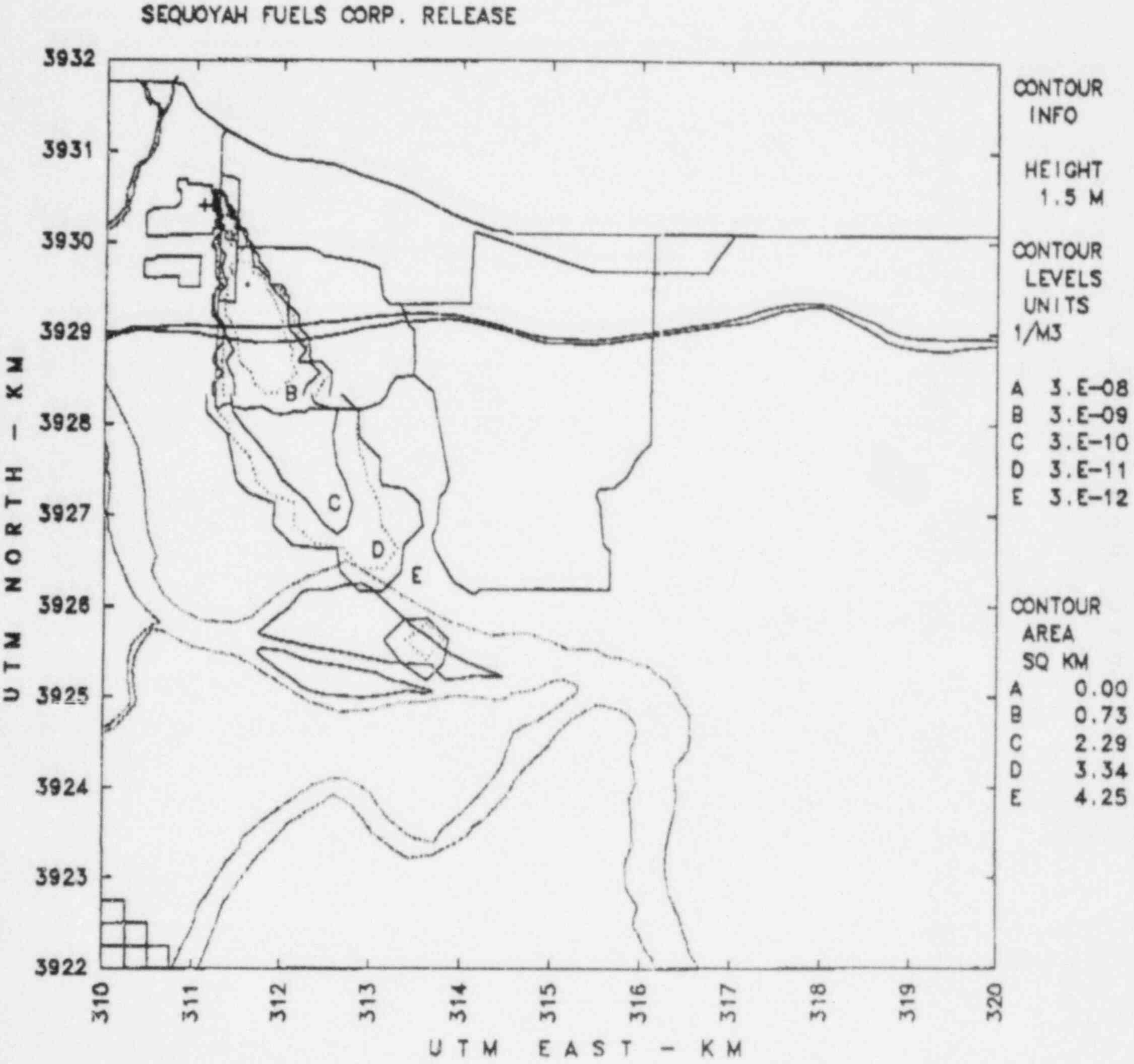


Figure 4.1.2.21A Instantaneous normalized air concentration of UO_2F_2 10 minutes after cylinder rupture

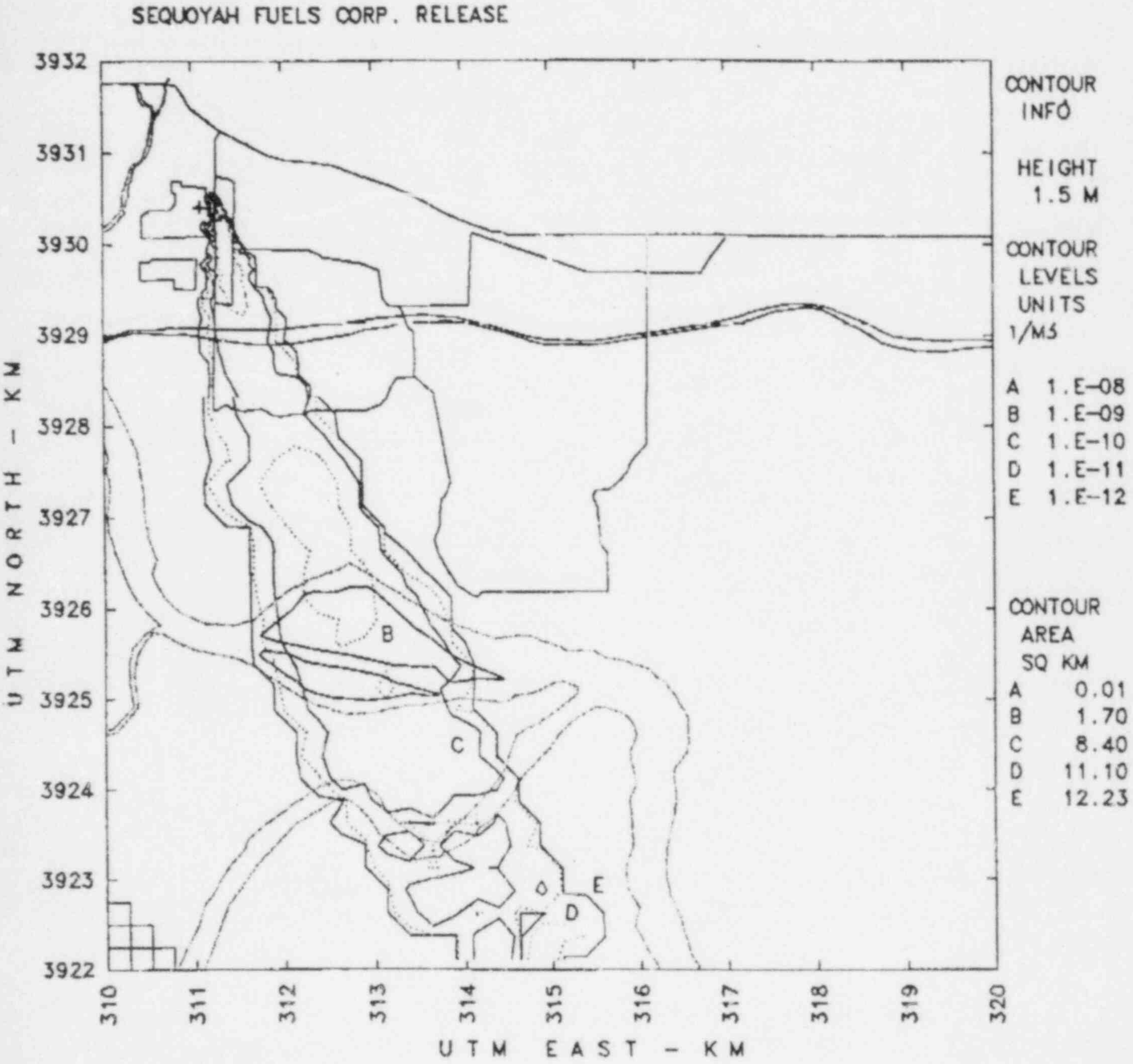


Figure 4.1.2.22A Instantaneous normalized air concentration of UO_2F_2 20 minutes after cylinder rupture

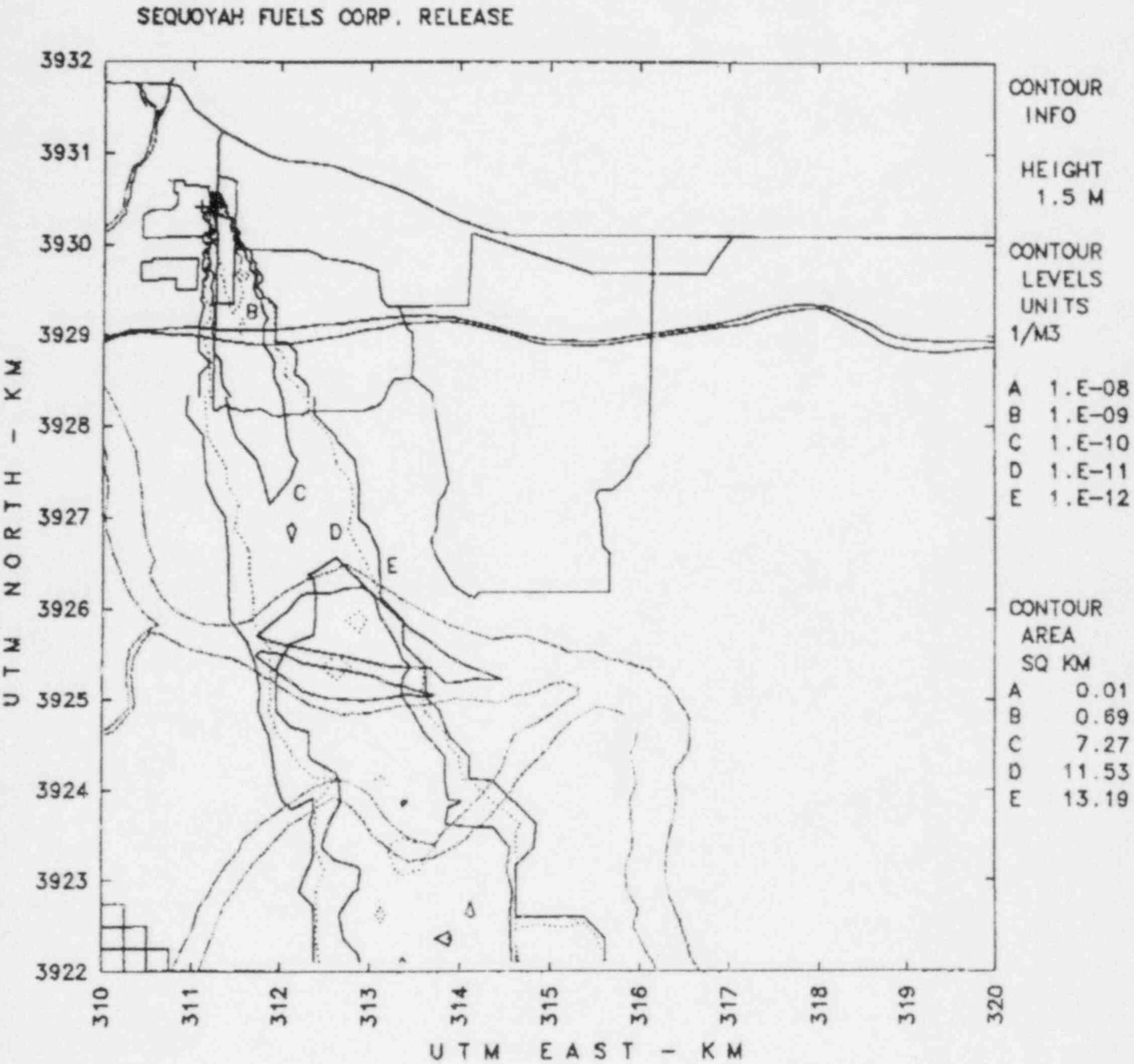


Figure 4.1.2.23A Instantaneous normalized air concentration of UO_2F_2 30 minutes after cylinder rupture

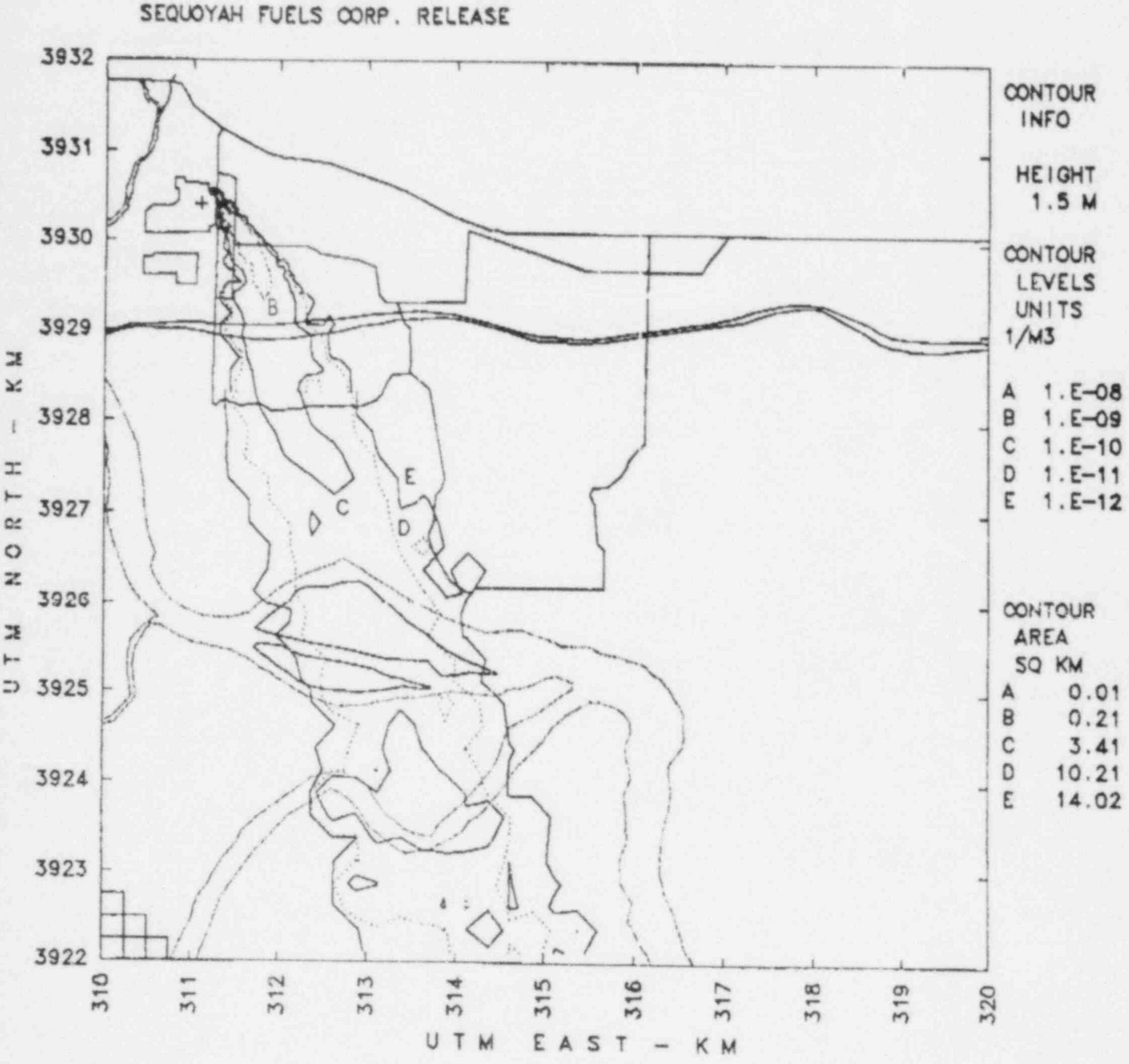


Figure 4.1.2.24A Instantaneous normalized air concentration of UO_2F_2 40 minutes after cylinder rupture

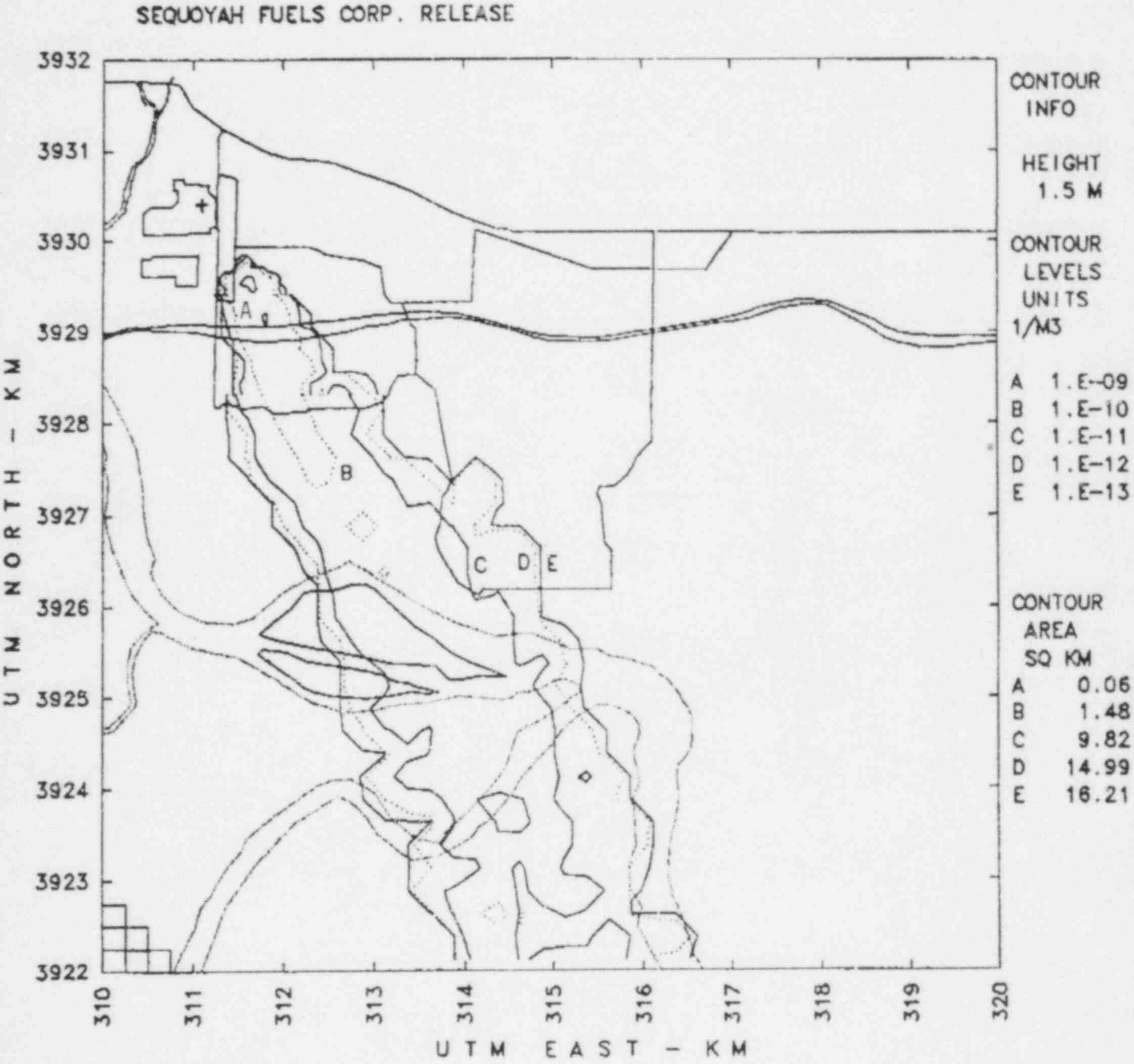


Figure 4.1.2.25A Instantaneous normalized air concentration of UO_2F_2 50 minutes after cylinder rupture

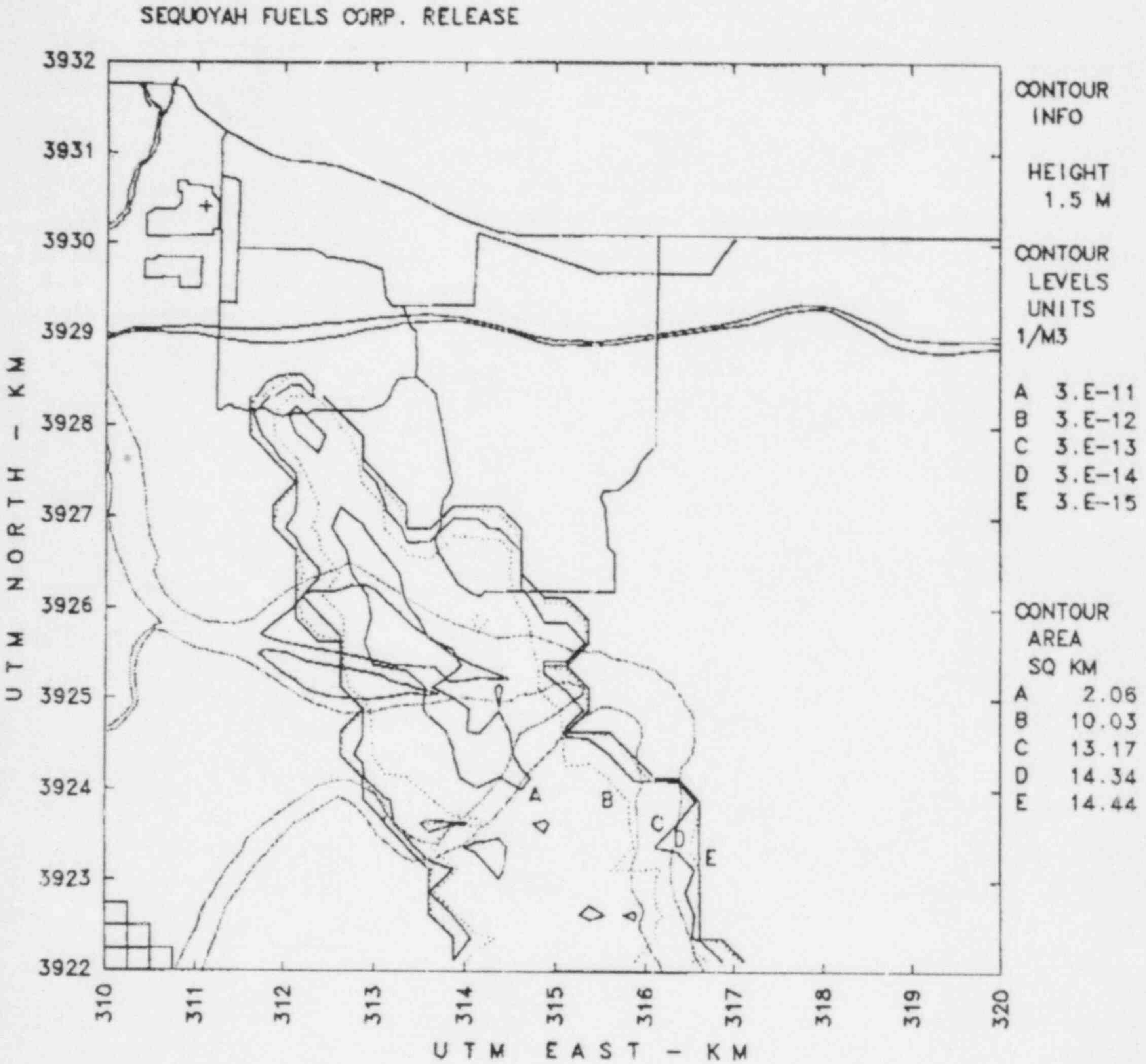


Figure 4.1.2.26A Instantaneous normalized air concentration of UO_2F_2 60 minutes after cylinder rupture

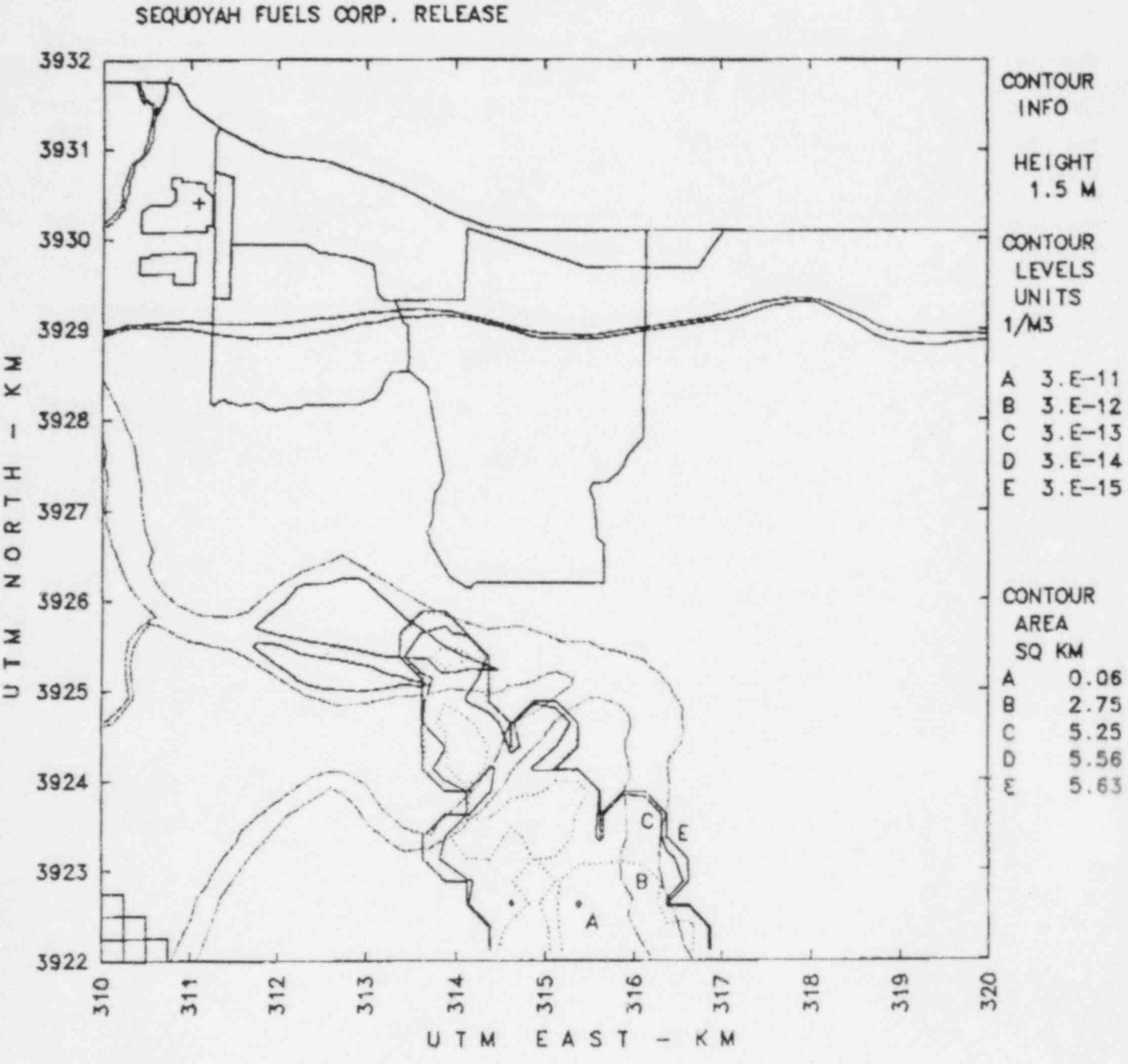


Figure 4.1.2.27A Instantaneous normalized air concentration of UO_2F_2 70 minutes after cylinder rupture

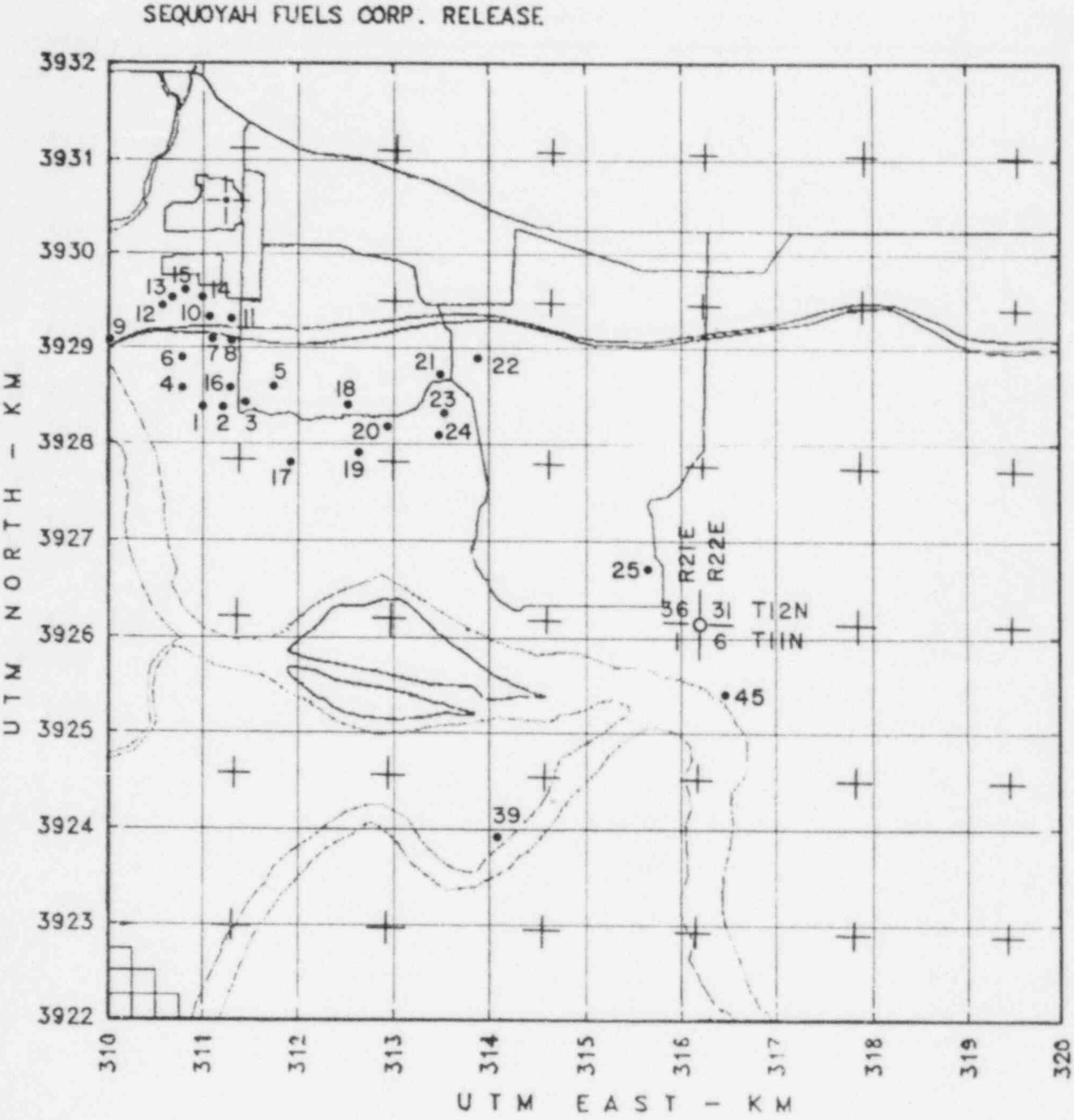


Figure 4.1.2.28A Locations, to 8 km downwind, of points for which numerical concentrations were calculated

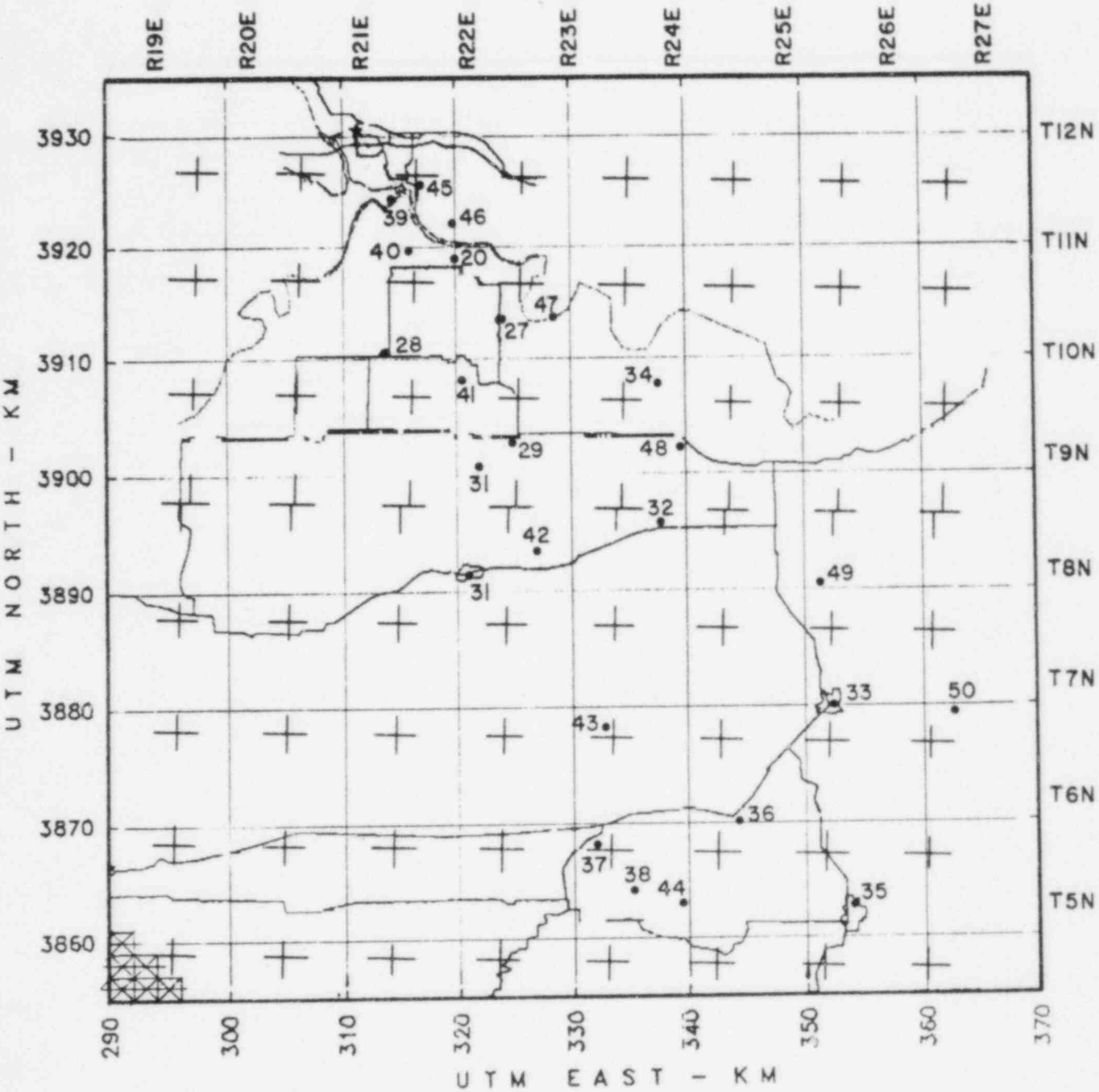


Figure 4.1.2.29A Locations, to 72 km downwind, of points for which numerical concentrations were calculated

Table 4.1.2.1A Integrated normalized air concentration and deposition

The numerical values below represent normalized cumulative ground depositions and integrated normalized air concentration values. A 10 km by 10 km calculational grid was used. Seventy-five percent of the material was assumed to be released in the first 5 minutes with the rest being released in the following 40 minutes. Measures of wind values from the Sequoyah Fuels Plant were used which showed a 335 degree initial wind direction. The release point location is UTME - 311.25, UTMN - 3930.54.

Location				HF		UO_2F_2	
Label		UTMN (km)	UTME (km)	Int. Norm. (s/m³)	Norm. Cum. (1/m²)	Int. Norm. (s/m³)	Norm. Cum. (1/m²)
1*	16	3928.4	311.0	0.0	0.0	0.0	0.0
2	17	3928.4	311.2	3.486E-9	0.0	2.410E-9	0.0
3	18	3928.4	311.4	9.386E-8	2.61E-10	1.017E-7	1.43E-10
4	19	3928.6	310.8	0.0	0.0	0.0	0.0
5	20	3928.6	311.7	2.725E-6	2.584E-8	2.704E-6	7.493E-9
6	21	3928.9	310.0	0.0	0.0	0.0	0.0
7	22	3929.1	311.1	0.0	0.0	0.0	0.0
8	23	3929.1	311.3	1.310E-7	2.021E-9	1.388E-7	1.600E-9
9	24	3929.1	310.0	0.0	0.0	0.0	0.0
10	25	3929.3	311.1	0.0	0.0	0.0	0.0
11	26	3929.3	311.3	2.225E-7	3.258E-9	2.236E-7	1.483E-9
12	27	3929.4	310.6	0.0	0.0	0.0	0.0
13	28	3929.5	310.7	0.0	0.0	0.0	0.0
14	29	3929.5	311.0	0.0	0.0	0.0	0.0
15	30	3929.6	310.8	0.0	0.0	0.0	0.0
16	P1	3928.6	311.3	4.247E-8	0.0	4.341E-8	0.0
17	P6	3927.8	311.9	8.534E-7	3.284E-9	8.597E-7	2.982E-10
18	P7	3928.4	312.5	1.146E-7	1.854E-10	1.144E-7	2.345E-10
19	P8	3927.9	312.6	9.937E-7	2.117E-9	9.112E-7	2.258E-9
20	P9	3928.2	312.9	5.492E-8	1.115E-12	7.418E-8	1.705E-10
21	P11	3928.7	313.5	0.0	0.0	0.0	0.0
22	P12	3928.9	313.8	0.0	0.0	0.0	0.0
23	P13	3928.3	313.5	2.893E-12	0.0	1.289E-11	0.0
24	P14	3928.1	313.4	2.894E-10	0.0	3.047E-10	0.0
25	P19	3926.7	315.6	0.0	0.0	0.0	0.0

*The locations in this column are shown in Figs. 4.1.2.28A and 4.1.2.29A.

Table 4.1.2.2A Integrated normalized air concentration and deposition

The numerical values represent normalized cumulative ground depositions and integrated normalized air concentration values. An 80 by 80 km grid was used. Seventy-five percent of the material was assumed to be released in the first 5 minutes with the rest being released in the following 40 minutes. Measures of wind values from the Sequoyah Fuels Plant were used which showed a 335 degree initial wind direction.

Location				HF		UO_2F_2	
Label		UTMN (km)	UTME (km)	Int. Norm. (s/m^3)	Norm. Cum. ($1/m^2$)	Int. Norm. (s/m^3)	Norm. Cum. ($1/m^2$)
26*	TA	3918.6	320.0	2.432E-7	1.297E-9	2.614E-7	2.093E-9
27	RH	3913.0	323.8	1.548E-7	4.795E-10	1.739E-7	5.165E-10
28	GA	3910.3	313.5	0.0	0.0	0.0	0.0
29	KE	3903.0	325.0	1.124E-7	1.032E-9	1.021E-7	1.114E-9
30	MC	3891.3	320.8	0.0	0.0	8.125E-13	0.0
31	IR	3901.0	322.1	4.485E-9	3.100E-11	8.220E-9	1.024E-10
32	BO	3895.3	337.3	3.760E-9	1.293E-10	3.785E-9	3.219E-11
33	PO	3880.0	352.3	2.380E-10	3.219E-13	1.230E-10	0.0
34	CO	3908.3	337.5	4.772E-13	0.0	3.218E-12	0.0
35	HE	3863.0	354.0	7.440E-10	0.0	1.277E-9	1.130E-11
36	WI	3870.0	344.0	1.376E-9	1.907E-12	3.665E-9	2.708E-12
37	FA	3868.0	332.0	9.963E-10	1.470E-13	3.680E-9	5.321E-11
38	SU	3864.4	335.0	4.343E-9	3.087E-12	1.226E-9	2.609E-11
39	S7	3923.9	314.1	1.671E-07	9.173E-11	2.012E-07	1.195E-10
40	S12	3919.3	315.9	6.112E-08	5.281E-10	7.530E-08	4.661E-10
41	S24	3908.2	320.5	2.070E-08	7.619E-11	2.203E-08	2.894E-10
42	S40	3893.4	326.7	2.019E-08	1.098E-10	1.734E-08	1.389E-10
43	S56	3878.5	332.9	4.990E-09	0.0	6.488E-09	8.836E-12
44	S72	3863.6	339.0	1.418E-09	1.022E-11	7.378E-10	2.807E-12
45	E7	3925.4	316.4	1.128E-09	7.025E-11	5.076E-10	1.648E-12
46	E12	3921.9	319.9	1.353E-08	1.067E-10	1.248E-08	9.529E-11
47	E24	3913.5	328.3	7.421E-12	0.0	7.129E-12	0.0
48	E40	3902.1	339.7	2.172E-11	2.378E-13	5.823E-11	9.133E-13
49	E56	3890.7	351.1	8.950E-11	0.0	3.723E-13	0.0
50	E72	3879.3	362.5	1.746E-11	0.0	8.602E-12	0.0

*The locations in this column are shown in Figs. 4.1.2.28A and 4.1.2.29A.

Table 4.1.2.3A Normalized peak air concentrations

Location	Normalized Air Concentration Approximating Peak 10-Minute Period ($1/m^3$)	
	UO_2F_2	HF
2	1.9×10^{-12}	5.3×10^{-12}
3	4.2×10^{-11}	5.4×10^{-11}
5	1.5×10^{-9}	1.6×10^{-9}
8	1.0×10^{-10}	1.3×10^{-10}
11	3.0×10^{-10}	1.4×10^{-10}
16	1.8×10^{-11}	4.3×10^{-11}
17	4.0×10^{-10}	4.9×10^{-10}
18	1.0×10^{-10}	1.1×10^{-10}
19	5.0×10^{-10}	7.0×10^{-10}
20	2.2×10^{-11}	2.6×10^{-11}
24	-----------	5.2×10^{-13}

Locations 2 through 11 are sampling points.

Locations 16, 17, 18, 19, 20 and 24 correspond respectively to residence locations 1, 6, 7, 8, 9 and 14 on Figure 4.1.3.1.

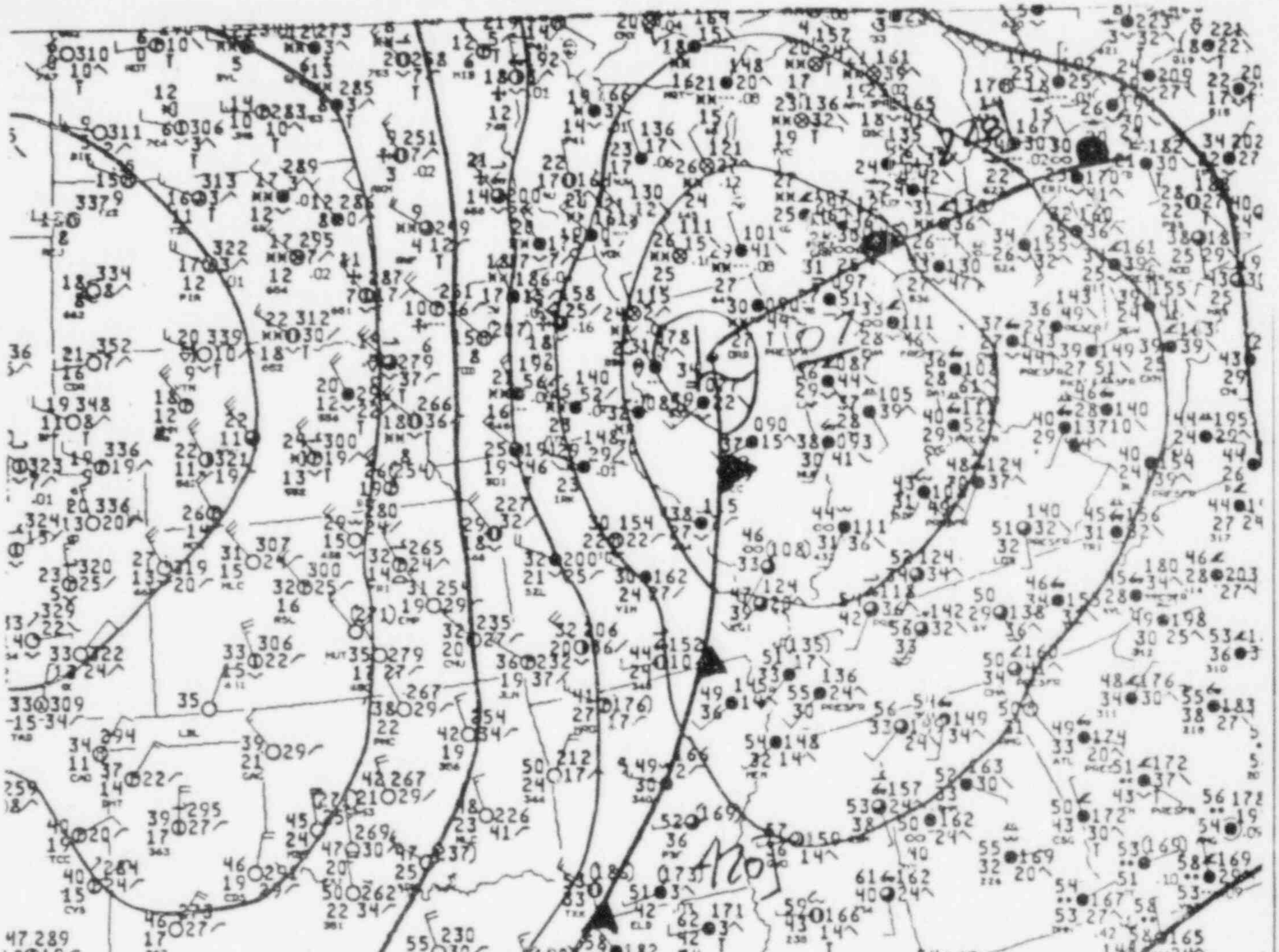


Figure 4.1.2.30A The Surface Weather Map at 12:00 noon January 4, 1986

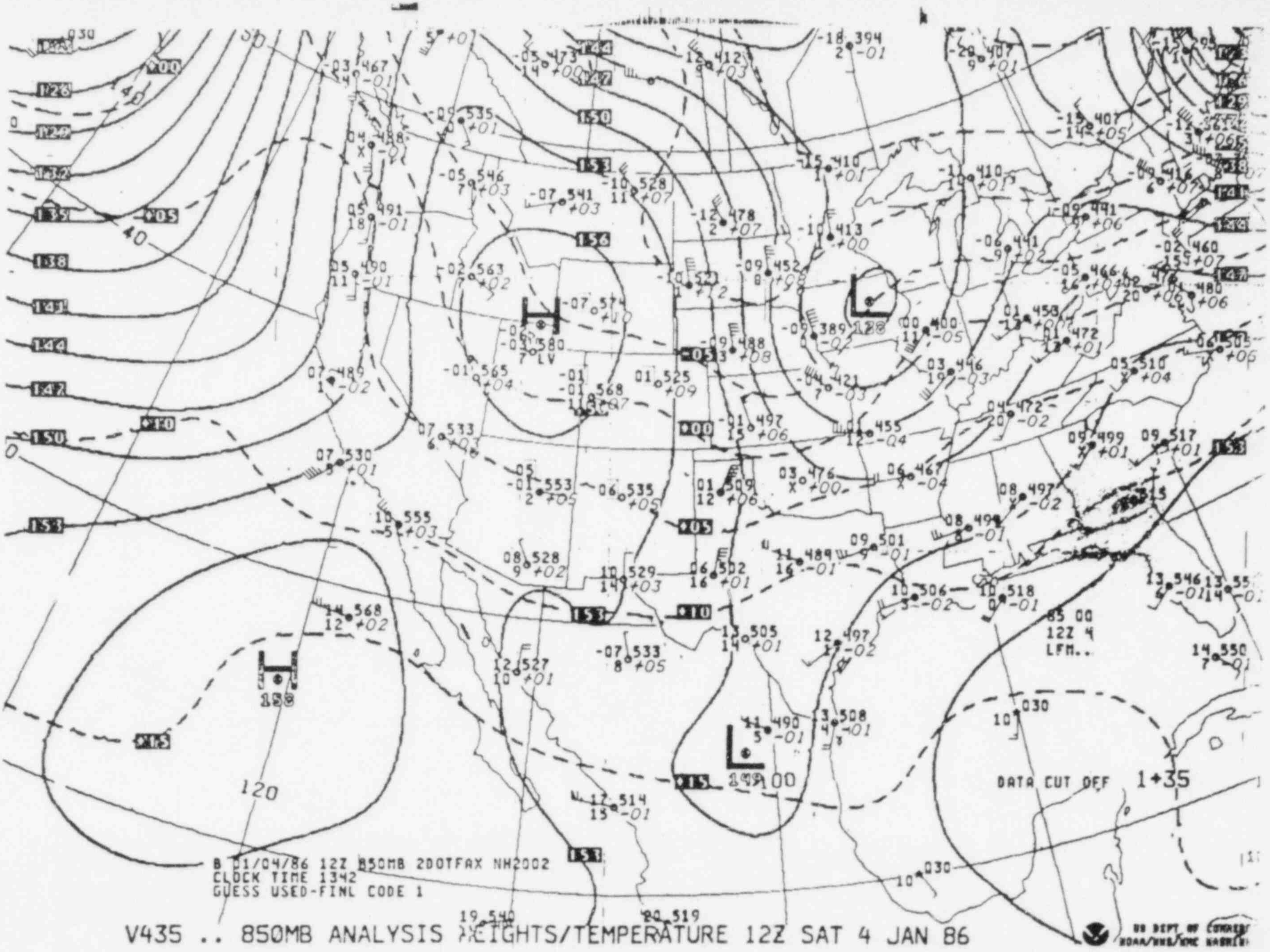


Figure 4.1.2.31A The 850 Millibar Weather Map at 6:00 a.m, January 4, 1986

APPENDIX 4.1.4.2

SFC'S INVESTIGATION REPORT OF THE EFFECTS ON CATTLE AND ANIMALS IN THE POTENTIALLY AFFECTED AREAS AFTER THE ACCIDENT

SEQUOYAH FUELS CORPORATION
INTERNAL CORRESPONDENCE

TO John Stauter

DATE January 31, 1986

FROM C. L. Couch

SUBJECT Task Force (Interagency) Investigation: Data Items Inquiry for Health Impact Analysis

As you requested in your letter dated 1-27-86, the following responses to the Data Items Inquiry for Health Impact Analysis, Section E Animal Population were prepared. These questions were answered by Carol Couch, Environmental Engineer and Dr. John Miller DVM, Warner, Oklahoma.

Section E. Animal Population

1. Characterization of animal population at risk:
    a. Description of sentinel herds
        1. Species, number, age, diet, water source location on premises of fuel plant.

RESPONSE (1) There were two herds of cattle (Bos taurus) that were exposed to the release on 1-4-86. Both herds belong to Kerr-McGee Corporation and were on facility owned lands. One herd consisted of 99 crossbred steers that were located southeast of the facility (Township 12N, Range 21E, parts of Sections 22 and 27). The other herd was 87 crossbred heifers located south-southwest of the facility (Township 12N, Range 12E, parts of sections 21 and 28).

Both herds were 10 months to 1 year of age. They are allowed to graze on open pasture lands consisting of predominantly bermuda and fescue grasses. Their diets are supplemented with cattle cubes, hay, salt and mineral. They water from stock ponds located on the pasture areas.

Sequoyah Fuels produces an ammonium-nitrate fertilizer solution as a by-product of the process. During the summer growing season this product is applied to company owned lands under the direction of Oklahoma State University Consulting Agronomist, Dr. Billy Tucker. It is very closely regulated and monitored in accordance with NRC guidelines.

Based upon years of research and data collection the NRC has permitted Kerr-McGee unrestricted use of the lands for cattle grazing.

The hay the animals are fed is grown on the pastures during the summer. These pastures are part of the facility's annual fertilizer program. The hay was analyzed for As, B, Co, Cu, Fe, Mn, Mo, Ni, Pb, V, Zn, U, Th-230, Ra-226, and nitrates prior to its release for animal consumption. The hay must meet guidelines set by the NRC for these element concentrations or it is not released for use.

Stock ponds in these pasture areas are monitored for N, As, Cu, Mo, Pb, Se, gross alpha, Ra-226s, Ra-226i, and U-238 as has been directed by the NRC to meet compliance of the annual fertilizer program.

QUESTION (2) Is there a regular health monitoring program for these animals that is supervised by a veterinarian? If so, what information is available regarding baseline health status?

RESPONSE (2) No. The ranch manager takes care of any immunization and regular herd health maintenance. If something should develop that he does not feel he can adequately handle a veterinarian is called.

There is not any baseline data on the herd. However they were received at the facility in good health and are growing and gaining weight very well.

QUESTION (3) Are blood, urine, or tissue specimens collected and analyzed on a regular basis? If so, what are baseline fluoride levels in the animals?

RESPONSE (3) No. The facility has very little if any effect on the surrounding environment. All facility discharges are well below standards set by the State, EPA, and NRC. There has not been any need prior, to the

QUESTION (4) Current status of the herds.

<u>RESPONSE</u> (4) Dr. John Miller DVM, has monitored the herds since 1-6-86. He feels that they are in good general physical health.

Urine samples were taken from 56 steers on 1/6-7/86. These samples were analyzed for uranium and fluoride. Analysis results are given in Item 1. Dr. Miller checked temperatures, eyes, nose, and mouth areas looking for any evidence of HF acid irritation, or toxin symptoms. Temperatures were normal. Their eyes did not show anything that would be acid related. There was not any excess mucus or lesions of the nose or mouth which would indicate a toxin. Their general health looked good.

The steers were held in a holding pen out of the plume area to prohibit any further contamination. However, two steers were lost due to the close confinement. Dr. Miller conducted necropsys on the two animals and found them to be stressed to death. The other steers "~~road~~ rode" them to death. This is common when strange cattle are introduced to a herd. (See Item 7)

The heifers were moved to an area well to the west of the plume path. Urine samples were taken from 12 of these animals on the 1-7-86. Dr. Miller examined the herd and found them to have normal temperature, no eye irritation or excessive mucus of the nose or mouth.

Heifer No. 320 was found dead on 1-15-86. Dr. Miller conducted a necropsy on the animal and determined the cause of death to be ~~blote~~ bloat. The heifer's diet had been changed causing her to bloat ~~blote~~ herself. (See Item 8)

Analysis of the heifers are attached in Item 2.

There was one horse in the same area as the steers. This animal was checked on 1-7-86. His physical condition was fine. His lungs were clear, heart rate and temperature was normal, there was not any signs of irritation of the eyes or exposed skin. A urine sample was taken. (Results are given in Item 3.) Further testing of this animal was not warranted.

The 11 heifers are being resampled weekly. Dr. Miller is checking the animals on a weekly basis. Twenty of the steers were selected for weekly testing. Dr. Miller is also keeping a watch on these animals. Testing of the urine for uranium and fluoride will continue until the levels have dropped to those of area control cattle. The remaining animals have been returned to their respective pastures. The test animals are being held in separate pastures to allow ease of testing.

The ranch manager does a daily check on all the animals and does a count to assure all the animals are accounted for and are in good health.

Dr. John Miller feels the herd are in good general health. They have some very common herd problems such as ringworms, one case of rot foot, lice rub, watering of the eyes from hay and dust. However, none of these problems are abnormal to any herd in the area. Dr. Miller has not found any illnesses that have been a result of the release. His comments are given in Item 5. Dr. Billy Tucker, OSU consultant, evaluated the urine data, his comments are attached. (See Item 6)

TOPIC (b) Description of domestic animal population in area surrounding the fuel plant:

QUESTION 1) Species, number, location of livestock, particularly range or pasture animals.

RESPONSE (1) The response to the inquiry is only an estimation. To be able to be specific a survey would need to be conducted.

Typical domestic animals in the area would be as follows: dogs, Canis familearis; cats, Felis catus; horses, Equus przewalski; cattle, Bos taurus. There could be some swine (Sus) and possibly some goats (Capra aegagrus) in the area.

After the release on 1-4-86 herds of animals south of the facility, that could have had exposure to the release were surveyed. Also as persons, even those well out of the plume area, requested visits were made to their farms to check their animals. Item 4 is a summary of these off-site visits and the results of this investigation.

TOPIC (c) Description of wild animal population in area:

1) Species, number, location.
2) Fish ponds in area or other sport or commercial fishing.

RESPONSE This is not a question that personnel at the facility or Dr. John Miller are qualified to answer. The State Fish and Wildlife Department should have this information.

TOPIC (2) Estimation of dose to animals:

QUESTION a) Have the sentinel herds been monitored since the incident for signs of illness? If so, describe illnesses.

RESPONSE (a) Yes. The ranch manager checks the herds daily and Dr. Miller checks the animals weekly. There have been no signs of illnesses that could or are related to the release.

QUESTION (b) Have any blood, urine, or tissue samples been collected from the sentinel herds since the incident? If so, what tissues were collected, what are the results of any analysis that have been done, and are any of these tissues still available? Slaughter and necropsy of sentinel herd animals would not be appropriate.

RESPONSE (b) Urine samples on 20 steers and 10 heifers are being collected weekly and this will continue until results fall within the range of control animals (See Item 4). The urine is being analyzed for uranium and fluoride.

No tissue was or is being collected.

QUESTION (c) What are the results of the survey of local veterinarians to determine if there have been any illnesses in livestock or pot animals that could be due to plume exposure? Provide a description of species affected illnesses seen, and location of animals in relation to fuel plant.

Provide the results of any milk samples collected. Provide the results of any analysis of any milk samples collected.

RESPONSE (c) Dr. John Miller has talked with Dr. Cindy Carter DVM, Gore, and she has not had any reported illnesses. Dr. Miller also visited with Dr. Gary Cox, DVM, Sallisaw. Dr. Cox had looked at some of resident 5R's swine and told him it was his opinion that the animals had swine dysentery and parasites. Dr. Cox did not feel the swine were ill as a result of the release. Dr. Cox did not report any other cases or illnesses.

Dr. Miller has responded to all the suspect cases that have been brought to the attention of the company. Dr. Miller has not found any illnesses that were a result of plume exposure.

The following types of domestic animals have been observed or examined and none have shown any illnesses as a result of the release:
Cattle (steers, heifers, cows, bulls), horses (gelding and mares) goats, swine, ducks, geese, rabbits, dogs, and cats. The location of these animals ranged from the facility sight to 15 miles southeast of the facility.

No milk samples have been collected.

QUESTION (d) Has the State Fish and Wildlife Service surveyed wild animal populations near the plant to determine if there have been increases in illnesses or deaths? Have there been reports of fish die-off in the reservoir or the rivers near the plant?

RESPONSE (d) This question should be addressed to the appropriate State agencies. But, to our knowledge the answers to the above questions are no.

QUESTION (e) What steps have been enacted to control the movement of livestock and poultry in and out of or within (quarantine) the contaminated area.

RESPONSE (e) There is not nor is there any need for a quarantine of the area. The only animals that have shown any contamination are the animals on the plant site that belong to Kerr-McGee and they are being monitored. They are showing no signs of illness. Off-site investigation of animals has not indicated any contamination or any plume related illnesses.

CLC:dd

Attachments

ITEM 1

Kerr-McGee

Steer Urine Analyses 1-6-86

Sample No.	F mg/l	U µg/l
4	12	200
39	8.5	110
49	5.9	87
87	5.8	1100
35	8.2	2400
43	16	150
18	16	1400
95	13	410
13	3.6	83
5	11	6400
90	4.2	350
82	9.7	1000
68	11	350
76	8.2	830
38	14	740
75	13	160
11	6.9	750
46	6.9	590
71	7.5	130
36	11	290
100	4.1	150
84	5.6	1100
17	10	1400
30	5.9	220
56	7.5	220
61	8.1	390
34	6.4	210
42	2.8	75
44	4.8	39
15	9.8	330
77	2.7	120
73	11	730
85	21	580
58	7.5	160
86	2.5	710
48	9.1	190
96	3.1	37
55	5.7	110
20	6.5	220

*63 composites of 3 samples		7.2	640
*24 composites of 4 samples		7.3	130
*60 composites of 6 samples		4.7	510
*88 composites of 6 samples		3.9	540
KM horse	Kerr-McGee horse	3.2	22

ITEM 2

Kerr-McGee

Heifer Urine Analyses

Sample No.	F mg/l	U ug/l
369 yellow	4.2	770
371 yellow	1.4	1800
356 white	5.5	320
449 white	6.2	63
574	14	590
404	3.7	450
473	19	2200
74 white	16	7200
369 white	15	840
320 (deceased)	2.6	570
293	20	2700

ITEM 3

Kerr-McGee
Horse Urine Analyses

Sample No.	F mg/l	U ug/l
K-M horse	3.2	22

ITEM 4

OFF SITE INVESTIGATION

INDEX:

ITEM 4

SECTION 1

RESIDENCE: 1R

DATE: **January 7, 1986**

LOCATION: Township 12N, Range 21E, Section 26

HERD TYPE: **Cross bred and hereford cattle**

HERD SIZE: **Approximately 43 head**

Dr. John Miller and I visited 1R and took urine samples from 4 of 1R's calves. 1R's herd size was approximately 43 head of herfords and crossbred cattle. Dr. Miller also examined two of 1R's young dogs. The dogs were in good health with no signs of illness or evidence of HF acid burn or toxin. The cattle were in good general health with signs common herd parasites. There was not any signs of acid or uranium related illnesses. Urine analysis results:

Sample No.	F mg/l	U mg/l
1 calf	1.3	Insufficient sample
2 calf	1.2	2
3 calf	0.9	8
4 calf	1.0	48

Urine analyses were normal and below those of the control group. Further testing was not warrented.

RESIDENCE: 2R **(lease land, no house)**

DATE: January 8, 1986

LOCATION: Township 12N, Range 21E, Section 27

HERD TYPE: Horses (mares)

HERD SIZE: 3

Sample No.	F mg/l	U ug/l
Pk mare	0.3	2

CONCLUSION: General physical health was fine. Heart rate was normal, lungs were clear, temperature and urine pH was normal, no eye irratations or excessive mucus from the nose or mouth. Urine did not contain significant amounts of uranium or fluorides. Further testing was not necessary.

RESIDENCE: 3R

DATE: January 7, 1986

LOCATION: Township 12N, Range 21E, Section 27

HERD TYPE: Cross bred cattle, horses

HERD SIZE: Approximately 21 head cattle, 2 horses

Sample No.	F mg/l	U µg/l
17 cow	1.2	3
2 cow	1.2	4
10 cow	1.1	3
3 cow	0.6	2
80C cow	0.8	2
84C cow	0.7	2
Black Welch gelding	0.2	2

CONCLUSION: Dr. Miller examined the animals and found the temperatures were normal, there was not any signs of acid related skin or eye irritation, no excessive mucus which would indicate toxin. Dr. Miller's exam found the herd in good general physical condition. The horse had a normal pulse rate, clear lungs, no indication of acid burn to the eyes or exposed skin, no signs of excessive mucus. The horse was also in good general physical condition. No significant uranium or fluorine in the urine. Follow-up sampling was not warranted.

RESIDENCE: 4R

DATE: January 7, 1986

LOCATION: Township 12N, Range 21E, Section 26

HERD TYPE: Hereford cattle

HERD SIZE: Approximately 10

Sample No.	F mg/l	U µg/l
1 cow	2.8	2
2 cow	1.3	2
3 calf (6 wks. old)	0.6	4

CONCLUSION: Dr. Miller examined the animals and did not find any HF acid or uranium suspect illnesses. Eye, mouth, nose areas appeared normal. Temperatures were normal. Dr. Miller did not find anything except normal herd parasites. The urine contained no significant uranium or fluoride, further testing was not warranted.

ITEM 4

SECTION 2

RESIDENCE: 5R

DATE: January 15, 1986

LOCATION: Township 11N, Range 23E, Section 29

HERD TYPE: Swine, cattle, ducks, geese, dog, cat, rabbits

HERD SIZE: (All estimates) - 25 swine, 5 cattle, 6 ducks,
4 geese, 1 dog, 1 cat, 6 rabbits

5R had lost 7 head of swine, he felt his animals were all ill due to the plant release. He also felt his illnesses were a result of the acid release.

No urine samples were taken at the time of this visit. Observation of the animals were as follows.

SWINE: The swine were of varying breeds and ages. The younger pigs were sick with diarhea and defecating at random. They were let run out in open dusty areas with little or no ground cover. The only feed available to the younger pigs was watered bread. The swine and cattle watered from a pond inhabited with water fowl (duck and geese). The fowl exhibited no signs of illness.

CATTLE: The cattle were also on the same barren pasture. They had been given loose hay. The cattle had some eye tearing which Dr. Miller felt was caused by the dust and hay. There was not excessive reddening of the eye area or skin irritations. The cattle did not show signs of excess mucus.

CAT: The cat appeared in good general health. No symptoms of any illnesses.

DOG: The dog had a case of diarrhea. However in talking to 5R he explained that he had ran over the dog with a backhoe. The dog had lost control of his tail and the tip had been severed. 5R also stated that the animal had had severe swelling in the backend. Other than these problems and the fact that the dog appeared underweight he looked fine. There was not any eye irritation or excessive mucus from the nose or mouth.

RABBITS: The rabbits were located next to the pasture area the swine and cattle were located in. The rabbits did not have any eye irritation, or any signs of acid burn to the ears. They appeared in good general health. They looked under weight. They did not have food or water available to them. The rabbits were observed eating fur off of one another from adjoining cages. 5R fed and watered the animals while we were there and the animals were very hungry and thirsty. 5R claims the animals were loosing weight since the release. Observation of the rabbits lends the impression that the rabbits were not being fed properly.

Dr. Miller suggested we purchase 3 swine and send two to OSU, Oklahoma Animal Diesease Diagnostic Laboratory. Three pigs were purchased and 5R gave the fourth pig, which was dying, for diagnoses. A full report from OSU is attached. See Item 9. Dr. Miller examined the other 2 pigs and found no evidence of HF or uranium related problems. Dr. Miller's findings were the same as those of OSU.

CONCLUSION: 5R's property was not in the plume path. Dr. Miller did not find any illnesses that were related to the facility release.

5R claimed his eyes were burned the day of the release and that he had holes burnt in his jean legs. However, his eyeglasses were not etched. The glass in the cab of his backhoe and vehicles showed no evidence of etching. Etching of glass should be quite evident and is characteristic of HF. None was observed.

Also, the rabbits should have shown some evidence of "burn" since they have extremely sensitive eyes and ears, but they did not.

In summary 5R had several noted items indicating poor animal husbandry, infections, and parasites in his herds.

RESIDENCE: 6R

DATE: January 27, 1986

LOCATION: Township 11N, Range 22E, Section 3

HERD TYPE: Goat (capra aegagrus)

HERD SIZE: 2 females

6R called the facility 1-27-86. She had had a pregnant goat that had died the night before. She wanted someone to check the animal and see if its death was related to the plant release.

Dr. Miller conducted a necropsy on the animal. The body cavity of the animal was packed with fat. The liver was discolored to a yellowish brown and there was not any blood present in the liver. The heart showed signs of dead muscle. There was a layer of fat around the outside of the atrium areas. The goat was pregnant with 3 fetus and was approximately 1 - 1 1/2 months from delivery.

The stomach and intestine area was filled with parasitic "barber pole" worms.

Dr. Miller determined the cause of death to be pregnancy toxemia. This is the reason for the "cooked" liver. The goat had so much fat that she could not get proper circulation to allow her vital organs to function properly.

6R also had another pregnant femal. Dr. Miller advised her to worm the animal and see that it was properly exercised each day.

6R witness the necropsy and was completely satisfied that the goat died of a physiological problem and not as a result of anything from the facility.

RESIDENCE: 7R

DATE: January 8, 1986

LOCATION: Township 12N, Range 21E, Section 36

HERD TYPE: Crossbred cattle, horse, cat

HERD SIZE: Approximately 15 cattle, 1 horse, 1 cat

Sample No.	F mg/l	U ug/l
609 cow	1.3	2
610 cow	1.8	3
611 cow	1.5	2
612 calf	0.7	2
P mare	0.8	2

CONCLUSION: Dr. Miller examined the 7R's cat and didn't find any release related symptoms. The cat did have a case of ear mites.
The palomino mare was in good general physical health without any illness.

The cattle had normal temperatures. Eyes, nose, mouth and skin areas were clear and without irritation.

Dr. Miller examined one cow that had a conjested right lung. Dr. Miller did not think that this was related to the release or that it was a problem to the cow's health.

Sample results did not warrant any further testing.

The herds' general condition was good. However, 7R requested some additional urine testing and this was conducted on 1-16-86. Dr. Miller examined some additional cattle in 7R's herd and found them to be in good health. Some of the cows had a common uterin virus but there was not any illnesses that were related to the facility release. Analyses on five head of cattle sampled on 1-16-86 are still pending.

ITEM 4

SECTION 3

CONTROL ANIMALS

RESIDENCE: 8R

DATE: January 9, 1986

LOCATION: Rabbit Hill property Township 12N, Range 19E, Section 25

HERD TYPE: Cross bred steers and Holstein Heifer

HERD SIZE: 12

Sample No.	F mg/l	U ug/l
614	2.0	98
615	2.0	6
616	6.2	30
617	1.4	5
Holst. Heifer	2.8	22

CONTROL ANIMALS

RESIDENCE: 8R

DATE: January 9, 1986

LOCATION: Webbers Falls, Township 11N, Range 21E, Section 9

HERD TYPE: Cross bred cattle

HERD SIZE: 12

Sample No.	F mg/l	U µg/l
Red cow	1.4	16
Bobtail	1.7	4
883	1.6	7
Blk. Pntr.	2.9	22
BWF cow	0.5	13

CONTROL ANIMALS

RESIDENCE: K-M Corporation
DATE: January 9, 1986
LOCATION: Township 12N, Range 12E, Section 22
HERD TYPE: Crossbred steers
HERD SIZE:

Sample No.	F mg/l	U µg/l
14CG	1.6	47
27CG	1.2	13
84CG	0.8	12
160CG	2.0	9
154CG	1.5	23

CONTROL ANIMALS

RESIDENCE: 9R

DATE: January 9, 1986

LOCATION: Township 13N, Range 22E, Section 15.

HERD TYPE: Limousin cattle, horses

HERD SIZE: 34 head of cattle, 3 horses

Sample No.	F mg/l	U ug/l
7961CG	0.6	< 2
Jenny	1.3	< 2
WCT8751	0.6	< 2
73BH27956	1.0	8
BH27961	0.5	10
CCCG	1.9	4
Poncho (horse)	1	< 2

ITEM 5

JOHN W. MILLER, D. V. M.
TOWN & COUNTRY VETERINARY CLINIC
BOX 447
WARNER, OKLA. 74469

TELEPHONE 918 . 463-2887

January 10, 1986

Ms. Carol Couch
Kerr-McGee, Inc.
Gore, Oklahoma 74435

Dear Ms. Couch:

As per your request, here are my observations on the conditions of the domestic animals I examined earlier this week.

Steers belonging to Kerr-McGee examined on 1-6-86 were in good general physical condition. Body temperatures and lung sounds of those examined were in normal ranges. Mucus membrane's of the eyes, lips, gums, and nasal passages appeared normal on 30 steers. We did notice several cases of ring worm and skinned places on rear legs.

On Tuesday, 1-7-86, I examined about 190 head. They all exhibited symptoms seen regularly in a large animal practice. The black gelding on Kerr-McGee property revealed normal vital signs and urine pH. I observed no lesions to the mucus membranes.

On 1-8-86 the 7 year old Appaloosa mare examined appeared normal. No lesions of the eyes or mouth were noticed. Urine was collected and revealed a pH of 7. Two other mares in the pasture appeared in good general physical condition. The cattle we collected urine samples from exhibited normal vital signs withthe exception of one black cow who exhibited congestion in the right lung. Her mucus membranes were normal as was her temperature. The palomino mare we collected urine from also appeared normal.

On 1-9-86 we examined and collected urine samples at four locations. All animals seen that day appeared normal.

Of the approximately 300 animals I have observed, examined, and/or collected urine from, I have not observed a syndrome that I would consider out of the ordinary for a large animal practice in this area.

Sincerely,

John W. Miller DVM

John W. Miller, D.V.M.

ITEM 6

1212 N. Jardot
Stillwater, Oklahoma 74074
January 27, 1986

Ms. Carol Couch
Sequoyah Fuels Incorporated
P. O. Box 610
Gore, OK 74435

Dear Carol:

I have reviewed the analyses from urine samples taken from the livestock owned by Sequoyah Fuels.

Even though concentrations of uranium and fluorine in the urine were higher in some of the animals than those generally found from other animals tested, these concentrations are still below suggested critical levels. Levels found in these animals pose no health problems to the animals and there is no risk of elevated levels being transmitted to the human chain from these animals or their products.

Sincerely yours,

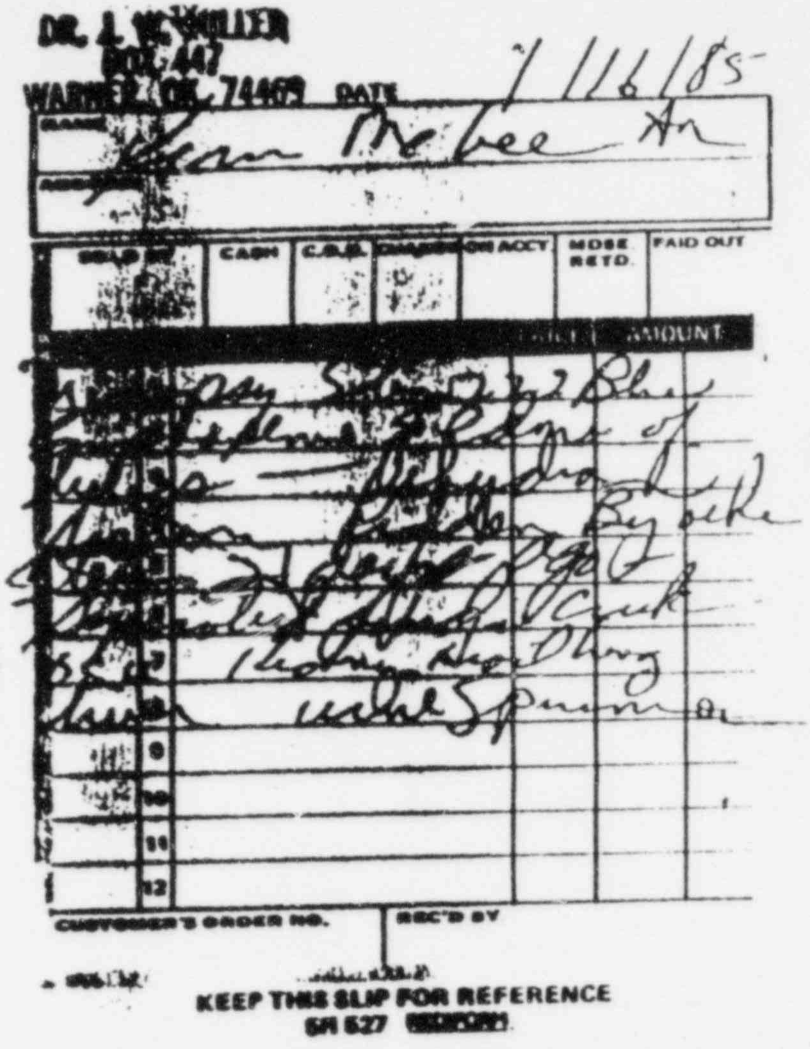
Billy B. Tucker

Billy B. Tucker
Agronomist and
Soil Scientist

BBT/jt

Enclosure

4266



DR. J. W. MILLER
BOX 447
WARNER, OK. 74469 DATE 7/16/85

NAME [illegible] McBee Jr

ADDRESS

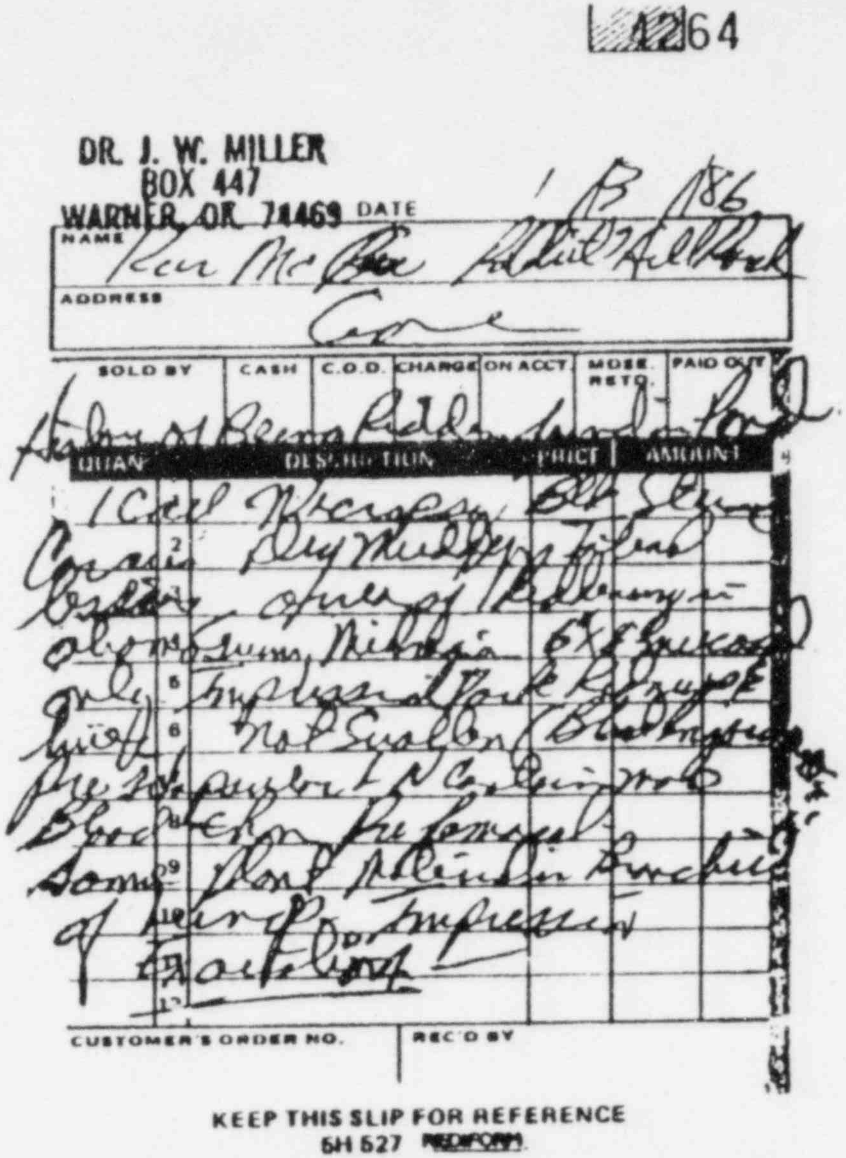
SOLD BY	CASH	C.O.D.	CHARGE	ON ACCT.	MDSE. RETD.	PAID OUT

QUAN.	DESCRIPTION	PRICE	AMOUNT
[illegible]	[illegible] 2 Blue		
[illegible]	[illegible] of		
[illegible]	[illegible]		
[illegible]	[illegible] By [illegible]		
[illegible]	[illegible]		
[illegible]	[illegible] Creek		
[illegible]	[illegible]		
[illegible]	[illegible]		

CUSTOMER'S ORDER NO. | REC'D BY

KEEP THIS SLIP FOR REFERENCE
5H 527 REDIFORM

4264



DR. J. W. MILLER
BOX 447
WARNER, OK 74469 DATE 1/13/86

NAME Ren McBee [illegible]

ADDRESS [illegible]

SOLD BY	CASH	C.O.D.	CHARGE	ON ACCT.	MDSE. RETD.	PAID OUT

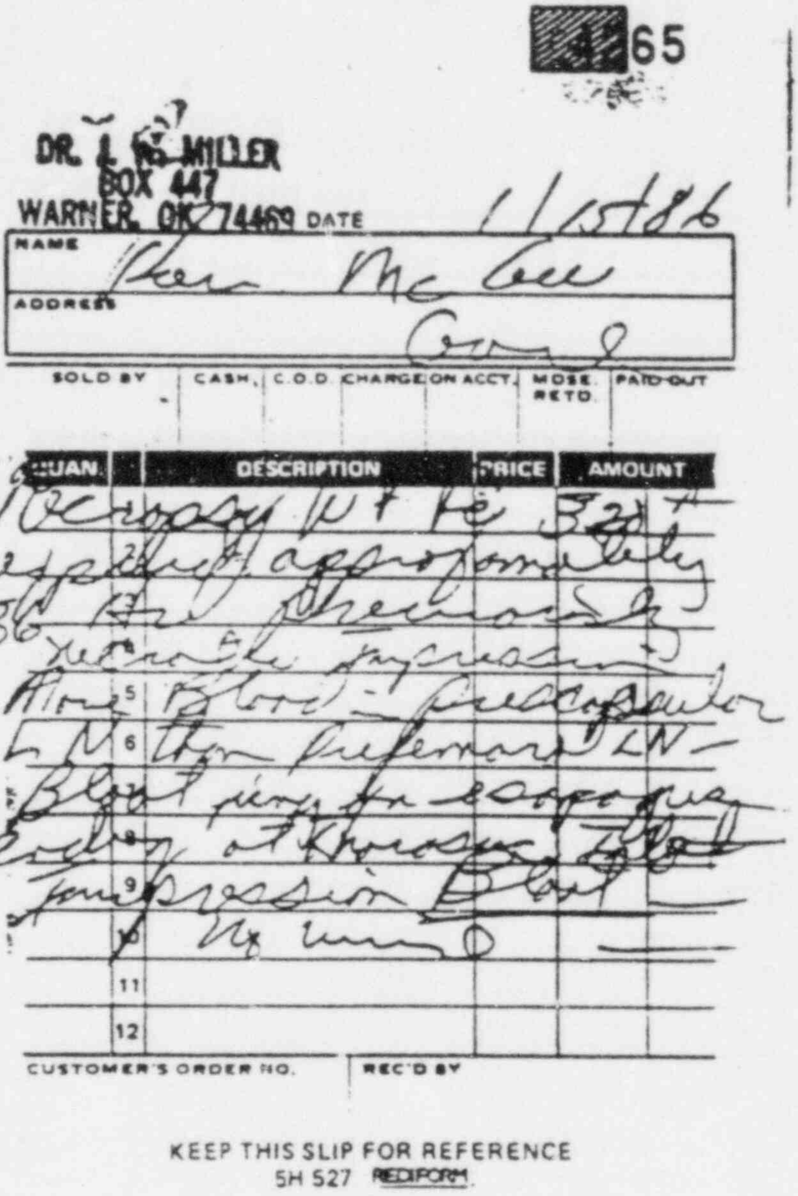
History of [illegible]

QUAN.	DESCRIPTION	PRICE	AMOUNT
1 Cell	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]		
[illegible]	Not [illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
Some	[illegible] in Bronchi		
of	[illegible] impression		
	[illegible]		

CUSTOMER'S ORDER NO. | REC'D BY

KEEP THIS SLIP FOR REFERENCE
5H 527 REDIFORM

ITEM 8



[redacted]65

DR. L W. MILLER
BOX 447
WARNER, OK 74469

DATE 1/15/86

NAME Dan McGee

ADDRESS Gore, O

SOLD BY	CASH	C.O.D.	CHARGE	ON ACCT.	MDSE. RETD.	PAID OUT

126

QUAN.		DESCRIPTION	PRICE	AMOUNT
10	1	[illegible] pt [illegible]	32	
exposed	2	approximately		
36	3	hrs previously		
[illegible]	4	[illegible] increasing		
[illegible]	5	Blood - [illegible]		
[illegible]	6	then [illegible] LN-		
Blood	7	[illegible]		
Ending	8	at [illegible]		
[illegible]	9	pression Blood		
	10	Rx [illegible]		
	11			
	12			

CUSTOMER'S ORDER NO. | REC'D BY

KEEP THIS SLIP FOR REFERENCE
5H 527 REDIFORM.

ITEM 9

Oklahoma State University
Oklahoma Animal Disease Diagnostic Laboratory

Case No: 112782

5R's pig

OSU

Oklahoma State University

OKLAHOMA ANIMAL DISEASE DIAGNOSTIC LABORATORY

STILLWATER, OKLAHOMA 74078
(405) 624-6623

January 22, 1986

Mr. Butch Garver
P.O. Box 393
Gore, Oklahoma 74435

Case No.: 112782
Owner: 5R

Dear Mr. Garver:

HISTOPATHOLOGIC EXAMINATION: Pig "A"- Colonic lesions consist of moderate to severe diffuse areas of superficial mucosal necrosis with associated accumulation of necrotic cellular debris and the presence of numerous bacterial colonies.

Mesenteric lymph nodes reveal moderate to heavy infiltrates of neutrophils, macrophages and occasional eosinophils within the paracortical areas with associated lymphoid hyperplasia of the cortical germinal centers.

There are no significant lesions in heart, lung, liver, spleen, kidney, stomach and intestines.

Pig "B" - Pulmonary findings include focally extensive infiltrates of neutrophils within significant portions of alveoli and air passages with the presence of several peribronchial and perivascular lymphoid infiltrates.

Colonic lesions reveal the presence of numerous trichura (whipworms) embedded within the superficial mucosa and extension into crypts.

There are no significant lesions in heart, liver, spleen, kidney, stomach and intestines.

Pig "C" - Colonic lesions reveal heavy numbers of Trichura sp (whipworms) embedded within the mucosa.

HISTOPATHOLOGIC CONCLUSION: Pig "A" - Severe necrotizing colitis; moderate suppurative lymphadenitis. Pig "B" - Moderate suppurative bronchopneumonia, severe trichuriasis. Pig "C" - severe trichuraisis.

Sincerely,

Ray W. Ely

Ray W. Ely, DVM, PhD
Pathologist

RWE:ds

CENTENNIAL
DECADE
1980 • 1990

Accession No. 8601105[illegible]

RECEIVED

JAN 1 6 1986

OKLAHOMA ANIMAL DISEASE
DIAGNOSTIC LABORATORY

DIAGNOSTIC LABORATORY

OKLAHOMA STATE UNIVERSITY
Stillwater, Oklahoma 74074

Telephone: 405-624-6623

Case No. ______

If a related case (e.g. paired serum) has been sent to the laboratory please indicate the case number ______

Condition of Specimen:
☐ Excellent
☐ Autolyzed
☐ Other (Specify)

PLEASE FILL OUT COMPLETELY WITH BLACK INK

OWNER 5R
ADDRESS X
ZIP
PHONE 918 773 8704
DATE SUBMITTED 1-16-86

VETERINARIAN DR. [illegible] W. MILLER
ADDRESS BOX 447 [illegible] OK [illegible]
ZIP
PHONE 918 463 2987
Location of Case (County & State) Sequoyah, Okla

Delivered by: Veterinarian ______ Mail ______ Owner ______ Other (Specify) Carried By Ken McBee Employ, Bill McGrody

HISTORY

SPECIES [illegible] BREED X AGE 2½ da [✓ mo] yr SEX ______ WEIGHT ______
NUMBER IN HERD (FLOCK) 25 NUMBER SICK (excluding dead) 12 NUMBER DEAD 7
RAISED ON OWNER'S PREMISES? YES ✓ NO ______ IF PURCHASED, WHEN? ______
ANY RECENT INTRODUCTIONS TO HERD (FLOCK)? YES ? DATE INTRODUCED ______ NO ______
FIRST NOTICED SICK 1-14-86
CLINICAL SIGNS (INCLUDE TEMPERATURES) & POSTMORTEM FINDINGS

Hogs Purchased By Ken McBee for Diagnosis
Box 393,
Gore Okla 74439
phone 918- 4895527

VACCINATION HISTORY (DATES)
FIELD DIAGNOSIS Rhinitis Swine Dysentery - Lung Worms —

✓ MATERIALS SUBMITTED	HOW MANY?	✓ REFRIGERATED	✓ FROZEN	✓ IN FORMALIN
☑ Live Animal	2	☐	☐	☐
☐ Dead Animal		☐	☐	☐
☐ Fetus		☐	☐	☐
☐ Blood (Clotted)		☐	☐	☐
☐ Blood (Anticoag)		☐	☐	☐
☐ Serum		☐	☐	☐
☐ Kidney		☐	☐	☐
☑ Liver	1	☑	☐	☐
☑ Intestine	1	☑	☐	☐
☐ Lung		☐	☐	☐
☐ Tumor (Show location on model)		☐	☐	☐
☐ Spleen		☐	☐	☐
☐ Brain		☐	☐	☐
☐ Lymph Node ______ (origin)		☐	☐	☐
☐ Eyeball		☐	☐	☐
☐ Milk		☐	☐	☐
☐ Urine		☐	☐	☐
☐ Cerebrospinal Fluid		☐	☐	☐
☐ Stomach Contents		☐	☐	☐
☐ Swab ______ (origin)		☐	☐	☐
☐ Feed		☐	☐	☐
☐ Water		☐	☐	☐
☐ Other ______		☐	☐	☐
☐ Other ______		☐	☐	☐

(Please record additional information on reverse.)


Ventral


Dorsal

✓ EXAMINATIONS REQUESTED
☑ Necropsy
☑ Histopathology*
☐ Cytology
☐ Mycoplasma Isolation
☑ Bacteriology
☐ Antibiotic Sensitivity
☐ Virus Isolation & identification**
☑ Parasitology floatation
☐ Mycology
☒ Hematology CBC.
☐ Fluorescent Antibody
(Specify test ______)
☐ Serology (Complete form, opposite side)
☐ Toxicology**
(Specify test ______)
☐ Other Clin Path- Ca, Phos
mg K

* Frozen tissues not suitable.
** Formalin fixed tissues not suitable.

Revised April, 1979

112782

SEROLOGY*

SAMPLE INFORMATION

Animal Identification						Lab Use
Tube	Name/No.	Species	Breed	Sex	Age	Only

*Samples for serology should be collected in sterile vacutainer tubes without anticoagulant. B-D tubes are satisfactory. Brucellosis tubes and some other vacuum tubes frequently contain toxic residues.

Laboratory charges are doubled for cases not owned by Oklahoma citizens.

TESTS REQUESTED

☐ Leptospira (includes pomona, ictero, grippo, hardjo, canicola) ($4.00)
☐ Anaplasmosis ($4.00)
☐ Neonatal Isoerythrolysis (Complement-Lysis test requires neonatal blood in anticoagulant) ($4.00)
☐ Brucella abortus (Not official regulatory test except for swine) ($4.00)
☐ IBR ($4.00)
☐ BVD ($4.00)
☐ Bluetongue ($4.00)
☐ Pi3 ($4.00)
☐ Respiratory Syncytial Virus ($4.00)
☐ Bovine Leukemia Virus ($4.00)
☐ Chlamydia ($4.00)
☐ Cattle Abortion Profile (Lepto, IBR, BVD, Brucella) ($9.00)
☐ Cattle Respiratory Disease Profile (IBR, Pi3, BVD) ($7.00)
☐ Swine Abortion Profile (Lepto, Brucella, Parvovirus, Pseudorabies) ($9.00)
☐ Horse Abortion Profile (Lepto, Rhinopneumonitis, EIA-send EIA form) ($9.00)
☐ Sheep Abortion Profile (Lepto, Brucella, Bluetongue, Chlamydia) ($9.00)
☐ Swine Influenza Virus ($4.00)
☐ Swine Parvovirus ($4.00)
☐ Pseudorabies ($4.00)
☐ TGE ($4.00)
☐ Brucella canis ($4.00)
☐ Canine Distemper (Serum or CSF) ($4.00)
☐ Feline Leukemia (need unfixed blood smears) ($4.00)
☐ EIA ($5.00)
☐ Equine Rhinopneumonitis ($4.00)
☐ Equine Influenza 1 ($4.00)
☐ Equine Influenza 2 ($4.00)
☐ Other ______
☐ Other ______
☐ Other ______
☐ Other ______

ADDITIONAL REMARKS

4-S herd pigs

Urine exam - ck uranium hexafluoride

Poor doing pigs

OSU
Oklahoma State University
OKLAHOMA ANIMAL DISEASE DIAGNOSTIC LABORATORY
STILLWATER, OKLAHOMA 74078
(405) 624-6623

January 22, 1986

Butch Garver
P.O. Box 393
Gore, Oklahoma 74435

Case No.: 112782
Owner: 5R
Referral Lab.: Boren Veterinary Medical
Teaching Hospital
Oklahoma State University
Stillwater, Oklahoma 74078

Dear Mr. Garver:

Attached hereto are the results of tests performed by an outside laboratory to which materials were referred from the above referenced case.

Sincerely,

Ray W. Ely

Ray W. Ely, DVM, PhD
Pathologist

RWE/cas

CENTENNIAL DECADE
1980 • 1990

CHART

Boren Veterinary Medical Teaching Hospital
Oklahoma State University

CADDL		☐ REMARKS	
DEPT.	ACCT #		

✓	TEST	RESULT	✓	TEST	RESULT
	ALB			LIPASE	
	A/G		✓	MG	2.3
	AMYLASE			NA	142
	BILI. T.		✓	K	5.3
	BILI. D.		✓	PHOS	10.19
	BUN			T.P.	
✓	CA	10.7		SAP	
	CHOL			SDH	
	CL			SGGT	
	CPK			SGPT	
	CKMB			SGOT	
	CREAT			DIGOXIN	
	CO₂			LDH	
	GLUC			LLDH	

Address Dr. Miller

Breed/Sp./Age/Sex Swine (B)

NOTES:

Date Done 1-17-86	Tech: BF	Reviewed By:	CHEMISTRY I	Total Chg. $ 13.00

CHART COPY

Boren Veterinary Medical Teaching Hospital
Oklahoma State University

RWE/Pt		1-17
DOCTOR	STUDENT	DATE
CADDL	5-1-67120-8000	
DEPT	ACCT #	

☐ STAT
☐ PRIORITY
☐ PLEASE CALL RESULTS
☐ REMARKS

CADDL 112782

Owner's Name

Address Dr. Miller

Breed Sp Age/Sex Swine (A)

NOTES:

✓	TEST	RESULT	✓	TEST	RESULT
				LIPASE	
	ALB		✓	MG	1.4
	A/G			NA	127
	AMYLASE		✓	K	5.1
	BILI. T.		✓	PHOS	7.51
	BILI. D.			T.P.	
	BUN			SAP	
✓	CA	7.7		SDH	
	CHOL			SGGT	
	CL			SGPT	
	CPK			SGOT	
	CKMB			DIGOXIN	
	CREAT			LDH	
	CO₂			LLDH	
	GLUC				

Date Done 1-17-86	Tech: BF	Reviewed By:	CHEMISTRY I	Total Chg. $ 13.00

22

☐ ROUTINE
☐ PRE-OP
☒ EMERGENCY
☐ REPEAT

NURSE
DATE REQUIRED

☒ CBC ☐ DIFF
☐ WBC ☐ HGB
☐ RBC ☐ HCT
☐ ALL

CADDL 112782
5-1-67120-8000
RWE/Pt 1-17-86 Swine (A)

Ti pot. 206
[illegible] variation
RBC morph. abnormal
5% began
clumped

OKLAHOMA STATE UNIVERSITY

OKLAHOMA ANIMAL DISEASE DIAGNOSTIC LABORATORY
STILLWATER, OKLAHOMA 74078 • (405) 624-6623

BACTERIOLOGY REPORT

☐ Preliminary Report ☒ Final Report

Veterinarian Dr. J.W. Miller Owner 5R

Species Porcine Date Received 1-16-96 Case No. 112712

Specimen(s) Pig A (live pig) Isolate(s)

☐ Lung
☒ Liver }
☒ Spleen } None
☐ Kidney
☒ Lymph node - None
☒ Intestine (small) }
☒ ~~Brain~~ Colon } Normal Flora
☐ Uterus
☐ Stomach contents
☐ Urine
☐ Feces
☐ Muscle
☐ Skin
☒ Turbinate swab - Contaminants

Specimen(s) Isolates(s)

☒ Pig B - (live pig submitted)
☒ Liver }
☒ Spleen } None
☒ Small intestine Normal Flora
☒ Colon
☐
☐
☒ Pig C (tissues submitted)
☒ Liver - contaminants
☒ Intestine - Normal flora
☐
☐
☐

☐ We were unable to isolate any bacteria from the sample(s) submitted.

☒ The bacteria isolated were not considered significant.

☐ The bacteria isolated were considered significant. See attached sheet for antibiogram(s).

☐ Isolate referred to another lab for identification: ____________. An addendum report will follow.

COMMENTS:

Intestinal samples were cultured for Salmonella spp. and Treponema hyodysenteriae with negative results.

Date 1-23-96

☐ Abstract

BMorton
R. J. Morton, DVM, MS
Bacteriologist

OKLAHOMA STATE UNIVERSITY

OKLAHOMA ANIMAL DISEASE DIAGNOSTIC LABORATORY
STILLWATER, OKLAHOMA 74078 • (405) 624-6623

Accession No. 86010563

TOXICOLOGY REPORT

Case No. 112782
Related Cases ______

Final x
Preliminary ___
Addendum ___

Date Received 1-16-86

Veterinarian J.W. Miller, DVM

Owner 5R / Kerr-McGee

SPECIMEN

x Liver
x Kidney
___ Brain
___ Lung
___ Fat
___ Stomach contents
___ Feces
___ Eyeball

___ Blood
___ Serum
___ CSF
___ Milk
___ Urine
___ Feed
___ Water
___ Soil
___ Other

ANALYTICAL METHODS

x Atomic Absorption
___ Gas Chromatography E.C.
___ Gas Chromatography Flame
___ Gas Chromatography N-P
___ Scanning UV
___ Hp Liquid Chromatography
x Ion Specific Electrode
___ TLC
___ Bench Chemistry
___ Infrared Spectrophotometry
___ Other

CONDITION

x Sample Satisfactory
___ Sample Unsatisfactory
___ Sample Depleted
___ Sample Referred
___ Sample Disposed of
x Sample Stored* (one month)

*Samples will be stored one month and will be discarded unless otherwise instructed. If conditions warrant, the submittor should collect and keep duplicate samples.

SPECIES: Swine

RESULTS AND COMMENTS:

Liver tissues were analyzed by ion specific electrode for fluoride.

Liver A <1 ppm fluoride
Liver B <1 ppm fluoride

Liver and kidney were analyzed by atomic absorption spectrophotometry. Results are in ppm wet weight.

	Liver	Kidney
Chromium	0.632	0.432
Cadmium	0.041	0.089
Lead	0.208	0.325
Arsenic	0.113	0.135

These levels are not clinically significant.

***Toxicology Charges ONLY** $ 60.00

Date Completed 1-22-86

***Please wait for statement before paying.**

William C Edwards
Veterinary Toxicologist
William C. Edwards, DVM

WCE/cas

Oklahoma State University

OKLAHOMA ANIMAL DISEASE DIAGNOSTIC LABORATORY

STILLWATER, OKLAHOMA 74078
(405) 624-6623

January 22, 1986

Butch Garver
P.O. Box 393
Gore, Oklahoma 74435

Case No : 112782
Owner: 5R
Referral Lab.: Boren Veterinary Medical
Teaching Hospital
Oklahoma State University
Stillwater, Oklahoma 74078

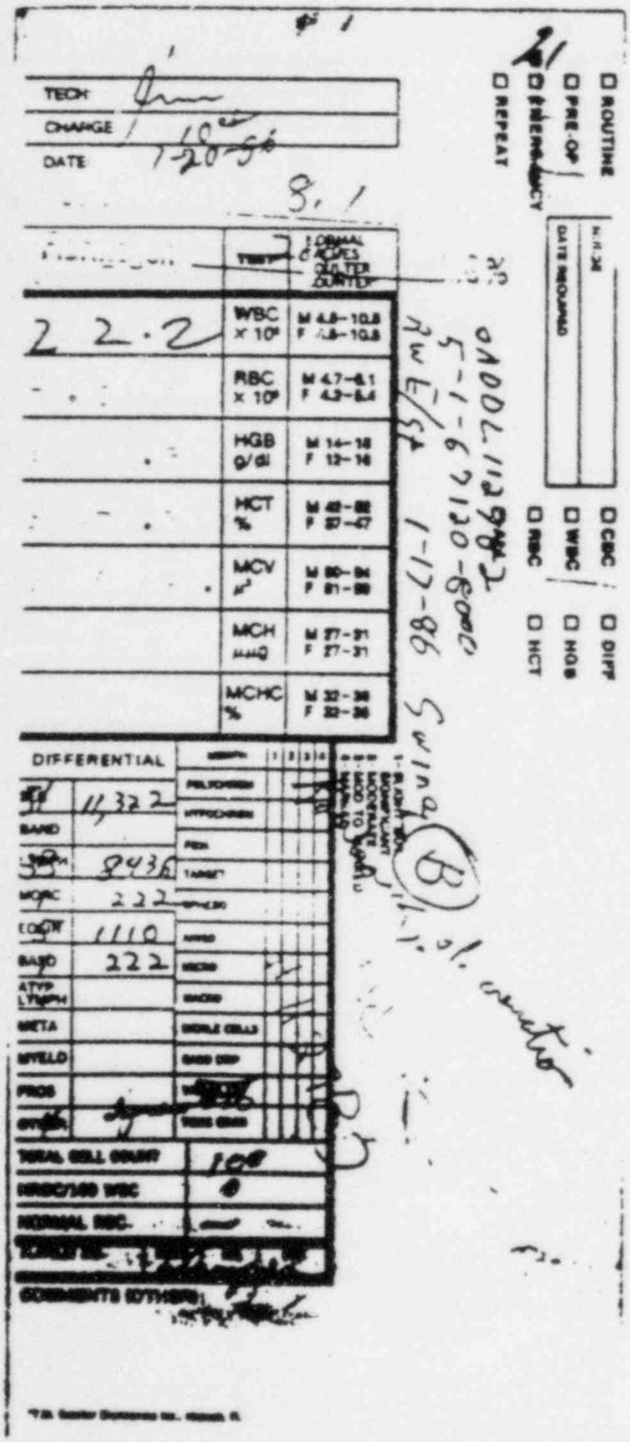
Dear Mr. Garver:

Attached hereto are the results of tests performed by an outside laboratory to which materials were referred from the above referenced case.

Sincerely,

Ray W. Ely, DVM, PhD
Pathologist

RWE/cas



#1

TECH	Jim
CHARGE	10
DATE	1-20-86

8.1

☐ ROUTINE
☐ PRE-OP
☐ EMERGENCY 21
☐ REPEAT

M.R.#

DATE REQUIRED

☐ CBC ☐ DIFF
☐ WBC ☐ HGB
☐ RBC ☐ HCT

0ADDL112942
5-1-67130-8000
RWE/St 1-17-86 Swing

	TEST	NORMAL VALUES
22.2	WBC × 10³	M 4.8–10.8 F 4.8–10.8
	RBC × 10⁶	M 4.7–6.1 F 4.2–5.4
	HGB g/dl	M 14–18 F 12–16
	HCT %	M 42–52 F 37–47
	MCV µ³	M 80–94 F 81–99
	MCH µµg	M 27–31 F 27–31
	MCHC %	M 32–36 F 32–36

DIFFERENTIAL		[illegible]	1	2	3	4
SEG	11,322	POLYCHROM				
BAND		HYPOCHROM				
LYMPH	8436	POIK				
MONO	222	TARGET				
EOSIN	1110	ANISO				
BASO	222	MICRO				
ATYP LYMPH		MACRO				
META		SICKLE CELLS				
MYELO		BASO STIP				
PROS						
OTHER		TOXIC GRAN				

1-SLIGHT
2-SIGNIFICANT
3-MODERATE
4-MOD TO MARKED

TOTAL CELL COUNT	100
NRBC/100 WBC	0
NORMAL RBC	
PLATELETS	

COMMENTS (OTHER):

(B)

1.0% reactio

OSU
Oklahoma State University
OKLAHOMA ANIMAL DISEASE DIAGNOSTIC LABORATORY

STILLWATER, OKLAHOMA 74078
(405) 624-6623

January 20, 1986

Mr. Butch Garver
P. O. Box 393
Gore, Oklahoma 74435

Case No.: 112782
Owner: 5R

Dear Mr. Garver:

Two pigs are presented to necropsy with clinical history of several in the herd not doing well and an increased mortality rate.

POSTMORTEM EXAMINATION: The small white pig (A) appeared extremely emaciated with approximately 2-3 inches of the rectum prolapsed through the anus. Internal gross lesions revealed extensive patchy foci of necrosis involving the rectal mucosa with extension to involve the mucosa of the spiral colon. There were no other significant gross lesions noted. Pig (B) (2½ month old Duroc) revealed extremely heavy numbers of Trichura sp. (whipworms embedded within the mucosa of the rectum, spiral colon and cecum with the presence of a relatively fluid fecal material. Examination of the nasal cavity revealed a heavy catarrhal exudate present with associated complete loss.

POSTMORTEM CONCLUSION: Pig A - Emaciation, prolapsed rectum, moderate to severe necrotizing colitis; Pig B - severe whipworm infection, atrophic rhinitis of both the dorsal and ventral turbinates. There are no other significant gross lesions noted.

COMMENTS: Several pathologic processess are evident in both pigs of either infectious and parasitic origin and probably account for the increased mortality and "poor doers" in this herd. Other tests are being performed and further reports are pending.

Sincerely,

Ray W. Ely

Ray W. Ely, DVM, PhD
Pathologist

RWE:mf

CENTENNIAL DECADE
1980 • 1990

Accession No. [illegible]

RECEIVED
JAN 1 0 1986
OKLAHOMA ANIMAL DISEASE DIAGNOSTIC LABORATORY

DIAGNOSTIC LABORATORY
[illegible]
OKLAHOMA STATE UNIVERSITY
[illegible]

Telephone: 405-624-6623

Case No. ____

If a related case (e.g. paired serum) has been sent to the laboratory please indicate the [illegible]

Condition of Specimen:
☐ Excellent
☐ Autolyzed
☐ Other (Specify)

Cl

PLEASE FILL OUT COMPLETELY WITH BLACK INK

5R

OWNER ____
ADDRESS X
ZIP ____
PHONE 918 773 8704
DATE SUBMITTED 1-10-86

VETERINARIAN DR. [illegible] W. MILLER
ADDRESS BOX 847
W[illegible], OK 74[illegible]
ZIP ____
PHONE 918 463 2987
Location of Case (County & State) Sequoyah, Okla

Delivered by: Veterinarian ____ Mail ____ Owner ____ Other (Specify) Brought By Ken McGee [illegible], Bill McCrosky

HISTORY

SPECIES Swine BREED X AGE 2½ da [✓ mo] yr SEX ____ WEIGHT ____
NUMBER IN HERD (FLOCK) 25 NUMBER SICK (excluding dead) 12 NUMBER DEAD 7
RAISED ON OWNER'S PREMISES? YES ✓ NO ____ IF PURCHASED, WHEN? ____
ANY RECENT INTRODUCTIONS TO HERD (FLOCK)? YES ? DATE INTRODUCED ____ NO ____
FIRST NOTICED SICK 1-14-86
CLINICAL SIGNS (INCLUDE TEMPERATURES) & POSTMORTEM FINDINGS

Hogs Purchased by Ken McGee for Diagnosis
Box 393,
Gore Okla 74439
phone 918- 4895527

VACCINATION HISTORY (DATES)
FIELD DIAGNOSIS Rhinitis Swine Dysentery - Lung Worms —

✓ MATERIALS SUBMITTED	HOW MANY?	✓ REFRIGERATED	✓ FROZEN	✓ IN FORMALIN
☑ Live Animal	2	☐	☐	☐
☐ Dead Animal		☐	☐	☐
☐ Fetus		☐	☐	☐
☐ Blood (Clotted)		☐	☐	☐
☐ Blood (Anticoag)		☐	☐	☐
☐ Serum		☐	☐	☐
☐ Kidney		☐	☐	☐
☑ Liver	1	☑	☐	☐
☑ Intestine	1	☑	☐	☐
☐ Lung		☐	☐	☐
☐ Tumor (Show location on model)		☐	☐	☐
☐ Spleen		☐	☐	☐
☐ Brain		☐	☐	☐
☐ Lymph Node (origin)		☐	☐	☐
☐ Eyeball		☐	☐	☐
☐ Milk		☐	☐	☐
☐ Urine		☐	☐	☐
☐ Cerebrospinal Fluid		☐	☐	☐
☐ Stomach Contents		☐	☐	☐
☐ Swab (origin)		☐	☐	☐
☐ Feed (origin)		☐	☐	☐
☐ Water		☐	☐	☐
☐ Other		☐	☐	☐
☐ Other		☐	☐	☐

P16-


Ventral


Dorsal

✓ EXAMINATIONS REQUESTED
☑ Necropsy
☑ Histopathology*
☐ Cytology
☐ Mycoplasma Isolation
☑ Bacteriology
☐ Antibiotic Sensitivity
☐ Virus Isolation & Identification**
☑ Parasitology floatation
☐ Mycology
☑ Hematology CBC
☐ Fluorescent Antibody (Specify test ____)
☐ Serology (Complete form, opposite side)
☐ Toxicology** (Specify test ____)
☐ Other [illegible] Path - Ca. Phos Mg K

* Frozen tissues not suitable.
** Formalin fixed tissues not suitable.

(Please record additional information on reverse.)

Revised April, 1979

112782

SEROLOGY

SAMPLE INFORMATION

Animal Identification						Lab Use
Tube	Name/No.	Species	Breed	Sex	Age	Only

*Samples for serology should be collected in sterile vacutainer tubes without anticoagulant. B-D tubes are satisfactory. Brucellosis tubes and some other vacuum tubes frequently contain toxic residues.

Laboratory charges are doubled for cases not owned by Oklahoma citizens.

TESTS REQUESTED

☐ Leptospira (includes pomona, ictero, grippo, hardjo, canicola) ($4.00)
☐ Anaplasmosis ($4.00)
☐ Neonatal isoerythrolysis (Complement-Lysis test requires neonatal blood in anticoagulant) ($4.00)
☐ Brucella abortus (Not official regulatory test except for swine) ($4.00)
☐ IBR ($4.00)
☐ BVD ($4.00)
☐ Bluetongue ($4.00)
☐ Pi3 ($4.00)
☐ Respiratory Syncytial Virus ($4.00)
☐ Bovine Leukemia Virus ($4.00)
☐ Chlamydia ($4.00)
☐ Cattle Abortion Profile (Lepto, IBR, BVD, Brucella) ($9.00)
☐ Cattle Respiratory Disease Profile (IBR, Pi3, BVD) ($7.00)
☐ Swine Abortion Profile (Lepto, Brucella, Parvovirus, Pseudorabies) ($9.00)
☐ Horse Abortion Profile (Lepto, Rhinopneumonitis, EIA-send EIA form) ($9.00)
☐ Sheep Abortion Profile (Lepto, Brucella, Bluetongue, Chlamydia) ($9.00)
☐ Swine Influenza Virus ($4.00)
☐ Swine Parvovirus ($4.00)
☐ Pseudorabies ($4.00)
☐ TGE ($4.00)
☐ Brucella canis ($4.00)
☐ Canine Distemper (Serum or CSF) ($4.00)
☐ Feline Leukemia (need unfixed blood smears) ($4.00)
☐ EIA ($5.00)
☐ Equine Rhinopneumonitis ($4.00)
☐ Equine Influenza 1 ($4.00)
☐ Equine Influenza 2 ($4.00)
☐ Other ______
☐ Other ______
☐ Other ______
☐ Other ______

ADDITIONAL REMARKS

4-5 dead pigs

Urine exam - ck Uranium hexaflouride

Poor doing pigs

[illegible]

Oklahoma State University

OKLAHOMA ANIMAL DISEASE DIAGNOSTIC LABORATORY

STILLWATER, OKLAHOMA 74078
(405) 624-6623

January 21, 1986

Mr. Butch Garver
P.O. Box 393
Gore, Oklahoma 74435

Case No.: 112782
Owner: 5R
Referral Lab.: Boren Veterinary Medical
Teaching Hospital
Parasitology Laboratory
Oklahoma State University
Stillwater, Oklahoma 74078

Dear Mr. Garver:

Attached hereto are the results of tests performed by an outside laboratory to which materials were referred from the above referenced case.

Sincerely,

Ray W. Ely

Ray W. Ely, DVM, PhD
Pathologist

RWE/cas

OSDDL 112782
5-1-67120-8000

117
RUE/lst

Dr Miller - swine (B)

TEACHING HOSPITAL
Oklahoma State University

PARASITOLOGY LABORATORY REPORT

Student ____________ Teaching ☐
Staff ____________ Non-Teaching ☐
Clinician ____________

RESULTS

Fecal exam — **No/hpf**

1. Coccidia (genus) ____________ ____
2. Giardia (cyst ____________ troph ____________) ____
3. Trichomonas (____________ troph ____________) ____
4. Tapeworm (genus) ____________ ____
5. Ancylostoma ____
6. Strongyles ____
7. Ascaris ____
8. Parascaris ____
9. Toxascaris ____
10. Toxocara ~~[illegible]~~
11. [illegible]
12. Other ____
13. ____________ ____
14. No eggs, larvae or protozoa demonstrated ____

Blood Examination/Serology

1. Dipetalonema ____
2. Dirofilaria ____
Other ____________ ____
None Demonstrated ____
Other Specimen Type ____________

Gross Parasite Identification ____________

Comments

Examined by AM 1-20-80

HISTORY

Weight ____________ No. Animals ____________ No. Sick ____________ County ____________

Antiparasiticide Yes ☐ What date ____________ No ☐ Unknown ☐

CLINICAL SIGNS:

Diarrhea: No ______ Yes ______ Pale Mucous Membranes: Yes ______ No ______ Nutritional Status: Good ______ Fair ______ Poor ______

Tarry ______ Vomition: Yes ______ No ______ CNS Signs: Yes ______ No ______

Blood ______

Mucoid ______ Coughing: Yes ______ No ______ Dermatitis: Yes ______ No ______

Watery ______

Other ______ Edema: Yes ______ No ______

Routine Physical: Yes ______ No ______ Tentative Diagnosis ____________

SPECIMEN (S):

Time Collected: Date ______ Hour ______

Paid Charge $3.00

Blood ______ If Gross Parasite, ______ Check Location:

Feces ______ Passed in Feces ______ Small Intestine ______

Other ______ Vomitus ______ Large Intestine ______

Skin ______ Other ______

Stomach ______

TEST DESIRED:

Blood ______ Baermann ______ [illegible] ______ [illegible] ______ Parasite Identification ______

Flotation ______ Identification ______ [illegible]

Sedimentation ______ Gross Worms in Feces ______ [illegible] ______ Skin Scraping ______

PARASITOLOGY LABORATORY REPORT

APPENDIX 5.1.1

AIR SAMPLE ANALYSES BY SFC AND ORNL

SEQUOYAH FUELS CORPORATION

POST OFFICE BOX 25861 • OKLAHOMA CITY, OKLAHOMA 73125

January 27, 1986

FEDERAL EXPRESS

Mr. Edward Shum
Uranium Fuel Licensing Branch
Division of Fuel Cycle & Material Safety
Office of Nuclear Material Safety & Safeguards
United States Nuclear Regulatory Commission
Willste Building
7915 Eastern Avenue
Silver Spring, Maryland 20912

Re: License SUB-1010
Docket 40-8027

Dear Mr. Shum:

During our telephone conversation on Monday, January 20, 1986, concerning NRC's evaluation of the UF_6 release at the Sequoyah Facility on January 4, you asked for background information on several items. Sequoyah Fuels continues to assemble and evaluate the data obtained from sampling following the accident. As those data are finalized, they will be submitted to NRC for its use. We provide the information below:

1. Describe the plant and residential potable water supply sources for the area south of the plant which may have been in the path of the plume.

   The plant potable water supply is provided by a pipeline from the Lake Tenkiller reservoir. The subject area residences are served by Rural Water District #5 which buys water from the Sequoyah County Rural Water Supply Association. The water comes from the Tenkiller reservoir. Ron Barnett, Sequoyah County Health Department, indicates all residences south of the facility and I-40 are on the rural water system for potable water. They are in the process of confirming this.

2. Is the Robert S. Kerr Reservoir used as a potable water source?

   To SFC's and the Sequoyah County Health Department's knowledge, it is not. The water is for recreational purposes.

3. Please provide a map showing the location of residences south of I-40 in the probable downwind plume direction.

   Attached is a map showing the residences, identified by family name. Additionally, known livestock assemblages in the area on the day of the release are noted. A key to the map is provided for reference noting family size and where sampling of livestock was done. Livestock sampling results will be submitted when completed.

A SUBSIDIARY OF KERR-McGEE CORPORATION

A map of the subject area, assembled from USGS quadrangle maps is also provided for your use. The USNRC on-site response team was provided with mylars of the subject study area, this map was one of them.

4. Please provide facility weather data for January 4, 1986. Information concerning temperature, relative humidity and general description (visibility) besides the wind speed and direction would be helpful.

   The plant wind speed and direction chart for the accident period are attached with reference to 11:30 AM, January 4, 1986 noted (1400 on the graph). Data from the Ft. Smith station concerning wind speed, direction, temperature and humidity are attached. The Oklahoma City station data for 11:00 AM, January 4, 1986 is also provided.

5. Please provide the results of uranium and fluoride analysis for the environmental air monitoring stations around the facility and off-site locations for the periods before, during and after the UF_6 release.

   The data for the fenceline and off-site monitor stations are attached. Sampling was done according to those procedures prescribed in license SUB-1010, Chapter 5.

6. Please provide the results of urinalysis taken of employees and off-site residents.

   This data was submitted on January 22, 1986, under separate cover to NRC Region IV. A copy was submitted to William Crow, NRC staff. Any updates to this submittal will be forwarded.

7. Have measurements been made to determine the amount of UF_6 that was potentially released to the environment?

   At the time of the release emergency actions were taken which included water spray, with fog nozzles, to minimize the release. The resulting wash down water was routed to the facility emergency basin for positive containment. Analysis of the basin contents resulting from the response action, shows that approximately 9,250 pounds uranium were recovered. This is 13,700 pounds of UF_6 or about 46 percent of the material believed to have been in the cylinder. Further analysis of sod removed from in front of the building and facility decontamination solutions continues and these amounts will be added as they are reported.

Please contact me if you need further information at this time.

Sincerely,

J.C. Stauter

J.C. Stauter, Director
Nuclear Licensing & Regulation

JCS/br

Attachments As Stated

cc: Robert L. Craig, Oklahoma State Department of Health

SEQUOYAH FACILITY
FENCELINE AIR SAMPLING

Sampling Time	E-1 EAST		E-2 WEST		E-3 SOUTH		E-4 NORTH	
	MPC	Fluoride	MPC	Fluoride	MPC	Fluoride	MPC	Fluoride
01/01/86 (0001) to 01/01/86 (2400)	0.16		0.18		0.18		0.17	
01/02/86 (0001) to 01/02/86 (2400)	0.32		0.38		0.42		0.34	
01/03/86 (0001) to 01/03/86 (2400)	0.17		0.22		0.28		0.28	
01/04/86 (0001) to 01/04/86 (1800)	154.0	0.1*	0.15	0.0015*	0.28	0.018*	0.22	0.0028*
01/04/86 (1800) to 01/05/86 (1030)	0.90		0.40		0.46		0.50	
01/05/86 (1030) to 01/05/86 (2400)	0.19		0.19		0.28		0.19	
01/06/86 (0001) to 01/06/86 (1600)	0.19		0.20		0.20		0.15	
01/06/86 (1600) to 01/07/86 (1600)	<0.05		0.08		0.06		0.08	
01/07/86 (1600) to 01/08/86 (1600)	0.06		0.07		0.06		<0.05	
01/08/86 (1600) to 01/09/86 (1600)	<0.05		<0.05		<0.05		<0.05	
01/09/86 (1600) to 01/10/86 (1700)	2.00		<0.05		<0.05		<0.05	
01/10/86 (1700) to 01/11/86 (1800)	0.07		0.09		0.10		0.10	
01/11/86 (1800) to 01/12/86 (1500)	0.40		0.52		0.46		0.46	
01/12/86 (1500) to 01/13/86 (2400)	0.20		0.20		0.18		0.18	
01/14/86 (0001) to 01/14/86 (2400)	0.40	0.0021**	0.64	0.0020**	0.64	0.0005**	0.64	0.0022**
01/15/86 (0001) to 01/15/86 (2400)	0.18		0.40		0.48		0.30	

Fluoride results reported in ugm/l
Fluoride detection limit is 0.0005 ugm/l
* On 12/31/85 (1200) Off 01/04/86 (1800)
** On 01/04/86 (1800) Off 01/14/86 (1200)
Sampling rate for fluoride is 0.2 cfm.
Fluoride collected on calcium-impregnated filter paper.

Radionuclide results reported as fraction of MPC
MPC = 5 x 10^{-12} uCi/ml
Detection limit is 2.5 x 10^{-13} uCi/ml (daily)
Sampling rate for radionuclides is 1 cfm.

SEQUOYAH FACILITY
OFF-SITE ENVIRONMENTAL AIR SAMPLING

	2103		2105		2106		2107		2108	
Sampling Time	MPC	Fluoride	MPC	Fluoride	MPC	Fluoride	MPC	Fluoride	MPC	Fluoride
12/10/85 (1200) to 12/17/85 (1200)	<0.007	<0.0005	<0.007	<0.0005	<0.007	<0.0005	<0.007	<0.0005	<0.007	<0.0005
12/17/85 (1200) to 12/24/85 (1200)	<0.007	<0.0005	<0.007	<0.0005	<0.007	<0.0005	<0.007	<0.0005	<0.007	<0.0005
12/24/85 (1200) to 12/31/85 (1200)	<0.007	<0.0005	<0.007	<0.0005	<0.007	<0.0005	<0.007	<0.0005	<0.007	0.00066
*12/31/85 (1200) to 01/04/86 (1800)	<0.007	0.0038	<0.007	0.00351	<0.007	0.00307	<0.007	0.00402	2.6	0.0038
*01/04/86 (1800) to 01/05/86 (1100)	<0.05		<0.05		<0.05		<0.05		<0.05	
*01/05/86 (1100) to 01/06/86 (1630)	<0.05		<0.05		<0.05		<0.05		<0.05	
01/06/86 (1630) to 01/07/86 (1530)	<0.05		<0.05		<0.05		<0.05		<0.05	
*01/07/86 (1530) to 01/08/86 (1530)	<0.05		<0.05		<0.05		<0.05		<0.05	
*01/08/86 (1530) to 01/09/86 (1530)	<0.05		<0.05		<0.05		<0.05		<0.05	
*01/09/86 (1530) to 01/10/86 (1700)	<0.05		<0.05		<0.05		NS		<0.05	
*01/10/86 (1700) to 01/11/86 (1700)	<0.05		<0.05		<0.05		<0.05		<0.05	
*01/11/86 (1700) to 01/12/86 (1500)	<0.05		<0.05		<0.05		<0.05		<0.05	
*01/12/86 (1500) to 01/14/86 (1200)	<0.05	0.00061	<0.05	0.00068	<0.05	<0.0005	<0.05	0.00051	<0.05	<0.0005

Fluoride results reported in ug/l
Sampling rate for fluoride is 0.2 cfm.
Fluoride collected on calcium-impregnated filter paper.

Radionuclide results reported as fraction of MPC.
Sampling rate for radionuclides is 1 cfm.
MPC = 5 x 10^{-12} uCi/ml
Detection limit is 3.6 x 10^{-14} uCi/ml (weekly); 2.5 x 10^{-13} uCi/ml (daily)
*Final count done on 01/23/86

Locations:

2103 -- East, 1,000 feet from plant
2105 -- $\frac{1}{2}$ Mile southwest of plant
2106 -- Carlisle School
2107 -- Highway 64 north of plant
2108 -- I-40 south of plant

OAK RIDGE NATIONAL LABORATORY
OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.

POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37831

February 19, 1986

Mr. Barry Zalcman
US Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Springs, MD 20910

Dear Barry:

Enclosed are the particle size distribution measurements taken on the Sequoyah Nuclear Fuel air filters E-1 (ORNL #32129) and 2108 (Dec 31-Jan 4 sampling period). The tabular data shows the number of particles in each size range; the histogram indicates the same data in graphical form. The 2108 specimen was denoted "filter blank" by the microscopist, and two imaging modes were utilized to show the particles. The photographs are in pairs; one set is the conventional scanning electron image which shows all particles on the filter, while the greater intensity (brightness) of the backscattered SEM images indicates higher atomic numbered particles. From the backscattered images, we note that many of the particles were of low atomic numbered elements (aluminum and silicon) typical of airborne dirt. The 2108 filter contained relatively few uranium particles, compared to filter E-1.

We performed characteristic uranium x-ray "maps" of typical areas on the filter surfaces to verify the exact location and size of the uranium particles. Please note that an overlay of the SEM and the U maps identify the locations of the uranium particles.

Please notify me if we can be of further assistance in data interpretation.

Sincerely,

Joseph H. Stewart, Jr.

Joseph H. Stewart, Jr.
CAPA Group

JHS:lp

cc: W. R. Laing

Sequoyah Air Sample - E-1 (ORNL #32129)
Taken from 0001 Hours 1/4/86 - 1800 Hrs. 1/4/86

Class	Diameter, μm	No. of Particles
0	<.16	0
1	.16 - .32	0
2	.32 - .48	0
3	.48 - .64	0
4	.64 - .80	7
5	.80 - .96	11
6	.96 -1.11	27
7	1.11 -1.27	25
8	1.27 -1.43	32
9	1.43 -1.59	32
10	1.59 -1.75	16
11	1.75 -1.91	21
12	1.91 -2.07	8
13	2.07 -2.23	8
14	2.23 -2.39	9
15	2.39 -2.55	1
16	2.55 -2.71	1
17	2.71 -2.87	3
18	2.87 -3.02	1
19	3.02 -3.18	0
20	3.18 -3.34	0
21	>3.34	2

```
Class  No. Particles  Percent in Class
---------------      ---------------------------------------
   0  0
   1  0    0
   2  0    0
   3  0    0
   4  7    3 *******
   5 11    5 ***********
   6 27   13 ***************************
   7 25   12 *************************
   8 32   16 ********************************
   9 32   16 ********************************
  10 16    8 ****************
  11 21   10 *********************
  12  8    4 ********
  13  8    4 ********
  14  9    4 *********
  15  1    0 *
  16  1    0 *
  17  3    1 ***
  18  1    0 *
  19  0    0
  20  0    0
  21  2      **
---------            ---------------------
```

Sample - Filter Blank

Class	Diameter, μm	No. of Particles
0	<.53	0
1	.53- .61	3
2	.61- .69	2
3	.69- .77	3
4	.77- .85	1
5	.85- .93	1
6	.93-1.01	2
7	1.01-1.09	2
8	1.09-1.17	3
9	1.17-1.25	1
10	1.25-1.33	2
11	1.33-1.41	1
12	1.41-1.49	0
13	1.49-1.57	0
14	1.57-1.64	0
15	1.64-1.72	0
16	1.72-1.80	0
17	1.80-1.88	0
18	1.88-1.96	2
19	1.96-2.04	0
20	2.04-2.12	0
21	>2.12	0

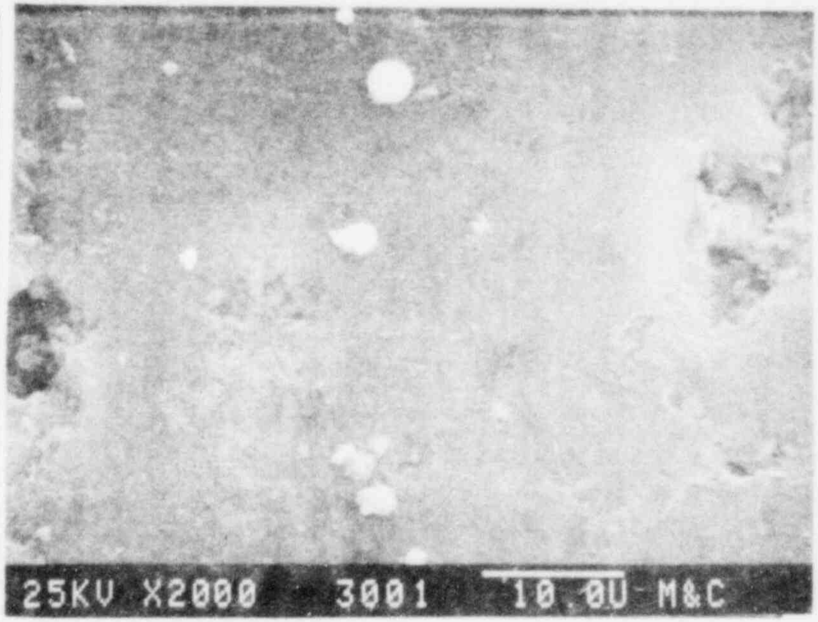
```
Class  No. Particles  Percent in Class
---------------------------------------------------------------------
  0  0
  1  3  13 *******************************************
  2  2   9 *****************************
  3  3  13 *******************************************
  4  1   4 **************
  5  1   4 **************
  6  2   9 *****************************
  7  2   9 *****************************
  8  3  13 *******************************************
  9  1   4 **************
 10  2   9 *****************************
 11  1   4 **************
 12  0   0
 13  0   0
 14  0   0
 15  0   0
 16  0   0
 17  0   0
 18  2   9 *****************************
 19  0   0
 20  0   0
 21  0
---------------------------------------------------------------------
```

OAK RIDGE NATIONAL LABORATORY
ANALYTICAL CHEMISTRY DIVISION

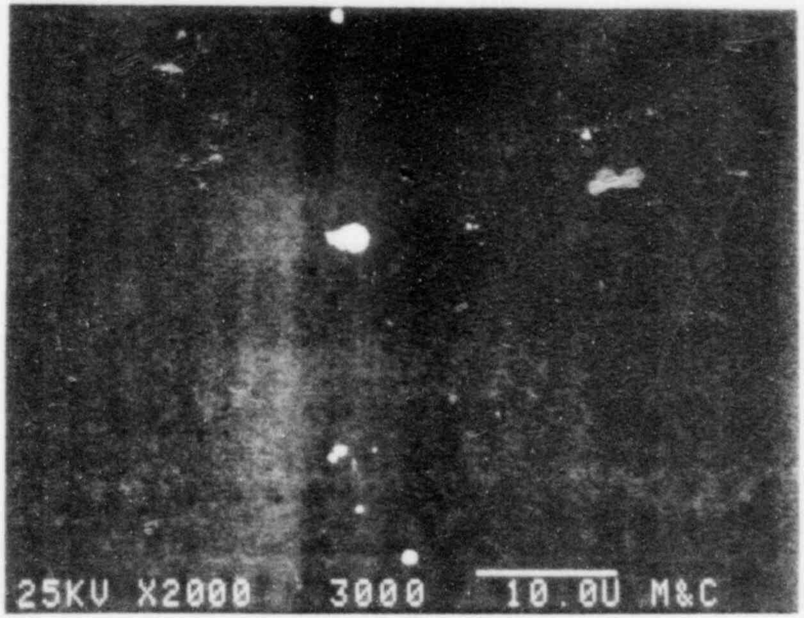
PHOTOGRAPHIC REPORT SHEET

BUILDING	Willste Bldg. RM 517
PHONE	8-427-4216
NAME	Barry Zalcman
ACD REQ. NO.	51195
SAMPLE NO.	9007 B
DATE	2/18/86
COMMENTS	

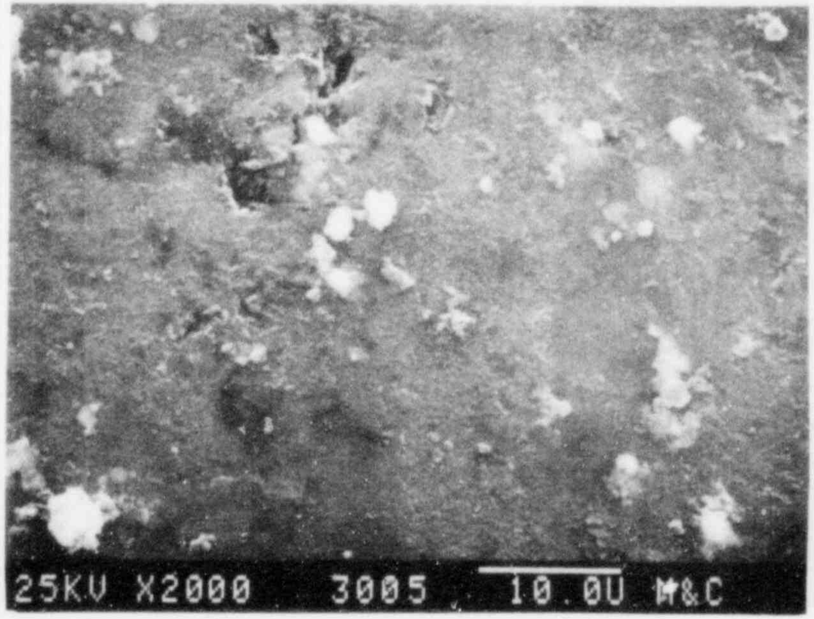
Sample Filter Blank
S - M&C
Mag: 2000X



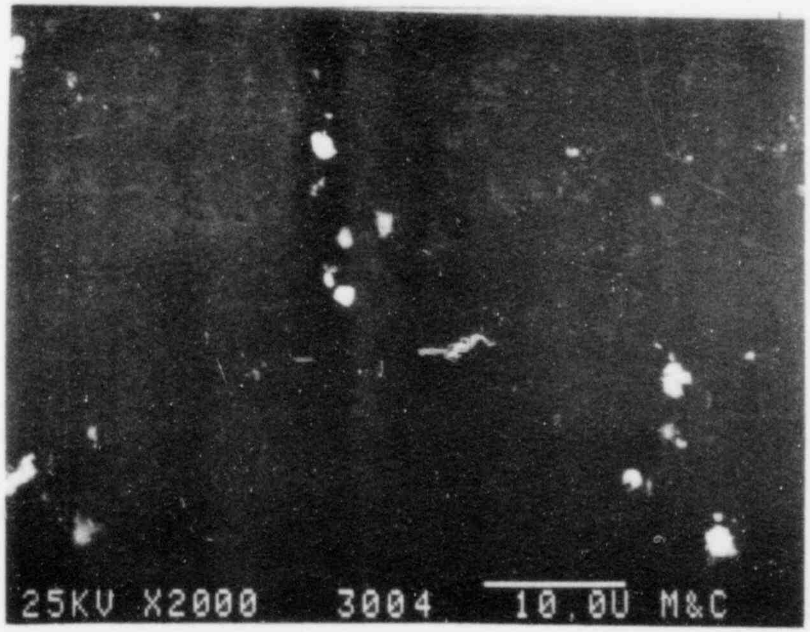
Sample Filter Blank (Backscatter Image)
S - M&C
Mag: 2000X



Sample Filter Blank
S - M&C
Mag: 2000X



Sample Filter Blank (Backscatter Image)
S - M&C
Mag: 2000X



Other photos in this set were omitted because they were difficult to reproduce.

APPENDIX 5.2.1

INTERORGANIZATIONAL COMPARISON RESULTS

Interlaboratory Comparison Results

	OSDH	KMTC			ORNL		
	F	F	U	wt Loss	F	U	wt Loss
Water	mg/ℓ	mg/ℓ	mg/ℓ		µg/ml	ppm	
COMP-3	.45	.4	.018		.38	≤.03	
COMP-4	.27	.1	<.002		.06	≤.03	
COMP-5	.24	.2	<.002		.18	≤.03	
Soil	mg/kg	ppm	ppm	%	µg/g	µg/g	%
COMP-1	5.44	90	72	24.3	-	-	-
COMP-2	2.76	70	23	26.0	2.9	8.4	26.2
COMP-3	1.96	90	15	25.6	4.6	6.1	26.1
COMP-4	1.48	140	<10	26.6	2.2	4.0	26.8
COMP-5	5.6	80	15	25.4	2.6	5.2	26.2
Vegetation	mg/kg	ppm	ppm	%	µg/g	µg/g	%
COMP-1	488	250	900	17.8	390	4970	16.8
COMP-2	164	90	80	22.5	128	44	20.7
COMP-3	238	120	160	19.0	144	22	18.3
COMP-4	7.36	17	.95	16.1	5	1.2	14.8
COMP-5	10.8	18	3	11.8	18	4.9	10.6

Note: Fluoride in soil from KMTC includes soluble and insoluble fluoride; fluoride in soil from OSDH and ORNL only includes soluble fluoride.

APPENDIX 5.2.2

K-M TECHNICAL CENTER LABORATORY ANALYSIS PROCEDURES

SEQUOYAH FUELS CORPORATION

POST OFFICE BOX 25861 • OKLAHOMA CITY, OKLAHOMA 73125

January 27, 1986

FEDERAL EXPRESS

Donald A. Cool, Ph.D.
Uranium Fuel Licensing Branch
Division of Fuel Cycle & Material Safety
Office of Nuclear Material Safety & Safeguards
United States Nuclear Regulatory Commission
Willste Building
7915 Eastern Avenue
Silver Spring, Maryland 20912

Re: License SUB-1010
Docket 40-8027

Dear Dr. Cool:

Per your request of Friday, January 24, 1986, attached are the Kerr-McGee Technology Diviison, Technical Center analytical procedures, equipment list and calibration procedures applicable for the analysis of samples from the Sequoyah Facility.

Copies of these procedures were provided to Dr. Blair Nickolas, USNRC Region IV, during a visit to the Technical Center on January 7, 8, 9 and 10, 1986.

If you have any further questions concerning the analytical procedures or quality control/quality assurance protocols used, please contact Dr. Garet Van de Steeg at (405) 341-8551.

Sincerely,

J.C. Stauter

J.C. Stauter, Director
Nuclear Licensing & Regulation

JCS/br

Attachments

A SUBSIDIARY OF KERR-McGEE CORPORATION

APPENDIX I

EQUIPMENT LIST AND CALIBRATION PROCEDURES

Appendix I

FUNCTIONS AND USE

A. Instrumentation for the Detection of Nuclear Events

1. Gamma Radiation

a. A Packard Auto-Gamma Multi-Channel Analyzer is a sodium iodide based gamma detection system. This analyzer is used for routine gamma spectral analysis where only limited spectral resolution is required. This instrument has a 300-sample capacity automatic sample changer, a 1024 channel multi-channel analyzer for storing the data, and a teletype for recording the spectral information. The entire system is situated in a controlled environment room where temperature is maintained at 21°C ± 1°C. The system and its essential components are to be maintained as follows:

1) Maintenance and repair of electronic components are to be performed by the manufacturer as required.

2) The counting system should be effficiency calibrated during each 300-sample run and energy calibrated weekly.

3) Outage of electricity sufficient to cause loss of bias to the detectors, or repair of detector or electronics is cause for recalibration prior to further analyses being performed.

b. A Canberra Gemini Series 90 Gamma Pulse Height Analysis System is used for qualitative and quantitative analysis. Four gamma detectors, three wide range Ge(Li)s and an intrinsic Ge are situated in low background gamma shields fabricated from 6-inch thick pre WW-II steel plate. This system is used for absolute measurement of gamma emitting radionuclides. The entire system is situated in a controlled environment room where the temperature is maintained at 21°C ± 1°C. The system and its essential components are to be maintained as follows:

1) Maintenance and repair for electronic components are to be performed by the manufacturer as required, but at least twice yearly.

2) Ge(Li) and Ge detector dewars are to be filled with liquid nitrogen weekly. The date of the liquid N_2 fill is to be logged into a file maintained at the detectors.

3) The Ge(Li) and Ge detectors are calibrated at least quarterly, and checked at least weekly, for efficiency and energy calibrations using standards directly traceable to the U. S. National Bureau of Standards.

2. Alpha and Beta Radiation

a. A Canberra Model 2400 Low-Background Gas Proportional Counter is used for the detection of alpha and/or beta radiation. The thin-window (gold-coated mylar) detector is used to detect alpha and beta particles from the sample. The sample detector is one part of the detector system, the other part being an aluminum cased guard detector. The alpha and beta particles from the sample pass easily through the mylar window, but are stopped before entering the aluminum cased guard detector. The guard detector is used to detect background radiation from cosmic radiation and gamma radiation, which might register as a detected particle. The guard detector is used in an anticoincidence mode to reject unwanted background. The sample counted is mounted in a two inch planchet, allowing for the counting of precipitates and electrodeposits. The system has an automatic sample changer and microprocessor control for unattended operation. Up to five distinct programs may be entered, with variables such as sample number, preset time, bias voltage, discriminator window, efficiencies, and backgrounds entered for each program. The entire system is situated in a controlled environment room where temperature is maintained at 21°C ± 1°C. The system and its essential components are to be maintained as follows:

1) Maintenance and repair of electronic components are to be performed by manufacturers as required.

2) Efficiency calibration and plateau curves should be verified every three months, and following each repair.

b. A Packard Tricarb Liquid Scintillation Spectrometer is used for the detection of alpha and/or beta radiation. This is a two-channel instrument which is capable of detecting two different radiation energies, or isotopes, simultaneously. The samples to be analyzed are first put in liquid form (in water, toluene or dioxane) and then mixed with special fluorescent materials. The nuclear radiation excites the fluorescent materials which, subsequently, fluoresce (emit light) and this light is detected by photomultiplier tubes. This is an automatic instrument capable of handling up to 150 samples at a time and can be operated overnight unattended. The entire system is situated in a controlled environment room where temperature is maintained at 21°C ± 1°C. The system and its essential components are to be maintained as follows:

1) Maintenance and repair of electronic components are to be performed by the manufacturer as required.

2) The counting system should be efficiency and energy calibrated at least once a year.

3) The system should have its "normalization" checked every three months.

4) Repair of detector or electronics is cause for recalibration prior to further analyses being performed.

c. Two Ludlum Model 148 (GEV-1) Scintilation Counters are used for the detection of alpha radiation. These are five-station scintillation counters using photomultiplier tubes to count the light pulses emanating from the zinc sulfide detectors. The zinc sulfide detectors are disposable mylar disks coated with ZnS(Ag) which are placed in intimate contact with, and atop, the sample to be counted. The sample may be either a precipitate mounted on a filter paper or a deposit mounted on a stainless steel disk. The system is manually operated. The background is typically less than one count per 1000 minutes. The system is to be maintained as follows:

1) Maintenance and repair of electronic components are to be performed by the manufacturer as required.

2) The counter is to have its efficiency calibrated every three months and a "plateau" curve checked yearly; each of these checks are to be run following any repair.

d. A Nuclear Measurements PC-4 Proportional Counter is used for alpha or beta counting. This is a manually operated, windowless, P-10 gas, proportional counter which is used to calibrate reference alpha or beta standards. Additionally, this counter is used for routine, but infrequent, low-level alpha or beta counting of selected samples. The entire counter is situated in a controlled environment room where temperature is maintained at 21C° ± 1°C. The counter is to be maintained as follows:

1) Maintenance and repair of electronic components are to be performed by the manufacturer as required.

2) The counting chamber is to be removed, checked and cleaned (if necessary) every three months.

3) The counting efficiency should be recalibrated every three months following the maintenance described in 2) above.

e. A Random Scintillation Counter is used for radium determinations by radon emanation. This photomultiplier tube based unit counts light pulses originating from within Lucas cells (containing radon) placed atop the PMT's. The interiors of the Lucas cells are coated with zinc sulfide which transforms the alphas emitted by radon and radon daughters to light pulses. The counter is to be maintained as follows:

1) Maintenance and repair of electronic components are to be performed by the manufacturer as required.

2) The counter is to have its "plateau" curve checked yearly or following any repair.

3) The Lucas cells are to have their efficiency checked every three months or as required, whichever occurs first.

f. A Princeton Gamma Tech Silicon Surface Barrier System, in conjunction with a Canberra Model 8100 Multi-Channel Analyzer, Canberra Bias Supplies and Amplifiers, and Houston Omnigraphic X-Y Recorder, is used for alpha pulse height analysis. Actinide elements are chemically separated into individual elements which are subsequently eectrodeposited onto stainless steel disks. The disks are then placed inside a vacuum chamber and beneath a silicon surface barrier detector (PGT-300-25-100). The instruments analyze the alpha emitted by the sample for energy, the energy being indicative of the isotope undergoing decay. The entire system is situated in a controlled environment room where temperature is maintained at 21°C ± 1°C. The system and its essential components are to be maintained as follows:

1) Maintenance and repair for electronic components are to be performed by the manufacturer as required.

2) Detectors and associated electronics are to be calibrated for energy and efficiency at least quarterly using KMTC standard reference sources prepared from NBS or NBS-traceable standard reference materials.

3) Repair of detectors or electronics is cause for recalibration of affected components prior to further analyses being performed

g. A Ludlum Model 248 (GEV-2) Scintillation Counter is used for the detection of alpha and beta radiation. This is a five-station scintillation counter using photomultiplier tubes to count the light pulses emanating from the zinc sulfide and beta phosphor detectors. The zinc sulfide detectors are disposable mylar disks coated with ZnS(Ag) which are placed in intimate contact with, and atop, the sample to be counted. The beta phosphors are 1/64 inch thick, Pilot-B beta phosphor disks. The sample is precipitate mounted on a filter paper. The system is manually operated. The background is typically less than one count per 1000 minutes for alpha and 10 counts per minute for beta. The counter is situated in a controlled environment room where the temperature is maintained at 21°C ± 1°C. The counter is to be maintained as follows:

1) Maintenance and repair of electronic components are to be performed by the manufacturer as required.

2) The counter is to have its efficiency calibrated every three months and a "plateau" curve checked yearly; each of these checks are to be run following any repair.

h. Capability

With the present intsrumentation, we are capable of performing most types of radiometric analyses such as alpha, beta or gamma spectroscopy, Ra-226, Th-230 and total U, Pu, Th, etc. Additionally, virtually any radioactive isotope can be analyzed radiometrically should the need arise. Extremely low-detection levels are maintained such that we routinely analyze at levels of 1×10^{-15} curies.

i. Tracers

A program to use radioactive tracers in the study of problems relating to chemical processing, analysis and engineering is available. Radioactive tracers (isotopes) are used to simplify the often difficult problem of monitoring the disposition of materials in dilute systems or to simplify otherwise difficult or impossible analytical procedures. We are licensed to use any isotopes of atomic numbers 1 through 96 in any chemical form.

B. Inductively Coupled Argon Plasma Emission Spectroscopy (ICP)

An argon plasma is maintained by the interaction of an RF field with ionized argon gas and is reported to reach temperatures as high as 12,000°K near the top load coil. Analytical measurements are made at plasma observation heights that correspond to temperatues in the range of 5500-8000°K. These high temperatures ensure complete dissociation and effective atomization of the various sample matrix elements, thus minimizing chemical interferences.

In order to form an argon plasma, RF power is applied through induction coils which surround the quartz plasma torch assembly. This creates an oscillating magnetic field. Three separate argon streams ultimately determine the symmetry of the plasma. A tangential stream of argon (plasma gas) flows between the outer two quartz tubes of the ICP torch assembly. This stream produces a vortex stabilization of the plasma discharge. A secondary stream of argon (coolant gas) passes between the sample introduction jet and the adjacent concentric tube. The coolant gas flow lifts the discharge slightly above the tip of the sample introduction jet to protect the quartz jet from the intense heat. The sample aerosol is carried through the center quartz tube of the assembly via a third argon stream (carrier gas). The plasma is initiated when the argon is exposed to the discharge of a Tesla coil, thus creating seed electrons and ions making the gas conductive. Inside the induced magnetic field, the charged particles are forced to flow in a closed annular path. As the particles meet resistance to their flow, ohmic heating takes place and additional ionization occurs. The process occurs almost instantaneously, and the plasma expands symmetrically.

The basis of all emission spectroscopy is that atoms or ions in an energized state, either directly or indirectly as a result of heating, spontaneously revert to a lower energy state and so doing emit a photon of energy. The ICP method of heating offers a much better chance for avoiding the self-absorption and self-reversal effects that are characteristic of both arcs and flames.

The light emitted by analyte atoms or ions must be converted to electrical signals that can be measured quantitatively. This is done by resolving the light into its component radiation by means of a diffraction grating and then measuring selected light intensities with photomultiplier tubes at specific analyte wavelengths.

After appropriate analyte emission wavelengths are chosen, the spectrometer can be calibrated using standard solutions. Then, analyte concentrations can be determined for all sample solutions.

ICP Instrumentation

Applied Research Laboratories (ARL) Model 3520

This ICP is a sequential instrument with a scanning 1.0 meter vacuum monochromator. It is equipped with a 1080 lines/mm concave reflecting grating (produced using laser interferometry) with a horizontal Paschen-Runge mounting. Light intensities are measured by two photomultiplier tubes (PMTs), one for UV and the other for visible up to IR. The two PMTs are mounted on a carriage. Metal-dielectric-metal, narrow bandpass filters allow the use of higher orders to provide higher resolution. The positioning of the primary slit, the selection of filters, the setting of PMT millivoltages, the selection PMTs, and the selection of PMT positions are microprocessor controlled.

The radio frequency (RF) generator is a crytal controlled oscillator operating at 27.12 MHz.

The central processor unit (CPU) is comprised of a PDP 11/23 computer with 16 bit parallel logic. It is equipped with a real time clock, 256K bytes MOS memory and bootstrap.

The computer is also equipped with an RL01 disk controller, a VT 100 display terminal, and an LA-120 printer.

The SAS/DPS software is a program package consisting of an RT-11 system and an SAP-11 Spectrometer Automation Program.

This ICP system is to be maintained as follows:

1) Maintenance and repair of major components are to be performed by the instrument and computer manufacturer as required.

2) There will be yearly preventive maintenance conducted by an ARL service engineer.

3) A system log will be generated daily and compared to the specifications set by the manufacturer.

4) The nebulizer will be cleaned daily.

5) Sensitivity will be evaluated monthly as prescribed by the manufacturer.

C. Atomic Absorption Specroscopy (AAS)

Atomic absorption is an analytical technique that is used for the quantitative determination of metal concentrations in a wide variety of materials.

Atomic absorption is the process that occurs when a ground state atom absorbs energy in the form of light of a specific wavelength and is thus elevated to an excited state. The amount of light energy absorbed at this wavelength will increase proportionately as the number of atoms of the selected element in the light path increases. Therefore, the linear relationship between the various analyte concentrations present in calibration standards and the light absorbed by those standards can be used to determine unknown analyte concentrations present in sample solutions.

The basic instrumentation for atomic absorption requires a primary light source, an atom source, a monochromator to isolate the specific wavelength of light to be used, a detector to measure the amount of light accurately, electronics to treat the signal and a data logging device to display the results. The light source used is either a hollow cathode lamp (HCL) or an electrodeless discharge lamp (EDL). The atom source used must produce free analyte atoms from the sample. The source of energy for free atom production is heat, most commonly in form of an air-acetylene or nitrous oxide-acetylene flame or a graphite furnace. The sample is introduced as an aerosol into the flame and as a liquid into the graphite furnace. The flame burner head or furnace cell is aligned so that the light beam passes through the flame or graphite tube where the light is absorbed.

Atomic Absorption Instruments

a. Two Perkin-Elmer (PE) Model 460s

These are microcomputerized double-beam atomic absorption spectrometers. They are equipped with a PE safety interlock burner system for use with nitrous oxide-acetylene and air-acetylene flames. One of these is equipped with a PE Model HGA-500 graphite furnace for ultra-trace (low ppb) metals analyses. Hollow cathode and electrodeless discharge light sources are used. These systems are to be maintained as follows:

1) Maintenance and repair are to be performed by the manufacturer as required.

2) The burner system is to be cleaned with a Contrad 70 cleaning solution and rinsed with 1+1 hydrochloric acid and deionized water. This is to be done on a daily basis or more frequently if required.

3) The nebulizer system is to be cleaned on a daily basis with a Contrad 70 cleaning solution and rinsed with 1+1 hydrochloric acid and deionized water. Replace the needle assembly and venturi every six months or sooner if required. Aspiration rate is to be adjusted to ~6 ml/min.

4) Visual inspection of the optics for "clouding" should be performed every 3 months, or sooner if needed.

5) The D_2 arc output and alignment should be checked monthly, or sooner if required.

6) The HGA-500 graphite furnace is to be checked as follows:

   - Internal gas flows - check with bubble flow meter as described in the HGA-500 manual every 3 months, or sooner if required.

   - Replace furnace cones every 3 months, or sooner if required.

   - Replace furnace quartz windows every 3 months, or sooner if required.

   - Furnace cooling system - check every 3 months, or sooner if required.

   - Inspect and clean optical heat sensor before each analysis.

7) Sensitivity checks must be conducted every 3 months, or sooner if required.

8) A system log will be prepared on a daily basis and compared to the specifications set by the manufacturer.

b. Perkin Elmer (PE) Model 280

This single beam instrument is equipped with a PE safety interlock burner system for use with nitrous oxide-acetylene and air-acetylene flames. It is to be maintained using the same procedures as are used for the (PE) Model 460s.

The instrument was recently equipped with a 60 Hz mechanical chopper. Now EDLs can be used with the Model 280 specifically for hydride generation and cold vapor mercury analyses. The MHS-20 Hydride Generation Apparatus has been installed on the Model 280.

D. X-Ray Radiation

X-ray diffraction (XRD) and x-ray fluorescence (XRF) both utilize high energy electromagnetic radiation. This radiation is produced when electrons are "boiled off" the surface of a heated tungsten filament, and accelerated by a high voltage potential toward a suitable target. Primary x-rays are generated by the stepwise deceleration of high velocity electrons as they approach the atoms that make up the target of the x-ray tube. These x-rays, traveling in straight lines at the speed of light, exhibit properties of both waves and discreet particles. This duality allows them to interact with matter in several ways. Examples of wave properties are reflection, refraction, polarization, coherent scatter, velocity and diffraction. Examples of corpuscular properties are incoherent scatter, gas ionization, photoelectric absorption and scintillation production.

X-ray diffraction occurs when x-rays are scattered by a crystalline material. The scattered x-rays will interact by constructive interference to yield diffracted rays. If x-rays of known wavelength λ impinge on a crystal whose lattice planes are separated by the distance d, the radiation will be strongly reflected at specific angles θ. Since the wavelength λ is known and the 2θ angles of the reflections measured, the corresponding values of d (lattice plane spacings) can be calculated. This phenomenon was investigated by W. L. Bragg and his father W. H. Bragg, and is defined as Bragg's equation: ($n\lambda = 2d \sin \theta$).

X-ray fluorescence occurs when primary x-rays create a vacancy by expelling an electron from the inner orbitals of the atoms of a sample. Electrons from orbitals that are farther away from the nucleus can then fall into the vacancy created. The difference in energy between the orbitals is emitted as a secondary x-ray of a precise quanta. This radiation is dispersed into the individual spectral lines by reflection at an analyzer crystal. The amount of the element present is related to the intensity of the secondary fluorescent radiation detected from the sample.

a. X-ray Diffraction (XRD) (Siemens D-500)

X-ray diffraction permits the rapid qualtitative identification of crystalline solids by yielding an XRD pattern that is characteristic for that crystalline material. This pattern is compared to the patterns of known compounds in the JCPDS literature

(Joint Committee for Powder Diffraction Standards) for matching. This search of the literature can be performed either manually or by computer. The entire JCPDS data base (40,000 compounds, inorganic and organic) can be searched by computer while the Siemac microprocessor is independently running a scan.

Quantitative x-ray diffraction analysis is also possible by analyzing a series of carefully chosen peaks present in both the samples and a prepared standard for the phases of interest.

With the automated sample changer, up to 40 samples may be run under the control of the PDP 11/23+ computer. This enables overnight, unattended operation for both qualtitative and quantitative analysis.

Unit cell refinement is also possible using the program, APPLE, and determination of crystallite size by the program CRYSIZ.

These x-ray analyses are nondestructive in nature and the sample is available afterwards for analysis by other techniques.

The Siemens D-500 system consists of a KRISTALLOFLEX 805 generator, thallium doped NaI detector with graphite monochromator, copper targeted x-ray tube (molybdenum optional), DIFFRAC V software package with JCPDS data base, Tektronix 4027A graphics terminal, DEC LA-120 printer, Hewlett-Packard 7220C graphics plotter, and DEC PDP 11/23+ computer for control of the 40 position sample changer and the goniometer.

Routine and emergency service is provided by Siemens under a yearly service contract. The following procedure will check on the alignment of the system optics. For the "five fingers of quartz" XRD scan, analyze the novaculite standard under the following conditions and compare to previous scans.

Slit Number	Degrees	KV	MA	Det. Volt
I	1	40	30	1050
II	1			
III	1	Time Constant = 1 second		
IV	.018	Goniometer speed = 1/5 per min		
V	.15	Chart speed = 2 cm/minute		

Scale = 1 x 10^3

Start the scan at 67.5 degrees and end at 68.7 degrees.

An additional check on the overall alignment may be performed by scanning the NBS silicon standard at .01 degree two-theta steps and counting for one second at each step. The program ADR is then run to locate the peaks and determine their intensities. The results of the scans are compared to previous scans.

Slit Number	Degrees	KV	MA
I	1	50	30
II	1		
III	1	Time constant = 1 second	
IV	.05		
V	.15		

Analyze the novaculite standard from 20.0 through 30.0 degrees two-theta and run the program ADR to locate the peaks and determine their intensities. Compare to previous scans.

Slit Number	Degrees	KV	MA
I	1	50	30
II	1		
III	1	Time constant = 1 second	
IV	.05		
V	.15		

b. X-Ray Fluorescence (XRF) (Siemens SRS-300)

X-ray fluorescence is a rapid qualitative and quantitative analytical method for the determination of elemental concentrations. It is useful over a wide range of concentrations and for a wide variety of samples. The Siemens SRS-300 automated sequential x-ray fluorescence unit is capable of detecting elements from boron (Z = 5) through uranium (Z = 92), but is presently configured to analyze from sodium (Z = 11) on up.

Under the control of the DEC PDP 11/23+ computer, up to 10 samples can be scanned under a wide range of operating parameters. The atmosphere of the sample chamber, the voltages, analyzing crystals, detectors, counting times, pulse height windows, soller slits, deadtime correction, filters, mask sizes, and sample rotation are under control of the computer. These can be varied to provide optimum analyzing conditions for each element and each matrix. Sample preparation is usually minimal, with grinding and pelletizing handling the majority of the samples submitted. The method is nondestructive; however, the sample usually has a binder added to it as an aid in pelletizing.

Routine and emergency service is provided by Siemens under a yearly service contract.

Presently, a synthetic ilmenite standard is being used as a check on the instrument's performance. A more durable standard would be beneficial for the long term. A polished metal alloy of known composition is something we hope to obtain shortly for use in verifing the instrument's operating condition.

E. Absorption of Ultraviolet, Visible and Infrared Light

a. Perkin-Elmer (PE) Model 1750 FT-IR

Instrumentation has been described which utilizes the emission of light for analysis. The converse, the absorption of light, is more adaptable for the analysis of ionic and molecular species in solutions, gases, and some solids, and it can also be used for the analysis of metal atoms in the atomic or ground state.

Fourier-Transform Infrared Spectroscopy (FT-IR) is a light absorption technique that employs the lower energy region of that part of the electromagnetic spectrum referred to as "light". Samples in solid, liquid or gaseous form are subjected to infrared radiation in the 2.5-25 micrometer wavelength range. When the energy of the radiation coincides with the proper energy to raise a molecule to an excited molecular state, the radiation is absorbed. The absorption energy is characteristic of the vibration (bending), stretching or rotation mode of the molecule. Infrared is principally used for the investigation of organic molecules.

b. The Varian Superscan I-BE is a recording ultraviolet (UV) - visible (Vis) spectrophotometer. Its range is from 190 to 900 nanometers (nm). Ultraviolet-Vis absorption spectroscopy employs the middle and higher energy region of that part of the electromagnetic spectrum referred to as "light". Samples in either solid, liquid, or gaseous form are subjected to UV or Vis radiation. When the energy of the radiation coincides with the energy of an electronic transition, an electron is promoted to a higher energy level and radiation is absorbed. The electronic may be either molecular (i.e., promoting an electron normally thought of as being associated with a chemical bond such as the UV absorption of aromatic molecules) or atomic (i.e., promoting an electron normally thought of as being associated with an atom such as d-d transition for "transition-series" elements in solution). Ultraviolet-Vis spectroscopy is principally used for the investigation of inorganic ions and inorganic complexes of "transition-series metals".

Other instruments available of this type, but less flexible, are the Beckman Models DU and DB.

c. A Jarrell-Ash Fluorimeter Model 26-000 is available for the determination of uranium in solid samples. Uranium in a mixed sodium-lithium fluoride melt will fluoresce under the influence of near ultraviolet light. The amount of fluorescence is dependent upon the quantity of uranium-VI present. Typical sensitivities are on the order of 1 to 5 parts per billion uranium.

d. Calibration Procedure

The spectrophotometers are situated in several areas of the KMTC and, at times, are moved to other locations. They are to be maintained as follows:

1) Maintenance and repair are to be performed by the manufacturer as required or at their direction.

2) Efficiency and/or wavelength calibrations, as required, will be performed prior to analysis of each sample set.

3) Wavelength calibrations will be checked at least annually.

F. Microscopy

1. Optical Microscopy

a. Petrographic Microscope

This microscope (Zeiss) is used for a variety of analyses. It is especially useful for studying rocks and minerals. Minerals can be identified in transmitted light by measuring optical properties such as indices of refraction. Thin sections of rocks may be studied to determine the relationship of ore minerals to gangue, types and degree of rock alteration, and other information useful in projects related to minerals exploration, ore recovery, and ore processing. This microscope also is used for measuring the particle size of powders, determining shapes of particles, degree of agglomeration, etc. Attachments are available for studying opaque materials in reflected light. Photomicroscopy accessories are also available.

b. Metallographic (Unitron)

The metallograph is used for studying metals, certain ceramics, and other opaque materials in reflected light. It can be used for identifying opaque ore minerals, measuring the grain size of metals and ceramics, studying inclusions in metals, determining the size and distribution of pores in ceramics, aiding in corrosion studies, etc. The metallograph is equipped with photomicroscopy accessories. Polishing equipment is available for preparing mounts.

2. Electron Microscopy

The Phillips EM-300 Electron Microscope is used to view details of interest that are too small to be seen with an optical microscope. The optical microscope theoretically resolves details down to 0.2 micrometers, but in actual practice very little information can be obtained in details less than 0.5 micrometers. The electron microscope is capable of resolving details down to about 0.5 nanometers. It is used to study fine-grained materials such as TiO_2 pigments, UO_2 powders, and MnO_2 powders. Small surface details on large size materials also can be examined. Particles less than 0.5 micrometers can be measured precisely by using a Zeiss particle-size analyzer in conjunction with photomicrographs of the materials of interest.

The electron microscope is to be calibrated annually as follows:

> Take a series of photographs of a standard line grid (54,864 lines/inch) at taps 1, 4, 7, 10, 13, 16 and 19. Compare photographs with photos taken from previous calibration checks under identical conditions.

G. Instrumentation for Analysis by Electrochemical Means

Instruments available in our laboratory which employ electrochemical principles are:

a. Sargent Electrodeposition Unit and Mercury Cathode

This instrument allows electrodeposition of metals such as copper, lead and zinc on platinum electrodes. The deposited metal is weighed and calculated as percent of sample. The mercury cathode is used to separate unwanted metals such as Fe, Cu, Ni, Cr, Mn, Mo and V. It has been instrumental in our development of a referee method for the determination of vanadium in ferrophosphorus material.

b. pH Meters and Specific Ion Meters

Ion concentrations (activities) are measured in solutions by employing a potentiometer to detect potential differences between a glass or specific ion electrode and reference electrode. Several meters are available.

c. Recording Titrators, Mettler and Metrohm/Brinkman

These instruments were designed to record and control all practical electrometric titrations using either glass or metal indicating electrodes.

Because their primary function is to record the voltage between the electrodes, the electrodes and the chemical system determine the limitations of their use. The second function is to control the rate of addition of titrant to the cell, thereby avoiding reaction rate errors on lengthy titrations.

H. Instrumentation for the Analysis of Gases and Liquids by Gas Chromatography, High Pressure Liquid Chromatography and Ion Chromatography

Gas chromatography (GC) is useful for the separation and analysis of gases and liquids with boiling points up to 450°C. Organics with boiling points above 450°C and thermally degradable species are analyzed by high pressure liquid chromatography (HPLC). Both techniques employ carrier fluids that are used to elute organic sample components through the columns at different rates, depending on how they partition between the stationary phase and carrier. Components are detected by various means as they emerge from the column. The detected components are displayed as peaks on a potentiometric strip chart recorder.

In GC, the carrier is a gas such as helium and samples are eluted as gases (liquids may be converted to gases in a heated compartment prior to entering the column). In HPLC, the carrier is a liquid such as methanol and components are eluted as liquids.

In GC, temperature programming is used to permit the analysis of both heavy and light components in a single sample. In HPLC, the temperature is usually low and constant and changes in column material and column polarity are used to effect the separation of heavy and light components in liquid samples.

a. Gas Chromatographs available are as follows:

Manufacturer	Model #	Thermal Conduct. Detector (TCD)	Flame Ionization Detector (FID)
Carle	SX-AGC	Yes	No
Hewlett-Packard	5830	No	Yes
Hewlett-Packard	5840	No	Yes

They are to be maintained and calibrated as follows:

1) Maintenance and repair are to be performed by the manufacturer or according to his specifications as required.

2) Standards are to be run prior to each sample set being analyzed to calibrate the instrument.

b. High Pressue Liquid Chromatograph

One HPLC instrument is available; namely, the Waters Model ALC-202/401 equipped with solvent programmer, refractive index and ultraviolet detectors and using the Fisher Recordall 2-pen recorder. It is to be maintained and calibrated as follows:

1) Maintenance and repair are to be performed by the manufacturer or according to his specifications as required.

2) Standards are to be run prior to each sample set being analyzed to calibrate the instrument.

c. Ion Chromatograph

A Dionex Model 16 ion chromatograph, capable of simulataneous anion and cation analysis, is available.

This technology, discovered by Branscomb at the National Bureau of Standards (1968), developed and reduced to practice by Dow Chemical Company (1975), is analogous to gas and high pressure liquid chromatography and is applicable to aqueous and select nonaqueous systems. Ions are separated, chromatographically, using proprietary ion-exchange resins; the eluted ions are then quantized by a specific conductance meter. Using this technique, most cations of moderate to strong bases or anions of moderate to strong acids may be determined, individually or in mixtures.

The ion chromatograph is to be maintained and calibrated as follows:

1) Maintenance and repair are to be performed by the manufacturer or according to his specifications as required.

2) Standards are to be run prior to each sample set being analyzed but at least once every eight hours.

d. A Perkin-Elmer Model 1 Integrator and a Beckman 10" strip chart recorder are used to integrate peaks and trace chromatograms respectively.

e. Two Hewlett-Packard Model 3390A Integrators are used to record and integrate peaks from gas, liquid, and ion chromatographs and provide trace chromatograms.

I. Organic Analysis

a. Coulometrics Carbon Analyzer

This method allows the determination of total inorganic carbon and/or total carbon and/or total organic carbon in aqueous and inorganic or organic solid samples. The carbon is oxidized to CO_2 or inorganic carbon liberated as CO_2 which is then measured coulometrically.

b. Ramsbottom Carbon Residue Analyzer

A Ramsbottom Carbon Residue Analyzer is available for determination of the amount of carbon residue remaining after evaporation and pyrolysis of an oil.

J. Muffle Furnaces

An assortment of muffle and tube furnaces is available.

K. Surface Area Analyzer

The Quantachrome Monosorb Model MS-8 is used to measure the total surface area of fine powders such as TiO_2, MnO_2, UO_2, etc. It performs this function by measuring the amount of nitrogen that is adsorbed on the surface. It is useful for characterizing materials and provides a means of establishing quality control on a variety of processed materials.

The instrument is to be calibrated quarterly as follows:

> Analyze commercially-prepared standards and compare data to accepted value. Inspect sample tubes for chips and/or cracks, and check heating mantles for proper operation.

L. Miscellaneous Equipment

a. A variety of small instruments, such as a Frantz Isodynamic Separator, Andreason Pipettes, Sieves, etc. are used to aid in phase separations, measure particle size, measure bulk densities and true density, etc. Many of the techniques used for characterizing materials do not require elaborate equipment.

b. The equipment available includes a 4" Jaw Crusher, 6" Jaw Crusher, Cone Crusher, BiCO Disk Pulverizer, Rotap Screen Shaker, a complete complement of U. S. Standard Screens, assorted riffles and other equipment necessary for the preparation of most types of mineral ores and coal for laboratory analysis.

c. Cleveland Open Cup and Pensky-Martins Closed Cup Tester

This equipment is used to determine the flash and fire points of petroleum.

d. Cameras (Polaroid MP-3, Crown-Graphic, Etc.)

Various cameras and related equipment are available for macrophotography and photomicroscopy. Photographs can be made for permanent records. Anything from coarse cores and large pieces of equipment down to the fine microscopic features on a variety of materials can be photographed.

e. Mechrolab Vapor Pressure Osmometer

The Mechrolab Vapor Pressure Osmometer is used for the determination of the molecular weight of organic molecules.

f. Brookfield Model HAT Viscometer

The Brookfield Model HAT Viscometer is used for measuring viscosities between 1-10 centipoise. Also available are Cannon-Fenske Viscometers for measuring liquids between 1-20,000 centipoise. The temperature range for viscosity measurements is 0-200°C.

The instrument is to be calibrated quarterly as follows:

> Analyze DC-200 Silicone Fluid at several temperatures up to 500°F and compare data with that obtained from previous analysis under identical conditions. Also, check instrument at room temperature by analyzing 900 cp and 11,000 cp standards.

g. pH Meters

These instruments are used for pH and millivolt determination. Standards or buffers are to be run prior to each sample set being analyzed to calibrate the instrument. In addition, the millivolt scale will be tested annually using a known potential source.

h. Specific Conductivity Meter - YSI-31

This instrument is used for specific conductivity determination. Standards are to be run prior to each sample set being analyzed.

i. Balances

Analytical balances are to be tested and certified biannually by an outside consultant and given internal checks annually.

M. Quality Assurance - Quality Control

A quality assurance - quality control program is maintained using the principles outlined in Quality Assurance Principles for Analytical Laboratories, Frederick M. Garfield, Association of Official Analytical Chemists, 1984.

a. Definition

Quality Control is defined as a planned system of activities whose purpose is to provide a quality product. Quality Assurance is defined as a planned system of activites whose purpose is to provide assurance that the quality control program is actually effective. For a quality assurance program to be effective, there must be a plan.

b. Quality Assurance Plan

In reality, a quality assurance plan is composed of three essential components, and costs are associated with each component:

- Prevention
- Assessment or appraisal
- Correction

Prevention requires an orderly program of planning and positive actions before or during analyses to ensure that analytical systems are functioning properly. Examples are quality control planning, training, calibration of instruments, instrument maintenance, and frequent standardization of "standard solutions", etc.

Assessment is a form of control that includes periodic checks on performance to determine precision and accuracy. Examples include analysis of duplicate and check samples, peer check of chart readings and calculations, and validation of methodology.

Correction is action taken to determine causes of quality defects and to restore proper functioning of the analytical system. This can involve trouble shooting to correct malfunctioning equipment, examination of more check samples, re-evaluations of methodology, retraining, etc.

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ANALYTICAL METHODS

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DETERMINATION OF Fluoride	TYPE OF SAMPLE Ilmenite	
ANALYTICAL METHOD Specific Ion Electrode	WRITTEN BY JRJ/GEV	APPROVED CHL

Method:

Fusion of ilmenite in Na_2CO_3, separation of fluoride from impurities by distillation and, then, fluoride determination using specific-ion electrode.

Apparatus:

1. Orion 9409A Fluoride Electrode
2. Calomel or Silver/Silver Chloride Reference Electrode
3. Metrohm pH Meter Model 102 (Brinkmann) or Equivalent
4. Metrohm - Single Probe pH Electrode or Equivalent
5. Platinum - 50 ml Size Crucible with Cover
6. Plastic Beakers, 150 ml, 400 ml
7. 250 ml Polyethylene Volumetric Flasks
8. Fisher Burners
9. Distillation Apparatus Consisting of a 500 ml Round-Bottom Flask, Graham Coil-Type Glass Condenser, Distillation Arm, Powerstat, heating Mantle.

Reagents:

1. Sodium Carbonate (Na_2CO_3) - Reagent Grade
2. Sulfuric Acid Solution - (1:1)
3. Acetic Acid - Reagent Grade
4. Sodium Chloride - Reagent Grade
5. 10N Sodium Hydroxide
6. Buffer Solution - Dissolve 58 g NaCl, 2 g CDTA (1,2-cyclohexylenedinitrilotetra-acetic acid) in 500 ml fluoride-free deionized water. Add 57 ml conc. acetic acid. Adjust pH of solution to between 5.0 and 5.5 with 10N NaOH. Dilute to one liter.
7. Fluoride Standard Stock Solution: Dissolve 2.211 gm of NaF (dried @ 105°C) in water and dilute to 1 liter. 1 ml = 1000 μgF.

8. Dilute 100 ml of stock fluoride solution to 1 liter. 1 ml = 100 μgF.

9. Dilute 10.0 ml of stock fluoride solution to 1 liter. 1 ml = 10 μgF.

10. Prepare 0, 1, 5, 10, 100 and 1000 μgF fluoride standards by using 50 ml of buffer and diluting to 100 ml with distilled water.

Procedure:

1. Weigh 0.5 g of 100% pass 100-mesh sample into a 50 ml platinum crucible. Add 10 g Na_2CO_3 and mix with metal stirring rod.[1]

2. Fuse at red heat for at least 30 minutes (1 hour preferred) over Fisher burner with cover and, then, cool.

3. Leach the Na_2CO_3 fused cake with water until dissolved, transferring leach to a 100 ml plastic beaker, dilute to 100 ml volume.

4. Transfer to a 500 ml distillation flask.

5. Neutralize sample (slowly) with 1 + 1 sulfuric acid, add a total of 150 ml of 1 + 1 sulfuric acid. Add another 50 ml of distilled water.

6. Connect the distillation flask to the distilling column and distill until SO_3 fumes. (Distillate volume should be about 225 ml). Rinse condenser with several milliliters of distilled water and add rinses to the distillate.

7. Transfer distillate to a 250 ml volumetric flask, dilute to volume. Mix well.

8. Transfer 50 ml of distillate to a 150 ml plastic beaker, add 50 ml of buffer (reagent No. 6).

9. Insert fluoride electrode into solution.

10. Wait 5 minutes or until equilibration is reached (electrode potential stabilizes).

11. Read mv, call this (S).

12. Add 50 μg fluoride (0.5 ml of 100 μg/mlF, reagent No. 8).

13. Allow to equilibrate.

14. Read mv, call this (A).

15. Add 50 μg fluoride (0.5 ml of 100 μg/mlF, reagent No. 8).

16. Allow to equilibrate.

17. Read mv, call this (B).

18. Plot μgF vs. mv on semilogarithmic graph paper[2,3].

19. From graph, record μg of S, A, and B.

20. Calculations:

$$\text{F, }\mu\text{g/g} = \frac{\mu\text{g of S} \times \mu\text{g of F added} \times 250\text{ ml}}{[\mu\text{g of (A + B)} - \mu\text{g of S}] \times 0.5\text{ g} \times 50\text{ ml}}$$

Note: [1] A blank of all reagents should be carried through the procedure for a blank determination.

[2] The concentration of fluoride is plotted on the log axis and the electrode potential developed with the standard on the linear axis.

[3] The dilution-error from the standard addition results in a potential error of 1% in the resulting potential obtained. This error may be considered negligible.

Precision studies on four different ilmenites, for a total of fifteen determinations, indicated by averaging the fifteen relative percent standard deviations, the precision in the 30-35 ppm range is ± 7.8% of the value. Accordingly, it is recommended that at 50 ppm F, two values from two different determinations should be considered in agreement if the average of the two lies within plus or minus 4 ppm and that the average be considered the assay of that sample if the sample is prepared and split in an approved manner. For a 50 ppm F standard, the value of plus or minus 4 ppm represents one standard deviation; which is to say, if a 50 ppm F absolute standard was assayed, a large number of times, 67% of the assays would fall within the range of one standard deviation or from 46 to 54 ppm (50 ± 4 ppm), 95% of the assays would fall within the range of two standard deviations or from 42 to 58 ppm (50 ± 8 ppm), and 99 + % of the assays would fall within the range of three standard deviations or from 38 to 62 ppm (50 ± 12 ppm).

Manpower Requirements:

One sample of ilmenite, run in duplicate, from a split of the original, requires eight clock hours and five manhours of labor. This assessment assumes a dual distillation set-up which may be run simultaneously. Each additional sample, to be run in duplicate, will require an additional three-and-one-half manhours.

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ANALYTICAL METHODS

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DETERMINATION OF Uranium	TYPE OF SAMPLE Urine	
ANALYTICAL METHOD Fluorimetric	WRITTEN BY DMK/GMFIII	APPROVED CHL

Method

An aliquot of urine is deposited on a fluorimetric flux mixture (2% lithium in fluoride - 98% Sodium Fluoride) in platinum dishes. The pellets are dried, fused, and allowed to cool, forming buttons which slide easily from the dish. The fluoresence of the fluoride button is measured in a Jarrel-Ash fluorimeter, compared with a standard uranium curve, and reported as micrograms of uranium per liter of urine.

Limits of the Method

The fluorimeter will measure from one to 10,000 micrograms of uranium per liter of Urine. Background fluoresence reduces the accuracy of the analysis at very low concentrations (1-10µg per liter). Above 10µg per liter, the accuracy is within 10%. High concentrations (over 1000µg) are usually diluted prior to analysis to prevent saturation of the fluoresence in the pellet.

Cost

The labor for the determination of a set of 20 pellets would be 40 minutes. The number of samples, depend upon the number of standards and blank analyzed per set of 20 pellets.

Equipment and Reagents

1. Jarrel-Ash Galvenck - Morrison Fluorimeter, Newtonville, Massachusetts.
2. Fusion Burner - Modified Fletcher Burner w/Nichrome gauze to accomodate 20 pellets.
3. Platinum dishes - Stamped from discs 0.015 inch thick and 0.75 inch in diameter purchased from J. T. Baker and Company, Newark, New Jersey.
4. Pellet Maker - Custom fabricated from Stainless steel.
5. Timer for fluorimetric burner - (TDAF)
6. Propane Regulator - with fluorinator and needle valve.
7. Air regulator - Air blower assemble w/booster pump.
8. Heat lamp.
9. Die for forming platinum fusion dishes.

10. Sodium Fluoride, reagent grade. Meets fluorimetric specifications, lithium fluoride flux.
    A reagent jar containing 98% sodium fluoride and 2% lithium fluoride powders is agitated on a shaker and or dilutable rolling mill for a period of 36 hours. Aliquots of the mixture is sampled until a suitable blank is determined or the entire procedure repeated.

11. Uranium Standard Solution (chemically pure, NBS - certified, Natural uranium).

    Stock Solution "A" 500μg/ml
    Dissolve 58.9 mg of NBS certified U_3O_8 in 2 ml conc HNO_3 and evaporate to dryness. Take up with 2 ml water containing 10 drops of conc HNO_3, transfer to a 100 ml Pyrex volumetric flask and dilute to volume.

    Standard Solution "B" 0.5μg/ml
    Transfer 0.1 ml of solution "A" to a 50 ml pyrex volumetric flask, add 5 drops of conc HNO_3 and dilute to volume. The standard solutions should be stored in polyethylene bottles.

Procedure

Sample Preparation

1. A clear sample may be used as received. The addition of 1% by volume of HCl at the time of sampling will prevent deterioration.

2. If the sample is cloudy, add 1% by volume of conc HCl and let stand overnight.

3. If the sample is clear, proceed with the analysis.

4. If the sample is still not clear, add 15 ml of conc HNO_3 and 2 ml of 30% H_2O_2. Carefully evaporate to dryness, cool, and make up to the original volume with distilled water.

Determination

1. Adjust the pellet maker to accommodate 400 mg of flux and add this amount onto each platinum disc.

2. Pipette 0.2 ml of urine onto each pellet. Using duplicate aliquots per sample.

3. Place samples under heat lamp and dry for 10 minutes.

4. Ignite the residue over the fusion burner using the following method.

    a. Set the timer switch for 3 min., and ignite the burner. (switch on timer)
    b. Adjust the volumeter setting to 18, this will approximate a pressure allowing flame temperature to fuse the flux at 900°C.
    c. After two minutes, adjust the volumeter to 21, decreasing the temperature 850°C.
    d. Allow the fusion to continue through the time period. The timer will cut off the air and the gas simultaneously.

5. When the fluoride melts have solidified, remove the gauze and dishes from the burner and allow to cool for at least 15 minutes.

Measurement of Fluorescence

1. Push the sample slide to the forward stop, so that the empty aluminum holder is in the read position.
2. Adjust the 0.1 key to zero on the meter scale, with the background control.
3. Adjust the 0.1 key to zero with the fine adjustment. (Use a screwdriver).
4. Pull the slide to the Front stop, depress the 0.1 key and check for zero, using the background control.
5. Invert each platinum dish and allow the fused button to slide out of the pan.
6. Using forceps, carefully arrange blanks, standards, and samples in preparation for measurement.
7. Place each sample in the aluminum holder, insert the slide to the forward or read position, depress the scale 0.1 or 1, and read the scale deflection, recording for calculation.

Calculations

From the following equation determine micrograms of U or U_3O_8 in the unknown urine sample.

Micrograms of U in unknown: μg of U_3O_8 in standard x $\left(\frac{\text{ave unknown - blank}}{\text{ave standard - blank}}\right)$

Cleaning of Platinum Ware

1. Rinse in hot distilled H_2O.
2. Let stand overnight in 9N HNO_3, and fuse with fluoride flux.
3. Fuse with potassium bisulfate, wash with tap water and soak in 9N HNO_3 as above.
4. Rinse with distilled water and dry over flame.
5. Fuse with fluroide flux on each dish. Usual fusing time.
6. Select 3 dishes and observe the reading on the meter scale. If any show a reading above a normal blank level the entire batch is re-cleaned, and three random samples again tested.

References

1. Fluorimetric Determinations of Uranium

Frederick A. Centanni, Arthur M. Ross, and Michael A. DeSesa, Raw Materials Development Laboratory, National Lead Co., Inc. Winchester, Mass. Analytical Chemistry, Vol 28, No. 11, November 1956.

KERR-McGEE CORPORATION TECHNICAL CENTER ANALYTICAL METHODS	KMTC - 149-EC-10 ISSUED 12/1/77 REVISED None PAGE 1 OF 8	
DETERMINATION OF Thorium, Uranium and Plutonium	TYPE OF SAMPLE Water, Soil, Vegetation and Products or By-Products	
ANALYTICAL METHOD Alpha Pulse Height Analysis	WRITTEN BY GEVS	APPROVED CHL

Method:

Except for natural uranium or natural thorium, environmentally important concentrations of actinides cannot be readily determined by ordinary chemical means. Additionally, chemical methods do not offer any information as to the isotopic composition of the element in question. Therefore, for samples where either an isotopic composition and/or ultra low level of detection is required, alpha pulse height analysis is the method of choice.

This method utilizes the following technologies:

1. In-situ formation of calcium phosphate is used to concentrate the actinides from a large aqueous volume.

2. Anion exchange is used to permit separation of the actinides into relatively pure form.

   a) For thorium, good separation is achieved from all elements except uranium. A separation factor in the vicinity of 10^6 is achieved for most elements, but only about 10^4 separation is achieved between uranium and thorium. As a result, some uranium will report to the electrodeposit when analyzing for thorium in a uranium rich material such as yellow cake.

   b) For uranium, good separation is achieved from all elements except thorium and those which form stable anion complexes with chloride (i.e., iron, aluminum, etc.). For this reason, whenever a material rich in these metals is to be analyzed for uranium, such as soils or mill tailings, the uranium must first be solvent-extracted from a nitrate or sulfate system in order to eliminate these interferences.

   c) For plutonium, good separation is achieved from all metals except for iron from iron-rich systems (i.e., liver tissue, iron or steel and their alloys, etc.). When analyzing an iron-rich system, the ion-exchange step should be repeated once. (Note: Three evaporations to dryness with concentrated nitric acid area required to completely remove traces of chloride and fluoride from the first ion-exchange strip liquor prior to the second ion-exchange. Failure to remove the chloride or fluoride will result in poor recovery of the plutonium.).

3. Electrodeposition is utilized to prepare an "infinitesimally thin" deposit necessary for good alpha pulse height energy resolution. A thick deposit ($\geq$ ten micrograms) causes alphas, from the bottom of the deposit, to degrade (lose energy) as they pass up through the deposit. As a result, the silicon surface barrier detector will see alphas with a lower energy which will produce

a spectral smear. Poor resolution of alpha energy will destroy the usefulness of the procedure. Alpha resolution should be < 50 KeV FWHM (full width at half maximum) and any spectra with an alpha resolution of > 100 KeV FWHM should result in rejection of the analysis.

Range and Precision:

Amounts of Th, U, or Pu as low as one femtocurie (1×10^{-15} curie or 3.7×10^{-5} disintegrations per second) can be detected over a counting time of 1000 minutes using silicon surface barrier alpha detectors in conjunction with a multichannel analyzer. The precision attained is a function of the activity in the sample and the recovery of the internal standard; however, typical precision, at one standard deviation, ranges from 3 to 50%.

Cost:

Cost (manhours) = k + nt

Where:

k = 2 manhours; t = 2 manhours, and n = number of samples.

Apparatus:

1. Silicon surface barrier detector(s) (Princeton Gamma Tech, 300-25-100) is used in conjunction with a multichannel analyzer.
2. Millipore filter equipment including 0.45µ Millipore Filter.
3. Magnetic stirring hotplate(s).
4. Ion-exchange column(s), Bio-Rad or equivalent, 1.5 cm I.D. X 15 cm in length, and accessories.
5. Ripple-free D. C. power supply capable of at least 1.5 amp @ 10 volts.
6. Electrodeposition cells - (Talvite, Anal. Chem. 1972) and polished stainless steel discs.
7. Assorted glass and plastic ware common to analytical laboratories.

Reagents:

1. a) Concentrated sulfuric acid (H_2SO_4).
   b) Concentrated hydrochloric acid (HCl).
   c) Concentrated nitric acid (HNO_3).
   d) Concentrated hydrofluoric acid (HF).
   e) Concentrated phosphoric acid (H_3PO_4).

f. Concentrated ammonium hydroxide (NH_4OH).

g. Concentrated perchloric acid ($HClO_4$).

2. 50% calcium nitrate solution [$Ca(NO_3)_2$].

3. 7.2F nitric acid

4. Bio-Rad (or Dowex) AG 1 X 4, 50-100 mesh, anion exchange resin.

5. 1.5F hydrochloric acid.

6. 0.1F silver nitrate.

7. 8F hydrochloric acid.

8. 0.5F hydrochloric acid.

9. 0.36F hydrochloric acid, 0.008F in hydrofluoric acid.

10. Thymol blue indicator.

11. 0.15F ammonium hydroxide.

12. 95% or 100% ethanol (not denatured).

13. 0.18F sulfuric acid (H_2SO_4).

14. Sodium nitrite.

15. Standard Pu-242, U-232 or Th-228 solution. The Pu-242 (99.9999 + %), prepared by cyclotron and purified by mass spectrometry (Alexander and Irene Dupzik, Lawrence Livermore Laboratory) is available from John Harley, New York Dept. of Health.

brated "in-house."

Sample Preparation:

A. Aqueous Solutions

1. Filter sample through 0.45μ Millipore filter.

2. For samples $\leq$ 100 ml, use 100-250-ml beaker.

    a) Add 25 ml conc. HNO_3, heat to 75-80°C while stirring.

    b) Add the spike (Pu-242, U-232 or Th-228). Make sure the exact amount of spike added is known and recorded. Add only that spike necessary for the analysis. For environmental samples, spikes should be on the order of 2-12 dpm.

    c) Continue the heating for at least 30 minutes (60 min for Pu).

    d) Evaporate the solution to dryness. CAUTION, DO NOT BAKE THE RESIDUE.

e) If insols begin to form when the volume is ≤ 10 ml, then, to the dry residue, add 25 ml 7.2F HNO_3, heat to 100°C, cool, filter through 0.45μ Millipore, wash residue twice with 10 ml 7.2F HNO_3, discard filter and any remaining residue, and, evaporate filtrate to dryness. CAUTION, DO NOT BAKE THE THE RESIDUE.

f) Save the residue for actinide determination.

3. For samples > 100 ml (or, at the option of the analyst samples $\leq$ 100 ml), use 1000-2000 ml beaker.

a) Where necessary, dilute to ~500 ml with double deionized, filtered water.

b) Add 40 ml conc. HNO_3 - make sure $pH < 2$. Stir sample.

c) Add 0.5 ml 50% $Ca(NO_3)_2$ solution with stirring.

d) Add 1 ml conc. H_3PO_4 with stirring.

e) Continue the stirring and add the spike (Pu-242, U-232 or Th-228). Make sure the exact amount of spike added is known and recorded. Add only that spike necessary for the analysis.

f) Heat the sample to 75 to 80°C on a stirring hot-plate; continue the stirring.

g) Continue the heating for at least 30 minutes (60 min for Pu). Do steps h) and i) while sample is at 75-80°C.

h) Slowly, and with vigorous stirring, add 200 ml conc. NH_4OH, at a rate of ~ 10 ml/minute. Check pH; if $pH < 9.5$ continue adding NH_4OH until $pH \geq 9.5$. Turn off heat.

i) Stir for 30 minutes.

j) Remove magnetic stirrer; allow sample to stand for at least 30 minutes to further cool and settle.

k) When sample is cool enough to handle, filter through 0.45μ Millipore. Filter by initially decanting supernatant liquor from top of beaker until ~ 100 ml remains. Slurry the precipitate in the remaining 100 ml and pour into the filter.

l) If precipitate remains in the beaker, or on the walls of the filter, wash with 1:5 NH_4OH and rinse into the filter. Discard filtrate.

m) Transfer the precipitate to a 50-100-ml beaker and ash the sample at 350°C in an O_2 atmosphere for 35 ± 5 minutes. Remove sample from oven and cool to room temperature.

n) Save the precipitate for actinide determination.

B. Non-Aqueous Samples: (0.1-10 gms dry weight)

1. Dry ash the sample in the high temperature oven.
   - a) Start sample at 300-350°C, no O_2, and maintain for ∿ 2 hours.
   - b) Turn on O_2 while maintaining sample at 350°C for ∿ 2 hours.
   - c) Increase temperature to 500°C, O_2 on, and heat for for at least 4 hours or overnight (∿ 16 hours).
   - d) Use platinum dish, Pyrex, or Vycor beaker.
2. Transfer the cool, dry ashed, sample to a Pt dish, cover with conc. HNO_3 (but at least 10 ml added very slowly) and mix well. Caution, vigorous gas evolution (CO_2) may occur. Add 5 to 10 ml of conc. HF and mix well.
3. Add spike (Pu-242, U-232 or Th-228). Make sure exact amount of spike added is known and recorded. Add only that spike necessary.
4. Heat to ∿ 100°C and slowly evaporate slurry to a moist residue (should take ∿ 1 hour). Remove from heat, repeat the HNO_3 and HF addition and reheat to evaporate slurry to a moist residue. Repeat until the residue becomes a white material.
5. Add 5 to 10 ml conc. $HClO_4$, fume to wet residue (1-3 ml volume), cool. (If Pu is to be determined, do not add $HClO_4$.)
6. Add 25 ml 7.2F HNO_3 and filter through 0.45μ Millipore filter. Wash residue twice with 5 ml each of 7.2F HNO_3. Discard Residue.
7. Save the filtrate for actinide determination.

C. Thorium Analysis:

1. To the residue (step 2.f) or 3.n) for aqueous samples or filtrate from step 7 for non-aqueous samples):
   - a) Dissolve or dilute to 80 ml with 7.2F HNO_3.
   - b) Pass the sample through a charged resin column. (Dowex 1 X 4 or BioRad 1 X 4, NO_3^- form, Cl^- free by $AgNO_3$ test). Flow rate should be 1 to 3 ml per minute. Discard eluate.
   - c) Wash the column with 150 to 250 ml 7.2F HNO_3 at 1-3 ml per minute. Discard washings.
   - d) Elute the thorium from the column with 80 ml 1.5F HCl at 1-3 ml per minute.
   - e) Save the HCl eluate for electrodeposition.

D. Uranium Analysis:

1. To the residue (step 2.f) or 3.n) for aqueous samples or step 7 for non-aqueous samples evaporated to moist residue), if Fe (III) content is > 1 ppm, proceed as follows:

   a) Dissolve residue into 10 ml 2F HNO_3/2F $Al(NO_3)_3$.

   b) Extract uranium twice into 10 ml ethylacetate.

   c) Transfer ethylacetate (20 ml) to clear, dry, beaker and evaporate to dryness. CAUTION, DO NOT BAKE RESIDUE.

2. If < 1 ppm, proceed to next step.

   a) Dissolve the residue in 80 ml 8F HCl.

   b) Pass the sample through a charged resin column. (Dowex 1 X 4 or BioRad 1 X 4, Cl^- form). The flow rate should be 1-3 ml per minute. Discard eluate.

   c) Wash the column with 150 to 250 ml 8F HCl. Discard washings. Use flow rate of 1-3 ml per minute.

   d) Elute uranium from column with 80 ml 0.5F HCl at a flow rate of 1-3 ml per minute.

   e) Save the HCl eluate for electrodeposition.

E. Plutonium Analysis:

1. To the residue (step 2.f) or 3.n) for aqueous samples or filtrate from step 7 for non-aqueous samples):

   a) Dissolve residue in 80 ml 7.2F HNO_3 or dilute to 80 ml with 7.2F HNO_3, and .5 g boric acid (H_3BO_3).

   b) Add several milligrams $NaNO_2$, heat to 90°C, cool and let stand overnight (or heat to, and maintain at, 100°C for at least 1 hour).

   c) Pass the sample through a charged resin column. (Dowex 1 X 4 or BioRad 1 X 4, NO_3^- form, Cl^- free by $AgNO_3$ test). Flow rate should be 1-3 ml per minute. Discard eluate.

   d) Wash column with 150-250 ml 7.2F HNO_3 at a flow rate of 1-3 ml per minute. Discard washings.

   e) Elute plutonium from column with 80 ml of 0.36F HCl/0.008F HF at a flow rate of 1-3 ml per minute.

   f) Save the HCl/HF eluate for electrodeposition.

F. Electrodeposition:

1. To the eluates from Th, U, or Pu procedures (step C.1.e) for Th, step D.1.e) for U, and step E.1.f) for Pu):

   a) Add 0.30 ml conc. H_2SO_4 and 5 ml conc. HNO_3.

   b) Evaporate to dense SO_3 fumes and cool.

   c) Add 5.0 ml H_2O.

   d) Add thymol blue indicator.

   e) Adjust pH to 2 (first color change) with gaseous NH_3. Do not overshoot pH of 2. Obtain NH_3 by cutting inside stem off of polyethylene wash bottle flush with cap. Fill wash bottle 1/2 full with conc. NH_3OH. "Puff" NH_3 vapors from bottle. Direct NH_3 stream at, but above, surface of liquid sample.

   f) Transfer to electrodeposition cell. Have clean, degreased stainless steel planchet in place in the cell.

   g) Add 5 ml 0.18F H_2SO_4 - use for beaker rinse.

   h) Repeat step g) at once.

   i) Adjust to pH of 2 (first color change) with gaseous NH_3. Do not overshoot pH of 2.

   j) Place cell in electrodeposition apparatus and plate actinide onto the cathode (stainless steel planchet) for 1.2 amp/hour (0.6 amps for 2 hours or 1.2 amps for 1 hour).

   k) With current flowing, add 5 ml conc. NH_4OH and continue current flow for 1-2 minutes.

   l) With current still flowing, remove platinum anode from solution. Turn off current and disconnect cell.

   m) Discard aqueous contents of cell.

   n) Wash cell three times with 0.15F NH_4OH. Do not direct stream onto plated surface.

   o) Wash cell twice with 95% ethanol.

   p) Disassemble cell and carefully remove planchet. Do not touch plated surface.

   q) Place planchet on hotplate at 250-300°C and heat for 5-10 minutes.

   r) Remove planchet from hotplate and cool to room temperature.

G. Alpha Pulse Height Analysis:

1. Active area of surface barrier detector should be at least 2X's that of the plated surface of the planchet.

2. Place planchet in close proximity to, but not touching, surface barrier detector. The surface barrier detector and sample must be inside a vacuum chamber with a pressure < 1mm Hg.

3. Count the sample, over the energy range 3.8 to 5.8 MeV, for 1000 minutes.

4. Integrate the alpha peaks and identify each isotope by its alpha energy.

5. For the internal standard, the recovery is determined by the equation

$$\frac{\text{counts per 1000 min found}}{\text{counts per 1000 min added}} = \text{Recovery Factor}$$

6. Divide each alpha integral by the recovery factor and divide the quotient by 1000. The result is the activity of that alpha (isotope) in the sample in units of disintegrations per minute (dpm).

7. To convert to picocuries per sample: dpm ÷ 2.22 = pCi
   To convert to femtocuries per sample: dpm ÷ .00222 = fCi

8. In alpha pulse height analysis, using silicon surface barrier detectors, the sample size should be chosen such that the alpha activity, on the planchet, exclusive of the internal standard, lies in the range of from 1.5 to 15 pCi. However, for low level samples it usually is impractical to exceed 1 liter or 10 grams of sample and, as a result, one often finds the alpha activity, exclusive of the internal standard, lies in the range of from < 0.001 to < 1.5 pCi.

9. For samples where the recovery of the internal standard is < 50%, based upon a measured counting geometry, the assay should be rejected.

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ANALYTICAL METHODS

KMTC - 200-XRF-1

ISSUED 7-15-85 REVISED

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DETERMINATION OF Quantitative Elemental Analysis	TYPE OF SAMPLE Solids and Liquids
ANALYTICAL METHOD General X-Ray Fluorescence	WRITTEN BY CDE
	APPROVED GEV

METHOD:

Primary x-rays are generated by the bombardment of a suitable target material by electrons from a heated tungsten filament. These electrons are accelerated to a high velocity by a high voltage potential between the tungsten filament and the target material.

As the electrons deccelerate, they give up their energy as x-rays in a series of stepwise transitions.

The primary x-rays from the rhodium-targeted tube are used to excite the inner electrons of a sample. These electrons (from the K, L and M shells primarily) are expelled from the inner shells of the atom. Electrons from orbitals farther away from the nucleus then fall into the vacancies created. The difference in energy between the orbitals is emitted as a secondary x-ray photon of an exact energy. Because the x-rays come from the inner electrons of the atoms, they are not related to any of the chemical properties of the elements nor to the compounds in which they may be present. These emitted wavelengths are detected by using various analyzing crystals with precisely known d-spacings (distances between the planes of the crystal). Coupled with the crystals is a flow proportional counter and thallium-doped NaI detector. These detectors are used both separately and in tandem.

RANGE:

The present configuration of the Siemens SRS-300 x-ray fluorescence unit provides analytical capabilities from Sodium (element 11) through Uranium (element 92) for a wide range of sample types. The detection limits range from a few ppm to 100 percent. This is dependent upon the element of interest, the matrix effects, the analyzing crystal used, the excitation conditions, the detector, sample preparation techniques, the use of air, vacuum or helium for the analysis conditions, etc. These instrumental parameters are best determined by optimizing the analysis conditions experimentally prior to analysis.

EQUIPMENT AND REAGENTS:

1. Siemens SRS-300 sequential wavelength x-ray spectrometer and 10-position sample changer under computer control (DEC family of PDP computers).

2. DEC VT-240 monochrome graphics display terminal and DEC Letterwriter 100 for printout of results plus graphic plots.

3. Retsch Micro-Mill for grinding samples prior to analysis.

4. Sample binder and various dies for pressing samples into pellets using a hydraulic press.

5. Sample cups with polypropylene covers plus sample holders for the instrument.

6. Compressed air to operate the system pneumatics, helium for the sample chamber atmosphere, P-10 gas for the flow proportional counter, plus a Haskris heat exchanger for the x-ray tube and generator.

SAMPLE PREPARATION:

To obtain a sample that is as homogeneous as possible, materials should be ground to as fine a particle size as practical. Particle size is an important consideration, especially when dealing with the lighter elements and their longer and less energetic wavelengths.

The ground solids are mixed with a binder and pressed into a pellet. A smooth surface on the finished pellet is desirable for both accurary and reproducibility of the analysis.

Liquids are generally homogeneous and may be pipetted into the sample cup as received. The cup and liquid should be set aside for approximately 30 minutes and then checked for leaks. As the sample is inverted directly over the x-ray tube, a leak may deposit sample directly on the beryllium window, causing erroneous results or possibly failure of the tube itself. Semisolid samples (i.e. ROSE samples) may be gently heated and poured into the sample cup. After cooling, they may be analyzed under a helium atmosphere like the liquids.

INSTRUMENTAL PARAMETERS:

These should be determined experimentally for each analyte and it's corresponding matrix.

The most effective wavelength for exciting an element is the wavelength approximately 0.2 Angstrom shorter than the absorption edge wavelength for that element. For example, the Cu K-alpha line at 1.54 Angstrom is very effective in exciting the iron K-spectrum with it's K absorption edge at approximately 1.7 Angstrom.

The kV and mA at which the x-ray tube is operated determine the wavelength and intesity of the primary radiation. These (kV and mA) can be optimized for the elements of interest. The analyzing crystals and detectors can also be optimized for each element of interest.

The use of air, helium, or vacuum in the spectrometer is dependent upon the characteristics of the sample itself.

ANALYSIS:

A qualitative scan can be quickly performed to yield information about the elements that make up the sample (from Z=11 to 92). A quantitative analysis may then be performed in a number of ways.

1. By standard addition of known quantities of the elements of interest.
2. By preparation of a set of standards that have a matrix that is very nearly the same as that of the sample.
3. By preparing a standard with known quantities of the elements of interest and using the fundamental parameters approach (Criss Software) to calculate the mass absorption coefficients based on theoretical considerations.

The fundamental parameters approach provides for the analysis of samples with widely divergent matrices, requiring the preparation of only one or two standards instead of an entire suite of standards.

INTERFERENCES:

There are a number of areas where problems may rise in the XRF analysis. Peak overlap can be a problem when analyzing elements that lie very close to a extremely strong peak. For example, the target of the tube is the element rhodium, Z=45; the peak for ruthenium, Z=44, is so close to the rhodium peak that it can not be resolved because of the massive cahracteristic radiation peak coming from the target itself.

Another problem is that the matrix may give rise to absorption-enhancement effects that may affect the analyte line intensity. Another is that samples and standards must be "infinitely thick", or at least the same thickness.

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ANALYTICAL METHODS

KMTC - 204-U-16
ISSUED 4/15/76 REVISED 1/22/85
PAGE 1 OF 9

DETERMINATION OF Uranium U_3O_8	TYPE OF SAMPLE Rocks, Pulps, Vegetations, Cuttings and Solutions
ANALYTICAL METHOD Fluorimetric	WRITTEN BY JRJ — APPROVED GEV

Method:

It has been proven experimentally and in actual application that, with the proper care, quick, dependable assays can be turned out with a minimum of manpower. One person can turn out one hundred assays per day without difficulty, including blanks and standards. A crew of three people can handle 80-120 solid samples per 8-hour day on a regular basis. The procedure adopted by the Kerr-McGee Technical Center laboratory was developed by National Lead Co., Winchester Laboratory, and reported in "Analytical Chemistry," Vol. 28, Page 1651, November, 1956.

A new rotary fusion burner system has been installed, on which 22 fluoride fusions are performed simultaneously under reproducible fusion conditions. A fluorometric flux mixture of 2% lithium fluoride and 98% sodium fluoride is used and has been found to be superior to other fluxes in sensitivity, precision and convenience. The coefficient of variation of the fusion method (only) employing this new flux has been determined to be 0.7%. This constitutes at least a sixfold improvement in precision over that of the previous fusion system. This method has been proven to be rapid, accurate and economical.

A combination of dilution and solvent extraction is used to separate the uranium from possible interferences and quenchers. An aliquot of a liquid sample or of a solution of a solid sample is diluted and acidified so that the diluted sample contains approximately .005 mg of U_3O_8 per ml in a 5% nitric acid solution. One milliliter of the diluted sample is salted with saturated aluminum nitrate solution and the uranium is extracted into 10 ml of ethyl acetate. Aliquots of 0.2 ml are removed and transferred onto pellets of 2% lithium fluoride/98% sodium fluoride flux in platinum dishes. The pellets are dried, fused and allowed to cool, forming buttons which slide easily from the dish. The fluorescence of the fluoride button is measured with a Jarrell-Ash Model 26000 fluorometer.

Apparatus:

40-ml Vials - 4-1/4" in length and 1" in diameter.

Aluminum Foil-Lined Caps - purchased in quantities and used only once.

Machlett Autopipet - 10-ml capacity.

Platinum Dishes - These dishes are formed from discs 0.015" thick and 0.75" in diameter. Discs are available from Englehard Instruments, Inc., 113 Astor Street, Newark, New Jersey.

Dish Forming Tool - Available from Jarrell-Ash Co., Waltham, Mass., Catalog No. 26100. Before forming, discs should be annealed at 850°C. After forming, they should be cleaned with 1:1 nitric acid and rinsed thoroughly with water.

Pellet Maker - Jarrell-Ash Co., Catalog No. 26110.

Rotary Burner - The burner is a rotary fusion burner. The burner is available from EDA Intruments Inc., 5151 Ward Road, Wheat Ridge, Colorado 80033. The system consists of fifteen Humboldt burners arranged in a circle, two flowmeters, temperature readout meter, gas igniter automatch, low heat timer, high heat timer.

Drying Units - Fabricated in house using four 500 watt infrared heat lamps mounted in two separate boxes of two lamps each 19" long, 12" deep and 10" high. The boxes are constructed of 1/2 inch thick transite and is closed all around except for a 19" x 10" opening in front.

Propane Regulator - Must be able to maintain 30 lbs output pressure.

Shaking Machine - Eberback Model 6010. Available from Scientific Products.

Fluorometer - Jarrell-Ash Co., Model 26000 fitted with reflectance attachment, Model 26050.

Microliter Pipet - Eppendorf 200-µl pipet with a supply of disposable pipet tips.

Reagents - The use of reagents that contains negligible uranium or other fluorescence impurities is essential. With the exception of sodium fluoride, it has been found that Mallinckrodt reagent grade chemicals give the best all-around performance.

98% Sodium FLuoride - 2% lithium fluoride Fluorometric grade, EDA Instruments, Inc., 5151 Ward Road, Wheat Ridge, Denver, Colorado 80033.

Ethyl Acetate - Mallinckrodt reagent grade.

Aluminum Nitrate - Mallinckrodt reagent grade.

A solution of aluminum nitrate is made by dissolving 5 lb in 1100 ml deionized H_2O.

A reagent blank prepared from the above reagent should read no more than 15 units on the most sensitive meter range. Full scale meter reading - 10 µamps.

Acid - Reagent grade nitric, perchloric, hydrochloric and hydrofluoric acids.

Mallinckrodt reagent grade.

Perchloric acid should only be used in approved hoods with washdown facilities.

Standard U_3O_8 Solution - 1.000 grams of 99.99% U_3O_8 is weighed into a 250-ml beaker. Add 10 ml $HClO_4$ and 10 ml HNO_3 and fume to 3-5 ml. Cool, rinse sides of beaker with DI H_2O, and 50 ml concentrated HNO_3 and dilute to 1.00 liter.

1.00 ml of this stock solution diluted to 200 ml will give a standard solution of 5 μg/ml U_3O_8 which should be made fresh once each month.

A. Sample Preparation

1. Aqueous Samples

Dilute all aqueous samples according to the estimated concentration so that 1 ml of the diluted sample contains approximately .005 mg of U_3O_8. Since the diluted sample should contain 5 percent (v/v) free nitric acid, samples which are alkaline must be neutralized before the proper amount of nitric acid is added.

Samples which are known to contain reduced uranium, such as Wet Phosphoric Acid (WPA), must be oxidized to uranium (VI). The preferred method is to pipet an aliquot into a 250-ml beaker. Add 5 ml $HClO_4$ and 5 ml HNO_3 and take to strong $HClO_4$ acid fumes, cool, add HNO_3 to make dilution 3-5% v/v HNO_3 and dilute in mixing cylinder.

Organic samples, such as those from solvent extraction studies, are treated by stripping the uranium into aqueous carbonate solution before proceeding with the dilution and extraction. Pipet a suitable volume of the sample into an extraction vial and add 2 to 3 ml of carbon tetrachloride to make the organic layer heavier than water. In special cases, wet oxidation is the preferred treatment.

Add 10 ml of 5 percent (w/v) sodium carbonate solution from an automatic pipet, cap the vial, agitate on the shaker for 1 to 2 minutes, and centrifuge to separate the phases completely. Treat the resulting carbonate solution according to the procedure described above for an aqueous sample.

2. Solids

Pulped samples are weighed, normally 2 grams, into a 250-ml beaker and treated with 10 ml each of perchloric acid and nitric acid. Place on hot plate and take to fumes, remove and add 5 ml perchloric, 10 ml of hydrochloric and mix. When hydrochloric acid ceases to effervesce, add 1-2 ml hydrofluoric acid. Cover and heat on low burner for a few minutes and then fume to 3-5 ml. Cool sample, add 5 ml HNO_3 and 25-30 ml H_2O and transfer to a 100-ml volumetric flask. Dilute to mark. No filtration is necessary. Shake well before aliquot is made for analysis.

3. Vegetations

Dry sample at 105°C over 16 hours. Pulverize dried sample using a Wiley Mill down to approximately 8-10 mesh. Weigh 30 gms of the dry pulverized sample into a 250-ml pyrex beaker. Ash in an oxygen oven overnight by slowly increasing the heat 50°C per hour to 550°C with an adequate oxygen flow on.

Cool and transfer the ash to a 250-ml PTFE beaker with a 10% nitric acid (HNO_3) rinse, using a rubber policeman to dislodge solids from sides of beaker. Add 10 ml nitric acid, 5 ml perchloric acid and 2 ml hydrofluoric acid to the sample. Digest the sample approximately 230°C on a hot-plate and evaporate to incipient dryness. Add 10 ml of nitric acid to the beaker and transfer contents to a 200-ml volumetric flask using distilled water. Dilute to mark with deionized water and shake well. Transfer a 2 or 3 ml aliquot into an extraction vial and proceed to the extraction section of this procedure. If the fluorescence is not greater than 1 unit above background, transfer a sufficient amount of sample to a 125-ml separatory funnel and proceed with the extraction step described in KMTC-125-U-17.

B. Extraction

Pipet the desired aliquot of the diluted sample into an extraction vial. If no dilution is required and the sample is alkaline, acidify by adding concentrated nitric acid dropwise to the aliquot taken for extraction. Add approximately 15 ml of saturated aluminum nitrate and exactly 10 ml of ethyl acetate from the automatic pipet. Cap the vial and agitate on the shaker for 3 to 4 minutes. To avoid dilution of the saturated aluminum nitrate in the extraction vial, which may lead to low uranium values, aliquots for extraction should not exceed 2 ml. Extract a reagent blank and standard with each set of samples.

C. Preparation of Pellets

Place 22 platinum dishes on wire rings and then ensure that the rings and the sample are level (see pattern Figure). Place the rings and dishes under the drying unit until all the dishes are dry. The dishes must be dry since placing flux pellets onto wet dishes will eventually cause a severe attack on the platinum.

Using the pellet maker, prepare and place a pellet of fluoride flux in each dry dish according to the following procedure: Fill a 250-ml beaker (or other suitable container) with flux to a depth of 2-1/2 to 3 inches. While rotating the beaker, pack the barrel of the pellet maker by plunging it vertically through the bed of flux. While the pellet maker is still in a vertical position, draw it across the bottom of the beaker. Holding the filled pellet maker about three-quarters of an inch above the platinum dish, push down on the plunger and discharge the pellet. Rotation of the beaker while filling the pellet maker will assure a uniform pellet weight, and drawing the pellet maker across the bottom of the beaker will assure a flat bottom to each pellet. Uniformity of pellet size is necessary to maintain reproductivity. Using the above procedure, adjust the pellet maker to form pellets that weigh 0.5 grams ± .02 grams.

Using a 200-$\mu\ell$ Eppendorf automatic pipet with disposable pipet tips, pipet 200 $\mu\ell$ of ethyl acetate containing 0.5 micrograms U_3O_8 per ml. The ethyl acetate solution is prepared by extracting 1 ml of a standard 5 μg/ml U_3O_8 aqueous solution using extraction method described above. Two pellets are reserved for the reagent blank. Volatilize the ethyl acetate from the pellets by placing the wire rings holding the dishes under the drying units for approximately 10 minutes.

D. Fusion

The wire ring holder with the twenty-two platinum dishes and pellets is placed on the burner assembly. Be sure that the rings and the sample dishes are level. Turn on the exhaust fan in the heat exhaust hood system. Place the power switch in the ON position. Place the disc rotation switch in the ON position. Be sure the low heat flowmeter is set at 30 ml/min before igniting the burners. Push the Start/Ignite button. The igniter tip can be manually adjusted to give proper spark gap. The igniter will continue to spark until the system has ignited. Adjust the low heat flowmeter to give the desired temperature. The Low Heat cycle is pre-adjusted to be approximately 30 seconds. When the High Heat Timer light goes on, adjust the High Heat Flowmeter to give the desired temperature of approximately 950°-1000°C (80 ml/min). This cycle is usually set at 2 minutes. The Pre-Cooling/Annealing cycle that follows the High Heat cycle will be the same temperature as the Low Heat cycle. After the 3 minute fusion cycle, the burner control unit will automatically shut off the gas supply. As soon as the melted flux has solidified, remove the wire screen and place on a heat-resistant pad to cool.

The fluorescence intensity increases for the first 15 minutes and then remains constant for about an hour. The cooling rate affects the ultimate crystalline structure of the fluoride buttons, which, in turn, affects the fluorescence of the buttons. Therefore, it is necessary to follow the same procedure in cooling each set of dishes; i.e., place the ring assembly on a heat-resistant material away from drafts. Protect the fluoride buttons from exposure to ultra-violet light during the cool-down period. Exposure to UV light decreases the intensity of the fluorescence. Unshielded fluorescent light tubes give off enough UV light to effect the uranium fluorescence.

If, after cooling, it is noticed that the fused flux has a brown or pinkish discoloration, it is probably due to too high a fusion temperature during the first two minutes. Reduce the temperature by increasing the gas flow 0.2 units or so on the flowmeter. Once gas and air settings are established for a burner, these settings will remain reasonably constant over long periods of time.

E. Measurement of Fluorescence

1. Instrument Adjustment

a. Adjust the phototube voltage to obtain a standard meter reading with a fluoride disk containing 0.1 microgram of U_3O_8. A suggested standard reading is 50 microamperes. If possible, all samples should be diluted to read approximately the same.

b. Adjust the meter zero by placing the slide in load position and manipulating the zero control.

c. Push the sample slide in, depress the lowest sensitivity scale key, and adjust the background current to zero.

2. Fluorescence Measurements

The fluorescence intensities of the first two standards are measured first. Then measure the samples and finish by measuring the last two standards.

a. Pick up a platinum dish with a pair of forceps and tip it so that the fluoride button slides into the polished depression in the slide.

b. Push the slide to the backstop. For buttons of unknown intensity, depress the keys in increasing order of sensitivity so as not to drive the meter needle off scale.

c. Pull the slide forward and remove the button with forceps, cleaning any fluoride particles from the slide by aspiration.

F. Calculations

For each set of twenty buttons, average the readings of all duplicate samples and the readings of the four control standards and subtract the reagent blank. Calculate uranium concentration by the following formula:

$$\text{mg/l } U_3O_8 = \frac{\mu\text{g/ml in Std}}{\text{Avg Std Reading}} \times \frac{(\text{Avg reading of unknown}) \times (\text{vol. of dilution in ml})}{\text{aliquots in milliliters}}$$

$$\text{ppm } U_3O_8 = \frac{\mu\text{g/ml in Std}}{\text{Avg Std Reading}} \times \frac{(\text{Avg reading of unknown}) \times (\text{vol. of dilution in ml})}{(\text{weight of sample in gms}) \times (\text{aliquot in milliliters})}$$

$$\text{e.g., ppm } U_3O_8 = \frac{5\ \mu\text{g}}{50\ \text{Units}} \times \frac{(50\ \text{units}) \times (100\ \text{ml dilution volume})}{(2\ \text{ml aliquot}) \times (2\text{g sample weight})} = 125\text{ppm}$$

The above calculation assumes that the same volume of ethyl acetate is used for the standards and the unknowns; e.g., 10 ml for extraction and 200 µl aliquot on the fluoride pellet or 1 ml aq. $\times \frac{5\ \mu g}{ml} \times \frac{0.2\ ml\ ETAC}{10\ ml\ ETAC}$ = 0.1 µg U_3O_8 actually on pellet.

G. Cleanliness

As with any other method employed for trace analysis, contamination must be carefully guarded against at all times. The fluorometric method of analysis is generally used in a laboratory or plant where uranium ore dust or even uranium concentrate dust is present in the atmosphere. Therefore, a room supplied with filtered air and used only for fluorometric analysis is a requirement. Each week all the floors and benches in the room should be washed and about once a month the walls and overhead fixtures should be vacuum cleaned.

Glassware and other equipment used for this analysis should not be used for other purposes and should be scrupulously cleaned after each use. People working in the fluorometer room should not use protective hand creams since these creams usually have a strong ultraviolet fluorescence, and anything touched by the hands will become contaminated.

For best quality ultra-trace analysis, only plastic and teflon ware should be used. All glassware and quartzware contains measureable levels of uranium which can bias high the final result when ultra-trace levels of uranium are being determined.

H. Costs

In groups of at least 15 rock or soil samples, the cost is 0.23 man-hours per sample, excluding sample preparation (crushing and pulping) cost.

I. Sensitivity, Precision and Accuracy

The lower limit is 1 ppm; upper recommended limit is 5000 ppm.

Accuracy is very dependent upon the nature of the sample and the quality of the standards. In no circumstances should accuracy be assumed to be equivalent to the precision. In a study on a Grand Junction analyzed sandstone certified at 0.107% U_3O_8, the following results were obtained over about a one-month period:

0.107% U_3O_8
0.101
0.112
0.107
0.109
0.117
0.113

$\bar{x}$ = 0.109% U_3O_8
S = 0.0052% U_3O_8
RSD = 4.72%

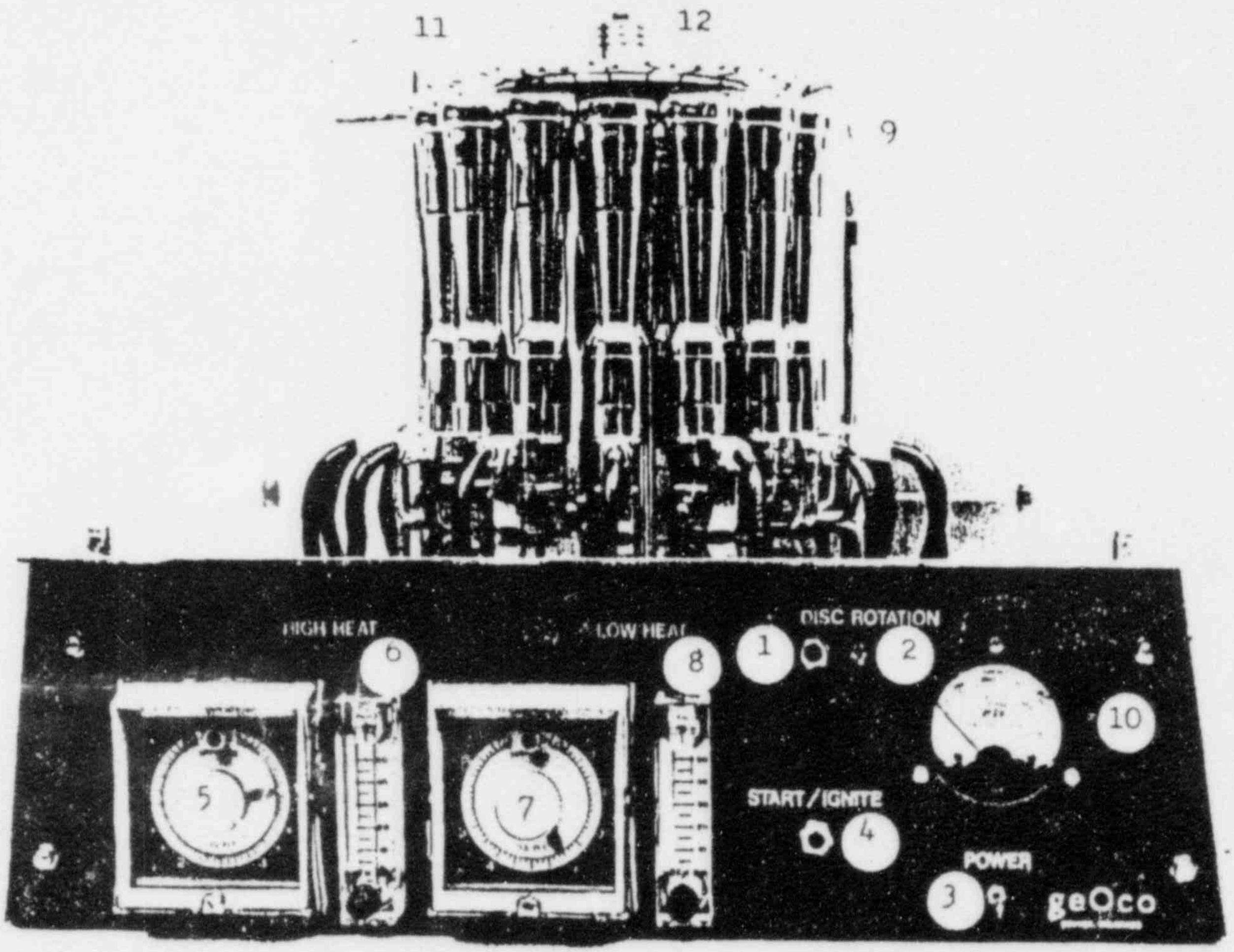
J. Other Precision Data

	Sample 1 Sand Tail, ppm U_3O_8	Sample 2 Slime Tail ppm U_3O_8	Sample 3 Sandstone, ppm U_3O_8	Sample 4 Sandstone, ppm U_3O_8
	33	64	140	230
	36	66	150	240
	31	62	150	240
	35	70	140	230
	36		150	230
	36		140	230
$\bar{x}$	34.5	65.5	145	233
S	2.07	3.4	5.5	5.2
RSD	6.0	5.22	3.8	2.2

From these five levels of U_3O_8, precision(s) can be described by a linear equation:

$$\pm s = -1.48 + .0478\,\bar{x}.$$

Figure 1


11
12
9
HIGH HEAT
6
LOW HEAT
8
1
DISC ROTATION
2
10
5
7
START / IGNITE
4
POWER
3
geOco

KERR-McGEE CORPORATION
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ANALYTICAL METHODS

KMTC - 208-EC-22

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DETERMINATION OF ~~The Solubility and Dissolution Rate~~
Classification of Air-Borne Particulates in
ANALYTICAL METHOD ~~Simulated Lung Fluid~~
In-Vitro

TYPE OF SAMPLE
Air-Borne Particulates

WRITTEN BY
AKD/AKW

APPROVED
GEV

INTRODUCTION:

The manufacture of nuclear fuel elements, as at the Sequoyah Facility of Sequoyah Fuels Corporation, where uranium hexafluoride is produced from the uranium concentrate, involves the processing of several uranium compounds which at certain stages are present in finely divided form. The continuous handling of large quantities of these materials, and some escape of volatile fluorides of uranium, inevitably results in some air contamination.(1) By determining the concentration and size-spectrum of particulates within the working environment as well as at the nearest residence, the likely intake and retention of material in the human body (a measure of associated hazard due to inhalation) may be calculated using the Standard Man data of the International Commission on Radiological Protection, "ICRP (1959)" in association with the lung model proposed by the ICRP Task Group on Lung Dynamics (1966). This special task group was created by the ICRP Committee (2) for the purpose of reviewing the so-called lung model; a scheme for computing dust deposition as a function of particle size and clearance from the human respiratory tract thereby providing a basis for lung dosimetry from radionuclide deposited and the setting of exposure limits. The clearance of deposited material in the human body is carried out by numerous biological processes. The rates of these processes depend upon the solubility of the materials concerned in biological fluids. It has been known for some years that some materials insoluble in water have nevertheless a significant solubility in biological fluids. The ICRP commented on it in lung dynamics. Some initial solubility studies were performed with real plasma, but due to bacterial deterioration of the plasma, enormous difficulties were encountered. It was subsequently decided to use a simulated lung fluid as the solvent for solubility studies of air-borne uranium particles.

According to the ICRP lung clearance model, the deposited material in the lung is classified into three groups. The basis of this classification is the rate at which it leaves the lung. These three classes are D, W, and Y, corresponding to half-times in the lung of 0 to 10 days, 11 to 100 days, and >100 days, respectively. It was originally assumed that the rate at which the mass leaves the lung is proportional to the lung burden and a simple relationship is obtained which predicts that the lung burden will diminish exponentially with time. But, in many cases, the clearance of material from the lung has been found to be progressively slower than predicted by a single exponential process, and it becomes necessary to include additional exponential terms. The deposited material is then classified according to the weight fractions of D, W and Y components. Although biological processes (3) like endocytosis and ciliary-mucus transport are known to contribute to the lung clearance, the complete and thorough biological data are not available. As a result, the dissolution half-times for materials (air-borne particles) in simulated lung fluid have been assumed to be approximately equal to their lung clearance half-times.(1,2) When the lung-clearance classification for a material is determined by the solubility test in simulated lung fluid, its transport rates between other anatomical compartments are automatically evaluated. From these values, the residence time of the material and the associated radiation dose in each compartment can be calculated.(4)

The Nuclear Regulatory Commission requires Kerr-McGee Corporation to carry out the dissolution-rate classification test of uranium on each quarterly composited dust sample collected near the uranium conversion plant. Samples from other locations or facilities may be required in the future. The method followed here for the dissolution test is that of D. R. Kalkwarf,(5) as required also by the NRC. The dissolution test is carried out at 37°C. Although the U.S. Environmental Protection Agency has recommended that all particulates with <10 μm be considered inhalable for hazard evaluations, the solubility test is performed on the whole sample which contains both respirable and non-respirable dust. Since the lung is believed to be a site for efficient dissolution, the solubility test is performed in a well-stirred suspension to achieve maximum clearance rates. As a result, these values should also approximate the lung clearance rates that include contributions from endocytosis and ciliary-mucus transport.

SAMPLE COLLECTION AND PREPARATION

For each quarter, air particulate samples are collected on filter papers. A high-volume air sampler is used for collection of air particulates. The filter paper used is replaced by a new one (8 X 10" Nucleopore or Millipore) every week during the quarter. The dust sample collected on the filter paper contains both respirable and non-respirable particulates.

Each filter paper containing air particulates is split. One-half of each filter paper for the quarter is either retained or sent to the U.S. Nuclear Regulatory Commission for performing the verification of uranium dissolution test in simulated lung fluid. The other half is again split; one-half of this is kept for gross alpha and uranium analysis, and the other half is utilized for the uranium solubility test.

In order to get a representative sample, filter paper strips of proper size are cut from each original filter paper containing the sample. The sizes (areas) of the strips are determined in such a way that the volume of air passing through each filter paper strip is approximately the same. These dust coated filter paper strips are dried in a desiccator over anhydrous calcium sulfate (Drierite) for 5 days. At the end of the drying period, the dust particles are 'vacuumed off' the surface of each filter paper strip with a vacuum line fitted with a plastic filter-holder (Millipore Corporation, Swinex 25) containing a 25-mm diameter membrane filter (Millipore, Type HA, pore size 0.45 μm). The dust collected on the membrane filter is sterilized by running ethylene oxide gas, from a small lecture bottle, through the membrane filter at a very slow rate for 4 hours. Sterilization is important so that the possible effects of bacterial growth in the suspension can be prevented. The dust collected on the membrane filter is then removed by a camel-hair brush into a weighed glass reacti-vial. The weight of the dust particles in the vial is determined. The dust particles in the glass vial are homogenized by shaking. This sample is generally found to contain some long fibers of the original filter paper.

If a sufficient mass of the dust sample is available, then a portion (known amount) of it is set aside for checking uranium mass balance, before transferring it to the glass vial.

PREPARATION OF SIMULATED LUNG FLUID:

The simulated lung fluid is prepared according to the method described by D. R. Kalkwarf.(5) The composition of the simulated lung fluid is given in Table I.

Table I

Composition of the Simulated Lung Fluid

Compound	Concentration, g/l of Water
Magnesium chloride, hexahydrate, $MgCl_2 \cdot 6H_2O$	0.203 g/l
Sodium chloride, NaCl	6.019 "
Potassium chloride, KCl	0.298 "
Disodium hydrogen phosphate, heptahydrate, $Na_2HPO_4 \cdot 7H_2O$	0.268 "
Sodium sulfate, Na_2SO_4	0.071 "
Anhydrous calcium chloride, $CaCl_2$	0.278 "
Sodium acetate, trihydrate, $NaH_3C_2O_2 \cdot 3H_2O$	0.953 "
Sodium bicarbonate, $NaHCO_3$	2.604 "
Sodium citrate, dihydrate, $Na_3H_3C_6O_7 \cdot 2H_2O$	0.097 "

The pH of this aqueous solution is adjusted to 7.3-7.4 by adding 1N HCl dropwise, with the help of a pH-meter. It has been found that the electrolytic composition of average human interstitial lung fluid is identical to that of the simulated lung fluid. For comparison, the electrolytic compositions of both lung fluids are given in Table II.

Table II

Electrolytic Compositions of Average Human Lung Fluid and Simulated Lung Fluid

Ion	Human Lung Fluid	Simulated Lung Fluid
Ca^{+2}	5.0 meq/l	5.0 meq/l
Mg^{+2}	2.0 "	2.0 "
K^{+}	4.0 "	4.0 "
Na^{+}	145.0 "	145.0 "
Total Cations	156.0 meq/l	156.0 meq/l
HCO^{3-}	31.0 meq/l	31.0 meq/l
Cl^{-}	114.0 "	114.0 "
$H_5C_6O_7^{-}$ (citrate)	-	1.0 "
$H_3C_2O_2^{-}$ (acetate)	-	7.0 "
Total Organic Anion	7.0 "	-
Protein	1.0 "	-
$HPO_4^{=}$	2.0 "	2.0 "
SO_4^{2}	1.0 "	1.0 "
Total Anions	156.0 meq/l	156.0 meq/l
pH	7.3 - 7.4	7.3 - 7.4

In this simulated lung fluid, acetate is substituted for all organic acid anions present in the actual lung fluid. Another difference between these two kinds of lung fluids is the absence of protein component in the simulated lung fluid. The lung fluid proteins are poorly characterized. Some investigations indicated that even the presence of very small amounts of protein substitutes (0.4% W/V)(1) which have very high molecular weight, renders the fluid almost unfilterable. It also causes bacterial growth in the solution. So, the protein is omitted in the main body of this work. The protein is present in very small amounts in the human lung fluid and is also known to be a poor ligand for complexing metal ions like uranium. Hence, the absence or presence of a protein component in the simulated lung fluid will not cause a significant change in the solubility of uranium compound. The protein component of the human lung fluid has been replaced by an ionically equivalent amount of citrate in the simulated lung fluid, as suggested by Moss(7). It is justified by the fact that the citrate ligand and the protein have comparable complexing capabilities.

The actual lung fluid also contains traces of phospholipids. These are not added to the simulated lung fluid because of the filtering problem. One recent study (8) showed that the dissolution rate of yellow cake (U_3O_8) is not affected by the presence of dipalmitoyl lecithin (a phospholipid) in the simulated lung fluid.

The pH of the simulated lung fluid prepared in the laboratory is checked periodically during the dissolution experiment. It is found that the solution becomes slightly cloudy and shows a higher pH on standing for several days. Under these circumstances, the pH of the solution is adjusted to 7.3 to obtain a clear solution or a fresh solution is made.

DISSOLUTION TECHNIQUE:

Equipment and Apparatus Needed:

1. Reacti-Therm Module with a low density heater which has a built-in stirring capability (Pierce Chemical).
2. 5-ml Reacti-vials (Pierce Chemical) with teflon-lined screw caps as shown in Figure 1.
3. Teflon-coated magnetic stirrers (Pierce Chemical).
4. Stainless steel filter holder (Millipore, Swinex).
5. Disposable plastic syringes.
6. Membrane filters (Millipore, 13-mm diameter, GC, 0.22 μm pores).
7. Fisher Centrific Centrifuge (Model 225).
8. Thermometer

Dissolution of the dust sample, which is vacuumed off the surface of the filter paper, is carried out in stirred, 5-ml volumes of simulated lung fluid at 37°C. Before the start of the actual dissolution test, the power of the Reacti-Therm Module is turned on and the temperature of the heating block/stirrer assembly is set at 39°C. It takes about 24 hours for the desired temperature to get stabilized within ± 1°C. Preliminary examination indicated that the actual temperature of the fluid itself in the Reacti-vial shows 37°C ± 1°C, when the temperature of the heating/stirring block reads 39 ± 1°C. The stirring rate is also kept constant during the experiment.

The Reacti-vial, containing a known amount of the dust sample, and another vial containing 5-ml of simulated lung fluid alone are both placed into the heating block for 5-10 minutes before they are mixed. When they reach the desired temperature (37°C), the lung fluid (5-ml) in the vial is withdrawn by a syringe and is added to the vial containing the sample. The time is noted and considered to be the starting (zero) time. The suspension in the vial is stirred with a Teflon-coated magnetic stirrer. After selected intervals of time, the vial is removed from the heating/stirring block, and centrifuged in the Fisher Centrific Centrifuge for 5 minutes. The supernatant liquid is drawn into a plastic syringe. A stainless steel filter holder (Millipore, Swinnex) containing a membrane filter (Millipore, 13 mm diameter, GC, 0.22 μm pores) is fitted on the end of the syringe. The solution is filtered into a plastic vial. Two drops of concentrated HNO_3 are added to this filtrate (5-ml) to prevent any adsorption of the uranium compound on the walls of the vial. This acidified solution is stored for uranium analysis. The membrane filter is then removed from the stainless steel filter holder and 5-ml of the simulated lung fluid is taken into the plastic syringe. The filter holder with a syringe needle attached is fitted onto the syringe. The small amount of solid left on the filter is washed down into the Reacti-vial with the jet of lung fluid from the syringe. The filter paper used is also stored for uranium analysis. The Reacti-vial is then capped, shakened to resuspend all the solid particles and replaced in the heating block. This process is repeated until all the samples are collected for selected dissolution periods. At the end of the dissolution trial, the residual sample is suspended in H_2O and this whole suspension is analyzed for uranium.

A blank is also run with the simulated lung fluid alone under identical conditions (37°C and the same stirring rate). The 5-ml samples are taken approximately at the same intervals of time throughout the experiment and analyzed for uranium to find out if there is any uranium leached out from the glass material of the Reacti-vial or present in the lung fluid itself.

Uranium Analysis:

The filtrates from the dissolution trial are analyzed for uranium by direct fluorometry. (9) In some cases where the uranium content is very low, preconcentration is carried out by extraction from aluminum nitrate with ethylacetate, followed by the fluorometric analysis on the extract. In the case of the solid residue and the membrane filters, they are first digested with concentrated HNO_3, diluted and then the fluorometric analysis is performed on these diluted samples.

Discussion:

A. Reduction of Data and Evaluation of Dissolution Half-Times

If the sample contains one pure component and the particles are present in a narrow size range (10), then the fraction of the component (sample) remaining undissolved will decrease exponentially with time. But in the case of a real world sample, many uranium components are usually present with different dissolution rates. As a result, there will be additional exponential terms and the dissolution data will be best fit by an equation of the following form:

$$F = f_1 \exp\left(-0.693\frac{t}{T_1}\right) + f_2 \exp\left(-0.693\frac{t}{T_2}\right) + \,.\;.\;.\;.\;+ f_n \exp\left(-0.693\frac{t}{T_n}\right)$$

where F is the fraction of total uranium remaining undissolved after time t, and f_i is the initial weight fraction of uranium components in the sample with dissolution half-time T_i. The values of F are calculated by substracting the amount of uranium dissolved during any sampling period from the amount undissolved at the beginning of that period and dividing this quantity by the total amount of uranium in the sample. The weight of uranium in the sample portion used in the dissolution trial is calculated by summing the amounts of uranium dissolved during the dissolution time increments and the amount of uranium in

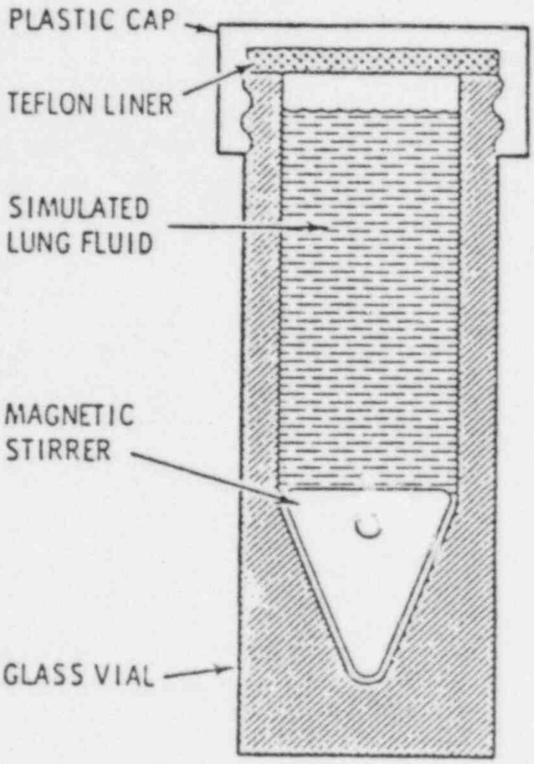


FIGURE 1. Cross Section of Dissolution Chamber for Dust Samples

the undissolved residue. As an example, the values of F calculated during the dissolution test of the third quarter, 1981 sample are given in Table III.

Table III

Amounts of Uranium Dissolved and Fraction of Total Uranium Remaining Undissolved During the Dissolution Test of the Air Particulate Sample (3rd Quarter, 1981)

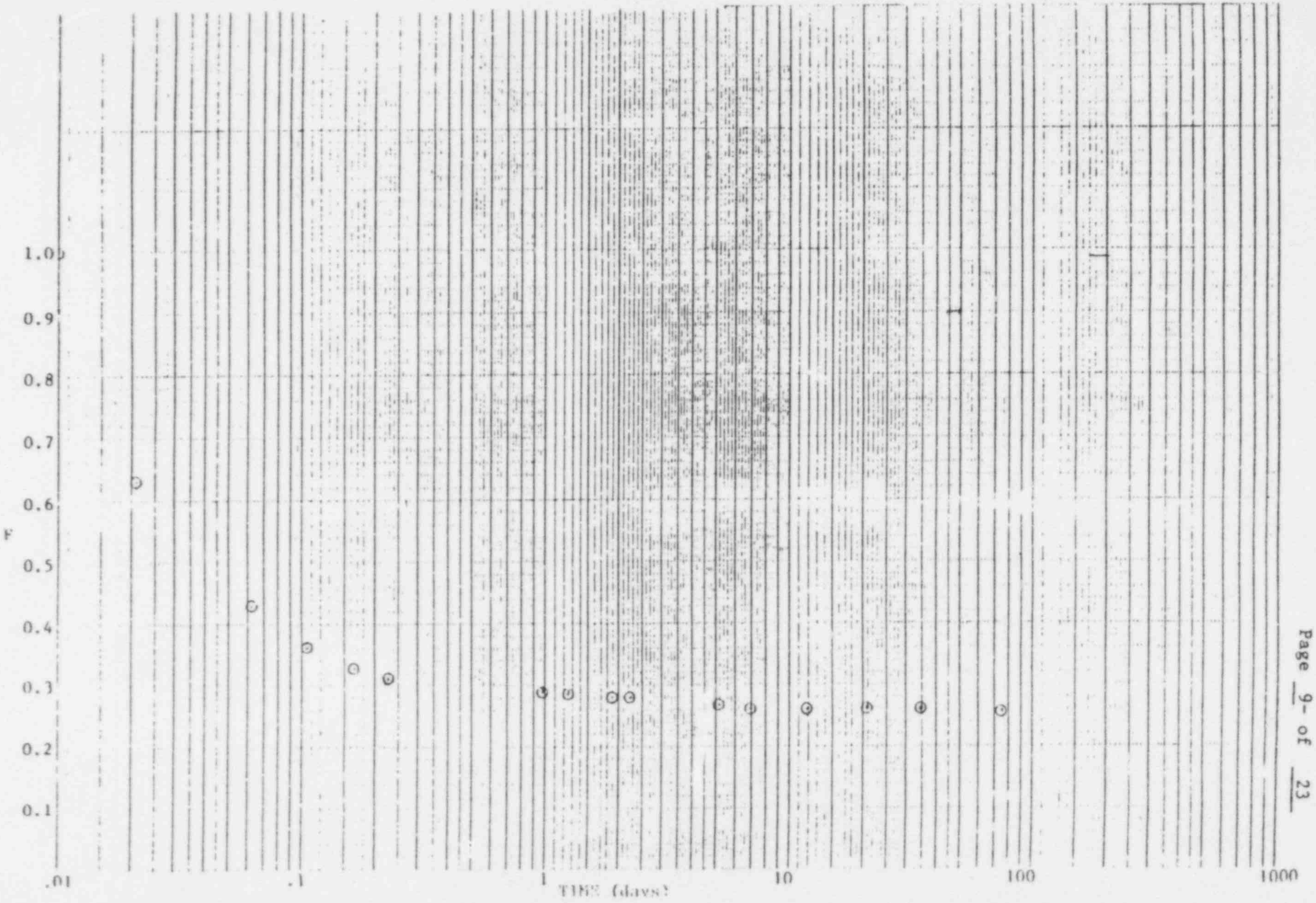
Time (Days)	Uranium Dissolved (μg)	Fraction Undissolved (F)
0.00	0.00	1.00
0.021	14	0.613
0.063	6.5	0.433
0.104	2.6	0.360
0.167	1.1	0.330
0.250	0.55	0.314
0.976	0.75	0.294
1.26	0.32	0.285
1.92	0.22	0.279
2.25	0.14	0.275
5.21	0.24	0.268
6.96	0.14	0.264
12.2	0.023	0.263
20.9	0.036	0.262
35.1	0.070	0.261
76.1	0.10	0.258

Solid residue and composite of filter papers used for filtration of different fractions	= 9.32 μg of U
Total uranium (μg) in the sample used for the experiment	= 36.2 μg of U

The values of F are plotted against t (days) on semi-log paper. The shape of this plot indicates that the dissolution involves mainly two rate processes; the first one is very fast, and the other is a slow dissolution process. The plot of F-values versus t(days) for the third quarter 1981 sample, is also shown in Figure 2. From this plot, the values of T_i and f_i can be determined manually from the slopes of the tangents drawn on the plot. The first portion of the curve is so steep that it is very difficult to draw a tangent accurately. As a result, the values of T_i and f_i determined manually can be associated with 50 to 100% error. Instead, the best values of f_1, T_1, f_2, T_2, f_3 and T_3 are obtained by fitting the experimental data into a 3-term equation of the form (see page 7). A program (<u>11</u>) for non-linear regression analysis was developed for five

FIGURE 2

Fraction of Uranium Undissolved (F) vs. Time (days)



independent variables. This program is called 'NEWBRIT' and its Fortran Coding is given in the Appendix. For determining the sixth variable, one condition has been introduced into the program, that the summation of the weight fractions of three components must be equal to 1, that is $f_1 + f_2 + f_3 = 1$. This particular program needs a "seed" error value associated with the feeding values of both F and t in order to start. The arbitrary values of 0.0001 and 0.01 are introduced as errors associated with t and F, respectively. In the iterative program, these values of error are varied in such a way that the best values of f_1, T_1, T_2 and T_3 are obtained with minimum errors. Then the value of f_3 is determined by difference.

The data is entered into the data file "ASOK" as in the following example:

```
.6689  .0092  .1383  1.2454  320
.1  .00001  .001  .01  50
1.  1. 1.  100  1E5
0  .0001  1. .01
0.0208  .0001  .724  .01
.0625  .0001  .647  .01
.1042  .0001  .613  .01
.1874  .0001  .583  .01
.2708  .0001  .563  .01
.9422  .0001  .526  .01
1.276  .0001  .508  .01
1.928  .0001  .498  .01
3.02  .0001  .489  .01
6.21  .0001  .48  .01
9.24  .0001  .473  .01
13.95  .0001  .468  .01
27.12  .0001  .459  .01
78.12  .0001  .349  .01
```

Lines 1-3 remain unchanged from sample to sample as these are the "seed" values used by the program to calculate the variables. Lines 4-18 are the actual data obtained experimentally. Column 1 is the time in days from the start of the test.

Columns 2 and 4 are the arbitrary error values discussed above. Column 3 is the fraction of uranium undissolved at the time listed in Column 1. After the data is entered, the program "NEWBRIT" is run manually. At each iteration the operator enters values for IT (number of iterations) = usually 1, IDEM (maximum number of deming iterations) = usually 1, and GAMACT (maximum feasible step from binding bounds) = any number from 10^{-5} to 10^{5}. After the first iteration, the value for GAMACT is varied to slowly approach the SumDEL (sum of values of the data adjustments) value calculated for the previous step. This method, when taken through 30-50 iterations, produces reproducible values for f_1, f_2, T_1, T_2 and T_3 with errors on the order of $\leq$ 1% of the value.

B. Dissolution Rate Classification

Solubility classification of the sample is based on the weight fractions and dissolution half-times of the uranium components. In order to make a solubility classification, let us consider the dissolution parameters (weight fraction, f, and dissolution half-times, T) for the third quarter, 1981 air particulate sample. These dissolution parameters are given in Table IV.

Table IV

Dissolution Parameters for Third Quarter, 1981
Air Particulate Sample

f_1	T_1 (days)	f_2	T_2 (days)	f_3	T_3 (days)
0.50±0.045	0.012±0.0014	0.223±0.044	0.083±0.018	0.277±0.063	547±232

From these values, it is inferred that 50% of the uranium in the third quarter, 1981 sample had a dissolution half-time of 0.012 days, 22% of the uranium with half-time of 0.083 days, and 28% of the uranium dissolved with half-time of 547 days. So the dissolution rate of the uranium in the sample is classified as 0.50D, 0.22 D, 0.28 Y. Since the sample contains two components in the D category of the ICRP task group lung model, these can be combined (added) to show the total weight fraction of uranium in this category.

Since the dissolution trial is carried out over a period of around 80 days, it is sufficient to categorize the uranium components into the solubility classes (1) used by the ICRP Task Group on Lung Dynamics. The classification scheme adopted is therefore:

(1) Soluble - compounds with a solubility half-life <1-10 days, inclusive, equivalent to clearance class D.

(2) Moderately Soluble - compounds with an estimated solubility half life >10-100 days, inclusive, equivalent to clearance class W.

(3) Relatively Insoluble - compounds with an estimated solubility half-life >100 days, equivalent to clearance class Y.

On this basis, the third quarter 1981 sample contains 72% soluble uranium compound and 28% insoluble uranium compound.

N. Cooke and F. B. Holt (1) studied the solubility of some known uranium compounds in simulated lung fluid and classified them into solubility classes similar to clearance classes used by ICRP.

Class D	Class W	Class Y
Very soluble	Moderately soluble	Relatively insoluble
0-10 days	>10-100 days	>100 days
Uranium hexafluoride	Ammonium diuranate	Uranium dioxide
Uranyl fluoride	Uranium trioxide	Uranium octoxide
Uranyl nitrate	Uranium tetrafluoride	

This is a very general classification, as Steckel and West (12) showed that the solubility in simulated lung fluid of a number of uranium process materials and laboratory-prepared oxides was related to the effect of thermal history on chemical composition and particle size. So, the solubility of a uranium compound is very much dependent on the condition (physical conditions) under which it has gone through.

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```
1010**RUNH*= (ULIB) RLIB;LIBRARY/APPLIB,R
1020 PARAMETER KP=14,MQVP=2,MDLP=1,NP=5,NXNP=(NP*(NP+1))/2,MXMP=(MDLP*(MDLP+1))/2
1022 CALL SR4J ; CALL CALLSS('REMO CLEARFILES\')
1024 CALL ACCESS('AF,/ASOK'33'#',$99)
1030 IMPLICIT REAL*8(A-H,O-Z)
1040 REAL*8 P(NP),DELP(NP),PFD(NP),LB(NP),UB(NP)
1050 REAL*8 F(MDLP),FF(MDLP),FZDZ(MDLP)
1060 REAL*8 Z(MQVP),ZM(MQVP),R(MQVP),DELZ(MQVP),ZWORK(MQVP)
1070 REAL*8 FPTWFP(NXNP),FT(NXNP),FPTWFI(NXNP)
1080 REAL*8 FP(MDLP,NP),FZ(MDLP,MQVP),FPTW(NP,MDLP)
1090 REAL*8 W(MXMP)
1100 REAL*8 ZMK(MQVP,KP),RK(MQVP,KP),DELZK(MQVP,KP)
1110 REAL*8 FK(MDLP,KP),FZDZK(MDLP,KP)
1120 REAL*8 FPK(MDLP,NP,KP),FZK(MDLP,MQVP,KP),WK(MXMP,KP)
1130* definitions
1140* NP   = N   = # of constants to evaluated
1150*                P(N), DELP(N), PFD(N)
1160* MDLP = MDL = # of model equations.
1170*                F(MDL), FF(MDL), FZDZ(MDL)
1180* MQVP = MQV = # of measured values
1190*                Z(MQV), ZM(MQV), ZWORK(MQV), DELZ(MQV), R(MQV)
1200* NXNP = NXN = correlation matrix = N*(N+1)/2
1210*                FPTWFP(NXN), FT(NXN), FPTWFI(NXN)
1220* MXMP = MXM = weighting matrix = MDL*(MDL+1)/2
1230*                W(MXM)
1240* limits sum MQV ≥ sum MDL > N
1250* Jacobian differentials FZ(MDL,MQV), FP(MDL,N)
1260 CALL FPARAM(1,132)
1270 CALL EXPDAT(KP,MQVP,MDLP,NP,MXMP,ZM,R,DELZ,F,FZDZ,FP,FZ,W,
1280&                  ZMK,RK,DELZK,FK,FZDZK,FPK,FZK,WK)
1290 KXP=KP ; N=NP ; MDL=MDLP ; MQV=MQVP ; NXN=NXNP ; MXM=MXMP
1300 SSND = 1D-4
1310* start data preparation
1320 READ(33,10)(P(I),I=1,NP)
1330 READ(33,10)(LB(I),I=1,NP)
1340 READ(33,10)(UB(I),I=1,NP)
1350 10 FORMAT(V)
1360 DO 20 JK=1,KP
1370 READ(33,10)ZM(2),R(2),ZM(1),R(1)
1380 CALL WEXPD(JK,ZM,R,DELZ,F,FZDZ,FP,FZ,W)
1390 20 CONTINUE
1400 CALL DATIM(AD8,HRS)
1410 WRITE(06,5000)HRS,AD8
1420 5000 FORMAT(1H1,/////,' Correlation run',80X,F10.2,3X,A8)
1430 CALL LUEBRI(ITER,KXP,MQVP,MDLP,NP,NXNP,MXMP,F,FF,Z,ZM,ZWORK,P,R,W,
1440&FZ,FP,FPTW,DELP,DELZ,FZDZ,FPTWFP,FT,FPTWFI,SSND,PFD,LB,UB)
1450 99 STOP ; END
1460*<<<
1470 SUBROUTINE EXPDAT(KP,MQVP,MDLP,NP,MXMP,ZM,R,DELZ,F,FZDZ,FP,FZ,W,
1480&                  ZMK,RK,DELZK,FK,FZDZK,FPK,FZK,WK)
1490 REAL*8 ZM(MQVP),R(MQVP),DELZ(MQVP)
1500 REAL*8 F(MDLP),FZDZ(MDLP)
1510 REAL*8 FP(MDLP,NP),FZ(MDLP,MQVP),W(MXMP)
1520 REAL*8 ZMK(MQVP,KP),RK(MQVP,KP),DELZK(MQVP,KP)
```

```
1530 REAL*8 FK(MDLP,KP),FZDZK(MDLP,KP)
1540 REAL*8 FPK(MDLP,NP,KP),FZK(MDLP,MQVP,KP),WK(MXMP,KP)
1550 RETURN
1560 ENTRY REXPD(K,ZM,R,DELZ,F,FZDZ,FP,FZ,W)
1570 DO 10 I=1,MQVP
1580 ZM(I) = ZMK(I,K)
1590 R(I) = RK(I,K)
1600 DELZ(I) = DELZK(I,K)
1610 DO 10 J=1,MDLP
1620 10 FZ(J,I) = FZK(J,I,K)
1630 DO 12 J=1,MDLP
1640 F(J) = FK(J,K)
1650 FZDZ(J) = FZDZK(J,K)
1660 DO 12 I=1,NP
1670 12 FP(J,I) = FPK(J,I,K)
1680 DO 14 I=1,MXMP
1690 14 W(I) = WK(I,K)
1700 RETURN
1710 ENTRY WEXPD(K,ZM,R,DELZ,F,FZDZ,FP,FZ,W)
1720 DO 20 I=1,MQVP
1730 ZMK(I,K) = ZM(I)
1740 RK(I,K) = R(I)
1750 DELZK(I,K) = DELZ(I)
1760 DO 20 J=1,MDLP
1770 20 FZK(J,I,K) = FZ(J,I)
1780 DO 22J=1,MDLP
1790 FK(J,K) = F(J)
1800 FZDZK(J,K) = FZDZ(J)
1810 DO 22 I=1,NP
1820 22 FPK(J,I,K) = FP(J,I)
1830 DO 24 I=1,MXMP
1840 24 WK(I,K) = W(I)
1850 RETURN
1860 END
1870*<<<
1880 SUBROUTINE MODEL(MQV,Z,MDL,F,N,P)
1890 REAL*8 Z(1),F(1),P(1),X,XZ
1900 XZ = -.693147181D0*Z(2)
1910 X = 0D0 ; IF(XZ/P(2).GT.-87D0) X = DEXP(XZ/P(2))
1920 F(1) = -Z(1) + P(1)*X
1930 X = 0D0 ; IF(XZ/P(4).GT.-87D0) X = DEXP(XZ/P(4))
1940 F(1) = F (1) + P(3)*X + (1D0 - P(1) - P(3))*DEXP(XZ/P(5))
1950 RETURN ; END
1960*<<<
1970 SUBROUTINE LUEBRI(ITER,KP,MQVP,MDLP,NP,NXNP,MXMP,F,FF,Z,ZM,ZWORK,P,R,W,
1980&FZ,FP,FPTW,DELP,DELZ,FZDZ,FPTWFP,FT,FPTWFI,SSND,PFD,LB,UB)
1990 IMPLICIT REAL*8(A-H,O-Z)
2000 REAL*8 P(NP),DELP(NP),PFD(NP),LB(NP),UB(NP)
2010 REAL*8 F(MDLP),FF(MDLP),FZDZ(MDLP)
2020 REAL*8 Z(MQVP),ZM(MQVP),R(MQVP),DELZ(MQVP),ZWORK(MQVP)
2030 REAL*8 FPTWFP(NXNP),FT(NXNP),FPTWFI(NXNP)
2040 REAL*8 SSND,LAM,E(24)
2050 REAL*8 FP(MDLP,NP),FZ(MDLP,MQVP),FPTW(NP,MDLP)
```

```
2060 REAL*8 W(MXMP)
2070 DIMENSION JJJ(24)
2080 STEP1 = 1D0+SSND
2090 STEP2 = 1D0-SSND
2100 5002 FORMAT(V)
2110 IDEM = 1 ; EAMACT = .1D0
2120 KXP=KP ; N=NP ; MDL=MDLP ; MQV=MQVP ; NXN=NXNP ; MXM=MXMP
2130*
2140*   start iteration loop
2150*
2170 1000 WRITE(06,900)
2180 900 FORMAT(' Input - IT,IDEM,GAMACT')
2190 READ(05,5002)IT,IDEM,EAMACT
2200 DO 90 JN=1,N
2210 PFD(JN) = 0D0
2220 DO 90 IN=1,JN
2230 KK = JN*(JN-1)/2 + IN
2240 90 FPTWFP(KK) = 0D0
2250*
2260*   start experimental data loop 1
2270*
2280 DO 400 JK=1,KXP
2290 CALL REXPD(JK,ZM,R,DELZ,F,FZDZ,FP,FZ,W)
2300 DO 100 JQ=1,MQV
2310 IF(IDEM.EQ.1)DELZ(JQ) = 0D0
2320 100 Z(JQ) = ZM(JQ) - DELZ(JQ)
2330 140 CALL MODEL(MQV,Z,MDL,F,N,P)
2340* COMMENT
2350 STEP = STEP1
2360 DENOM = 1D0
2370 DO 142 JM=1,MDL
2380 DO 142 JQ=1,MQV
2390 142 FZ(JM,JQ) = 0D0
2400 144 DO 146 JQ=1,MQV
2410 146 ZWORK(JQ) = Z(JQ)
2420 DO 148 JQ=1,MQV
2430 IF(JQ.GT.1)ZWORK(JQ-1) = Z(JQ-1)
2440 ZWORK(JQ) = STEP*Z(JQ)
2450 IF(Z(JQ).EQ.0D0) ZWORK(JQ) = STEP - 1D0
2460 CALL MODEL(MQV,ZWORK,MDL,FF,N,P)
2470 A = Z(JQ)
2480 IF(A.EQ.0D0) A=1D0
2490 DO 148 JM=1,MDL
2500 148 FZ(JM,JQ) = ((FF(JM)-F(JM))/SSND/A - FZ(JM,JQ))/DENOM
2510 IF(STEP.NE.STEP1) GOTO 150
2520 STEP = STEP2
2530 DENOM = -2D0
2540 GOTO 144
2550 150 CONTINUE
2560*      start FP calc.
2570 STEP = STEP1
2580 DENOM = 1D0
2590 DO 152 JM=1,MDL
```

```
2600 DO 152 JN=1,N
2610 152 FP(JM,JN) = 0D0
2620 154 DO 156 JN=1,N
2630 156 DELP(JN) = P(JN)
2640 DO 158 JN=1,N
2650 IF(JN.GT.1) DELP(JN-1) = P(JN-1)
2660 DELP(JN) = STEP*P(JN)
2670 IF(P(JN).EQ.0D0) DELP(JN) = STEP - 1D0
2680 CALL MODEL(MQV,Z,MDL,FF,N,DELP)
2690 A = P(JN)
2700 IF(A.EQ.0D0)A=1D0
2710 DO 158 JM=1,MDL
2720 158 FP(JM,JN) = ((FF(JM)-F(JM))/SSND/A - FP(JM,JN))/DENOM
2730 IF(STEP.NE.STEP1) GOTO 160
2740 STEP = STEP2
2750 DENOM = -2D0
2760 GOTO 154
2770 160 CONTINUE
2780*      start W calc.
2790 DO 200 JM=1,MDL
2800 DO 200 IM=1,JM
2810 KK = JM*(JM-1)/2 + IM
2820 W(KK) = 0D0
2830 DO 200 JQ=1,MQV
2840 200 W(KK) = W(KK) + FZ(IM,JQ)*FZ(JM,JQ)*R(JQ)**2
2850 IF(MDL.EQ.1)W(1) = 1D0/W(1)
2860 IF(MDL.GT.1)CALL DSINV(W,MDL,1.E-12,IER)
2870 DO 210 JM=1,MDL
2880 DO 210 JN=1,N
2890 FPTW(JN,JM) = 0D0
2900 DO 210 IM=1,MDL
2910 KK = MAX(JM*(JM-1),IM*(IM-1))/2 + MIN(JM,IM)
2920 210 FPTW(JN,JM) = FPTW(JN,JM) + FP(IM,JN)*W(KK)
2930 DO 220 IN=1,N
2940 DO 220 JIN=1,IN
2950 KK = IN*(IN-1)/2 + JIN
2960 DO 220 IM=1,MDL
2970 220 FPTWFP(KK) = FPTWFP(KK) + FPTW(JIN,IM)*FP(IM,IN)
2980 DO 230 JM=1,MDL
2990 FZDZ(JM) = 0D0
3000 DO 240 JQ=1,MQV
3010 240 FZDZ(JM) = FZDZ(JM) + FZ(JM,JQ)*DELZ(JQ)
3020 230 FZDZ(JM) = FZDZ(JM) + F(JM)
3030 DO 260 JN=1,N
3040 DO 260 JM=1,MDL
3050 260 PFD(JN) = PFD(JN) + FPTW(JN,JM)*FZDZ(JM)
3060 CALL WEXPD(JK,ZM,R,DELZ,F,FZDZ,FP,FZ,W)
3070 400 CONTINUE
3080*
3090*   end experimental data loop 1
3100*
3110 LAM = 0D0
3120 DO 300 JIN=1,10
```

```
JO = 0
SUM = 0D0
DO 310 JN=1,N
DO 310 IN=1,JN
JO = JO+1
FT(JO) = FPTWFP(JO)
IF(JN-IN)310,312,310
312 IF(JIN.GT.1) FT(JO) = FT(JO) + LAM*DABS(FT(JO))
IF(JIN.GT.1.AND.FT(JO).EQ.0D0) FT(JO) = (1D0+LAM)*AVG
SUM = SUM + DABS(FT(JO))
310 CONTINUE
AVG = SUM/N
CALL DSINV(FT,N,1.E-12,IER)
IF(IER.EQ.0) GOTO 320
IF(JIN.EQ.1) LAM = 5.D-3
300 LAM = LAM*10D0
RETURN
320 JO = 0
DO 330 JN=1,N
DELP(JN) = 0D0
DO 330 IN=1,JN
JO = JO+1
FPTWFI(JO) = FT(JO)
DELP(JN) = DELP(JN) + FPTWFI(JO)*PFD(IN)
IF(JN.NE.IN) DELP(IN) = DELP(IN) + FPTWFI(JO)*PFD(JN)
330 CONTINUE
GAMMAX = 1D38
CALL GRADPJ(LB,UB,P,FPTWFI,DELP,E,JJJ(N+1),JJJ(2*N+1),JJJ(3*N+1),N,GAMMAX,IF
GAMACT = MIN(GAMACT,GAMMAX)
SUMDEL = 0D0
DO 340 JN=1,N
BASE = P(JN)
IF(BASE.EQ.0D0) BASE = DELP(JN)
IF(BASE.EQ.0D0) BASE = 1D0
SUMDEL = SUMDEL + (DELP(JN)/BASE)**2
IF(IT.EQ.1) WRITE(06,5008)JN,P(JN),DELP(JN)
340 P(JN) = P(JN) - GAMACT*DELP(JN)
SUMDEL = DSQRT(SUMDEL/N)
WRITE(06,5004)IT,SUMDEL,GAMACT
5004 FORMAT(I4,' SUMDEL = ',1PE15.8,', GAMACT = ',E15.8)
WSUM = 0D0 ; SUMSQ = 0D0 ; RUMSQ = 0D0
*
*   start experimental data loop 2
*
DO 410 JK=1,KXP
CALL REXPD(JK,ZM,R,DELZ,F,FZDZ,FP,FZ,W)
DO 350 JN=1,N
DO 350 JM=1,MDL
350 FZDZ(JM) = FZDZ(JM) - GAMACT*FP(JM,JN)*DELP(JN)
DO 360 JQ=1,MQV
ZWORK(JQ) = 0D0 ; RUMSQ = RUMSQ + 1D0/(R(JQ))**2
DO 370 JM=1,MDL
DO 370 IM=1,MDL
```

```
3660 KK = MAX(JM*(JM-1),IM*(IM-1))/2 + MIN(JM,IM)
3670 370 ZWORK(JQ) = ZWORK(JQ) + FZ(JM,JQ)*W(KK)*FZDZ(IM)
3680 DELZ(JQ) = ZWORK(JQ)*R(JQ)**2
3690 IF(IT.LE.0.OR.ABS(SUMDEL).LT.1.D-4) WRITE(06,5008)JQ,ZM(JQ),DELZ(JQ)
3700 360 SUMSQ = SUMSQ + (DELZ(JQ)/R(JQ))**2
3710 KK = 0 ; DO 380 IM=1,MDL ; KK = KK+IM
3720 380 WSUM = WSUM + W(KK)
3730 CALL WEXPD(JK,ZM,R,DELZ,F,FZDZ,FP,FZ,W)
3740 410 CONTINUE
3750*
3760*   end experimental data loop 2
3770*
3780 SIGMA = DSQRT((SUMSQ*KXP)/(WSUM*(KXP-N)))
3790 WRITE(06,5010)SUMSQ,WSUM,SIGMA
3800 5010 FORMAT('  SUMSQ = ',1PE15.8,',    WSUM = ',E15.8,',  SIGMA = ',E15.8)
3810 WRITE(06,5018)
3820 5018 FORMAT(1H ,4X,'#',3X,'Parameter',8X,'Sigma',12X,'Delta')
3830 KK = 0 ; DO 5006 I=1,N ; KK = KK+I
3840 FT(KK) = DSQRT(SUMSQ*FPTWFI(KK)/(KXP-N))
3850 WRITE(06,5008)I,P(I),FT(KK),DELP(I)
3860 5008 FORMAT(I6,1PE17.8,2E17.8)
3870 5006 CONTINUE
3880 5014 FORMAT(3X,1PE12.4,9E12.4)
3890 IF(ABS(SUMDEL).LT.1.D-8.AND.IDEM.EQ.0.OR.IDEM.LT.0)GOTO 1002
3900 IF(IT.GT.0) GOTO 1000
3910*
3920*   end iteration loop
3930*
3940 1002 WRITE(06,5016)
3950 5016 FORMAT(' Correlation matrix ')
3960 WSUM = WSUM/1D0 ; KK = 0 ; DO 1004 I=1,N
3970 KK = KK+I ; KKK = KK-I+1
3980 1004 WRITE(06,5014)(FPTWFI(J),J=KKK,KK)
3990 IF(IPERR.NE.0) RETURN
4000 1012 CONTINUE
4010 SUMSQF = 0D0
4020 DO 420 JK=1,KXP
4030 CALL REXPD(JK,ZM,R,DELZ,F,FZDZ,FP,FZ,W)
4040 CALL MODEL(MQV,ZM,MDL,F,N,P)
4050 DO 430 JM=1,MDL
4060 430 SUMSQF = SUMSQF + F(JM)**2
4070 420 CONTINUE
4080 PRINT,'  ERR',SUMSQF
4090 RETURN
4100 END
4110*<<<
4120*SERID BRITT    CLASS A NAME DSINV        FORTRAN      06/01/79 17:08:06
4130*READ  DSINV    FORTRAN  B1 TESTLB  5/04/79  12:37
4140*$ #1 BY: BRITT DATE: 01/04/79 FIRST ABSORB
4150       SUBROUTINE DSINV(A,N,EPS,IER)
4160       DIMENSION A(1)
4170       REAL *8 A,DIN,WORK
4180       CALL DMFSD(A,N,EPS,IER)
```

```
      IF(IER) 9,1,1
    1 IPIV=N*(N+1)/2
      IND=IPIV
      DO 6 I=1,N
      DIN=1.D0/A(IPIV)
      A(IPIV)=DIN
      MIN=N
      KEND=I-1
      LANF=N-KEND
      IF(KEND) 5,5,2
    2 J=IND
      DO 4 K=1,KEND
      WORK=0.D0
      MIN=MIN-1
      LHOR=IPIV
      LVER=J
      DO 3 L=LANF,MIN
      LVER=LVER+1
      LHOR=LHOR+L
    3 WORK=WORK+A(LVER)*A(LHOR)
      A(J)=-WORK*DIN
    4 J=J-MIN
    5 IPIV=IPIV-MIN
    6 IND=IND-1
      DO 8 I=1,N
      IPIV=IPIV+I
      J=IPIV
      DO 8 K=I,N
      WORK=0.D0
      LHOR=J
      DO 7 L=K,N
      LVER=LHOR+K-I
      WORK=WORK+A(LHOR)*A(LVER)
    7 LHOR=LHOR+L
      A(J)=WORK
    8 J=J+K
    9 RETURN
      END
*<<<
*SERID BRITT    CLASS A NAME DMFSD        FORTRAN       06/01/79 17:09:18
*READ  DMFSD    FORTRAN  B1 TESTLB  5/04/79  12:36
*$ #1 BY: BRITT DATE: 01/04/79 FIRST ABSORB
      SUBROUTINE DMFSD(A,N,EPS,IER)
      DIMENSION A(1)
      REAL *8 DPIV,DSUM,A
      IF(N-1) 12,1,1
    1 IER=0
      KPIV=0
      DO 11 K=1,N
      KPIV=KPIV+K
      IND=KPIV
      LEND=K-1
      TOL=ABS(EPS*SNGL(A(KPIV)))
```

```
4720       DO 11 I=K,N
4730       DSUM=0.DO
4740       IF(LEND) 2,4,2
4750     2 DO 3 L=1,LEND
4760       LANF=KPIV-L
4770       LIND=IND-L
4780     3 DSUM=DSUM+A(LANF)*A(LIND)
4790     4 DSUM=A(IND)-DSUM
4800       IF(I-K) 10,5,10
4810     5 IF(SNGL(DSUM)-TOL) 6,6,9
4820     6 IF(DSUM) 12,12,7
4830     7 IF(IER) 8,8,9
4840     8 IER=K-1
4850     9 DPIV=DSQRT(DSUM)
4860       A(KPIV)=DPIV
4870       DPIV=1.DO/DPIV
4880       GO TO 11
4890    10 A(IND)=DSUM*DPIV
4900    11 IND=IND+I
4910       RETURN
4920    12 IER=-1
4930       RETURN
4940       END
4950*>>>>
4960       SUBROUTINE GRADPJ(LB,UB,P,R,S,E,M,K,IDX,N,SSMAX,IER)
4970       IMPLICIT REAL*8(A-H,O-Z)
4980       REAL*8 LB(N),UB(N),P(N),R(1),  S(N),E(N,1)
4990       INTEGER M(N),K(N),IDX(N)
5000*
5010*         LOCATE  SYMMETRIC STORAGE MODE ARRAY ELEMENT FOR I>=J
5020*
5030       LOC(I,J)= I*(I-1)/2+J
5040*
5050*         CHECK FOR  ACTIVE   BOUNDS AND SET UP M AND K ARRAYS
5060*
5070       IER=0
5080       NAC=0
5090       DO 10 I=1,N
5100       IF(DABS(P(I)-LB(I)) .LT. 1D-6) GO TO 4
5110       IF(P(I) .LT. LB(I)*1.00001DO) GO TO 4
5120       GO TO 5
5130*         LOWER BOUND ACTIVE
5140     4 NAC=NAC+1
5150       P(I) = LB(I)
5160       M(NAC)=1
5170       K(NAC)=1
5180       IDX(NAC)=I
5190       GO TO 10
5200     5 IF(DABS(P(I)-UB(I)) .LT. 1D-6) GO TO 6
5210       IF(P(I) .GT. 0.99999DO*UB(I)) GO TO 6
5220       GO TO 10
5230*         UPPER BOUND ACTIVE
5240     6 NAC=NAC+1
```

```
      P(I) = UB(I)
      M(NAC)=-1
      K(NAC)=1
      IDX(NAC)=I
   10 CONTINUE
*         IF IN INTERIOR, NO PROJECTION
      IF(NAC.EQ.0) GO TO 60
*
*         CONSTRUCT TABLEAU AND FIND BINDING BOUNDS
*
      DO 20 I=1,NAC
      E(I,NAC+1)=-S(IDX(I))
      DO 20 J=1,NAC
      IF(I.GE.J) E(I,J)=R(LOC(IDX(I),IDX(J)))
      IF(I.LT.J) E(I,J)=R(LOC(IDX(J),IDX(I)))
   20 CONTINUE
      ICOUNT=0
   25 ICOUNT=ICOUNT+1
      IF(ICOUNT.LE.10*NAC) GO TO 27
      IER=1
      RETURN
   27 A=1D38
      DO 30 I=1,NAC
      AI=M(I)*K(I)*E(I,NAC+1)
      IF(AI.GE.A)  GO TO 30
      A=AI
      IR=I
   30 CONTINUE
      IF(A.GT.-1D-6) GO TO 40
      K(IR)=-1
      CALL GJPVT(NAC,NAC+1,N,IR,IR,E,IER)
      IF(IER.EQ.0) GO TO 25
      RETURN
*
*         COMPUTE PROJECTION STEP
*
   40 DO 50 J=1,NAC
      IF(K(J).NE.-1) GO TO 50
      DO 45 I=1,N
      IF(I.GE.IDX(J)) S(I)=S(I)+R(LOC(I,IDX(J)))*E(J,NAC+1)
      IF(I.LT.IDX(J)) S(I)=S(I)+R(LOC(IDX(J),I))*E(J,NAC+1)
   45 CONTINUE
   50 CONTINUE
*
*         FOR BINDING BOUNDS SET STEP TO IDENTICALLY 0.0 AND LOAD
*         LAGRANGE MULTIPLIERS(SENSITIVITY DERIVATIVES) INTO THE FIRST
*         COLUMN OF E FOR RETURN. SET ALL OTHER MULTIPLIERS TO 0.0
*
      DO 54 I=1,N
   54 E(I,1)=0.0
      DO 55 I=1,NAC
      IF(K(I).NE.-1) GO TO 55
      S(IDX(I))=0.0
```

```
      E(IDX(I),1)=-E(I,NAC+1)
   55 CONTINUE
*
*        MAXIMUM FEASIBLE STEP SIZE AND EXIT
*
   60 SSMAX=1D38
      DO 65 I=1,N
      IF(S(I).LT.0.0) SSMAX=DMIN1(SSMAX,-(UB(I)-P(I))/S(I))
      IF(S(I).GT.0.0) SSMAX=DMIN1(SSMAX,-(LB(I)-P(I))/S(I))
   65 CONTINUE
      M(1)=NAC
      IF(NAC.NE.0) RETURN
      DO 70 I=1,N
   70 E(I,1)=0.0
      RETURN
      END
      SUBROUTINE GJPVT(N,M,ND,I,J,B,IER)
      REAL*8 B(1)
*
      PERFORM GAUSS-JORDAN PIVOT ON MATRIX B(N,M)
          STORED IN AN ARRAY WITH ROW DIMENSION ND
          USING  B(I,J) AS THE PIVOT ELEMENT
          ON RETURN, IER = 0 IF NO ERROR
                     IER =-1 IF B(I,J) = 0
*
      REFERERENCE: BARD,Y.,B.,'NONLINEAR PARAMETER ESTIMATION,'ACADEMIC
                   PRESS,NEW YORK,1974,SEC.A-3
*
      PROGRAMMER: R.F. WILLIAMS, OCT 76
*
*        L IS A FUNCTION TO LOCATE MATRIX ELEMENT B(IROW,JCOL) IN ARRAY
*
      L(IROW,JCOL)=ND*(JCOL-1)+IROW
      IER = 0
      IF(B(L(I,J)).NE.0.D0) GO TO 10
      IER=-1
      GO TO 200
   10 DO 100 IP=1,N
      DO 100 JQ=1,M
      IF(IP.EQ.I.OR.JQ.EQ.J) GO TO 100
      B(L(IP,JQ))=B(L(IP,JQ))-B(L(I,JQ))*B(L(IP,J))/B(L(I,J))
  100 CONTINUE
      DO 120 IP=1,N
      IF(IP.EQ.I) GO TO 120
      B(L(IP,J))=-B(L(IP,J))/B(L(I,J))
  120 CONTINUE
      DO 140 JQ=1,M
      IF(JQ.EQ.J) GO TO 140
      B(L(I,JQ))=B(L(I,JQ))/B(L(I,J))
  140 CONTINUE
      B(L(I,J))=1.D0/B(L(I,J))
  200 RETURN
      END
```

APPENDIX 5.2.3

ORNL'S ANALYTICAL PROCEDURE

OAK RIDGE NATIONAL LABORATORY
OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.

POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37831

January 30, 1986

Mr. Barry Zalcman
U. S. Nuclear Regulatory Commission
Willste Bldg., Room 517
7915 Eastern Avenue
Silver Springs, Maryland 20910

Dear Barry:

I enclose the copies of the specific analytical procedures used to measure the uranium and fluoride concentrations in the specimens received after the January 4, 1986 Sequoyah Nuclear Fuels incident.

As we discussed by telephone, we utilized our neutron activation facility to determine the uranium concentrations in the vegetation, soils, and water specimens. The limits of detection for uranium are 0.030 micrograms per milliliter in water, and 0.020 micrograms per gram of vegetation or soil. The confidence level is 10.0 ± 0.2 micrograms of uranium.

The uranium concentrations in the two shipments of urine specimens were determined by ultraviolet excitation and measurement of the characteristic yellow-green uranium fluorescence. The limit of detection for uranium is 0.005 micrograms of uranium per milliliter of urine. The relative standard deviation is 7.6 percent at the 0.05 microgram per milliliter concentration level. The detailed procedure is included, for your information, together with a letter which details the quality assurance standards measured with your specimens. Please note that we measured more standards than specimens, and that these quality assurance concentrations covered the entire range experienced in the specimens.

The procedures for measuring fluoride concentration in vegetation and water are attached. The fluoride in the soil specimens was extracted with deionized fluoride-free water, the extract was filtered to remove soil particles, and the final determination of fluoride was measured with a fluoride specific ion electrode as detailed in the surface water procedure. We analyzed a 4.0 microgram per gram National Bureau of Standards orchard grass standard as a quality assurance test and recovered 3.4 micrograms of fluoride. We also prepared duplicate ORNL standards containing 20.0 micrograms of fluoride and subjected them to the entire analytical procedure, including distillation. We recovered 20.3 and 20.9 micrograms of fluoride to demonstrate excellent recoveries.

As requested by Mr. Jerry Swift, I also enclose the data sheet from the NRC shipment of the COMP water, soil, and vegetation specimens received at ORNL on January 22, 1986. I have taken the information written on the plastic specimen bags and included it on the data sheet that was in the shipping carton.

KERR-McGEE CORPORATION
TECHNICAL CENTER

ANALYTICAL METHODS

KMTC - 149-EC-10

ISSUED 12/1/77 REVISED None

PAGE 1 OF 8

DETERMINATION OF Thorium, Uranium and Plutonium	TYPE OF SAMPLE Water, Soil, Vegetation and Products or By-Products
ANALYTICAL METHOD Alpha Pulse Height Analysis	WRITTEN BY GEVS APPROVED CHL

Method:

Except for natural uranium or natural thorium, environmentally important concentrations of actinides cannot be readily determined by ordinary chemical means. Additionally, chemical methods do not offer any information as to the isotopic composition of the element in question. Therefore, for samples where either an isotopic composition and/or ultra low level of detection is required, alpha pulse height analysis is the method of choice.

This method utilizes the following technologies:

1. In-situ formation of calcium phosphate is used to concentrate the actinides from a large aqueous volume.

2. Anion exchange is used to permit separation of the actinides into relatively pure form.

   a) For thorium, good separation is achieved from all elements except uranium. A separation factor in the vicinity of 10^6 is achieved for most elements, but only about 10^4 separation is achieved between uranium and thorium. As a result, some uranium will report to the electrodeposit when analyzing for thorium in a uranium rich material such as yellow cake.

   b) For uranium, good separation is achieved from all elements except thorium and those which form stable anion complexes with chloride (i.e., iron, aluminum, etc.). For this reason, whenever a material rich in these metals is to be analyzed for uranium, such as soils or mill tailings, the uranium must first be solvent-extracted from a nitrate or sulfate system in order to eliminate these interferences.

   c) For plutonium, good separation is achieved from all metals except for iron from iron-rich systems (i.e., liver tissue, iron or steel and their alloys, etc.). When analyzing an iron-rich system, the ion-exchange step should be repeated once. (Note: Three evaporations to dryness with concentrated nitric acid area required to completely remove traces of chloride and fluoride from the first ion-exchange strip liquor prior to the second ion-exchange. Failure to remove the chloride or fluoride will result in poor recovery of the plutonium.).

3. Electrodeposition is utilized to prepare an "infinitesimally thin" deposit necessary for good alpha pulse height energy resolution. A thick deposit ($\geq$ ten micrograms) causes alphas, from the bottom of the deposit, to degrade (lose energy) as they pass up through the deposit. As a result, the silicon surface barrier detector will see alphas with a lower energy which will produce

a spectral smear. Poor resolution of alpha energy will destroy the usefulness of the procedure. Alpha resolution should be $<$ 50 KeV FWHM (full width at half maximum) and any spectra with an alpha resolution of $>$ 100 KeV FWHM should result in rejection of the analysis.

Range and Precision:

Amounts of Th, U, or Pu as low as one femtocurie (1×10^{-15} curie or 3.7×10^{-5} disintegrations per second) can be detected over a counting time of 1000 minutes using silicon surface barrier alpha detectors in conjunction with a multichannel analyzer. The precision attained is a function of the activity in the sample and the recovery of the internal standard; however, typical precision, at one standard deviation, ranges from 3 to 50%.

Cost:

Cost (manhours) = k + nt

Where:

k = 2 manhours; t = 2 manhours, and n = number of samples.

Apparatus:

1. Silicon surface barrier detector(s) (Princeton Gamma Tech, 300-25-100) is used in conjunction with a multichannel analyzer.
2. Millipore filter equipment including 0.45µ Millipore Filter.
3. Magnetic stirring hotplate(s).
4. Ion-exchange column(s), Bio-Rad or equivalent, 1.5 cm I.D. X 15 cm in length, and accessories.
5. Ripple-free D. C. power supply capable of at least 1.5 amp @ 10 volts.
6. Electrodeposition cells - (Talvite, Anal. Chem. 1972) and polished stainless steel discs.
7. Assorted glass and plastic ware common to analytical laboratories.

Reagents:

1. a) Concentrated sulfuric acid (H_2SO_4).
   b) Concentrated hydrochloric acid (HCl).
   c) Concentrated nitric acid (HNO_3).
   d) Concentrated hydrofluoric acid (HF).
   e) Concentrated phosphoric acid (H_3PO_4).

We are pleased that the Martin Marietta Energy Systems staff and facilities were able to respond to your needs during the incident.

Please notify me if we can be of further assistance.

Sincerely,

Joseph H. Stewart, Jr.

J. H. Stewart, Jr.
CAPA Group Leader
Analytical Chemistry Division
Oak Ridge National Laboratory

JHS:sdc

Enclosures

cc: W. R. Laing
W. D. Shults
J. R. Stokely, Jr.

ENVIRONMENTAL ANALYSIS PROCEDURE

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
OAK RIDGE, TENNESSEE · PADUCAH, KENTUCKY

NUMBER EC 410
DATE July 21, 1977
SUPERSEDES
PAGE 1 OF 3

FLUORIDE (IN VEGETATION), ION-SELECTIVE ELECTRODE METHOD

1.0 SCOPE AND APPLICATION

1.1 This method is applicable to vegetation such as grasses, leaves, and forest floor litter.

1.2 The range of the method may be varied by sample size and/or dilution. For a 3 gram sample, the lowest fluoride concentration reported is 3μg/g.

2.0 SUMMARY OF METHOD

2.1 The sample is air dried, pulverized in a Wiley mill and digested in potassium hydroxide. Phosphoric acid is added and the fluoride determined by the ion-selective electrode method using the standard addition technique.

3.0 INTERFERENCES

3.1 The strong phosphoric acid solution in which the fluoride is measured eliminates the interference of complexing agents such as aluminum, iron, thorium, and silicon compounds.

4.0 SAMPLE HANDLING AND PRESERVATION

4.1 No special requirements.

5.0 APPARATUS

5.1 Orion Model 801 digital pH/mV meter or similar instrument for use with ion-selective electrodes.

5.2 Fluoride ion-selective electrode

5.3 Reference electrode

5.4 pH Meter

5.5 Wiley Mill, Intermediate Model

5.6 Magnetic stirrers.

APPROVED BY Y-12 R.W. Morrow	APPROVED BY ORGDP T. Kwasnoski
APPROVED BY PGDP R.E. Simmons	APPROVED BY ORNL

6.0 REAGENTS

6.1 Fluoride Standard, 2000 mg/liter: dissolve 2.2102 grams of dried reagent grade sodium fluoride in distilled water and dilute to 500 ml. One milliter = 2.0 milligrams fluoride.

6.2 Hydrochloric acid, concentrated.

6.3 Phosphoric acid, 18 N: dilute 407 ml reagent grade phosphoric acid, 85%, to one liter with distilled water.

6.4 Potassium hydroxide, 2 N: dissolve 112 g reagent grade potassium hydroxide in distilled water and dilute to one liter.

7.0 PROCEDURE

7.1 Grind the dried sample to minus 40 mesh in the Wiley mill. Weigh a 3-g sample, or less if more than 400 micrograms of fluoride is expected, and transfer to a 150-ml beaker.

7.2 Add 35 ml of 2 N potassium hydroxide, cover beaker with watch glass and place on hot plate adjusted to a low setting. Also, place a beaker containing 35 ml of 2 N potassium hydroxide on hot plate and carry through the procedure as a reagent blank.

7.3 Digest sample for a total of 90 minutes, rinsing the beaker walls and cover with distilled water after 30 and 60 minutes of digestion.

7.4 After 90 minutes, remove beakers from hot plate, rinse covers and walls and cool to room temperature.

7.5 Add 25 ml of 18 N phosphoric acid and adjust solutions to pH 1.0 by dropwise addition of concentrated hydrochloric acid.

7.6 Place beaker on a magnet stirrer. Insert the fluoride ion-selective electrode and the reference electrode. Allow stirred sample to equilibrate and record the millivolt reading.

7.7 Add 0.20 ml of the 2.0 mg/ml fluoride standard. The volume of standard added must be small so as not to significantly affect the volume of the sample solution.

7.8 Allow stirred sample to equilibrate again and record the second millivolt reading. Determine the fluoride content of the sample using the calculations given below.

7.9 If the sample is found to contain more than 400 micrograms of fluoride, repeat the analysis using a smaller sample.

8.0 CALCULATION

8.1 $$C_0 = \frac{C_a}{(\text{antilog}\,\frac{\Delta\ mV}{S}) - 1}$$

where:

C_0 = total micrograms fluoride in sample solution
C_a = micrograms standard fluoride added
Δ mV = difference in potential of sample solution and fluoride spiked sample solution
S = 59.2, the theoretical electrode slope value for S at 25°C

8.2 Fluoride concentration, µg/g = $\frac{C_0 - B}{W}$

where:

C_0 = the micrograms F in sample solution, from (8.1),
B = the micrograms F in reagent blank, and
W = the sample weight in grams.

9.0 REFERENCES

9.1 Galloway, H. L., Shoaf, R. E., Skaggs, C. H., "A *Rapid Method for the Determination of Fluoride in Vegetation*"; American Industrial Hygiene Association Journal, 36 p. 721 (1975).

ENVIRONMENTAL ANALYSIS PROCEDURE

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
OAK RIDGE, TENNESSEE • PADUCAH, KENTUCKY

NUMBER	EC 133
DATE	March 24, 1977
SUPERSEDES	
PAGE	OF

FLUORIDE, ION-SELECTIVE ELECTRODE METHOD

1.0 SCOPE AND APPLICATION

1.1 This method is applicable to the measurement of fluoride in drinking, surface, and saline waters, domestic and industrial wastes.

1.2 Concentrations of fluoride from 0.1 up to 1000 mg/liter may be measured.

1.3 For total or total dissolved fluoride, the Bellack distillation (10.1) must be performed on samples prior to electrode analysis. The distillation must also be performed when samples are not known to be free from extreme interferences.

2.0 SUMMARY OF METHOD

2.1 The fluoride is determined potentiometrically using an ion-selective electrode in conjunction with a standard single junction sleeve-type reference electrode and a pH meter having an expanded millivolt scale or an ion-selective meter having a direct concentration scale for fluoride.

2.2 The fluoride electrode consists of a lanthanum fluoride crystal across which a potential is developed by fluoride ions. The cell may be represented by $Ag/AgCl, Cl^-(0.3), F^-(0.001)$ LaF/test solution/SCE/.

2.3 Using a 300-ml sample, the lowest concentration reported is 0.1 mg/liter

3.0 SAMPLE HANDLING AND PRESERVATION

3.1 No special requirements.

4.0 INTERFERENCES

4.1 Extremes of pH and the presence of polyvalent cations of Si^{+4}, Fe^{+3}, and Al^{+3} which form complexes with fluoride interfere. The degree of interferences depends upon the concentration of the complexing cations, the concentration of fluoride, and the pH of the sample. Sample pH should be initially adjusted to between 5 and 9. Final adjustment is accomplished by addition of pH 5.0 buffer (described below) containing a strong, chelating agent which preferentially complexes aluminum (the most common interference), silicon, and iron.

APPROVED BY Y-12 Roy W Morrow	APPROVED BY GROUP T. Kwasnoski	
APPROVED BY PGDP R. L. Simmons	APPROVED BY ORNL W. R. Laing	NUMBER EC 133

5.0 APPARATUS

5.1 Electrometer (pH meter), with expanded mV scale, or an ion-selective meter such as the Orion Model 801.

5.2 Fluoride Ion Activity Electrode, such as Orion No. 94-09

5.3 Reference electrode, single junction, sleeve-type, such as Orion No. 90-01, Beckman No. 40454, or Corning No. 476010.

5.4 Magnetic Mixer, Teflon-coated stirring bar.

5.5 Direct distillation apparatus for fluoride, as shown in Figure 1.

6.0 REAGENTS

6.1 Buffer solution, pH 5.0-5.5: To approximately 500 ml of distilled water in a 1-liter beaker add 57 ml of glacial acetic acid, 59 g of sodium chloride and 2 g of CDTA (1, 2 cyclohexylene dinitrilo tetracetic acid or cyclohexane diamine tetracidic acid). Stir to dissolve and cool to room temperature. Adjust pH of solution to between 5.0 and 5.5 with 5 N sodium hydroxide (about 150 ml will be required). Transfer solution to a 1-liter volumetric flask and dilute to the mark with distilled water. For work with brines, additional NaCl should be added to raise the chloride level to twice the highest expected level of chloride in the sample.

6.2 Sodium fluoride, stock solution: 1.0 ml = 0.1 mg F. Dissolve 0.2210 g of sodium fluoride in distilled water and dilute to 1 liter in a volumetric flask. Store in chemical-resistant glass or polyethylene. Use anhydrous NAF in preparing this solution.

6.3 Sodium fluoride, standard solution: 1.0 ml = 0.01 mg F. Dilute 100.0 ml of sodium fluoride stock solution (6.2) to 1000 ml with distilled water.

6.4 Sulfuric acid, conc.

7.0 CALIBRATION

7.1 Prepare a series of appropriate standards using the fluoride standard solution (6.3). The range of the concentration of the standards should enclose the concentration of the samples.

7.2 Calibration of Electrometer: Proceed as described in (8.2). Using semilogarithmic graph paper, plot the concentration of fluoride in mg/liter on the log axis vs the electrode potential developed by the standard on the linear axis, starting with the lowest concentration at the bottom of the scale. Calibration of an ion-selective meter: Follow the directions of the manufacturer for the operation of the instrument.

8.0 PROCEDURE

8.1 Distillation

8.1.1 Place 400 ml distilled water in the distilling flask and carefully add 200 ml conc. H_2SO_4. Swirl until the flask contents are homogeneous. Add 25-35 glass beads and connect the apparatus as shown in Figure 1 making sure all joints are tight. Begin heating slowly at first, then as rapidly as the efficiency of the condenser will permit (the distillate must be cool) until the temperature of the flask contents reaches 180°C. Discard the distillate. This process serves to remove fluoride contamination and to adjust the acid-water ratio for subsequent distillations.

8.1.2 After cooling the acid mixture remaining from the steps outlined in 8.1.1 or previous distillations, to 120°C or below, add 250 ml of sample, mix thoroughly, and distill as before until the temperature reaches 180°C. To prevent sulfate carry-over, do not permit the temperature to exceed 180°C.

8.1.3 Add silver sulfate to the distilling flask at the rate of 5 mg per milligram of chloride when high-chloride samples are distilled.

8.1.4 Continue to use the sulfuric acid solution in the flask until the contaminants from the water samples accumulate to an extent that recovery is affected or interferences appear in the distillate. Check suitability of the acid periodically by distilling standard fluoride samples. After the distillation of high-fluoride samples, flush the still with 300 ml distilled water and combine the two fluoride distillates. If necessary, repeat the flushing operation until the fluoride content of the distillates is at a minimum. Include the additional fluoride recovered with that of the first distillation. After periods of inactivity, similarly flush the still and discard the distillate.

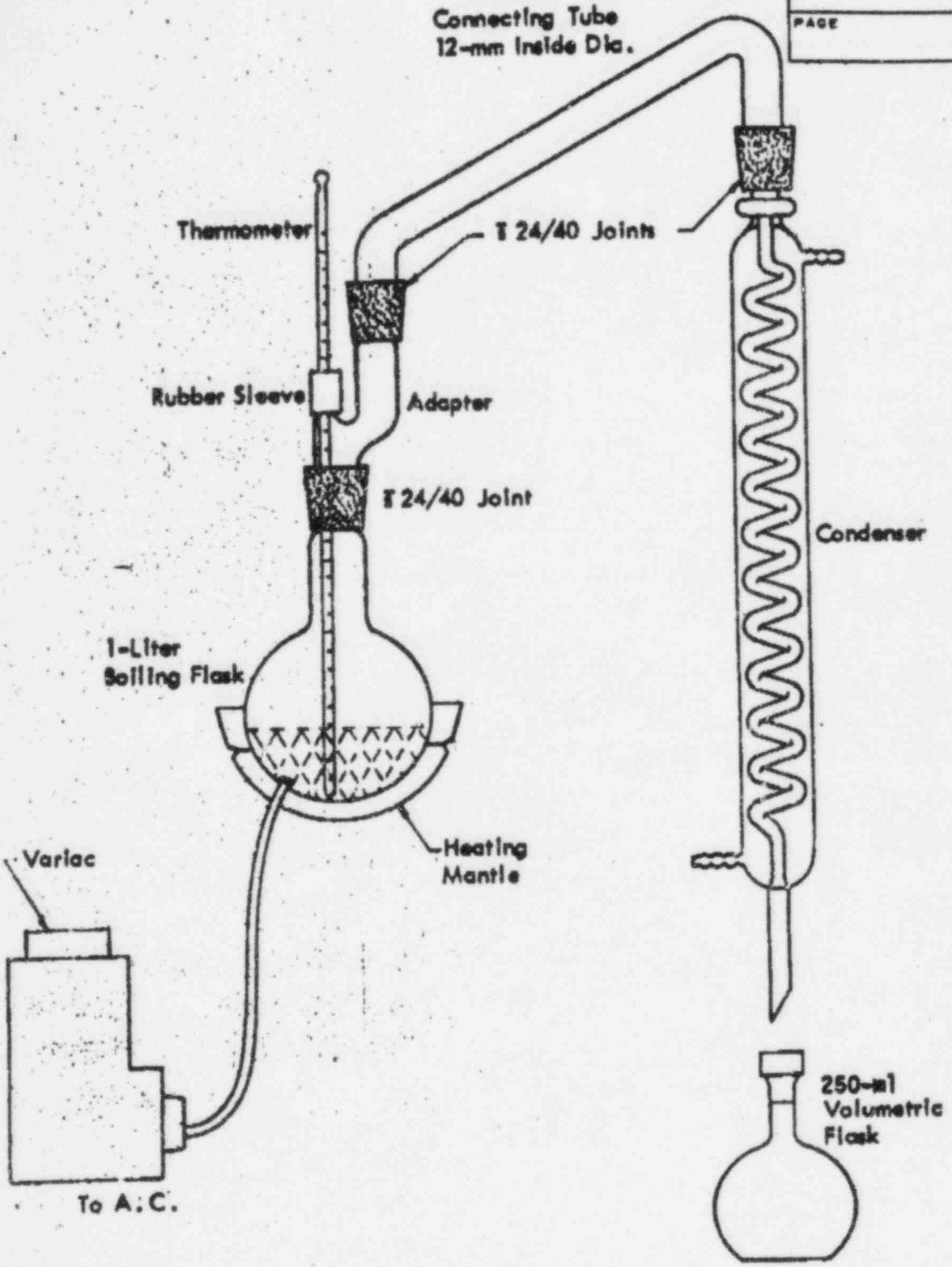


Figure 1. DIRECT DISTILLATION APPARATUS FOR FLUORIDE.

MARTIN MARIETTA

Internal Correspondence

MARTIN MARIETTA ENERGY SYSTEMS, INC.

January 27, 1986

J. H. Stewart, 4500-S, MS-140, X-10 (4-4895)

Analysis of NRC Urine Samples from Kerr-McGee Plant

Two sets of urine samples from Kerr-McGee were analyzed for total uranium by the Y-12 Plant Laboratory. The first set received by the laboratory on January 8, 1986, totaled 218 samples, and the second set received on January 10, 1986, totaled 175 samples. For both sets, blanks and appropriate concentrations of calibration standards, internal controls and external controls were used. In addition, approximately every fourth sample was spiked with suitable aliquots of prepared standard solutions to ensure that no interfering substances were encountered in the urine. All samples and spikes were run in duplicate, with reruns made as necessary to confirm results.

Three sets of calibration standards were used to cover a range of 0 to 10 µg/mL: 0 to 0.05 µg/mL; 0 to 0.1 µg/mL; and 0.05 to 10.0 µg/mL. All samples were read with the appropriate calibration standards, along with internal and external controls. Calibration standards, internal controls, and spikes were prepared and diluted using 0.05 µg/mL and 10.0 µg/mL stock solutions. Listed below are the calibration sets and the controls that were used with each set. All values and readings are given in µg/mL.

A.

Calibration Standards	Internal Controls	External Controls
0 and 0.050	0.025	Blank, 0.020, 0.033
0 and 0.1	0.025, 0.050	Blank, 0.020, 0.033
0.050 and 10.0	0.1	0.631, 1.26, 5.05

B.

Internal Controls	Total No. Read	Average Readings (95% Confidence Level)
0.025	159	0.024 ± 0.006
0.050	57	0.052 ± 0.008
0.1	48	0.104 ± 0.020

External Controls*		
0.020	149	0.020 ± 0.006
0.033	144	0.033 ± 0.008
0.631	48	0.660 ± 0.052
1.26	38	1.30 ± 0.19
5.05	48	4.98 ± 0.71

*External control samples were prepared for the Plant Laboratory by the Y-12 Quality Division. The standard values for the external controls were calculated by the Quality Division.

Concentrations and amount of spikes used depended upon the readings of the sample. The samples were spiked so that the spike of sample readings were approximately twice that of the sample. For this purpose, various dilutions were prepared using the stock uranium solutions. The average recovery of all the spiked samples was 99 ± 24%.

K. D. Pickell

K. D. Pickell, 9995, MS-1, Y-12 (4-2958) - NoRC

KDP:dh

cc: J. G. Dorsey, 9995, MS-2
R. J. McElhaney, 9995, MS-2
L. E. White, 9995, MS-1

INDUSTRIAL HYGIENE ANALYSIS PROCEDURE

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
OAK RIDGE, TENNESSEE - PADUCAH, KENTUCKY

NUMBER	IHA-490
DATE	June 15, 1983
SUPERSEDES	Nov. 27, 1979
PAGE	1 OF 5

URANIUM IN URINE, FLUOROMETRIC METHOD

Analyte:	Uranium	Method No.:	IHA-490
Matrix:	Urine	Range:	0.005 to 10.0 μg/mL
Procedure:	Fluorometric after fluoride pellet fusion	Precision:	15% RSD at 0.01 μg/mL 7.5% RSD at 0.05 μg/mL

1.0 Principle of the Method

1.1 A small aliquot of urine is placed in a small flat platinum dish and evaporated to dryness by an infrared lamp.

1.2 A flux pellet is placed in the dish and fused by controlled heat. The dish is then cooled.

1.3 The yellow-green uranium fluorescence induced by ultraviolet illumination is measured using a fluorophotometer and compared to the fluorescence of known uranium standards.

2.0 Range and Sensitivity

2.1 The normal operating range of the method is 0.005 to 1.0 μg/mL. The range may be extended to 10 μg/mL by using higher concentration calibration standards.

2.2 The limit of detection is 0.005 μg/mL.

3.0 Interference

3.1 No interferring substances are encountered in urin at concentrations normally experienced.

4.0 Precision and Accuracy

4.1 The precision (limit of error) at the 95% confidence level is ±30% (15% relative standard deviation, RSD) at 0.01 μg/mL and ±15% (7.5% RSD) at 0.05 μg/mL.

APPROVED BY Y-12	LAB RJ McElhaney	APPROVED BY ORGDP	LAB D. H. Frazier	APPROVED BY UCCND-COORD'R C W Weber
	IH D. J. Bean		IH D. J. Duncan	
APPROVED BY PGDP	LAB R.E. Simmons	APPROVED BY ORNL	LAB N. M. Ferguson	NUMBER IHA-490
	IH C. K. Turok		IH James A. Early	

UCN-13234
(1 238 1-79)

4.2 The accuracy of the method depends on how well the matrix of the calibration standards matches that of the sample being analyzed. No significant bias has been identified.

5.0 Advantages and Disadvantages of the Method

5.1 Advantages over previous methods include simplicity, speed, and sensitivity.

5.2 One disadvantage is that, without chemical separation of the uranium, the accuracy of the measurement depends on the amount of dissolved solids in the sample, and on how well this matches the calibration standard.

6.0 Apparatus

6.1 Fluorophotometer, modified Oak Ridge National Laboratory Model Q-1165, or equivalent.

6.2 Furnace, induction; or burner, modified Fletcher.

6.3 Dishes, platinum fusion, 1/2-inch diameter, 1/16-inch lip, 1/8-inch deep.

6.4 Fusion dish holder.

6.5 Pelletizer, delivering 0.3 or 0.6-g pellet of flux.

6.6 Infrared lamp and stand, 375-w.

6.7 Pipet, 100-or 200-µL, semiautomatic.

7.0 Reagents

7.1 Sodium fluoride - 2% lithium fluoride flux: Put 1359 g (3 pounds) of fluorometric grade sodium fluoride and 27 grams of lithium fluoride into a clean 5-pound glass reagent jar. Place the jar on the mechanical roller and roll for 48 hours.

7.1.1 Alternate flux, sodium fluoride: the lithium fluoride additive is unnecessary when induction heating is used for the fusion.

7.2 Stock uranium solution: Dissolve 117.9 mg of natural U_3O_8 in 8 M HNO_3 in a 100-mL beaker. Transfer the solution to a 100-mL volumetric flask using 2 M HNO_3 to transfer. Dilute to volume with 2 M HNO_3 and mix thoroughly. (1 mL = 1 mg U.)

7.3 Calibration Standards:

7:3.1 Dilute suitable aliquots of the stock uranium solution (7.2) with acidified, blanked, and blended urine to give at least two appropriate standards within the operating range of 0.005 to 10 µg/mL. The standards--usually a high and a low--should bracket the working range needed.

8.0 Procedure

8.1 Cleaning Fusion Dishes

8.1.1 Adequate cleaning of the platinum fusion dishes is critical to the prevention of cross-contamination. Thoroughly mix 2 tablespoons of boric acid with 150 mL of water in a Pyrex dish. Carefully add 100 mL of conc sulfuric acid and boil the platinum dishes gently in this solution for 2 hours. Drain and rinse the dishes with distilled water.

8.1.2 Cover the dishes with 1:1 HNO_3 and slowly add 30% hydrogen peroxide until mild effervescence occurs. Soak overnight.

8.1.3 Dishes can be tested for cleanliness in the fluorophotometer. Dishes that resist cleaning by the method described in 8.1.1 and 8.1.2 can be cleaned by fusing potassium pyrosulfate pellets in them and then soaking them in 1:1 HNO_3 overnight.

8.2 Pelletizing and Fusion

8.2.1 Place the required number of platinum fusion dishes in the dish holder or on a nichrome screen.

8.2.2 Swirl each sample bottle to mix the sample and to suspend all solids. Process a blank and the calibration standards with each set of samples.

8.2.3 Quickly insert the semiautomatic pipet into the sample bottle and withdraw an appropriate aliquot of solution (usually 100 µL for a 0.3-g pellet or 200 µL for a 0.6-g pellet); discharge the contents of the pipet into a platinum dish.

8.2.4 Place the dish holder or screen and the platinum dishes under the infrared lamp and evaporate all samples to dryness. Then remove the holder or screen from under the lamp.

8.2.5 With the pelletizer, place a 0.3- or 0.6-g pellet of the fluoride flux into each platinum fusion dish.

8.2.6 Fusion using a modified Fletcher Burner.

8.2.6.1 Place the screen over the fusion burner; fuse for 2 minutes at approximately 1100°C, then reduce to 950°C and fuse for 1 minute. (An optical pyrometer will provide temperature estimates.)

8.2.6.2 Remove the screen containing the dishes from the burner and allow to cool.

8.2.7 Alternate fusion, using an Induction Furnace:

8.2.7.1 Place four dishes at a time in the induction furnace coil.

8.2.7.2 Apply 600 ma current for 60 seconds.

8.2.7.3 Transfer the dishes back to the holder to cool. (CAUTION: Use forceps.)

8.3 Fluorescence Measurement

8.3.1 Place the platinum dishes containing the blank, uranium standards, and sample melts on the turn-table of the fluorophotometer.

8.3.2 Move the blank under the ultraviolet light and adjust the zero control knob to make the instrument read zero.

8.3.3 Move the high uranium standard melt under the ultraviolet light and adjust the calibration control until the instrument reads the known value of the standard.

8.3.4 Move the low uranium standard melt under the ultraviolet light. It should read the known value of the standard if the instrument is properly calibrated. The fluorophotometer is now calibrated for direct readout of uranium in the working range, which could extend from 0.005 to 10 μg/mL. Readout may be in appropriate units other than μg/mL.

8.3.5 Move the sample pellets under the ultraviolet light of the fluorophotometer and read the uranium content of the aliquots. Record the readings.

9.0 Calculations

9.1 If the readings are in μg/mL, no further calculations are necessary.

9.2 If the readings are in μg or ng, use the following formulas:

$$U,\ \mu g/mL = \frac{\mu g\ U}{A}$$

$$U,\ \mu g/mL = \frac{ng\ U}{A \cdot 1000}$$

where: A = volume of sample (see 8.2.3) pipetted onto the pellet, mL.

9.3 If the μg U/day for an employee is to be reported, use the following formula:

$$U,\ \mu g/day = U\ \mu g/mL \times \frac{V}{T} \times 24$$

where: V = volume excreted, mL
T = time interval, hr
24 = hr/day

10.0 Reference

10.1 Centanni, F. A., Moss, A. M., and DeSesse, M. A.; "Fluorometric Determination of Uranium": Anal. Chem., 28, p. 1651 (1956).

5 11924
5-22-80

Determination of Uranium by Neutron Activation and Delayed Neutron Counting

1.0 SCOPE

This method is applicable to the determination of ^{235}U in liquid or solid samples. Total uranium analyses can be obtained by the method if the isotopic composition of uranium in the sample is known.

2.0 PRINCIPLE

This procedure assumes familiarity with the delayed neutron counting facility and pneumatic tube control panel at the Oak Ridge Research Reactor (ORR). After irradiation time and aliquot size are established, the sample is irradiated and the neutrons emitted following decay of certain short-lived fission products of ^{235}U are counted. A ^{235}U standard that corresponds to the configuration of the unknown sample is irradiated and counted exactly in the same manner as the sample. An empty rabbit is also irradiated and the neutron count rate is subtracted from the count rates of the sample and standard. The resulting count rates and weights of the standard and sample are compared to obtain the uranium content of the sample.

3.0 APPARATUS

Analytical balance

Micro-pipettes

Heat lamp

Rabbits and inserts

Soldering iron

4.0 SAFETY

The hood that contains the rabbit loading station is considered a contamination zone and general health physics rules apply. Care should be taken when loading a rabbit so as not to touch any contaminated equipment.

5.0 PROCEDURE

5.1 Sample Preparation

5.1.1. If a solid specimen is large and crystalline in structure, it should be crushed or ground to a fine consistency and blended well before weighing.

5.1.2. Transfer the sample to a previously prepared and tared insert and weigh the sample. Record the weight in the log book for delayed neutron measurements along with the sample identification. Cap the insert and heat seal the cap to the body of the insert. Load the insert into a rabbit for irradiation.

5.1.3. If a small insert is used, the finger of a plastic glove or other similar material should be put in the rabbit to keep the insert in place.

5.1.4. If the specimen is a liquid, pipet an aliquot (usually 1 ml) directly into an insert and evaporate the liquid under a heat lamp. After the solution has evaporated, allow it to cool and heat seal the insert. Transfer the insert to a rabbit for irradiation.

5.1.5. Some organic compounds that will not dry under ordinary heat lamp temperatures must be treated differently. Pipet these kinds of samples into an insert that contains enough accelerator (Fisher #9-906) to absorb the aliquot (usually 100 µl). Heat seal the insert and load it in a rabbit for irradiation.

5.2. Standardization of the Delayed Neutron Counting System

5.2.1. Take a 400 second background count of the empty system and record it in the log book. Place the ^{241}Am-boron neutron source into the access tube of the system and count it for 400 seconds. These two counts are not used in the actual analysis, but they are a good check as to the status of the system.

5.2.2. Set the control panel for a 20 second irradiation with the rabbit return selector switched for return to the delayed neutron counter. Set the decay timer for 12 seconds and the timer for the counter on 40 seconds.

5.2.3. Irradiate, count, and record counts for three blanks using this set up.

5.2.4. Irradiate, count, and record counts for two ^{235}U standards and one N.B.S. coal and fly ash (Note A).

5.3. Analysis of the Samples

5.3.1. Irradiate, count, and record the counts for each of the samples in the same manner as with the standards and quality control samples. The samples must correspond in configuration with the standards (standard in large insert - sample in large insert, etc.).

5.3.2. The uranium contents can be calculated by hand or by using the MONSTR program on the PDP-15 computer. Hand calculations are performed with the following equation:

$$^{235}\text{U, ppm} = AB/CD$$

$$\text{Natural U, ppm} = U/P$$

where:

A = sample aliquot counts corrected for background,

NOTE A: The uranium standards are prepared beforehand exactly as the unknowns are prepared. They may be reused if the insert remains in good condition.

B = weight of ^{235}U in the standard, μg,

C = aliquot weight, g,

D = standard counts corrected for background,

U = ^{235}U, ppm,

F = abundance of ^{235}U in sample U.

5.3.3. Store the data on DEC tape and save the line printer output for reporting the data.

6.0 PRECISION

6.1. The precision for uranium by this method is excellent if the count rate of the sample is significantly above the blank count rate. Precision can be improved by careful preparation of the unknowns and standards and careful attention to maintaining the same irradiation geometry for standards and samples. If the criteria are met, the accuracy is probably ±2.5%

7.0 INTERFERENCES

A specimen that is either depleted or enriched in ^{235}U will of course give erroneous natural-U results. Any element present in high concentration with a high capture cross section could cause a negative bias in the results. Under a high gamma field, the BF_3 neutron detectors lose efficiency, and the resulting count rate may be somewhat low giving erroneous results.

8.0 REFERENCES

1. Dyer, F. F., Emery, J. F., and Leddicotte, G. W., A Comprehensive Study of the Neutron Activation Analysis of Uranium by Delayed Neutron Counting. ORNL-3342 (1962).

1. "Reactor Operations and Experiments," ORNL Radiation Safety and Control Manual, Section 8-9.

Written by:

J. W. Wade

Approved by:

1. J. R. Stokely, Section Head
2. W. D. Shults, Director, ORNL Analytical Chemistry Division

APPENDIX 5.2.4

OSDH SAMPLING PROCEDURE

Joan K. Leavitt, M.D.
Commissioner

OKLAHOMA STATE
DEPARTMENT OF HEALTH

P.O. BOX 53551
1000 N.E. TENTH
OKLAHOMA CITY, OK 73152

AN EQUAL OPPORTUNITY EMPLOYER

January 27, 1986

MEMORANDUM

To: Sequoyah Fuels Incident File

From: Robert L. Craig, Director
Radiation Protection Division

Subject: Sample Collection Technique

Samples collected after January 5 and before January 10 taken as follows:

> Soil - collected by sticking a shovel into the ground about 2 to 4 inches and placing it in a plastic bag.
>
> Vegetation - a quantity of leaves (either dead or living) were placed in a plastic bag. The vegetation was collected in the general area of the soil sample.

These samples are suitable for tracing the path of the plume but are not suitable for determining depositions of material per unit area.

Soil and vegetation samples collected after January 9 were taken by removing the grass and leaves from an area measuring one foot on each side. The vegetation was placed in a plastic bag. After removal of the vegetable matter, the soil from that square foot area was removed and placed in another plastic bag. An attempt was made to remove only the 1/2 to 1 inch of soil but in some cases as much as 2 inches of soil was taken.

All water samples were collected from standing surface water and placed in half-gallon plastic jugs.

Two samples of each type were taken from each sampling location. One was sent the NRC Laboratory and the other to the OSDH Laboratory for analysis.

APPENDIX 5.2.5

SFC SAMPLING PROCEDURE (2 DOCUMENTS)

SEQUOYAH FUELS CORPORATION
INTERNAL CORRESPONDENCE

TO W. L. Utnage DATE January 21, 1986

FROM A. W. Norwood SUBJECT Sequoyah Recovery Operation

Information concerning the survey and sampling techniques used, and the chronological sequence of actions taken by the Sequoyah Fuels' Cimarron Facility Response team has been requested by E.G.&G. personnel. With your concurrence this correspondence will be provided to them to assist in the documentation of the sample and survey results.

Cimarron survey and sampling team members at various points in time were:

A. W. Norwood - Cimarron Facility Manager
Ron Fine - Health Physics Supervisor
Will Rogers - Decontamination Supervisor
Joe Kegin - Maintenance Supervisor
Claude Thompson - Health Physics Specialist
Jack Andrews - Senior Health Physics Technician
Frank Murch - Senior Health Physics Technician
Don Rall - Decontamination Supervisor

All of the direct alpha survey readings provided on the survey map documents were taken with portable alpha survey instruments with 60 cm^2 probes. The sensitiviy of the portable alpha survey instruments allows good confidence in readings as low as 200 dpm/60 cm^2; therefore, negative readings are shown as <200 dpm/60 cm^2 on the survey maps.

Off-site smears at the residences south of highway I-40 were counted with portable smear counters with a sensitivity that allows good confidence in readings as low as 6 dpm/100 cm^2. Most of the smears taken on site within the exclusion area fence were counted with portable alpha survey instruments with negative readings shown as <200 dpm/100 cm^2. All smear readings shown on the survey maps are per 100 cm^2.

The sampling criteria for the vegetation and soil grab samples taken around the residences by the Cimarron team was only that at least 100 grams of sample be taken to assure an ample quantity for analysis. This same criteria was used for the 180' grid grab samples taken on-site from the lawn between the process building and the south exclusion area fence as shown on the grid map. Five of these grab samples were taken immediately outside of the exclusion area fence as shown on the grid map. The five grab samples taken just outside of the exclusion area fence were split with NRC. Both vegetation and soil grab samples were taken on the 180' grid pattern and soil grab sampling was repeated in the areas where the grass was removed on the same grid pattern.

The soil, vegetation, and 12" core sampling of the area outside of the exclusion area south to highway I-40 was started on Wednesday, January 8. These samples consisted of all of the vegetation on one square foot and one square foot of soil (1/4" deep). The soil was taken from the same square foot from which the vegetation sample had been removed. The core samples were taken in the same general area.

Survey maps and sampling grid maps were submitted to document control covering the following chronological sequence of actions taken by the Cimarron response team.

<u>Saturday, January 4, 1986</u>

Supplemented on-site survey instrumentation with equipment from Cimarron, spot surveyed administration area and ~~paint~~ plant entrance area, checked plant air support systems and began a survey of eight residences located south of I-40. Direct and smear surveys of out buildings, fences, vehicles, etc., were taken using alpha survey meters. Both vegetation and soil samples were also collected and submitted to the research center.

One two man team accompanied Scott Munson to the Sallisaw and Ft. Smith Hospitals to survey, clean and release the locations used to treat personnel. Medical staffs were also surveyed and cleared. Upon completion of the residence survey, the remaining team returned to the plant and began a survey of the administration area. Contamination was found, offices were cleaned, plastic was placed over the carpet to contain the in-place contamination, shoe covers were issued, and two contamination control points were established. One H-P technician remained at the guard station to survey personnel and vehicles exiting and entering the plant. Decontaminated H-P office for air sample service.

<u>Sunday, January 5, 1986</u>

One team of H-P technicians went to all the area hospitals to survey, clean and release. One H-P went to the Carlisle School with Bob Craig, OHD, to survey. Highway 10 was surveyed and closed. The south guard station was also surveyed and closed. The North guard station was established as the facility entry gate and survey~~ed~~ of personnel and vehicles exiting the facility was initiated. One H-P stayed at the guard station. Additional equipment and supplies were brought from Cimarron. Surveyed residence.

<u>Monday, January 6, 1986</u>

Definition of the radiological dropout from the plume was conducted by surveying south of the facility and water samples were taken in indicated plume area. Cleaning of Highway 10 began. Samples of the defined plume area were taken on 180' centers for vegetation and soil inside the exclusion area fence. The Tyler home south of I-40 was surveyed and samples were taken and submitted for analysis. A survey of the process area was made by Ron Fine. Don Majors was established as the focal point to document environmental surveys and sample results onto maps.

Tuesday, January 7, 1986

Orientations of contractor personnel for health and safety was given and stripping of the contaminated areas in front of the plant began to avoid further contamination spread. H-P monitors were used to control traffic through the high airborne area and to monitor operations. Definition of the plume area was completed between exclusionary fence and I-40. The ambulances used to transport the injured employees were tracked down, surveyed, and released. Washing of the contaminated grass outside the plant fence was initiated with water/soda ash solution. Cleaning of Highway 10 was completed. It was surveyed at 10' intervals and released.

Wednesday, January 8, 1986

Stripping operations continued by contractor personnel wearing respirators. The drivers were also wearing lapel samples. Began taking samples of the plume area (i.e., one on the center line, one on each boundary, and one at 1000 feet outside the plume on each side). These samples were taken at 1000 foot intervals with baseline samples. One square foot of grass, one square foot of soil (1/4") and a core sample at each location was taken for the NRC. Urine samples of the stripping operators were collected each day.

Thursday, January 9, 1986

Completed grass stripping. Moved the excavated soil to a diked storage area northwest of plant. Completed the soil and vegetation sampling of the plume grid and began taking NRC core samples. Began washdown operations of roadways and vehicles. Pulled "pinch" samples of soil where the grass had been removed for counting in the H-P proportional counter. Resampled the soil after excavation in accordance with the previous grid.

Friday, January 10, 1986

Completed the roadway and sidewalk survey at 25 foot intervals (NRC verified). Surveyed the O.G.&E. substation and recorded - no cleaning was done. Received data from proportional counter on pinch sampling taken on Thursday indicating soil remaining in front yard was 8 dpm/2" planchet. Resurveyed office area. Steam cleaned vehicles. Washed down front of building. Continued NRC core sampling.

Saturday, January 11, 1986

Contacted Quadrex for H-P assistance to monitor personnel exit of the restricted area in response to NRC's comments. Continued NRC core sampling. Lined sod storage with PVC liner for contaminat~~ed~~ion control. Cleaned and released south guard station, Highway 10 entry, and service road and re-established south guard station operations. Watered Highway 10. Steam cleaned poles and signs at front of plant and released.

Sunday, January 12, 1986

Surveyed UF_4 construction site and released. Surveyed all roads inside of perimeter fence and released. Resurveyed plant administration area. Continued NRC core sampling.

Monday, January 13, 1986

Resodding began after orientation by H-P. Surveyed administration areas for final release of shoe cover requirements. Continued NRC core sampling. Wayne Norwood assumed additional responsibilities for process clean-up.

Tuesday, January 14, 1986

Met with NRC and released administration area of shoe cover requirements. Completed NRC core sampling (for the third time). Surveyed, cleaned and released lunchroom vendor's car. Follow-up to ensure fencing of sod and storage area was completed. Continued resodding. Resampled areas in plume area as follow-up to water samples taken on 1/6/86. Urine samples from the re-sodders will be collected upon completion of the work activity.

A. W. Norwood

AWN:dd

xc: C. A. Grosclaude
Document Control

To Don Majors 1/17/86
From J. E Cleveland

Subject - Sampling Procedure

Environmental Samples Taken South of I-40@ for evaluation of impact as a result of the accident at Sequoyah Fuels on 1/4/86. All samples were sent to the KM-Tech Center for analysis for U and F. All samples were taken during the week of 1/6/86. Sample method were as follows.

1. Vegitation - Where vegitation was present an area 1 ft² in area was marked off. Clippers were used to cut the vegation off and transferred to plastic sacks. These were then marked for identification and transported to the plant. Juniper, Cat Tail ~~Cat tail~~, bass and other samples other than ground cover were sampled near the location as a grab sample.
2. Soil - The area directly below the vegitation sample was collected to a depth of appox ½" inch. These samples were transferred to a plastic bag and ~~[illegible]~~ marked for identification. In area where no ground cover was

available a 1 ft^2 area was collected to a depth of approx 1/2".

3. Radiation Measurements. — direct alpha readings were made at each sampling site using a alpha scintillation probe and PAC-1 Scaler. A background measurement was made covering the probe with the plastic Guard. Direct alpha measurement was then made by placing the probe directly over the area to be measured. Both Background and direct measured counts were noted. 1 minute counts were used.

4 Water Samples — Grab samples were taken at all drainages South of I 40 on the County Road at locations indicated on map (CN-247) No preservation or filtration was done. Samples were transported to the Tech center for analysis for U, F and Gross α.

APPENDIX 5.2.6

OSDH LABORATORY ANALYSIS PROCEDURES

January 13, 1986

MEMORANDUM

TO: Dale McHard, Chief
Radiation and Special Hazards

FROM: Judith A. Duncan, Chief JAD
State Environmental Laboratory Service

SUBJECT: Summary of analytical methods used for analyses of soil, vegetation and water samples from the area of the recent Sequoyah Fuels Incident.

Bob Craig requested that we provide a written summary of our analytical methods and quality control procedures for the recent fluoride analyses which we performed on samples submitted in relation to the Sequoyah Fuels Incident earlier this month. It is my understanding that NRC requested this information.

Attached you will find an outline of our methods. Should you or anyone from NRC have any questions, please contact me.

SEDIMENTS: 5 grams of sediment were weighed into a 100 milliliter beaker. Equal amounts of Deionized water and TISAB (Total Ionic Strength Adjustment Buffer) were added. Sample was then refluxed for 1 hour. Sample was brought back up to original volume with D.I. water if evaporation occurred. After sample cooled it was analyzed on an Orion Fluoride Meter. Fluoride value was determined by following calculation:

$$\frac{V_w \times C_f}{wt} = C_s \text{ mg/kg}$$

where
V_w = Volume of D.I. water added in ml.
C_f = Concentration of fluoride read from meter
wt = Weight of sample used in grams
C_s = Concentration of fluoride in sample

FOLIAGE: The procedure for foliage differs from that of sediment only in the weight of sample used and the need to remove the foliage from the DI/TISAB solution to enable stir bar to rotate.

QUALITY CONTROL: Duplicates and spikes were done every 10 samples. % Recovery ranged from 60% to 127%. The data measurements were made in hopes of approximating the passage of the plume by looking for gross differences in the fluoride concentration.

GROSS ALPHA AND GROSS BETA ANALYTICAL PROCEDURES

SAMPLE PREPARATION:

SOIL: The sample was dried on a hot plate and ground. 2.5 grams of sample was placed in a 50 ml capped centrifuge tube, 25 ml of deionized water was added, shaken for about 10 minutes and centrifuged. 10 ml of the supernatant was transferred to a 2 in. x 1/4 in. ringed SS planchette and dried under a heat lamp. The planchette was counted on a low background, thin window proportional counter for 10 minutes.

VEGETATION: 2 grams of the sample (as received) were placed in a 50 ml capped centrifuge tube, 25 ml of deionizied water was added and shaken for about 10 minutes. The liquid was decanted and centrifuged. 10 ml of the liquid was transferred to a 2 in. x 1/4 in. tared planchette and sufficient $CaSO_4$ solution was added to ensure that the solids on the planchette would be in excess of 10 milligrams. The planchette was dried under a heat lamp, weighed, and counted for 10 minutes.

CALCULATION: Gross alpha and gross beta concentrations were calculated as follows:

$$\text{Activity (pCi/gm)} = \frac{\text{Net X 2.5}}{\text{WT X EFF X 2.22}}$$

Where:

Net = Net cpm of alpha or beta activity
WT = Sample weight in grams
EFF = Counting efficiency (cpm/dpm)
2.5 = Ratio of volume of water added to sample volume of sample analyzed.
2.22= dpm/pCi

QUALITY CONTROL: Counter background and counting efficiency were checked prior to counting each batch of samples.

APPENDIX 5.2.7

ENVIRONMENTAL SAMPLING: VEGETATION AND SOIL

APPENDIX 5.2.7

Preface

Shortly after the UF_6 release on January 4, 1986, an extensive program of environmental measurements and sampling was begun, with the objective of obtaining measurements sufficient to establish the nature and extent of contamination from the release. The effort involved staff from SFC, from the Oklahoma State Department of Health, from Headquarters and Region IV of NRC, and, under the auspices of the Department of Energy, from EG&G, Inc.

Acknowledgements

For the production of this data base through many long days of environmental sampling, an exemplary achievement under the circumstances, we must extend our thanks to the following:

- To Robert Craig, Dale McHard and other staff of the Oklahoma State Department of Health and local government agencies for their cooperation and generous efforts in extending and completing the sample collection of soil, vegetation and water,
- To John Stauter, Jim Cleveland, Don Majors, WAyne Norwood and the other staff of the Sequoyah Facility and Kerr-McGee for their cooperation in the extensive sampling effort,
- To John Doyle, Zolin Burson, Allen Fritzsche, Keith Roesner, Ronald Reiman, Marc Rivera, Hollis Berry and the 15 other people of EG&G, Inc., who performed the aerial photography, the Aerial Measurements System survey, the in situ surface level radioactive contaminated survey, the computerized sampling data management system, and the magnificent photographic record of the proceedings,
- To Marvin Dockter of the Department of Energy for his on-the-scene coordination of the EG&G efforts and to Joseph Deal and Fritz Wolff of DOE Headquarters for their support to this effort,
- To Jerry Everett, Blair Spitzberg, Harry Pettengill, and Candice Jierree of NRC's Region IV for their aid and guidance in establishing a standardized sampling system and an organized data base,
- To George Greenly, Kevin Foster, John Nostrom and Thomas Sullivan of LLNL-ARAC for their assistance on atmospheric dispersion,
- To Joseph Stewart, Susan Allay, and their staff at ORNL for their skillful and cooperative efforts on sample analyses,
- To Barry Zalcman of NRC Headquarters who provided essential on-the-scene coordination.

Sample Collection

Environmental sampling began on January 4, 1986, soon after the release. Initially, "grab" samples of soil, vegetation, and water were taken. These served to indicate roughly the concentrations and extent of contamination. However, comparisons of results from different locations and sampling organizations were difficult due to use of nonuniform sampling procedures. Therefore, procedures for more uniform sampling of the ground surface were designed, and put into practice by the SFC sampling teams on January 8, 1986, and by the OSDH sampling teams on January 10, 1986. Thus samples collected on those dates or later are of a more uniform quality.

Samples were collected by two organizations, the Oklahoma State Department of Health and by Sequoyah Fuels Corporation. Most samples were split, with the second portion being sent to Oak Ridge National Laboratory for confirmatory analysis. Thus analyses were performed by SFC or the Kerr-McGee Technical Center (designated K-M), by OSDH and by ORNL.

Maps of Sampling Locations and Results

Sampling locations were plotted at the SFC directly on overlays on two base maps, one being a 1" = 400' map of the site and its immediate surroundings, and the other a composite of 1:24,000 scale U.S. Geological Survey maps covering a larger area. These two base map areas have been designated the near-field and the far-field areas. They are also characterized by having different sampling location coordinate systems, the near field using the SFC plant grid and the far field using the land survey township-range-section grid found on the USGS maps. (Futher details on the coordinate systems are in a later section.)

The sampling locations and results on (in most cases) the original overlays have been superimposed on base maps and are included here (reduced in size) as Figures 5.2.7.1A through 5.2.7.24A. The significance of use of the originals is that they reflect the location plotting done at the time, at the SFC, and thus they include the contribution to accuracy made by input of the individuals who personally collected the samples. Figures 5.2.7.1A through 5.2.7.4A show the sampling locations for vegetation, soil, and water. Figures 5.2.7.5A through 5.2.7.24A show the analysis results for vegetation and soil (results for water sampling are in Appendix 5.3.1). Results for grab samples are italicized. Some grab sample locations were resampled under the systematic sampling program and thus one location may have two results, for example, fluoride on vegetation. For reproduction here, the overlays have been superimposed on basemaps redrawn to eliminate topography and other extraneous detail which tends to obscure the results.

Tables of Sampling Locations and Results

The plots of analysis results are followed by tables of the results. The tables provide the sample label, the coordinates (plant grid or township-range-section) of the sample location, a designation of the organization which performed the sample analysis, the date the sample was collected, the type of analysis (i.e., whether for uranium or for fluoride), the numerical result and its units, and comments which call out unusual characteristics of the sample. Some samples were analyzed for alpha and beta radioactivity (rather than for uranium per se) and are listed accordingly.

At the time the samples were collected, some, taken near residences, were labeled with the residents' names. To allow the residents some privacy, these labels have been changed.

Tables 5.2.7.1A through 5.2.7.17A are listings by type of analysis (e.g., U or F) and by the analysis-performing organization. Tables 5.2.7.18A through 5.2.7.25A are the same information sorted numerically and alphabetically by the sample label (to simplify looking up results by a location label); these tables also include water sample results as found in Appendix 5.3.1.

Coordinate Systems

The near-field figures, e.g., Figure 5.2.7.1A, show the plant grid; the grid is in feet, with the lines shown being 1,000 feet apart. The plant buildings are in Section 21 of T12N, R21E; Highway 10 runs north-south on the east boundary of Section 21. The southeast corner of Section 21 (which is in Highway 10) is the point on the plant grid which has coordinates N-10,000, E-10,000. The N-10,000 line of the plant grid lies along the section line (in Highway 10). The availability of maps with the plant grid superimposed made the plant grid a natural choice for the locations of near-field sampling.

Similarly, the availability of U.S. Geological Survey maps showing the sections and section lines made the township-range-section grid a natural choice for the locations of far-field sampling. In Oklahoma, as in much of the United States, the land was surveyed in sections which are a square, one mile on each side. Where the topography permits, many roads and fences run on the section line, or at right angles to it at 1/2 or 1/4 of the section. Thus it is relatively simple to determine one's location on a map which also shows the section lines. The far-field figures, e.g., Figure 5.2.7.3A, show the section lines, the township and range lines, and the section numbers of the sections adjoining the intersections of the township and range lines. Figure 5.2.7.25A shows the section numbering in each 6-mile by 6-mile township, and the relationship of the numbers of the sections with the numbers of adjacent sections. For purposes of designating a sampling location more precisely than the nearest mile (section), an ad-hoc division of sections into 1/14-mile subdivisions was made, with 14 strips designated A through N from north to south, and 14 strips numbered 1 through 14 from west to east. This arrangement is shown in Figure 5.2.7.26A. This arrangement permits designating a sample location to the nearest 1/14 mile, roughly 100 meters.

For its atmospheric dispersion simulation calculations, LLNL-ARAC chose to use the Universal Transverse Mercator (UTM) coordinate system, which is also indicated on the U.S. Geological Survey maps, in kilometers. The advantage of the UTM coordinate system is that it is shown on the maps for long distances without significant corrections. (The plant grid is only shown for a few miles. The township-range-section grid contains offsets at the T8N, T9N line and at the T12N, T13N line, and is significantly offset at the Oklahoma-Arkansas border.) A difficulty with the UTM coordinate system is that it is set about 1.2 degrees of angle counterclockwise from the section lines at the plant site, and the angular difference changes slightly over long distances. For reference, the southeast corner of Section 21, T12N, R21E (N-10,000; E-10,000 on the plant grid) is approximately at UTM 3929.49N, 311.41E (coordinates in km). Figures 4.1.2.7, 4.1.3.1, 4.1.2.28A and 4.1.2.29A, show both the UTM coordinate grid and the township-range-section grid.

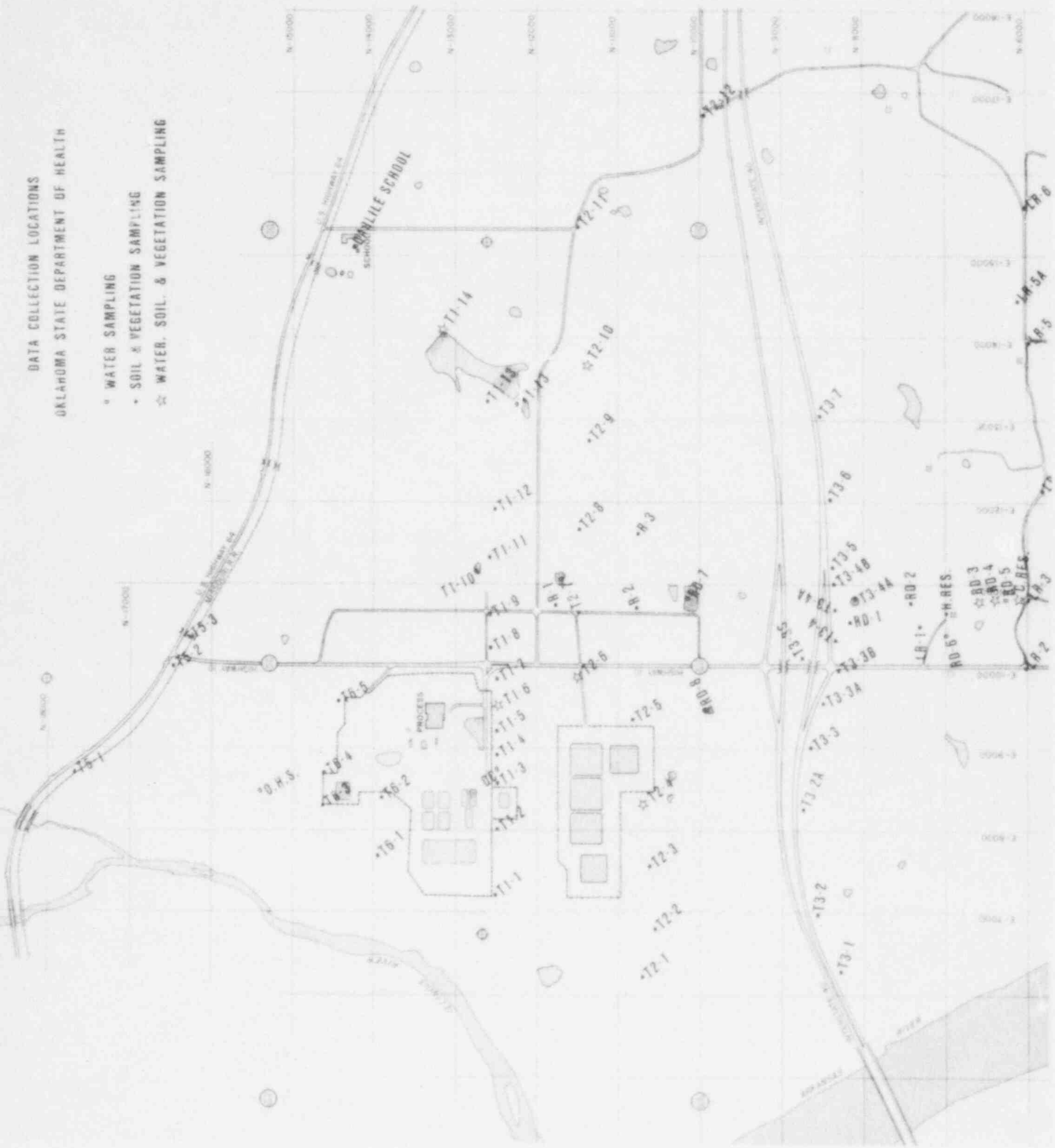


Figure 5.2.7.1A Near field locations sampled by OSDH

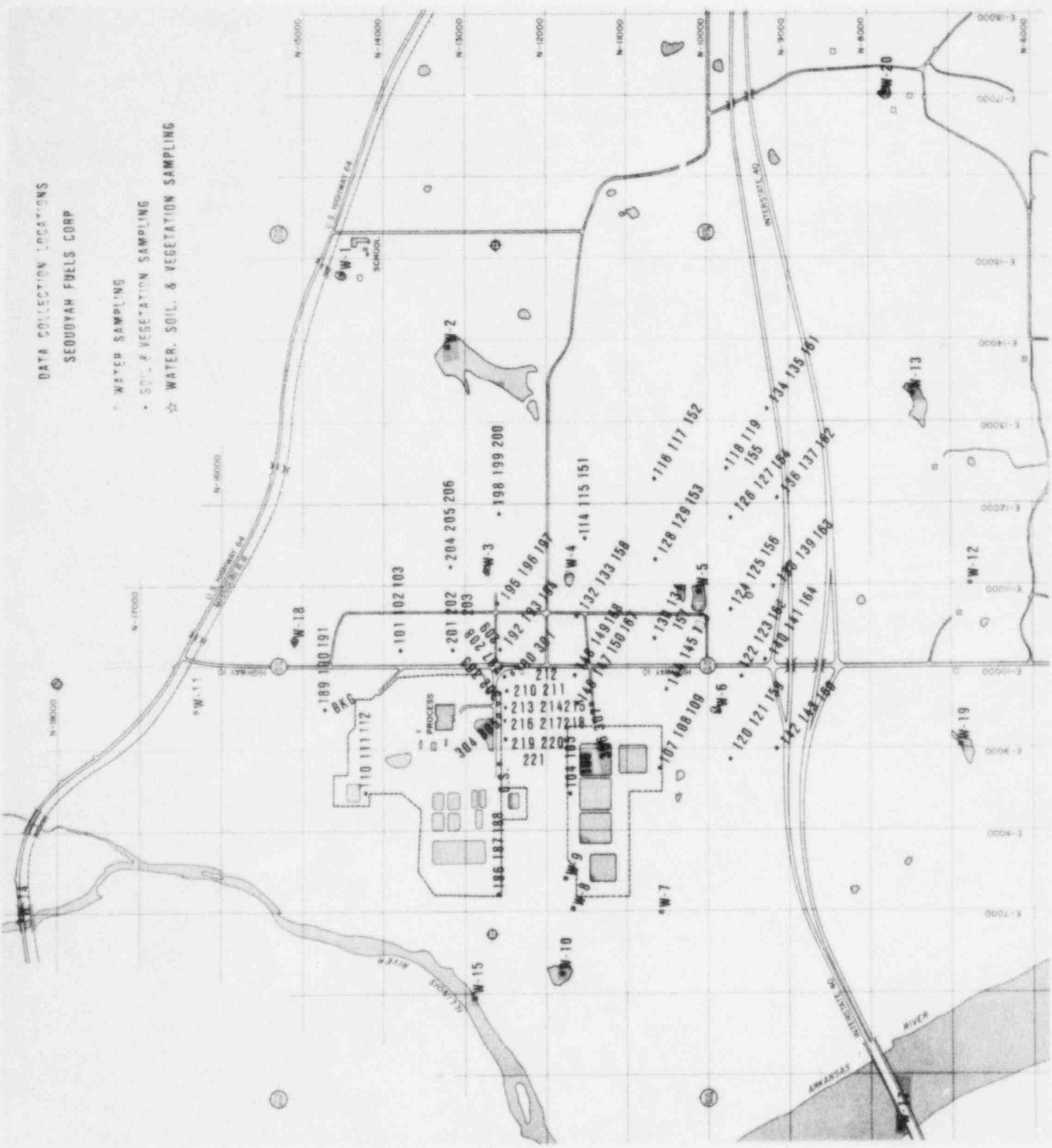


Figure 5.2.7.2A Near field locations sampled by SFC

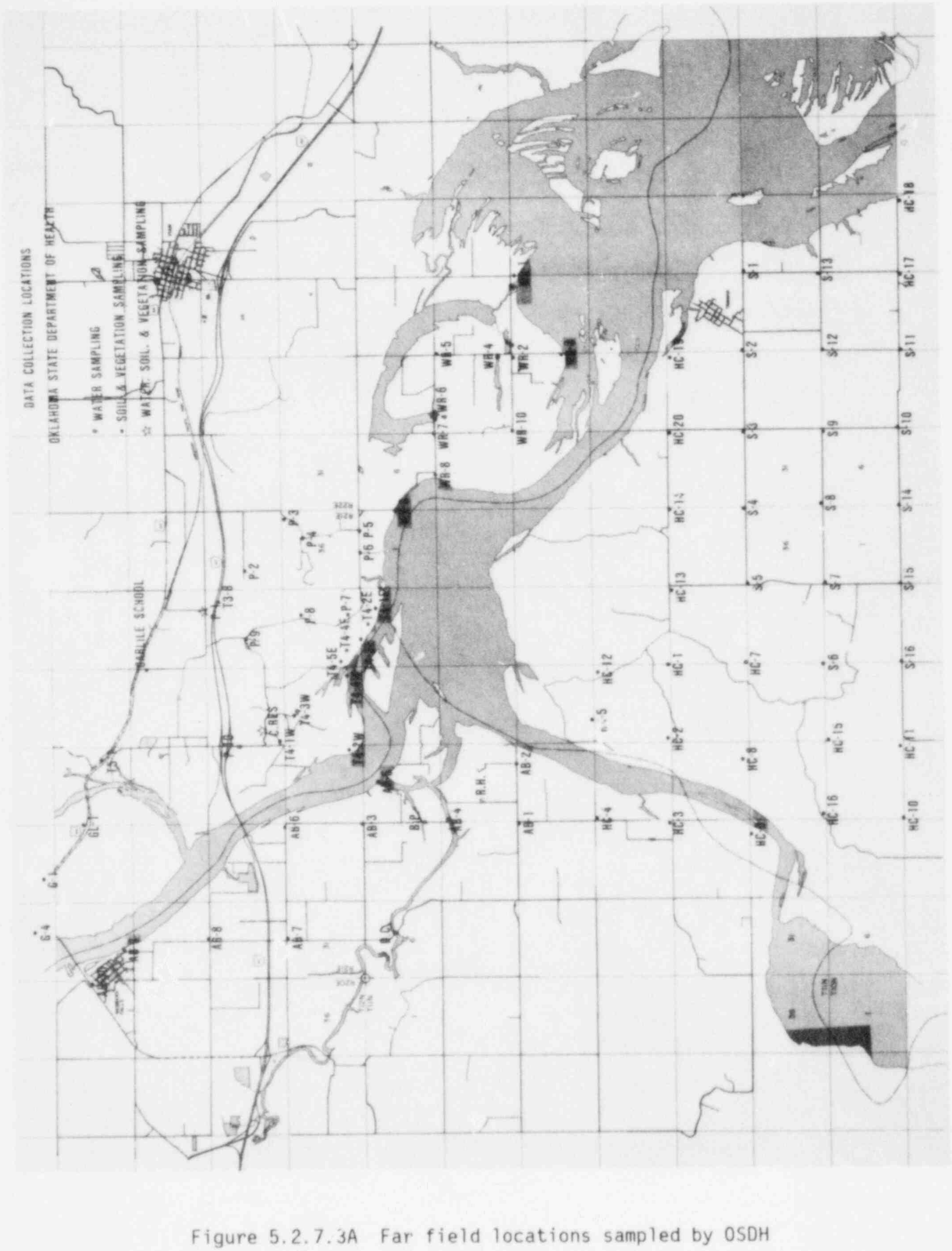


Figure 5.2.7.3A Far field locations sampled by OSDH

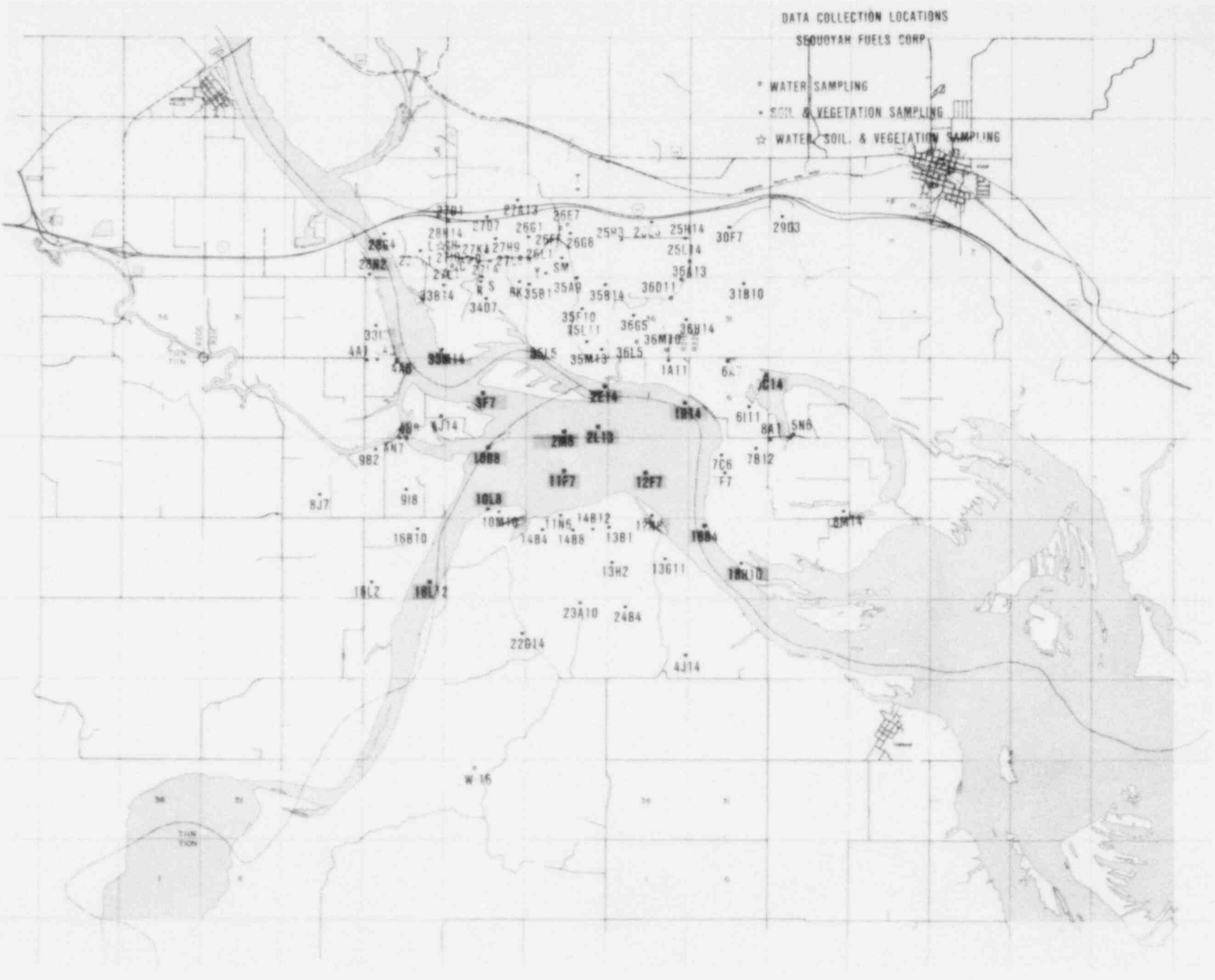


Figure 5.2.7.4A Far field locations sampled by SFC

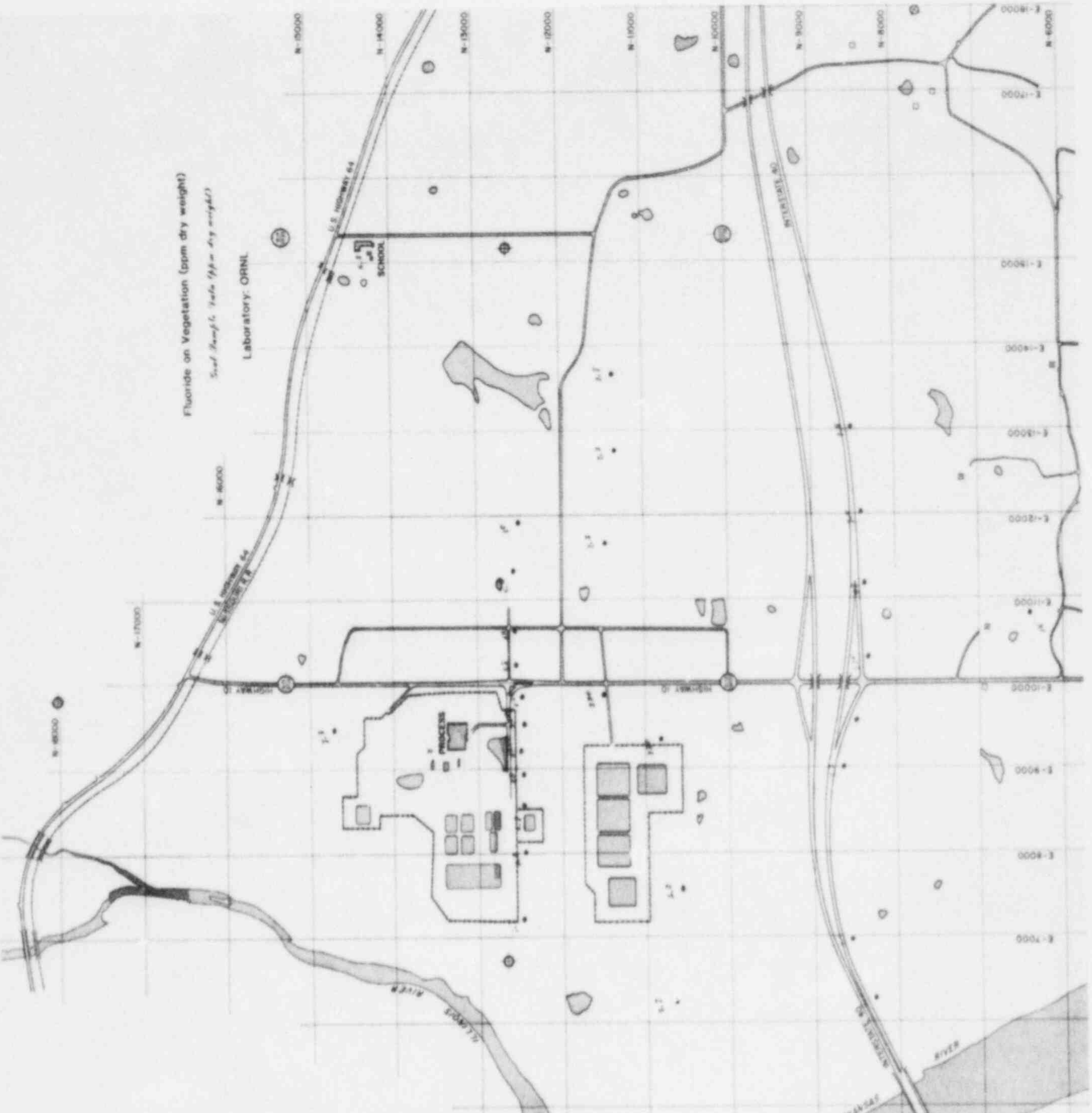


Figure 5.2.7.5A ORNL results, near field, fluoride on vegetation

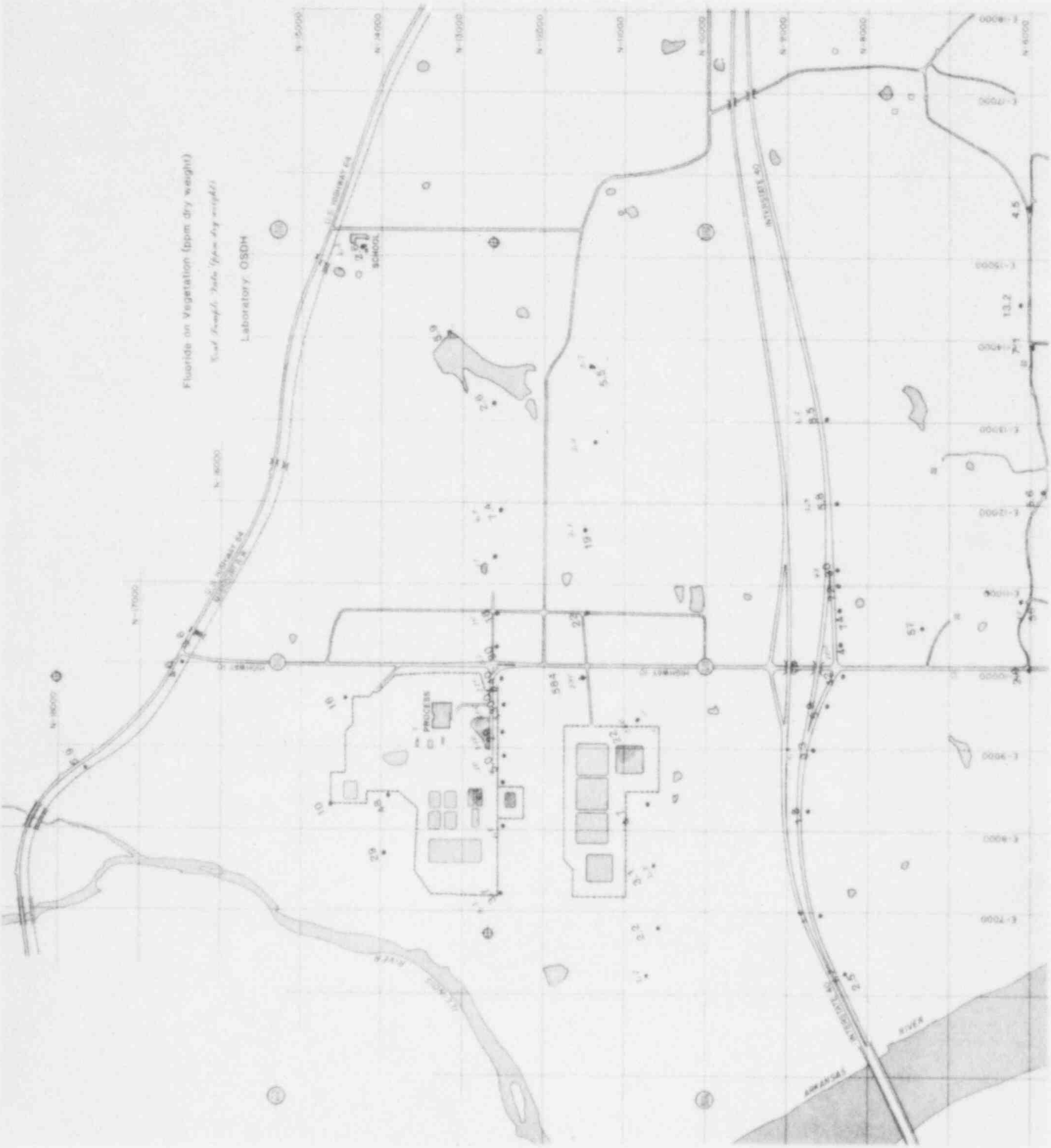


Figure 5.2.7.6A OSDH results, near field, fluoride on vegetation

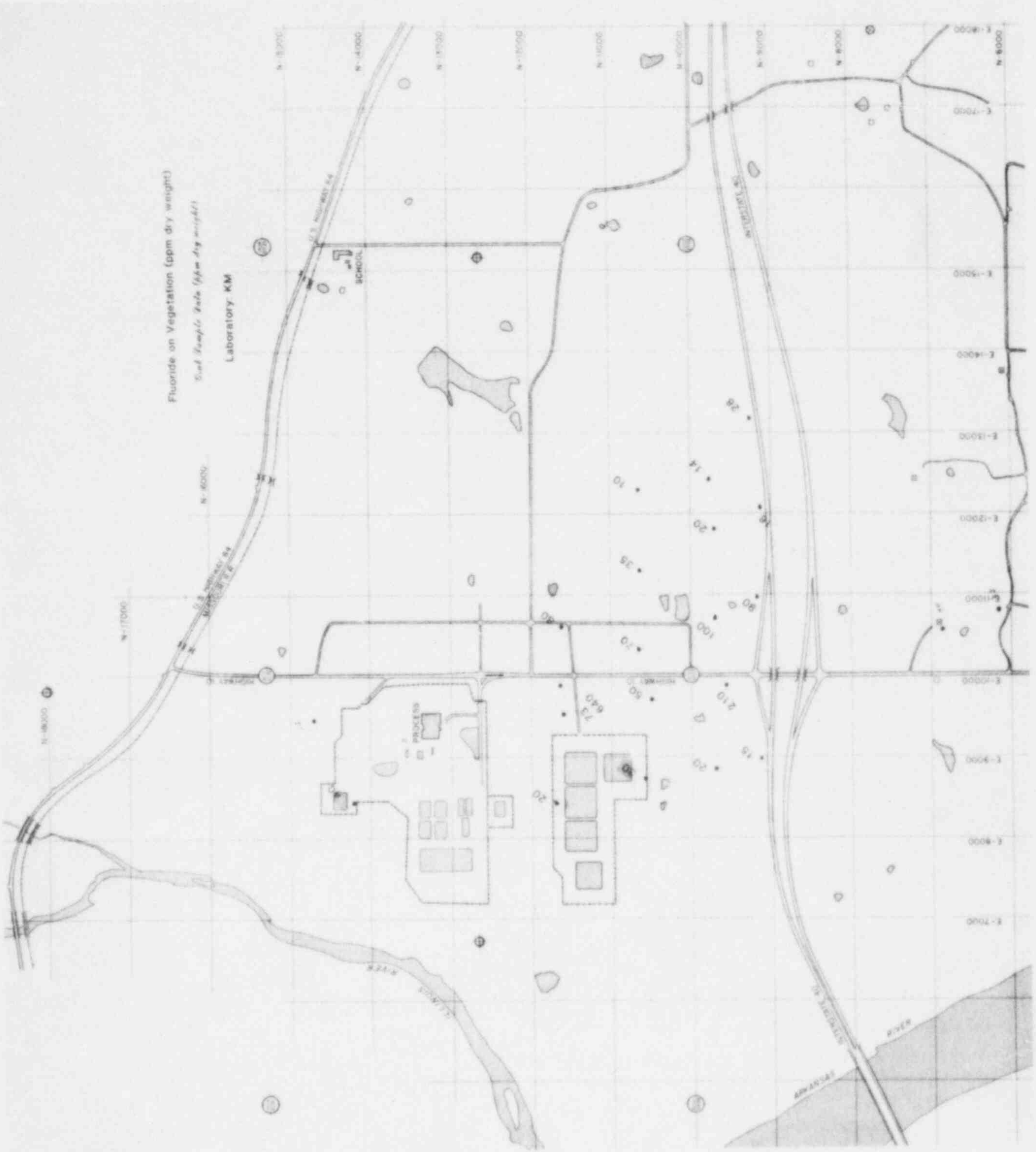


Figure 5.2.7.7A K-M results, near field, fluoride on vegetation

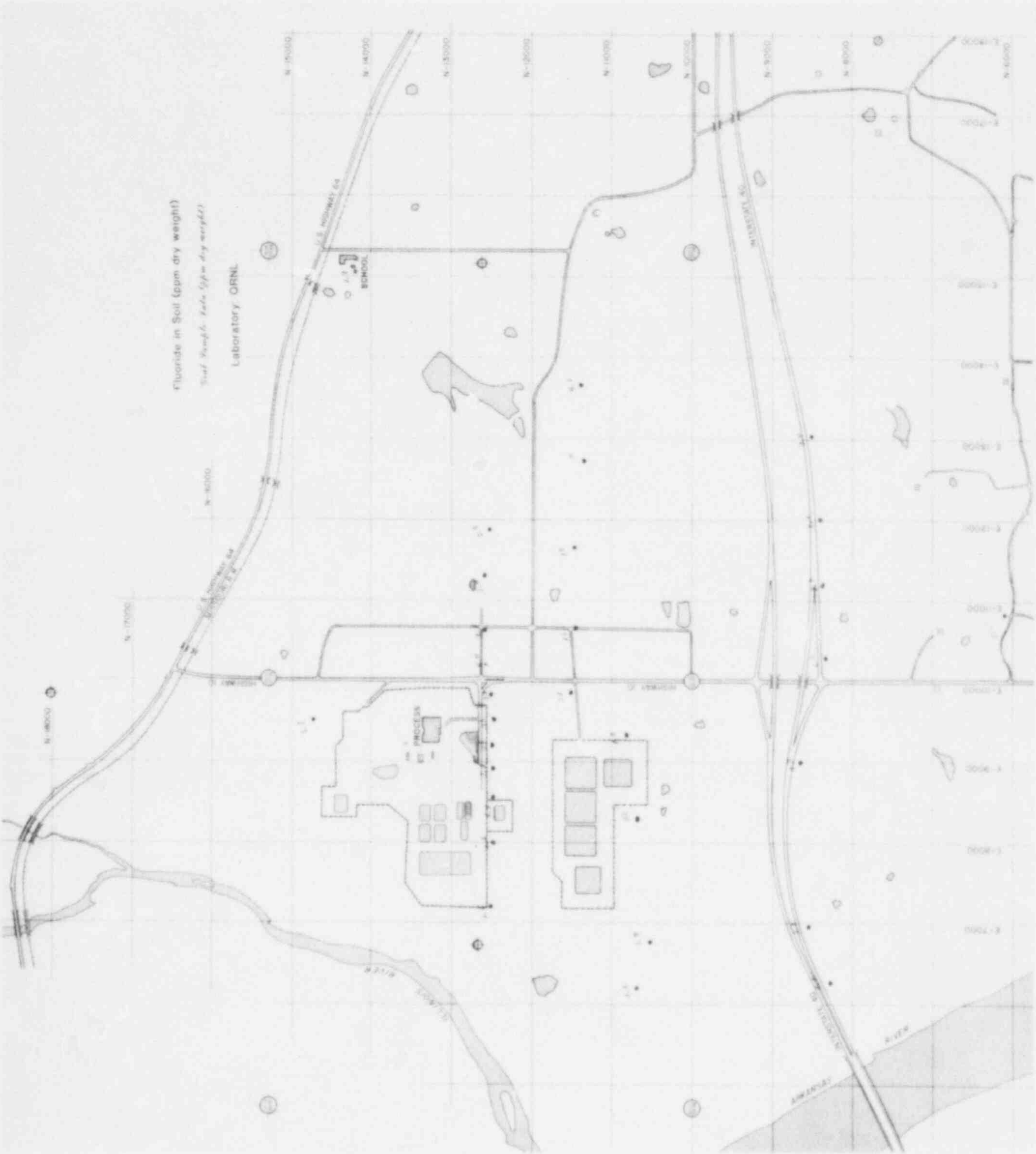


Figure 5.2.7.8A ORNL results, near field, fluoride in soil

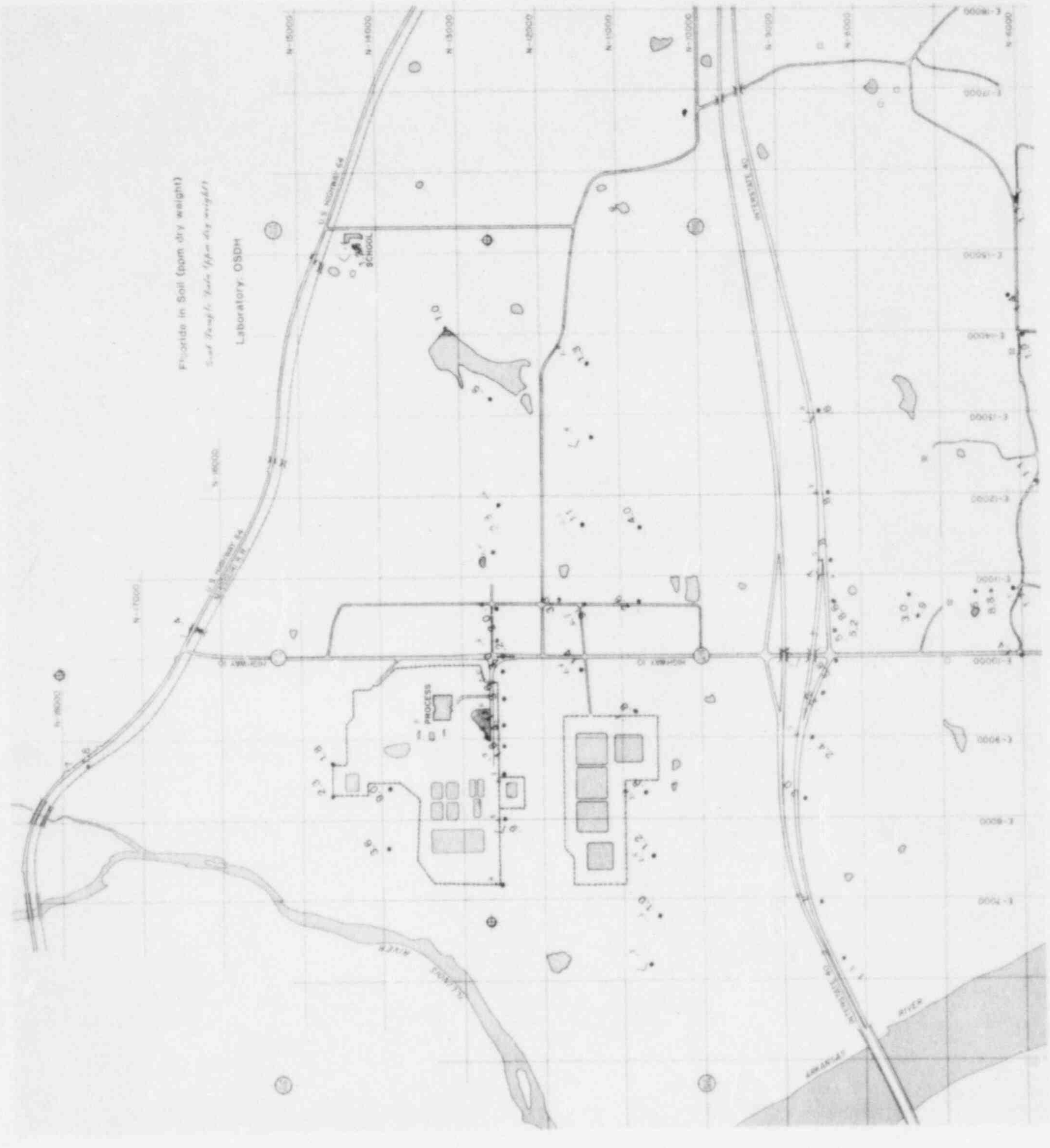


Figure 5.2.7.9A OSDH results, near field, fluoride in soil

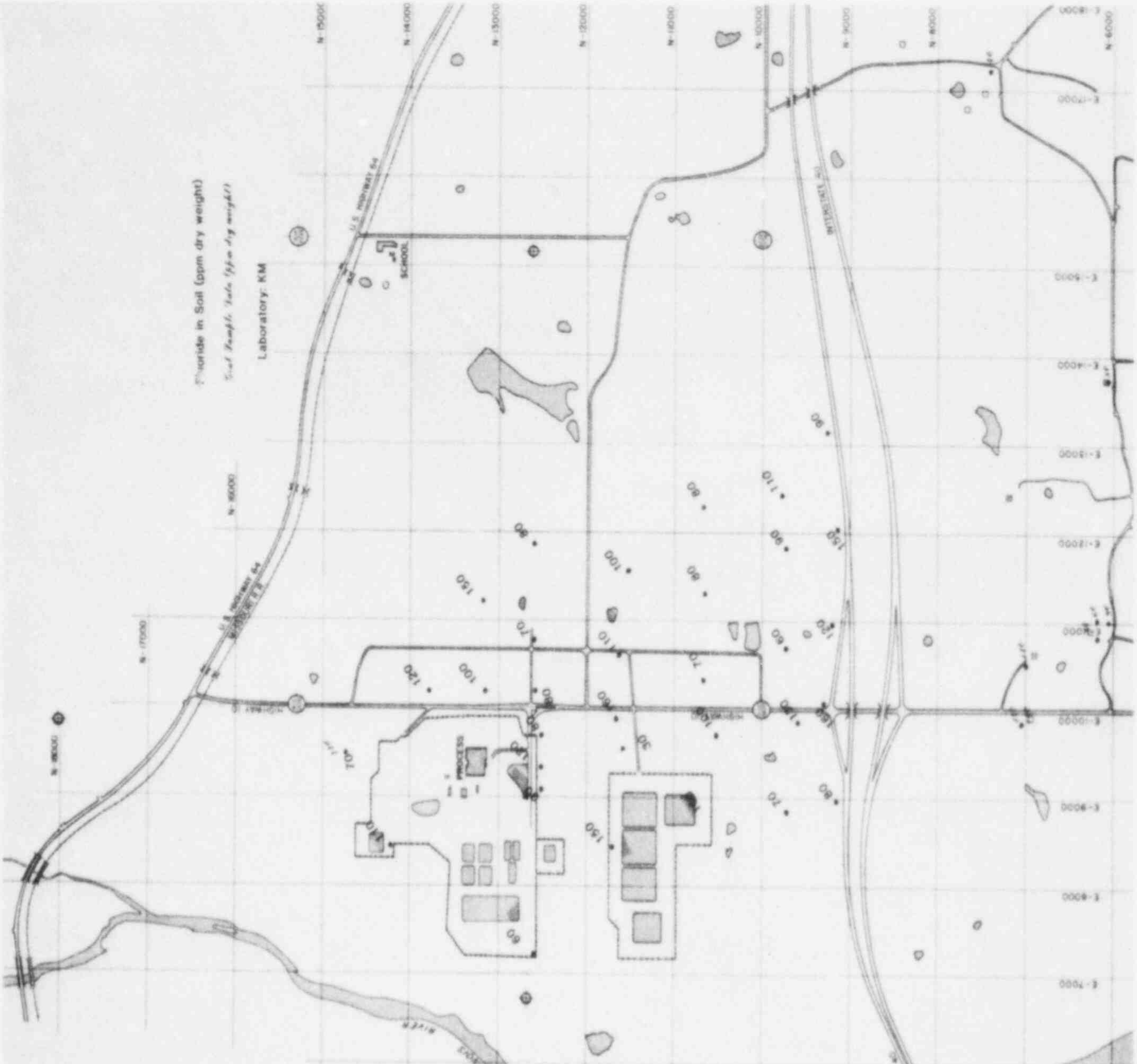


Figure 5.2.7.10A K-M results, near field, fluoride in soil

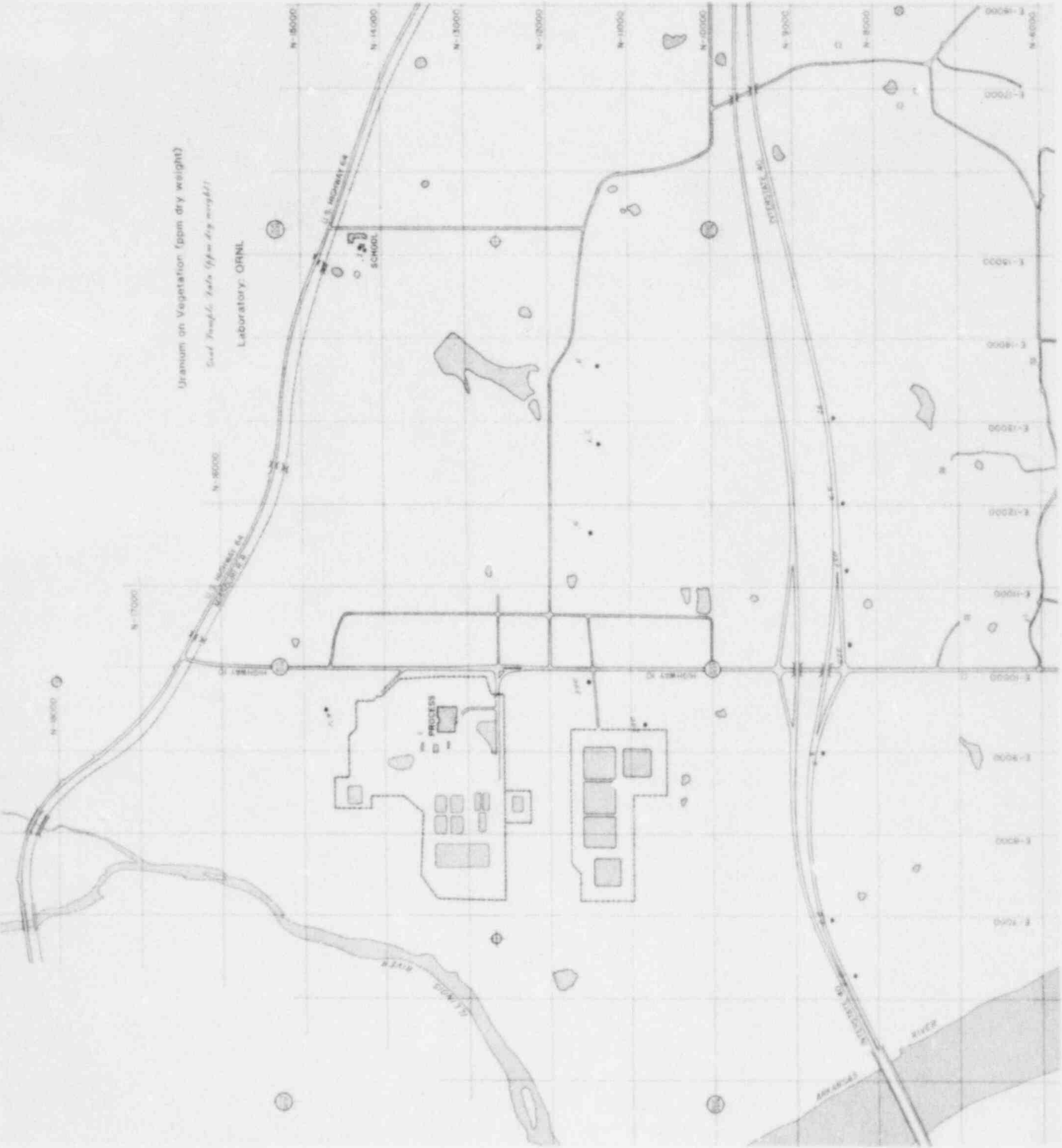


Figure 5.2.7.11A ORNL results, near field, uranium on vegetation

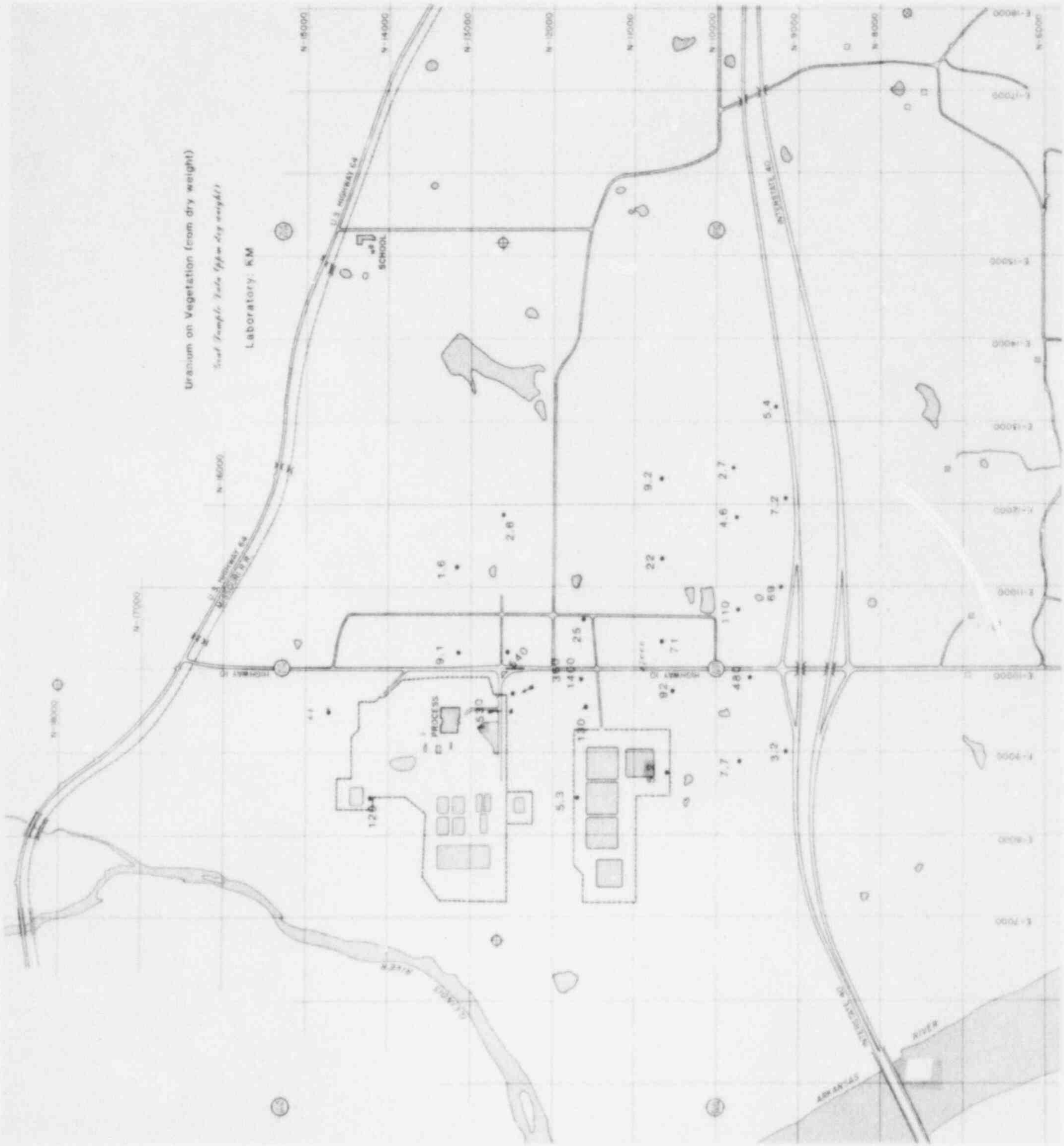


Figure 5.2.7.12A K-M results, near field, uranium on vegetation

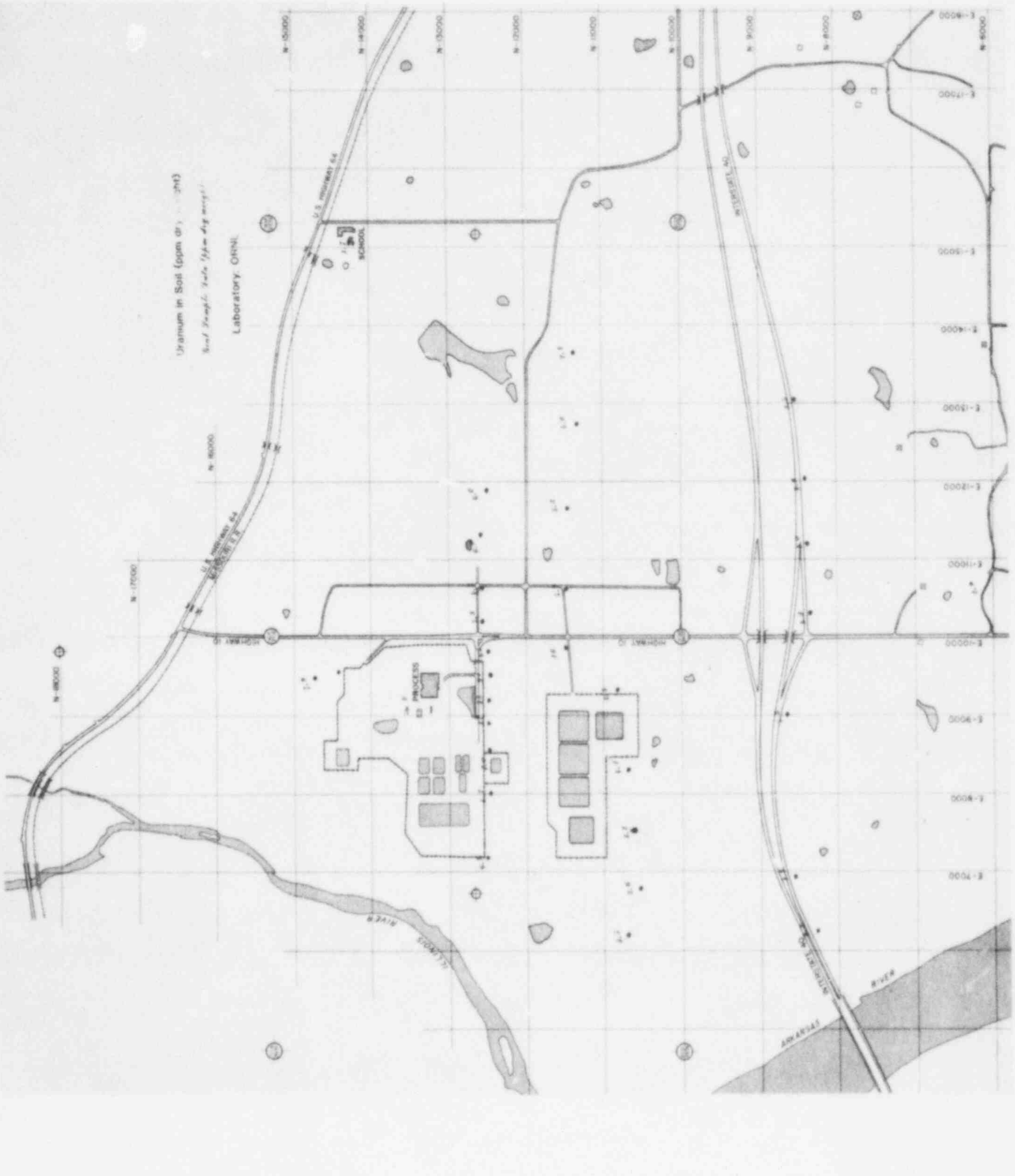


Figure 5.2.7.13A ORNL results, near field, uranium in soil

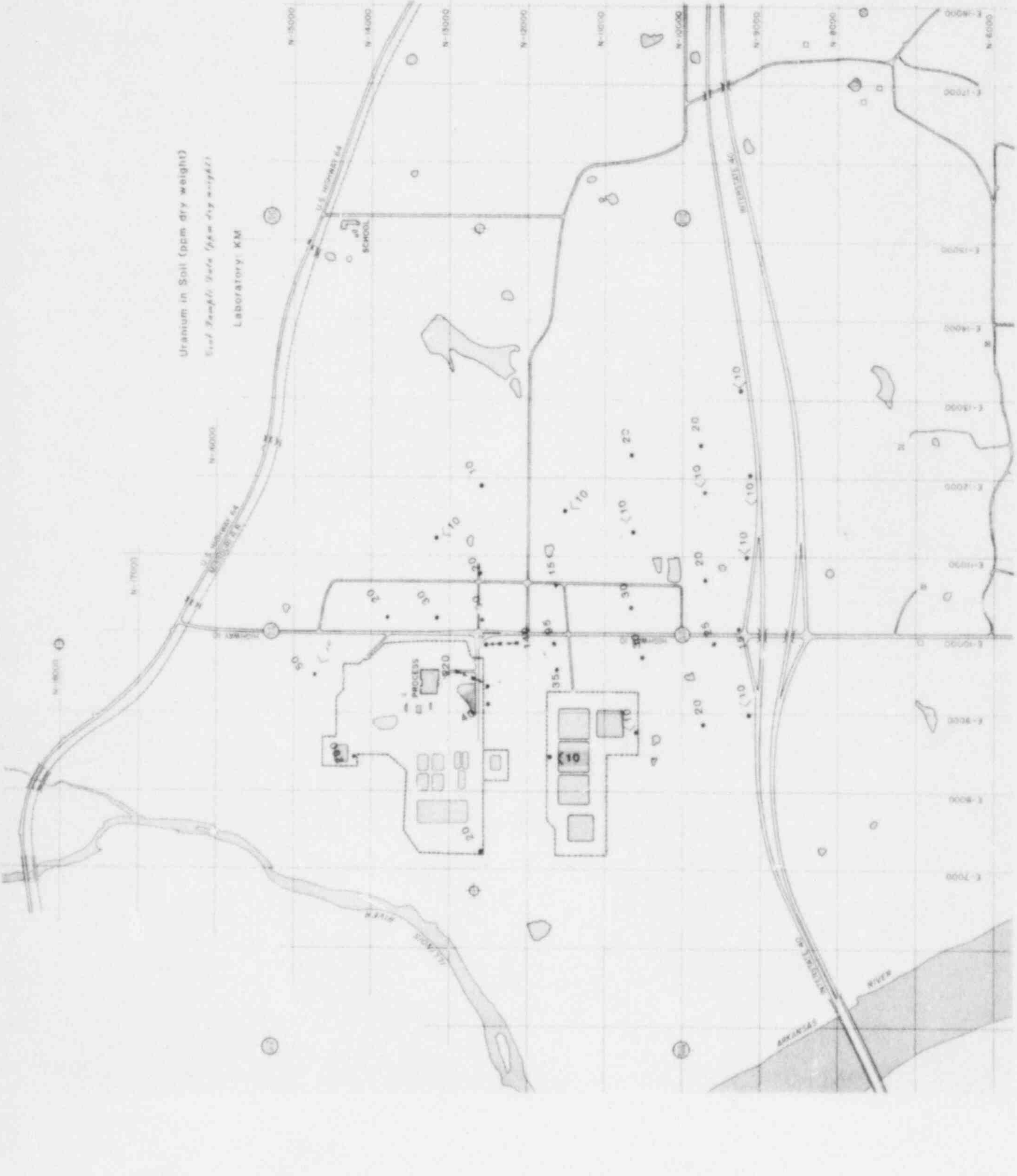


Figure 5.2.7.14A K-M results, near field, uranium in soil

Figure 5.2.7.15A ORNL results, far field, fluoride on vegetation

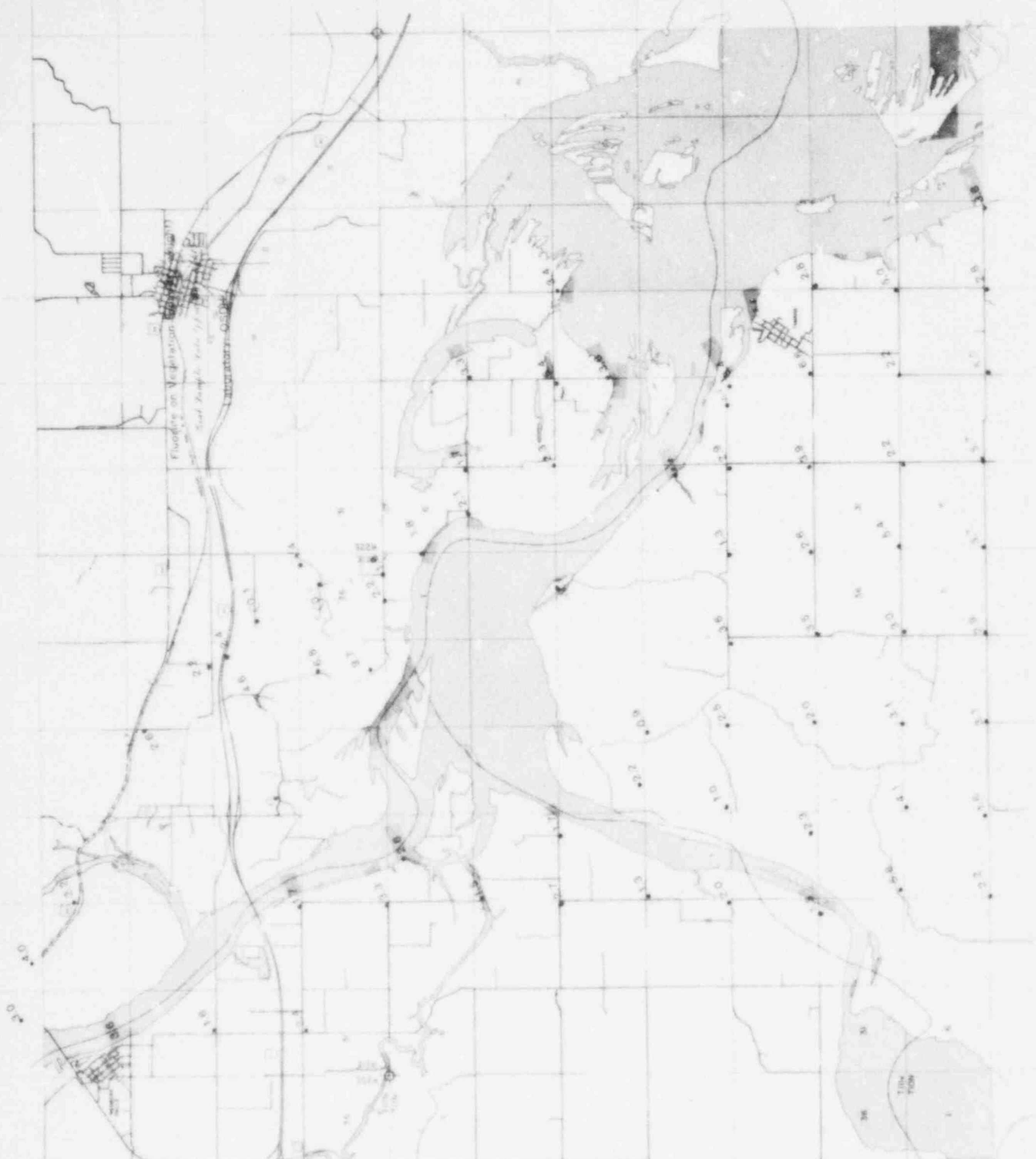


Figure 5.2.7.16A OSDH results, far field, fluoride on vegetation

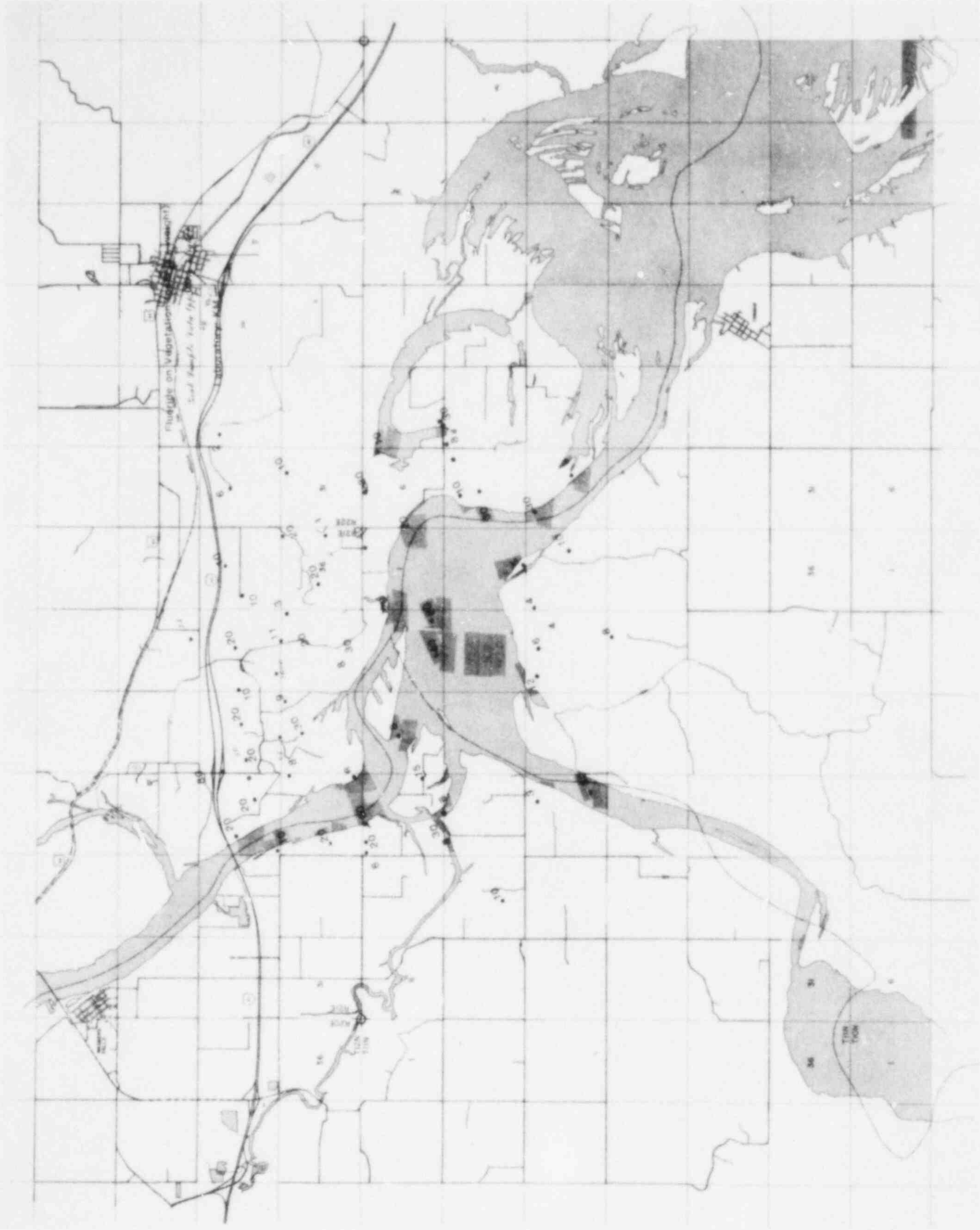


Figure 5.2.7.17A K-M results, far field, fluoride on vegetation

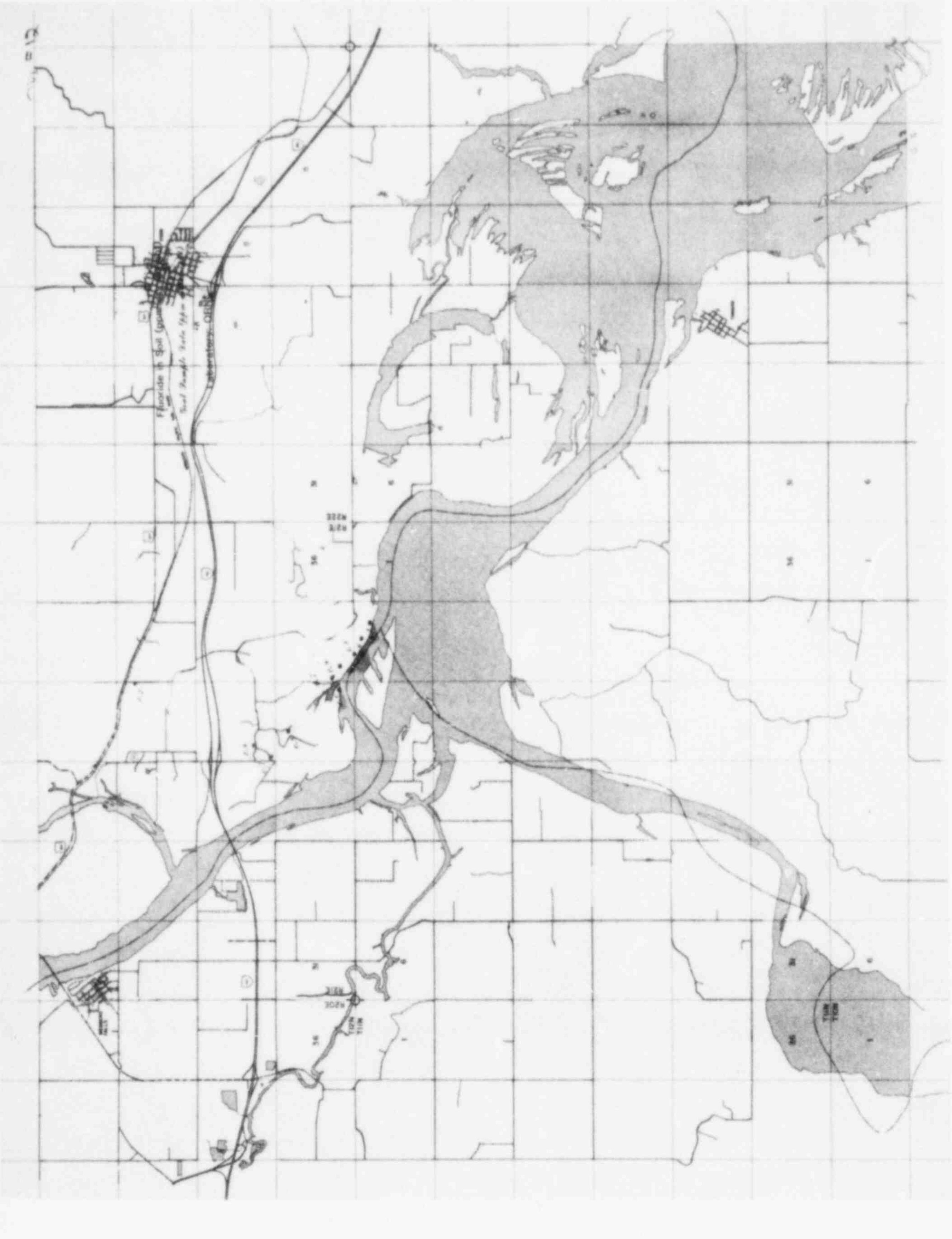


Figure 5.2.7.18A ORNL results, far field, fluoride in soil

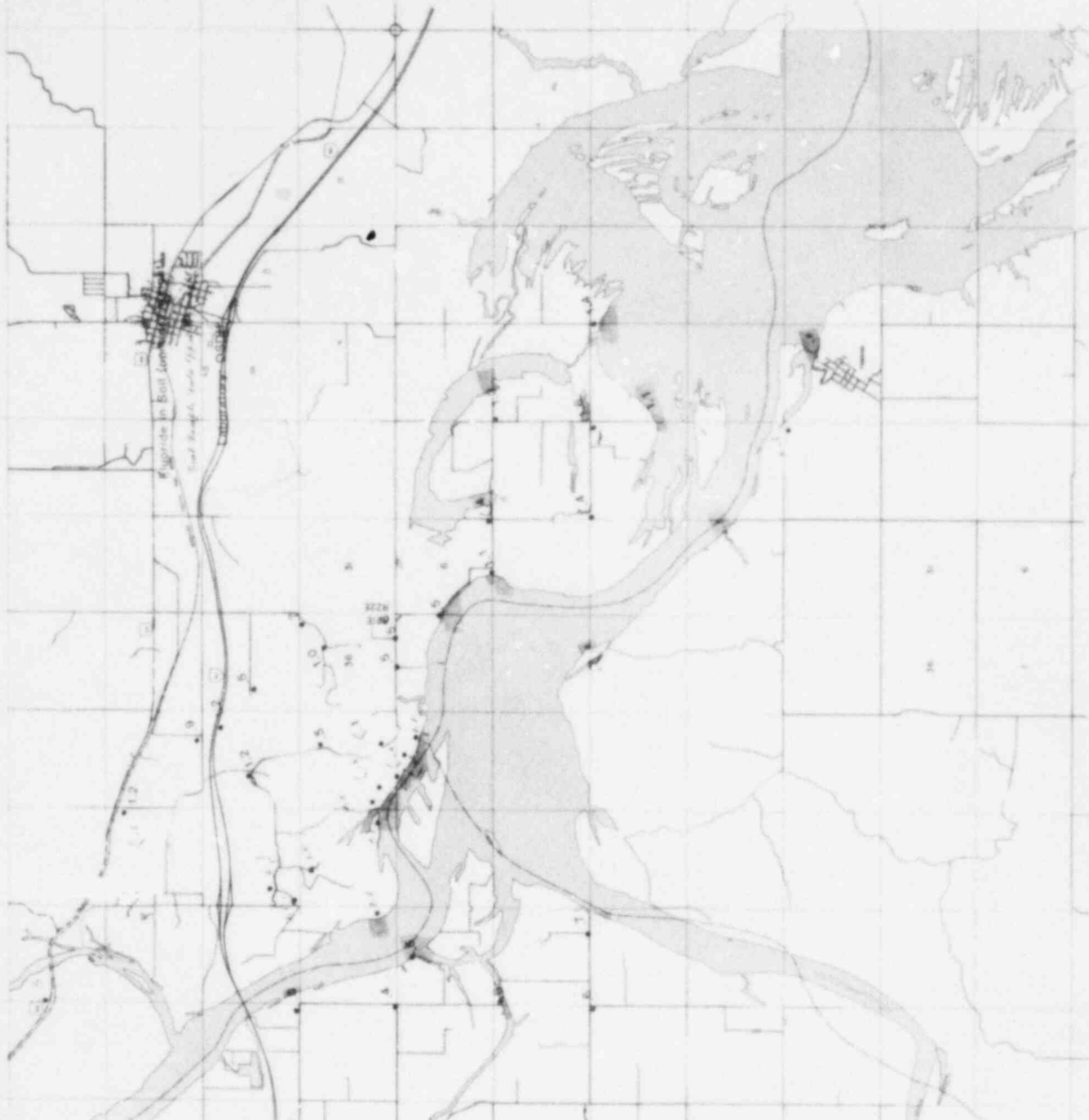


Figure 5.2.7.19A OSDH results, far field, fluoride in soil

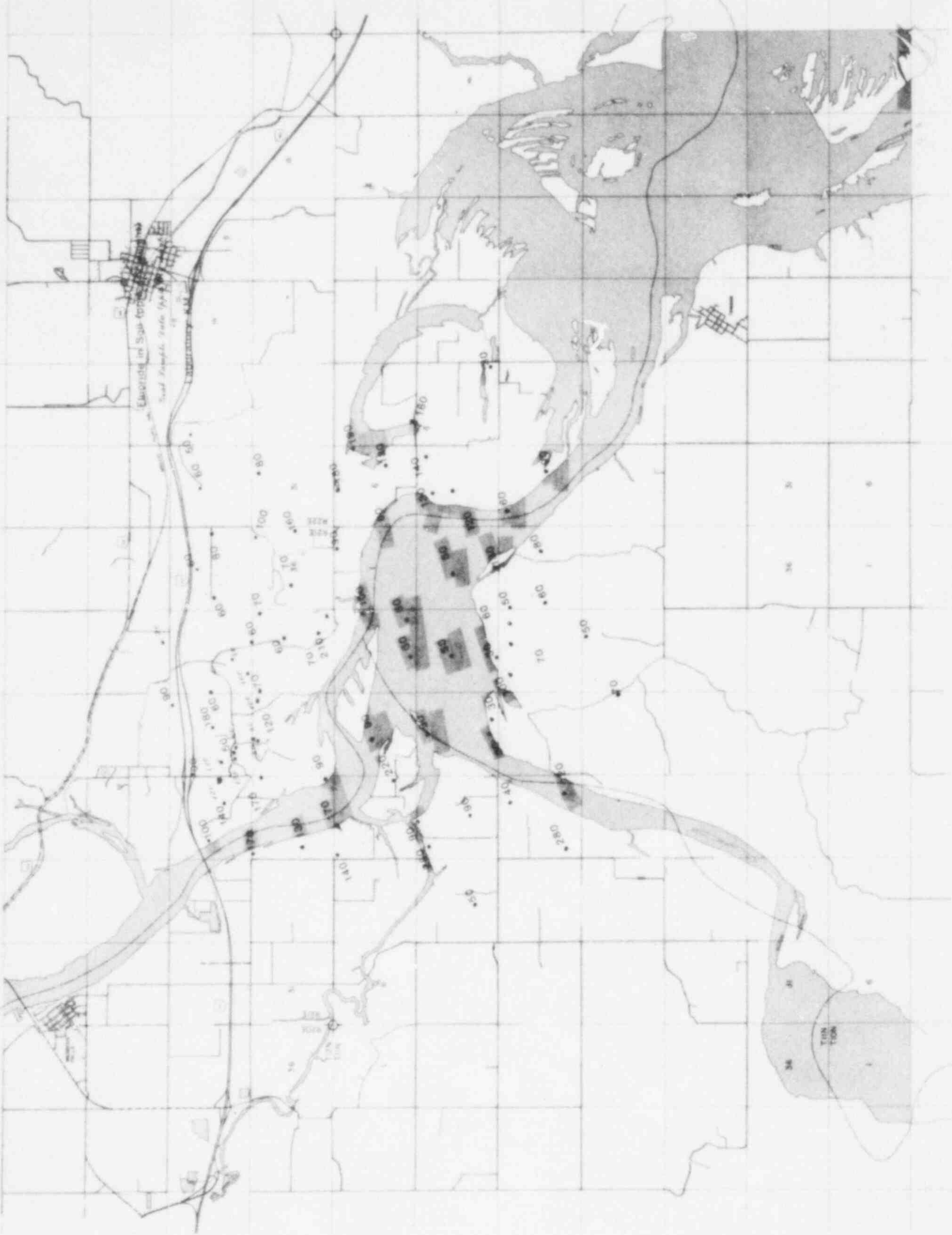


Figure 5.2.7.20A K-M results, far field, fluoride in soil

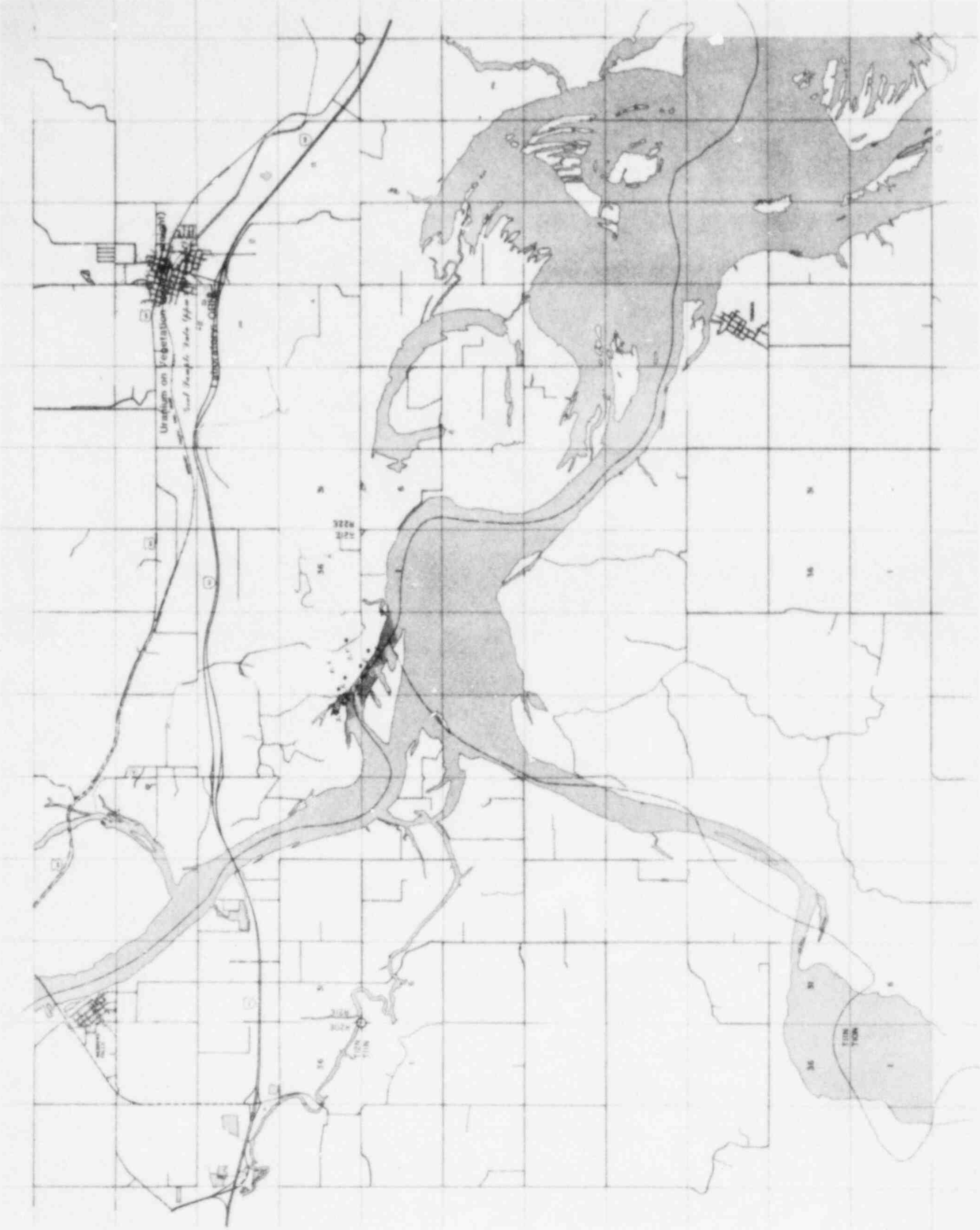


Figure 5.2.7.21A ORNL results, far field, uranium on vegetation

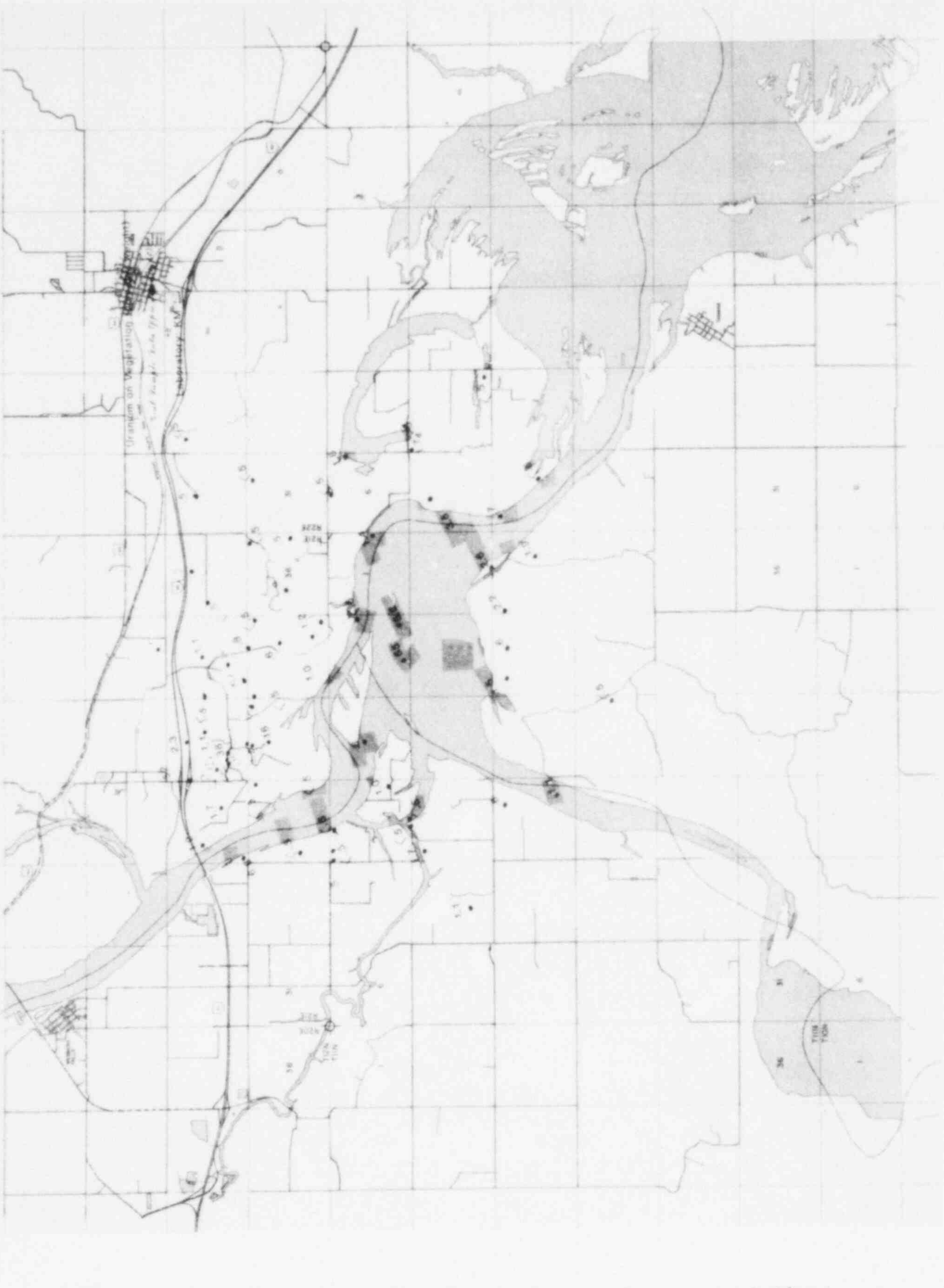
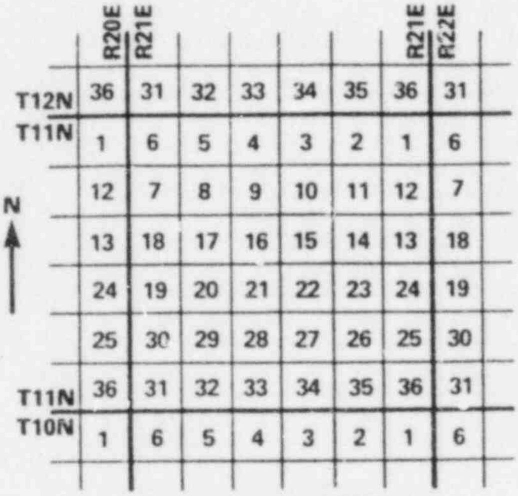


Figure 5.2.7.22A K-M results, far field, uranium on vegetation

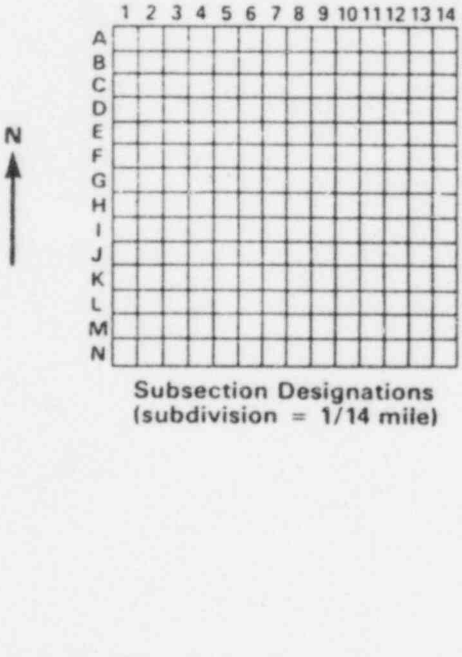
Figure 5.2.7.23A ORNL results, far field, uranium on soil

Figure 5.2.7.24A K-M results, far field, uranium in soil



Arrangement of Sections
(one mile square) by
Township and Range

Figure 5.2.7.25A Township-Range-Section grid



Subsection Designations
(subdivision = 1/14 mile)

Figure 5.2.7.26A Grid for subsection designations

RAW SOIL AND VEGETATION DATA

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS BY MEDIA AND TYPE ANALYSIS

Table 5.2.7.1A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE ON VEGETATION SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
105	11700	8450	KMTC	1-09	F	20.0	ppm	
108	10600	8750	KMTC	1-09	F	30.0	ppm	
111	14250	8450	KMTC	1-09	F	40.0	ppm	
116	10650	12300	KMTC	1-09	F	10.0	ppm	
118	9750	12450	KMTC	1-09	F	14.0	ppm	
120	9700	8850	KMTC	1-09	F	20.0	ppm	
122	9600	9900	KMTC	1-09	F	210.0	ppm	
124	9700	10700	KMTC	1-09	F	100.0	ppm	
126	9750	11850	KMTC	1-09	F	20.0	ppm	
128	10650	11300	KMTC	1-09	F	35.0	ppm	
130	10650	10350	KMTC	1-09	F	70.0	ppm	
132	11600	10650	KMTC	1-09	F	80.0	ppm	
134	9250	13150	KMTC	1-09	F	28.0	ppm	
136	9150	12050	KMTC	1-09	F	16.0	ppm	
138	9200	11000	KMTC	1-09	F	90.0	ppm	
142	9150	9000	KMTC	1-09	F	15.0	ppm	
144	10500	9700	KMTC	1-09	F	50.0	ppm	
146	11600	9550	KMTC	1-09	F	73.0	ppm	
150	11450	9700	KMTC	1-09	F	640.0	ppm	
50	10750	10100	KMTC	1-06	F	1500.0	ppm	CEDAR
A-01	13130	9220	KMTC	1-06	F	2100.0	ppm	
A-07	13130	9400	KMTC	1-06	F	2600.0	ppm	
A-13	13130	9580	KMTC	1-06	F	3000.0	ppm	
A-19	13130	9760	KMTC	1-06	F	230.0	ppm	
A-25	13130	9950	KMTC	1-06	F	35.0	ppm	
BG 1/4	14750	9500	KMTC	1-06	F	40.0	ppm	1/4 N.GATE
CRES08	6150	10750	KMTC	1-03	F	42.0	ppm	CRES
DRES12	6100	11100	KMTC	1-04	F	160.0	ppm	DRY LEAVES
E-01	13000	9230	KMTC	1-06	F	700.0	ppm	
E-07	13000	9410	KMTC	1-06	F	3100.0	ppm	
E-13	13000	9600	KMTC	1-06	F	3700.0	ppm	
E-19	13000	9770	KMTC	1-06	F	760.0	ppm	
E-25	13000	9950	KMTC	1-06	F	80.0	ppm	
HRES02	6950	10650	KMTC	1-04	F	24.0	ppm	
HRES03	6950	10650	KMTC	1-04	F	80.0	ppm	
J-07	12840	9410	KMTC	1-06	F	870.0	ppm	
J-13	12840	9600	KMTC	1-06	F	1700.0	ppm	
J-19	12840	9780	KMTC	1-06	F	1300.0	ppm	
J-25	12840	9950	KMTC	1-06	F	140.0	ppm	
LRES04	6950	9900	KMTC	1-04	F	3.0	ppm	TREE DATA DRCT
P-01	12670	9230	KMTC	1-06	F	270.0	ppm	
P-07	12670	9410	KMTC	1-06	F	2600.0	ppm	
P-12	12670	0	KMTC	1-06	F	450.0	ppm	
P-13	12670	9600	KMTC	1-06	F	2900.0	ppm	AVERAGE VALUE
P-25	12670	9950	KMTC	1-06	F	320.0	ppm	
R-15	6050	13750	KMTC	1-04	F	32.0	ppm	
SM-21	7450	17250	KMTC	1-04	F	5.0	ppm	LEAVES
A-25	13130	9950	ORNL	1-06	F	33.0	ug/g	
BG 1/4	14750	9500	ORNL	1-06	F	7.3	ug/g	

Table 5.2.7.1A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE ON VEGETATION SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
CARLILE	14250	15100	ORNL	1-05	F	8.3	ug/g	
CRES	6150	10800	ORNL	1-05	F	16.2	ug/g	
E-25	13000	9950	ORNL	1-06	F	58.0	ug/g	
J-25	12840	9950	ORNL	1-06	F	150.0	ug/g	
P-19	12670	9780	ORNL	1-06	F	2900.0	ug/g	
P-25	12670	9950	ORNL	1-06	F	280.0	ug/g	
T1-01	12500	7200	ORNL	1-05	F	1.7	ug/g	
T1-01	12500	7200	ORNL	1-05	F	1.7	ug/g	
T1-02	12500	8000	ORNL	1-05	F	1.2	ug/g	
T1-03	12500	8550	ORNL	1-05	F	4.7	ug/g	
T1-04	12500	8900	ORNL	1-05	F	19.2	ug/g	
T1-05	12500	9200	ORNL	1-05	F	1800.0	ug/g	
T1-06	12500	9500	ORNL	1-05	F	930.0	ug/g	
T1-07	12500	9850	ORNL	1-05	F	750.0	ug/g	
T1-08	12600	10200	ORNL	1-05	F	44.6	ug/g	
T1-09	12600	10600	ORNL	1-05	F	17.5	ug/g	
T1-11	12600	11300	ORNL	1-05	F	8.8	ug/g	
T1-12	12550	11900	ORNL	1-05	F	10.2	ug/g	
T2-01	10750	6200	ORNL	1-05	F	4.7	ug/g	
T2-03	10650	7550	ORNL	1-05	F	5.2	ug/g	
T2-05	10800	9300	ORNL	1-05	F	250.0	ug/g	
T2-06	11450	9950	ORNL	1-05	F	290.0	ug/g	
T2-08	11500	11650	ORNL	1-06	F	2.3	ug/g	
T2-09	11350	12700	ORNL	1-06	F	2.3	ug/g	
T2-10	11400	13700	ORNL	1-06	F	2.7	ug/g	
T3-01	8300	6250	ORNL	1-06	F	4.7	ug/g	
T3-02	8600	6950	ORNL	1-06	F	3.0	ug/g	
T3-03	8650	9000	ORNL	1-06	F	7.2	ug/g	
T3-04	8350	10300	ORNL	1-06	F	420.0	ug/g	
T3-05	8350	11200	ORNL	1-06	F	67.0	ug/g	
T3-06	8400	12050	ORNL	1-06	F	7.0	ug/g	
T3-07	8550	13050	ORNL	1-06	F	3.6	ug/g	
CARLILE	14250	15100	OSDH	1-05	F	4.3	mg/kg	GRASS
CARLILE	14100	15300	OSDH	1-14	F	2.56	mg/kg	
COMP-1	11800	9500	OSDH	1-16	F	488.0	mg/kg	LAB COMPARISON
COMP-2	8800	10100	OSDH	1-16	F	164.0	mg/kg	LAB COMPARISON
COMP-3	10050	10700	OSDH	1-16	F	128.0	mg/kg	LAB COMPARISON
COMP-4	14450	14800	OSDH	1-16	F	7.36	mg/kg	LAB COMPARISON
COMP-5	12700	11200	OSDH	1-16	F	1080	mg/kg	LAB COMPARISON
CRES	6150	10750	OSDH	1-05	F	32.0	mg/kg	GRASS
HRES	6950	10650	OSDH	1-08	F	24.0	mg/kg	
LR-01	7300	10450	OSDH	1-11	F	56.8	mg/kg	
LR-01	7300	10450	OSDH	1-11	F	56.8	mg/kg	
LR-02	6000	10000	OSDH	1-11	F	2.96	mg/kg	
LR-02	6000	10000	OSDH	1-11	F	2.96	mg/kg	
LR-03	6000	10800	OSDH	1-11	F	56.00	mg/kg	
LR-03	6000	10800	OSDH	1-11	F	56.00	mg/kg	
LR-04	5800	12100	OSDH	1-11	F	5.60	mg/kg	
LR-04	5800	12100	OSDH	1-11	F	5.60	mg/kg	
LR-05	5975	13950	OSDH	1-11	F	7.12	mg/kg	

Table 5.2.7.1A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE ON VEGETATION SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
LR-05	5975	13950	OSDH	1-11	F	7.12	mg/kg	
LR-05A	6100	14450	OSDH	1-14	F	13.20	mg/kg	
LR-05A	6100	14450	OSDH	1-14	F	13.20	mg/kg	
LR-06	6000	15600	OSDH	1-14	F	4.48	mg/kg	
R-01	11750	10700	OSDH	1-11	F	33.60	mg/kg	
R-02	10800	10700	OSDH	1-11	F	84.00	mg/kg	
R-03	10750	11550	OSDH	1-11	F	6.80	mg/kg	
RD-01	8150	10550	OSDH	1-16	F	40.00	mg/kg	
RD-02	7400	10750	OSDH	1-16	F	46.40	mg/kg	
RD-03	6700	10750	OSDH	1-16	F	53.60	mg/kg	
RD-04	6300	10750	OSDH	1-16	F	64.00	mg/kg	
T1-01	12500	7200	OSDH	1-05	F	1.2	mg/kg	EVERGREEN
T1-01	12500	7200	OSDH	1-14	F	3.68	mg/kg	
T1-02	12500	8000	OSDH	1-05	F	1.8	mg/kg	GRASS
T1-03	12500	8550	OSDH	1-05	F	2.6	mg/kg	GRASS
T1-04	12500	8900	OSDH	1-05	F	10.4	mg/kg	EVERGREEN
T1-04	12500	8900	OSDH	1-14	F	4.96	mg/kg	
T1-05	12500	9200	OSDH	1-05	F	408.0	mg/kg	EVERGREEN
T1-05	12500	9200	OSDH	1-14	F	28.8	mg/kg	
T1-06	12500	9500	OSDH	1-05	F	500.0	mg/kg	GRASS
T1-06	12500	9500	OSDH	1-14	F	1320.0	mg/kg	
T1-07	12500	9850	OSDH	1-05	F	216.0	mg/kg	GRASS
T1-07	12500	9850	OSDH	1-14	F	240.0	mg/kg	
T1-08	12600	10200	OSDH	1-05	F	55.0	mg/kg	GRASS
T1-08	12600	10200	OSDH	1-14	F	20.0	mg/kg	
T1-09	12600	10600	OSDH	1-05	F	20.0	mg/kg	GRASS
T1-09	12600	10600	OSDH	1-14	F	17.6	mg/kg	
T1-11	12600	11300	OSDH	1-05	F	11.3	mg/kg	GRASS
T1-12	12550	11900	OSDH	1-05	F	9.9	mg/kg	EVERGREEN
T1-12	12550	11900	OSDH	1-14	F	7.36	mg/kg	
T1-13	12650	13200	OSDH	1-14	F	2.56	mg/kg	
T1-14	13200	14100	OSDH	1-14	F	5.92	mg/kg	
T2-01	10750	6200	OSDH	1-05	F	4.0	mg/kg	
T2-02	10550	6800	OSDH	1-14	F	2.16	mg/kg	
T2-03	10650	7550	OSDH	1-05	F	1.6	mg/kg	
T2-03	10650	7550	OSDH	1-14	F	3.12	mg/kg	
T2-04	10700	8400	OSDH	1-14	F	4.72	mg/kg	
T2-05	10800	9300	OSDH	1-14	F	21.6	mg/kg	
T2-05	10800	9300	OSDH	1-05	F	91.3	mg/kg	
T2-06	11500	9850	OSDH	1-14	F	584.0	mg/kg	
T2-06	11500	9850	OSDH	1-06	F	122.2	mg/kg	
T2-07	11500	10650	OSDH	1-14	F	22.4	mg/kg	
T2-08	11500	11650	OSDH	1-06	F	3.1	mg/kg	
T2-08	11500	11650	OSDH	1-14	F	18.8	mg/kg	
T2-09	11350	12700	OSDH	1-06	F	<0.8	mg/kg	
T2-10	11400	13700	OSDH	1-06	F	1.6	mg/kg	
T2-10	11400	13700	OSDH	1-14	F	5.52	mg/kg	

Table 5.2.7.1A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE ON VEGETATION SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
T3-01	8300	6250	OSDH	1-06	F	4	mg/kg	EVERGREEN
T3-01	8300	6250	OSDH	1-14	F	2.48	mg/kg	
T3-02	8600	6950	OSDH	1-06	F	2.4	mg/kg	EVERGREEN
T3-02A	8250	8750	OSDH	1-16	F	1.76	mg/kg	
T3-03	8650	9000	OSDH	1-06	F	8.8	mg/kg	EVERGREEN
T3-03	8650	9000	OSDH	1-14	F	9.28	mg/kg	
T3-03A	8500	9550	OSDH	1-16	F	5.92	mg/kg	
T3-03B	8300	9950	OSDH	1-16	F	41.60	mg/kg	
T3-03C	8800	10050	OSDH	1-16	F	13.68	mg/kg	
T3-04	8350	10300	OSDH	1-06	F	102.0	mg/kg	EVRGRN/LEAVES
T3-04	8350	10300	OSDH	1-14	F	4.00	mg/kg	
T3-04	8350	10700	OSDH	1-16	F	73.60	mg/kg	
T3-04B	8350	11000	OSDH	1-16	F	72.00	mg/kg	
T3-05	8350	11200	OSDH	1-06	F	93.0	mg/kg	EVERGREEN
T3-05	8350	11200	OSDH	1-14	F	30.4	mg/kg	
T3-06	8400	12050	OSDH	1-06	F	5.8	mg/kg	EVERGREEN
T3-06	8400	12050	OSDH	1-14	F	5.84	mg/kg	
T3-07	8550	13050	OSDH	1-06	F	4.2	mg/kg	GRASS
T3-07	8550	13050	OSDH	1-14	F	8.48	mg/kg	
T5-01	17700	8700	OSDH	1-15	F	5.92	mg/kg	
T5-01	17700	8700	OSDH	1-08	F	2.48	mg/kg	
T5-02	16500	10000	OSDH	1-08	F	4.56	mg/kg	
T5-02	16500	10000	OSDH	1-08	F	1.76	mg/kg	
T5-03	16300	10350	OSDH	1-08	F	3.6	mg/kg	
T5-04	15500	8500	OSDH	1-08	F	2.56	mg/kg	
T6-01	13950	7700	OSDH	1-08	F	28.8	mg/kg	
T6-02	13900	8400	OSDH	1-08	F	48.0	mg/kg	
T6-03	14650	8300	OSDH	1-08	F	10.48	mg/kg	
T6-05	14450	9550	OSDH	1-08	F	15.84	mg/kg	

Table 5.2.7.2A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE IN SOIL SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
103	13800	10200	KMTC	1-09	F	120.0	ppm	
106	11700	8450	KMTC	1-09	F	150.0	ppm	
109	10600	8750	KMTC	1-09	F	160.0	ppm	
112	14250	8450	KMTC	1-09	F	110.0	ppm	
115	11500	11600	KMTC	1-09	F	100.0	ppm	
117	10650	12300	KMTC	1-09	F	80.0	ppm	
119	9750	12450	KMTC	1-09	F	110.0	ppm	
121	9700	8850	KMTC	1-09	F	70.0	ppm	
123	9600	9900	KMTC	1-09	F	130.0	ppm	
125	9700	10700	KMTC	1-09	F	60.0	ppm	
127	9750	11850	KMTC	1-09	F	90.0	ppm	
129	10650	11300	KMTC	1-09	F	80.0	ppm	
131	10650	10350	KMTC	1-09	F	70.0	ppm	
133	11600	10650	KMTC	1-09	F	110.0	ppm	
135	9250	13150	KMTC	1-09	F	90.0	ppm	
137	9150	12050	KMTC	1-09	F	150.0	ppm	
139	9200	11000	KMTC	1-09	F	120.0	ppm	
141	9300	10100	KMTC	1-09	F	160.0	ppm	
143	9150	9000	KMTC	1-09	F	80.0	ppm	
145	10500	9700	KMTC	1-09	F	100.0	ppm	
147	11600	9550	KMTC	1-09	F	30.0	ppm	
149	11650	9900	KMTC	1-09	F	160.0	ppm	
187	12600	7200	KMTC	1-14	F	60.0	ppm	
190	14750	9500	KMTC	1-14	F	70.0	ppm	
193	12550	10200	KMTC	1-14	F	80.0	ppm	
196	12600	10750	KMTC	1-14	F	70.0	ppm	
199	12550	11850	KMTC	1-14	F	80.0	ppm	
202	13150	10200	KMTC	1-14	F	100.0	ppm	
205	13150	11250	KMTC	1-14	F	150.0	ppm	
209	12500	9900	KMTC	1-14	F	80.0	ppm	
218	12500	9350	KMTC	1-14	F	120.0	ppm	
221	12500	9100	KMTC	1-14	F	90.0	ppm	
A-01	13130	9220	KMTC	1-06	F	250.0	ppm	
A-07	13130	9400	KMTC	1-06	F	410.0	ppm	
A-07	13130	9400	KMTC	1-09	F	410.0	ppm	
A-13	13130	9580	KMTC	1-06	F	320.0	ppm	
A-13	13130	9580	KMTC	1-09	F	140.0	ppm	
A-25	13130	9950	KMTC	1-06	F	110.0	ppm	
BG 1/4	14750	9500	KMTC	1-06	F	220.0	ppm	
CRES10	6150	10750	KMTC	1-04	F	190.0	ppm	CRES
DRES11	6100	11100	KMTC	1-04	F	40.0	ppm	
DRES13	6100	11100	KMTC	1-04	F	60.0	ppm	
E-01	13000	9230	KMTC	1-06	F	100.0	ppm	
E-01	13000	9230	KMTC	1-09	F	180.0	ppm	
E-07	13000	9410	KMTC	1-06	F	170.0	ppm	
E-07	13000	9410	KMTC	1-09	F	170.0	ppm	
E-13	13000	9600	KMTC	1-06	F	230.0	ppm	
E-13	13000	9600	KMTC	1-09	F	150.0	ppm	
E-19	13000	9770	KMTC	1-06	F	40.0	ppm	
E-25	13000	9950	KMTC	1-06	F	170.0	ppm	
HRES01	6950	10650	KMTC	1-04	F	110.0	ppm	

Table 5.2.7.2A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE IN SOIL SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
J-07	12840	9410	KMTC	1-06	F	150.0	ppm	
J-07	12840	9410	KMTC	1-09	F	180.0	ppm	
J-13	12840	9600	KMTC	1-06	F	220.0	ppm	
J-13	12840	9600	KMTC	1-09	F	200.0	ppm	
J-19	12840	9780	KMTC	1-06	F	90.0	ppm	
J-25	12840	9950	KMTC	1-06	F	110.0	ppm	
LRES05	6950	9900	KMTC	1-04	F	120.0	ppm	
LRES06	6950	9900	KMTC	1-04	F	60.0	ppm	
P-07	12670	9410	KMTC	1-06	F	300.0	ppm	
P-07	12670	9410	KMTC	1-09	F	170.0	ppm	
P-13	12670	9600	KMTC	1-06	F	50.0	ppm	
P-13	12670	9600	KMTC	1-09	F	290.0	ppm	
P-19	12670	9780	KMTC	1-06	F	210.0	ppm	
P-25	12670	9950	KMTC	1-06	F	90.0	ppm	
R-16	6050	13750	KMTC	1-04	F	80.0	ppm	
SM-20	7450	17250	KMTC	1-04	F	40.0	ppm	
A-25	13130	9760	ORNL	1-06	F	9.0	ug/g	WET
A-25	13130	9760	ORNL	1-06	F	11.4	ug/g	DRY
BG 1/4	14750	9500	ORNL	1-06	F	3.7	ug/g	WET
BG 1/4	14750	9500	ORNL	1-06	F	4.7	ug/g	DRY
CARLILE	14250	15100	ORNL	1-05	F	1.2	ug/g	DRY
CARLILE	14250	15100	ORNL	1-05	F	0.8	ug/g	WET
CRES	6150	10750	ORNL	1-05	F	1.9	ug/g	WET
CRES	6150	10750	ORNL	1-05	F	2.8	ug/g	DRY
E-25	13000	9950	ORNL	1-06	F	7.4	ug/g	WET
E-25	13000	9950	ORNL	1-06	F	8.6	ug/g	DRY
J-25	12840	9950	ORNL	1-06	F	8.3	ug/g	WET
J-25	12840	9950	ORNL	1-06	F	11.2	ug/g	DRY
P-19	12670	9600	ORNL	1-06	F	28.7	ug/g	WET
P-19	12670	9600	ORNL	1-06	F	32.8	ug/g	DRY
P-25	12670	9780	ORNL	1-06	F	14.2	ug/g	WET
P-25	12670	9780	ORNL	1-06	F	21.0	ug/g	DRY
T1-01	12500	7200	ORNL	1-05	F	3.1	ug/g	DRY
T1-01	12500	7200	ORNL	1-05	F	2.3	ug/g	WET
T1-02	12500	8000	ORNL	1-05	F	1.4	ug/g	DRY
T1-02	12500	8000	ORNL	1-05	F	1.2	ug/g	WET
T1-03	12500	8550	ORNL	1-05	F	4.2	ug/g	DRY
T1-03	12500	8550	ORNL	1-05	F	3.4	ug/g	WET
T1-04	12500	8900	ORNL	1-05	F	7.5	ug/g	DRY
T1-04	12500	8900	ORNL	1-05	F	5.7	ug/g	WET
T1-05	12500	9200	ORNL	1-05	F	23.5	ug/g	DRY
T1-05	12500	9200	ORNL	1-05	F	17.7	ug/g	WET
T1-06	12500	9500	ORNL	1-05	F	22.5	ug/g	WET
T1-06	12500	9500	ORNL	1-05	F	26.3	ug/g	DRY
T1-07	12500	9850	ORNL	1-05	F	12.2	ug/g	WET
T1-07	12500	9850	ORNL	1-05	F	22.8	ug/g	DRY
T1-08	12600	10200	ORNL	1-05	F	6.6	ug/g	DRY
T1-08	12600	10200	ORNL	1-05	F	5.1	ug/g	WET
T1-09	12600	10600	ORNL	1-05	F	2.1	ug/g	DRY
T1-09	12600	10600	ORNL	1-05	F	1.7	ug/g	WET
T1-11	12600	11300	ORNL	1-05	F	7.6	ug/g	DRY

Table 5.2.7.2A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE IN SOIL SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
T1-11	12600	11300	ORNL	1-05	F	4.6	ug/g	WET
T1-12	12550	11900	ORNL	1-05	F	2.4	ug/g	DRY
T1-12	12550	11900	ORNL	1-05	F	1.4	ug/g	WET
T2-01	10750	6200	ORNL	1-05	F	1.1	ug/g	DRY
T2-01	10750	6200	ORNL	1-05	F	0.9	ug/g	WET
T2-02	10550	6800	ORNL	1-05	F	2.9	ug/g	DRY
T2-02	10550	6800	ORNL	1-05	F	2.5	ug/g	WET
T2-04	10700	8400	ORNL	1-05	F	15.1	ug/g	DRY
T2-04	10700	8400	ORNL	1-05	F	13.9	ug/g	WET
T2-05	10800	9300	ORNL	1-05	F	1.4	ug/g	DRY
T2-05	10800	9300	ORNL	1-05	F	1.2	ug/g	WET
T2-06	11450	9950	ORNL	1-05	F	21.4	ug/g	DRY
T2-06	11450	9950	ORNL	1-05	F	20.2	ug/g	WET
T2-07	11500	10650	ORNL	1-06	F	14.9	ug/g	DRY
T2-07	11500	10650	ORNL	1-06	F	14.3	ug/g	WET
T2-08	11500	11650	ORNL	1-06	F	13.9	ug/g	DRY
T2-08	11500	11650	ORNL	1-06	F	10.2	ug/g	WET
T2-09	11350	12700	ORNL	1-06	F	0.6	ug/g	DRY
T2-09	11350	12700	ORNL	1-06	F	0.5	ug/g	WET
T2-10	11400	13700	ORNL	1-06	F	4.1	ug/g	WET
T2-10	11400	13700	ORNL	1-06	F	6.5	ug/g	DRY
T3-01	8300	6250	ORNL	1-06	F	1.1	ug/g	DRY
T3-01	8300	6250	ORNL	1-06	F	0.9	ug/g	WET
T3-02	8600	6950	ORNL	1-06	F	3.4	ug/g	DRY
T3-02	8600	6950	ORNL	1-06	F	2.9	ug/g	WET
T3-03	8650	9000	ORNL	1-06	F	3.2	ug/g	DRY
T3-03	8650	9000	ORNL	1-06	F	2.8	ug/g	WET
T3-04	8350	10300	ORNL	1-06	F	1.4	ug/g	DRY
T3-04	8350	10300	ORNL	1-06	F	1.3	ug/g	WET
T3-05	8350	11200	ORNL	1-06	F	2.2	ug/g	DRY
T3-05	8350	11200	ORNL	1-06	F	1.6	ug/g	WET
T3-06	8400	12050	ORNL	1-06	F	2.1	ug/g	DRY
T3-06	8400	12050	ORNL	1-06	F	1.7	ug/g	WET
T3-07	8550	13050	ORNL	1-06	F	2.0	ug/g	DRY
T3-07	8550	13050	ORNL	1-06	F	1.4	ug/g	WET
CARLILE	14100	15300	OSDH	1-14	F	1.24	mg/kg	
CARLILE	14250	15100	OSDH	1-05	F	<0.4	mg/kg	
COMP-1	11800	9500	OSDH	1-16	F	5.44	mg/kg	LAB COMPARISON
COMP-2	8800	10100	OSDH	1-16	F	2.76	mg/kg	LAB COMPARISON
COMP-3	10050	10700	OSDH	1-16	F	1.96	mg/kg	LAB COMPARISON
COMP-4	14450	14800	OSDH	1-16	F	1.48	mg/kg	LAB COMPARISON
COMP-5	12700	11200	OSDH	1-16	F	5.6	mg/kg	LAB COMPARISON
CRES	6150	10750	OSDH	1-05	F	0.6	mg/kg	
LR-01	7300	10450	OSDH	1-11	F	0.88	mg/kg	
LR-01	7300	10450	OSDH	1-11	F	0.88	mg/kg	
LR-02	6000	10000	OSDH	1-11	F	1.36	mg/kg	
LR-02	6000	10000	OSDH	1-11	F	1.36	mg/kg	
LR-03	6000	10800	OSDH	1-11	F	1.68	mg/kg	
LR-03	6000	10800	OSDH	1-11	F	1.68	mg/kg	
LR-04	5800	12100	OSDH	1-11	F	1.12	mg/kg	
LR-04	5800	12100	OSDH	1-11	F	1.12	mg/kg	

Table 5.2.7.2A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE IN SOIL SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
LR-05	5975	13950	OSDH	1-11	F	1.92	mg/kg	
LR-05	5975	13950	OSDH	1-11	F	1.92	mg/kg	
LR-05A	6100	14450	OSDH	1-14	F	1.36	mg/kg	
LR-06	6000	15600	OSDH	1-14	F	1.12	mg/kg	
R-01	11750	10700	OSDH	1-11	F	3.32	mg/kg	
R-02	10800	10700	OSDH	1-11	F	2.64	mg/kg	
R-03	10750	11550	OSDH	1-11	F	4.00	mg/kg	
RD-01	8150	10550	OSDH	1-16	F	5.20	mg/kg	
RD-02	7400	10750	OSDH	1-16	F	2.96	mg/kg	
RD-03	6700	10750	OSDH	1-16	F	0.48	mg/kg	
RD-04	6300	10750	OSDH	1-16	F	8.80	mg/kg	
T1-01	12500	7200	OSDH	1-05	F	0.8	mg/kg	
T1-02	12500	8000	OSDH	1-05	F	<0.4	mg/kg	
T1-02	12500	8000	OSDH	1-14	F	0.92	mg/kg	
T1-03	12500	8550	OSDH	1-05	F	1.3	mg/kg	
T1-04	12500	8900	OSDH	1-05	F	0.9	mg/kg	
T1-04	12500	8900	OSDH	1-14	F	1.84	mg/kg	
T1-05	12500	9200	OSDH	1-05	F	4.8	mg/kg	
T1-05	12500	9200	OSDH	1-14	F	4.08	mg/kg	
T1-06	12500	9500	OSDH	1-05	F	3.6	mg/kg	
T1-06	12500	9500	OSDH	1-14	F	3.64	mg/kg	
T1-07	12500	9850	OSDH	1-05	F	2.0	mg/kg	
T1-07	12500	9850	OSDH	1-14	F	3.00	mg/kg	
T1-08	12600	10200	OSDH	1-05	F	0.8	mg/kg	
T1-08	12600	10200	OSDH	1-14	F	2.20	mg/kg	
T1-09	12600	10600	OSDH	1-05	F	0.6	mg/kg	
T1-09	12600	10600	OSDH	1-14	F	1.96	mg/kg	
T1-11	12600	11300	OSDH	1-05	F	1.0	mg/kg	
T1-12	12550	11900	OSDH	1-05	F	0.8	mg/kg	
T1-12	12550	11900	OSDH	1-14	F	3.76	mg/kg	
T1-13	12650	13200	OSDH	1-14	F	0.48	mg/kg	
T1-14	13200	14100	OSDH	1-14	F	0.96	mg/kg	
T2-01	10750	6200	OSDH	1-05	F	<0.4	mg/kg	
T2-02	10550	6800	OSDH	1-14	F	1.0	mg/kg	
T2-02	10550	6800	OSDH	1-05	F	0.48	mg/kg	
T2-03	10650	7550	OSDH	1-14	F	1.2	mg/kg	
T2-03	10650	7550	OSDH	1-05	F	1.6	mg/kg	
T2-04	10700	8400	OSDH	1-14	F	0.76	mg/kg	
T2-04	10700	8400	OSDH	1-05	F	1.96	mg/kg	
T2-05	10800	9300	OSDH	1-14	F	0.8	mg/kg	
T2-05	10800	9300	OSDH	1-05	F	0.4	mg/kg	
T2-06	11500	9850	OSDH	1-14	F	1.4	mg/kg	
T2-06	11500	9850	OSDH	1-06	F	1.12	mg/kg	
T2-07	11500	10650	OSDH	1-14	F	0.92	mg/kg	
T2-07	11500	10650	OSDH	1-06	F	6.72	mg/kg	
T2-08	11500	11650	OSDH	1-14	F	11.2	mg/kg	
T2-08	11500	11650	OSDH	1-06	F	3.12	mg/kg	
T2-09	11350	12700	OSDH	1-06	F	<0.8	mg/kg	
T2-10	11400	13700	OSDH	1-14	F	1.32	mg/kg	

Table 5.2.7.2A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE IN SOIL SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
T2-10	11400	13700	OSDH	1-06	F	1.6	mg/kg	
T3-01	8300	6250	OSDH	1-06	F	0.8	mg/kg	
T3-01	8300	6250	OSDH	1-14	F	1.32	mg/kg	
T3-02	8600	6950	OSDH	1-06	F	1.2	mg/kg	
T3-02A	8250	8750	OSDH	1-16	F	3.00	mg/kg	
T3-03	8650	9000	OSDH	1-06	F	2.5	mg/kg	
T3-03	8650	9000	OSDH	1-14	F	2.36	mg/kg	
T3-03A	8500	9550	OSDH	1-16	F	21.60	mg/kg	
T3-03B	8300	9950	OSDH	1-16	F	5.56	mg/kg	
T3-03C	8800	10050	OSDH	1-16	F	<0.40	mg/kg	
T3-04	8350	10300	OSDH	1-06	F	<0.8	mg/kg	
T3-04	8350	10300	OSDH	1-14	F	0.52	mg/kg	
T3-04A	8350	10700	OSDH	1-16	F	8.80	mg/kg	
T3-04B	8350	11000	OSDH	1-16	F	1.68	mg/kg	
T3-05	8350	11200	OSDH	1-06	F	1.2	mg/kg	
T3-05	8350	11200	OSDH	1-14	F	0.84	mg/kg	
T3-06	8400	12050	OSDH	1-06	F	1.4	mg/kg	
T3-06	8400	12050	OSDH	1-14	F	0.76	mg/kg	
T3-07	8550	13050	OSDH	1-06	F	<0.8	mg/kg	
T3-07	8550	13050	OSDH	1-14	F	0.64	mg/kg	
T5-01	17700	8700	OSDH	1-15	F	1.84	mg/kg	
T5-01	17700	8700	OSDH	1-08	F	0.68	mg/kg	
T5-03	16300	10350	OSDH	1-08	F	<0.4	mg/kg	
T6-01	13950	7700	OSDH	1-08	F	3.56	mg/kg	
T6-02	13900	8400	OSDH	1-08	F	9.0	mg/kg	
T6-03	14650	8300	OSDH	1-08	F	2.28	mg/kg	
T6-04	14650	8700	OSDH	1-08	F	1.8	mg/kg	

Table 5.2.7.3A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
URANIUM ON VEGETATION SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
105	11700	8450	KMTC	1-09	U	5.3	ppm	
108	10600	8750	KMTC	1-09	U	5.2	ppm	
111	14250	8450	KMTC	1-09	U	120.0	ppm	
116	10650	12300	KMTC	1-09	U	9.2	ppm	
118	9750	12450	KMTC	1-09	U	2.7	ppm	
120	9700	8850	KMTC	1-09	U	7.7	ppm	
122	9600	9900	KMTC	1-09	U	480.0	ppm	
124	9700	10700	KMTC	1-09	U	110.0	ppm	
126	9750	11850	KMTC	1-09	U	4.6	ppm	
128	10650	11300	KMTC	1-09	U	22.0	ppm	
130	10650	10350	KMTC	1-09	U	71.0	ppm	
132	11600	10650	KMTC	1-09	U	25.0	ppm	
134	9250	13150	KMTC	1-09	U	5.4	ppm	
136	9150	12050	KMTC	1-09	U	7.2	ppm	
138	9200	11000	KMTC	1-09	U	69.0	ppm	
142	9150	9000	KMTC	1-09	U	3.2	ppm	
144	10500	9700	KMTC	1-09	U	92.0	ppm	
146	11600	9550	KMTC	1-09	U	130.0	ppm	
150	11450	9700	KMTC	1-09	U	1400.0	ppm	
198	12550	11850	KMTC	1-14	U	2.6	ppm	
201	13150	10200	KMTC	1-14	U	9.1	ppm	
204	13150	11250	KMTC	1-14	U	1.6	ppm	
208	12500	9900	KMTC	1-14	U	540.0	ppm	
211	12500	9700	KMTC	1-14	U	360.0	ppm	
214	12500	9500	KMTC	1-14	U	1530.0	ppm	
50	10750	10100	KMTC	1-06	U	17000.0	ppm	
A-01	13130	9220	KMTC	1-06	U	4200.0	ppm	
A-07	13130	9400	KMTC	1-06	U	8000.0	ppm	
A-13	13130	9580	KMTC	1-06	U	6200.0	ppm	
A-19	13130	9760	KMTC	1-06	U	7150.0	ppm	
A-25	13130	9950	KMTC	1-06	U	49.0	ppm	
BG 1/4	14750	9500	KMTC	1-06	U	64.0	ppm	
CRES08	6150	10750	KMTC	1-04	U	12.0	ppm	
DRES12	6100	11100	KMTC	1-04	U	220.0	ppm	
E-01	13000	9230	KMTC	1-06	U	1340.0	ppm	
E-07	13000	9410	KMTC	1-06	U	14200.0	ppm	
E-13	13000	9600	KMTC	1-06	U	7420.0	ppm	
E-19	13000	9770	KMTC	1-06	U	21600.0	ppm	
E-25	13000	9950	KMTC	1-06	U	40.0	ppm	
HRES02	6950	10650	KMTC	1-04	U	32.0	ppm	
HRES03	6950	10650	KMTC	1-04	U	0.95	ppm	
J-07	12840	9410	KMTC	1-06	U	1520.0	ppm	
J-13	12840	9600	KMTC	1-06	U	6640.0	ppm	
J-19	12840	9780	KMTC	1-06	U	3220.0	ppm	
J-25	12840	9950	KMTC	1-06	U	210.0	ppm	
LRES04	6950	9900	KMTC	1-04	U	<0.4	ppm	
P-01	12670	9230	KMTC	1-06	U	5300.0	ppm	
P-07	12670	9410	KMTC	1-06	U	4480.0	ppm	
P-12	12670	0	KMTC	1-06	U	5940.0	ppm	
P-13	12670	9600	KMTC	1-06	U	3800.0	ppm	

Table 5.2.7.3A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
URANIUM ON VEGETATION SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
P-25	12670	9950	KMTC	1-06	U	360.0	ppm	
R-15	6050	13750	KMTC	1-04	U	0.6	ppm	
SM-21	7450	17250	KMTC	1-04	U	0.6	ppm	
A-25	13130	9950	ORNL	1-06	U	11.8	ppm	
RG 1/4	14750	9500	ORNL	1-06	U	3.91	ppm	
CARLILE	14250	15100	ORNL	1-05	U	0.188	ppm	
CRES	6150	10800	ORNL	1-05	U	13.8	ppm	
E-25	13000	9950	ORNL	1-06	U	24.2	ppm	
J-25	12840	9950	ORNL	1-06	U	148.0	ppm	
P-19	12670	9780	ORNL	1-06	U	3600.0	ppm	
P-25	12670	9950	ORNL	1-06	U	186.0	ppm	
T2-05	10800	9300	ORNL	1-05	U	393.0	ppm	
T2-06	11450	9950	ORNL	1-05	U	285.0	ppm	
T2-08	11500	11650	ORNL	1-06	U	0.633	ppm	
T2-09	11350	12700	ORNL	1-06	U	1.53	ppm	
T2-10	11400	13700	ORNL	1-06	U	0.596	ppm	
T3-01	8300	6250	ORNL	1-06	U	5.03	ppm	
T3-02	8600	6950	ORNL	1-06	U	3.21	ppm	
T3-03	8650	9000	ORNL	1-06	U	3.39	ppm	
T3-04	8350	10300	ORNL	1-06	U	624.0	ppm	
T3-05	8350	11200	ORNL	1-06	U	177.0	ppm	
T3-06	8400	12050	ORNL	1-06	U	6.0	ppm	
T3-07	8550	13050	ORNL	1-06	U	35.6	ppm	

Table 5.2.7.4A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
URANIUM IN SOIL SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
103	13800	10200	KMTC	1-09	U	20.0	ppm	
106	11700	8450	KMTC	1-09	U	<10	ppm	
109	10600	8750	KMTC	1-09	U	<10	ppm	
112	14250	8450	KMTC	1-09	U	290.0	ppm	
115	11500	11600	KMTC	1-09	U	<10	ppm	
117	10650	12300	KMTC	1-09	U	20.0	ppm	
119	9750	12450	KMTC	1-09	U	20.0	ppm	
121	9700	8850	KMTC	1-09	U	20.0	ppm	
123	9600	9900	KMTC	1-09	U	25.0	ppm	
125	9700	10700	KMTC	1-09	U	20.0	ppm	
127	9750	11850	KMTC	1-09	U	<10	ppm	
129	10650	11300	KMTC	1-09	U	<10	ppm	
131	10650	10350	KMTC	1-09	U	30.0	ppm	
133	11600	10650	KMTC	1-09	U	15.0	ppm	
135	9250	13150	KMTC	1-09	U	<10	ppm	
137	9150	12050	KMTC	1-09	U	<10	ppm	
139	9200	11000	KMTC	1-09	U	<10	ppm	
141	9300	10100	KMTC	1-09	U	15.0	ppm	
143	9150	9000	KMTC	1-09	U	<10	ppm	
145	10500	9700	KMTC	1-09	U	30.0	ppm	
147	11600	9550	KMTC	1-09	U	35.0	ppm	
149	11650	9900	KMTC	1-09	U	95.0	ppm	
187	12600	7200	KMTC	1-14	U	20.0	ppm	
190	14750	9500	KMTC	1-14	U	50.0	ppm	
193	12550	10200	KMTC	1-14	U	30.0	ppm	
196	12600	10750	KMTC	1-14	U	20.0	ppm	
199	12550	11850	KMTC	1-14	U	10.0	ppm	
202	13150	10200	KMTC	1-14	U	30.0	ppm	
205	13150	11250	KMTC	1-14	U	<10	ppm	
209	12500	9900	KMTC	1-14	U	140.0	ppm	
218	12500	9350	KMTC	1-14	U	220.0	ppm	
221	12500	9100	KMTC	1-14	U	40.0	ppm	
A-01	13130	9220	KMTC	1-06	U	2180.0	ppm	
A-07	13130	9400	KMTC	1-09	U	590.0	ppm	
A-07	13130	9400	KMTC	1-06	U	730.0	ppm	
A-13	13130	9580	KMTC	1-06	U	655.0	ppm	
A-13	13130	9580	KMTC	1-09	U	200.0	ppm	
A-25	13130	9950	KMTC	1-06	U	25.0	ppm	
BG 1/4	14750	9500	KMTC	1-06	U	<10	ppm	
CRES10	6150	10750	KMTC	1-04	U	<10	ppm	
DRES11	6100	11100	KMTC	1-04	U	15.0	ppm	
DRES13	6100	11100	KMTC	1-04	U	13.0	ppm	
E-01	13000	9230	KMTC	1-06	U	210.0	ppm	
E-01	13000	9230	KMTC	1-09	U	300.0	ppm	
E-07	13000	9410	KMTC	1-06	U	465.0	ppm	
E-07	13000	9410	KMTC	1-09	U	380.0	ppm	
E-13	13000	9600	KMTC	1-06	U	130.0	ppm	
E-13	13000	9600	KMTC	1-09	U	130.0	ppm	
E-19	13000	9770	KMTC	1-06	U	15.0	ppm	
E-25	13000	9950	KMTC	1-06	U	20.0	ppm	
HRES01	6950	10650	KMTC	1-04	U	<10	ppm	

Table 5.2.7.4A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
URANIUM IN SOIL SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
J-07	12840	9410	KMTC	1-06	U	125.0	ppm	
J-07	12840	9410	KMTC	1-09	U	250.0	ppm	
J-13	12840	9600	KMTC	1-06	U	200.0	ppm	
J-13	12840	9600	KMTC	1-09	U	125.0	ppm	
J-19	12840	9780	KMTC	1-06	U	165.0	ppm	
J-25	12840	9950	KMTC	1-06	U	20.0	ppm	
LRES05	6950	9900	KMTC	1-04	U	<10	ppm	
LRES06	6950	9900	KMTC	1-04	U	<10	ppm	
P-07	12670	9410	KMTC	1-06	U	235.0	ppm	
P-07	12670	9410	KMTC	1-09	U	90.0	ppm	
P-13	12670	9600	KMTC	1-05	U	55.0	ppm	
P-13	12670	9600	KMTC	1-09	U	175.0	ppm	
P-19	12670	9780	KMTC	1-06	U	90.0	ppm	
P-25	12670	9950	KMTC	1-06	U	40.0	ppm	
R-16	6050	13750	KMTC	1-04	U	<10	ppm	
SM-20	7450	17250	KMTC	1-04	U	11.0	ppm	
A-25	13130	9760	ORNL	1-06	U	10.5	ppm	WET
A-25	13130	9760	ORNL	1-06	U	13.2	ppm	DRY
BG 1/4	14750	9500	ORNL	1-06	U	6.1	ppm	WET
BG 1/4	14750	9500	ORNL	1-06	U	7.88	ppm	DRY
CARLILE	14250	15100	ORNL	1-05	U	2.7	ppm	WET
CARLILE	14250	15100	ORNL	1-05	U	3.7	ppm	DRY
CRES	6150	10750	ORNL	1-05	U	2.9	ppm	DRY
CRES	6150	10750	ORNL	1-05	U	2.0	ppm	WET
E-25	13000	9950	ORNL	1-06	U	8.9	ppm	WET
E-25	13000	9950	ORNL	1-06	U	10.3	ppm	DRY
J-25	12840	9950	ORNL	1-06	U	9.8	ppm	WET
J-25	12840	9950	ORNL	1-06	U	13.1	ppm	DRY
P-19	12670	9600	ORNL	1-06	U	135.0	ppm	WET
P-19	12670	9600	ORNL	1-06	U	154.0	ppm	DRY
P-25	12670	9780	ORNL	1-06	U	19.2	ppm	WET
P-25	12670	9780	ORNL	1-06	U	28.4	ppm	DRY
T1-01	12500	7200	ORNL	1-05	U	4.6	ppm	WET
T1-01	12500	7200	ORNL	1-05	U	6.2	ppm	DRY
T1-02	12500	8000	ORNL	1-05	U	5.7	ppm	DRY
T1-02	12500	8000	ORNL	1-05	U	4.5	ppm	WET
T1-03	12500	8550	ORNL	1-05	U	5.7	ppm	WET
T1-03	12500	8550	ORNL	1-05	U	7.0	ppm	DRY
T1-04	12500	8900	ORNL	1-05	U	13.0	ppm	WET
T1-04	12500	8900	ORNL	1-05	U	17.3	ppm	DRY
T1-05	12500	9200	ORNL	1-05	U	34.0	ppm	WET
T1-05	12500	9200	ORNL	1-05	U	45.1	ppm	DRY
T1-06	12500	9500	ORNL	1-05	U	90.7	ppm	DRY
T1-06	12500	9500	ORNL	1-05	U	77.6	ppm	WET
T1-07	12500	9850	ORNL	1-05	U	33.7	ppm	WET
T1-07	12500	9850	ORNL	1-05	U	62.7	ppm	DRY
T1-08	12600	10200	ORNL	1-05	U	7.3	ppm	DRY
T1-08	12600	10200	ORNL	1-05	U	5.7	ppm	WET
T1-09	12600	10600	ORNL	1-05	U	4.5	ppm	DRY
T1-09	12600	10600	ORNL	1-05	U	3.6	ppm	WET
T1-11	12600	11300	ORNL	1-05	U	6.0	ppm	DRY

Table 5.2.7.4A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
URANIUM IN SOIL SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
T1-11	12600	11300	ORNL	1-05	U	3.7	ppm	WET
T1-12	12550	11900	ORNL	1-05	U	6.0	ppm	DRY
T1-12	12550	11900	ORNL	1-05	U	3.5	ppm	WET
T2-01	10750	6200	ORNL	1-05	U	2.9	ppm	WET
T2-01	10750	6200	ORNL	1-05	U	3.5	ppm	DRY
T2-02	10550	6800	ORNL	1-05	U	2.6	ppm	DRY
T2-02	10550	6800	ORNL	1-05	U	2.2	ppm	WET
T2-03	10650	7550	ORNL	1-05	U	3.2	ppm	WET
T2-03	10650	7550	ORNL	1-05	U	3.9	ppm	DRY
T2-04	10700	8400	ORNL	1-05	U	4.1	ppm	DRY
T2-04	10700	8400	ORNL	1-05	U	3.2	ppm	WET
T2-05	10800	9300	ORNL	1-05	U	4.5	ppm	DRY
T2-05	10800	9300	ORNL	1-05	U	3.9	ppm	WET
T2-06	11450	9950	ORNL	1-05	U	25.9	ppm	DRY
T2-06	11450	9950	ORNL	1-05	U	24.4	ppm	WET
T2-07	11500	10650	ORNL	1-06	U	5.23	ppm	DRY
T2-07	11500	10650	ORNL	1-06	U	5.0	ppm	WET
T2-08	11500	11650	ORNL	1-06	U	5.21	ppm	DRY
T2-08	11500	11650	ORNL	1-06	U	3.8	ppm	WET
T2-09	11350	12700	ORNL	1-06	U	3.95	ppm	DRY
T2-09	11350	12700	ORNL	1-06	U	3.0	ppm	WET
T2-10	11400	13700	ORNL	1-06	U	2.4	ppm	WET
T2-10	11400	13700	ORNL	1-06	U	3.86	ppm	DRY
T3-01	8300	6250	ORNL	1-06	U	4.34	ppm	DRY
T3-01	8300	6250	ORNL	1-06	U	3.3	ppm	WET
T3-02	8600	6950	ORNL	1-06	U	3.86	ppm	DRY
T3-02	8600	6950	ORNL	1-06	U	3.3	ppm	WET
T3-03	8650	9000	ORNL	1-06	U	5.34	ppm	DRY
T3-03	8650	9000	ORNL	1-06	U	4.7	ppm	WET
T3-04	8350	10300	ORNL	1-06	U	4.28	ppm	DRY
T3-04	8350	10300	ORNL	1-06	U	3.9	ppm	WET
T3-05	8350	11200	ORNL	1-06	U	4.0	ppm	DRY
T3-05	8350	11200	ORNL	1-06	U	3.0	ppm	WET
T3-06	8400	12050	ORNL	1-06	U	4.88	ppm	DRY
T3-06	8400	12050	ORNL	1-06	U	3.9	ppm	WET
T3-07	8550	13050	ORNL	1-06	U	3.9	ppm	DRY
T3-07	8550	13050	ORNL	1-06	U	2.8	ppm	WET

Table 5.2.7.5A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
SOIL AND VEGETATION SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
CRES09	6150	10750	KMTC	1-04	F	90.0	ppm	MIX SOIL/VEG
CRES09	6150	10750	KMTC	1-04	U	<10	ppm	

Table 5.2.7.6A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
ALPHA ON VEGETATION SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
CARLILE	14250	15100	OSDH	1-05	ALPHA	0.8	pCi/g	GRASS
CRES	6150	10750	OSDH	1-05	ALPHA	1.1	pCi/g	GRASS
HRES	6950	10650	OSDH	1-08	ALPHA	5.0	pCi/g	
T1-01	12500	7200	OSDH	1-05	ALPHA	1.4	pCi/g	EVERGREEN
T1-02	12500	8000	OSDH	1-05	ALPHA	0.1	pCi/g	GRASS
T1-03	12500	8550	OSDH	1-05	ALPHA	0.5	pCi/g	GRASS
T1-04	12500	8900	OSDH	1-05	ALPHA	1.3	pCi/g	EVERGREEN
T1-05	12500	9200	OSDH	1-05	ALPHA	4020.0	pCi/g	EVERGREEN
T1-06	12500	9500	OSDH	1-05	ALPHA	1220.0	pCi/g	GRASS
T1-07	12500	9850	OSDH	1-05	ALPHA	124.0	pCi/g	GRASS
T1-08	12600	10200	OSDH	1-05	ALPHA	1.0	pCi/g	GRASS
T1-09	12600	10600	OSDH	1-05	ALPHA	0.0	pCi/g	GRASS
T1-11	12600	11300	OSDH	1-05	ALPHA	1.3	pCi/g	GRASS
T1-12	12550	11900	OSDH	1-05	ALPHA	0.0	pCi/g	EVERGREEN
T2-01	10750	6200	OSDH	1-05	ALPHA	-0.2	pCi/g	
T2-03	10650	7550	OSDH	1-05	ALPHA	-0.4	pCi/g	
T2-05	10800	9300	OSDH	1-05	ALPHA	78.0	pCi/g	
T2-06	11500	9850	OSDH	1-06	ALPHA	41.0	pCi/g	
T2-08	11500	11650	OSDH	1-06	ALPHA	-0.5	pCi/g	
T2-09	11350	12700	OSDH	1-06	ALPHA	0.1	pCi/g	
T2-10	11400	13700	OSDH	1-06	ALPHA	0.3	pCi/g	
T3-01	8300	6250	OSDH	1-06	ALPHA	1.6	pCi/g	EVERGREEN
T3-02	8600	6950	OSDH	1-06	ALPHA	1.0	pCi/g	EVERGREEN
T3-03	8650	9000	OSDH	1-06	ALPHA	0.6	pCi/g	EVERGREEN
T3-04	8350	10300	OSDH	1-06	ALPHA	1070.0	pCi/g	EVRGRN/LEAVES
T3-05	8350	11200	OSDH	1-06	ALPHA	27.0	pCi/g	EVERGREEN
T3-06	8400	12050	OSDH	1-06	ALPHA	0.7	pCi/g	EVERGREEN
T3-07	8550	13050	OSDH	1-06	ALPHA	0.6	pCi/g	GRASS
T5-01	17700	8700	OSDH	1-08	ALPHA	0.2	pCi/g	
T5-02	16500	10000	OSDH	1-08	ALPHA	-0.2	pCi/g	
T5-02	16500	10000	OSDH	1-08	ALPHA	0.0	pCi/g	
T5-03	16300	10350	OSDH	1-08	ALPHA	0.0	pCi/g	
T5-04	15500	8500	OSDH	1-08	ALPHA	0.2	pCi/g	
T6-01	13950	7700	OSDH	1-08	ALPHA	1.2	pCi/g	
T6-02	13900	8400	OSDH	1-08	ALPHA	2.5	pCi/g	
T6-03	14650	8300	OSDH	1-08	ALPHA	1.0	pCi/g	
T6-05	14450	9550	OSDH	1-08	ALPHA	0.9	pCi/g	

Table 5.2.7.7A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
BETA ON VEGETATION SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
CARLILE	14250	15100	OSDH	1-05	BETA	0.7	pCi/g	GRASS
CRES	6150	10750	OSDH	1-05	BETA	0.2	pCi/g	GRASS
HRES	6950	10650	OSDH	1-08	BETA	1.9	pCi/g	
T1-01	12500	7200	OSDH	1-05	BETA	1.0	pCi/g	EVERGREEN
T1-02	12500	8000	OSDH	1-05	BETA	1.2	pCi/g	GRASS
T1-03	12500	8550	OSDH	1-05	BETA	1.1	pCi/g	GRASS
T1-04	12500	8900	OSDH	1-05	BETA	0.1	pCi/g	EVERGREEN
T1-05	12500	9200	OSDH	1-05	BETA	110.0	pCi/g	EVERGREEN
T1-06	12500	9500	OSDH	1-05	BETA	95.0	pCi/g	GRASS
T1-07	12500	9850	OSDH	1-05	BETA	23.0	pCi/g	GRASS
T1-08	12600	10200	OSDH	1-05	BETA	5.0	pCi/g	GRASS
T1-09	12600	10600	OSDH	1-05	BETA	0.5	pCi/g	GRASS
T1-11	12600	11300	OSDH	1-05	BETA	1.7	pCi/g	GRASS
T1-12	12550	11900	OSDH	1-05	BETA	0.3	pCi/g	EVERGREEN
T2-01	10750	6200	OSDH	1-05	BETA	0.7	pCi/g	
T2-03	10650	7550	OSDH	1-05	BETA	3.1	pCi/g	
T2-05	10800	9300	OSDH	1-05	BETA	7.0	pCi/g	
T2-06	11500	9850	OSDH	1-06	BETA	6.0	pCi/g	
T2-08	11500	11650	OSDH	1-06	BETA	6.0	pCi/g	
T2-09	11350	12700	OSDH	1-06	BETA	2.3	pCi/g	
T2-10	11400	13700	OSDH	1-06	BETA	0.3	pCi/g	
T3-01	8300	6250	OSDH	1-06	BETA	0.6	pCi/g	EVERGREEN
T3-02	8600	6950	OSDH	1-06	BETA	0.4	pCi/g	EVERGREEN
T3-03	8650	9000	OSDH	1-06	BETA	0.0	pCi/g	EVERGREEN
T3-04	8350	10300	OSDH	1-06	BETA	77.0	pCi/g	EVRGRN/LEAVES
T3-05	8350	11200	OSDH	1-06	BETA	8.0	pCi/g	EVERGREEN
T3-06	8400	12050	OSDH	1-06	BETA	-0.1	pCi/g	EVERGREEN
T3-07	8550	13050	OSDH	1-06	BETA	-0.1	pCi/g	GRASS
T5-01	17700	8700	OSDH	1-08	BETA	-0.0	pCi/g	
T5-02	16500	10000	OSDH	1-08	BETA	-0.2	pCi/g	
T5-02	16500	10000	OSDH	1-08	BETA	-0.1	pCi/g	
T5-03	16300	10350	OSDH	1-08	BETA	-0.3	pCi/g	
T5-04	15500	8500	OSDH	1-08	BETA	-0.1	pCi/g	
T6-01	13950	7700	OSDH	1-08	BETA	0.7	pCi/g	
T6-02	13900	8400	OSDH	1-08	BETA	1.1	pCi/g	
T6-03	14650	8300	OSDH	1-08	BETA	0.3	pCi/g	
T6-05	14450	9550	OSDH	1-08	BETA	-0.5	pCi/g	

Table 5.2.7.8A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
ALPHA IN SOIL SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
CARLILE	14250	15100	OSDH	1-05	ALPHA	0.1	pCi/g	
CRES	6150	10750	OSDH	1-05	ALPHA	-0.1	pCi/g	
T1-01	12500	7200	OSDH	1-05	ALPHA	0.1	pCi/g	
T1-02	12500	8000	OSDH	1-05	ALPHA	0.1	pCi/g	
T1-03	12500	8550	OSDH	1-05	ALPHA	0.4	pCi/g	
T1-04	12500	8900	OSDH	1-05	ALPHA	0.9	pCi/g	
T1-05	12500	9200	OSDH	1-05	ALPHA	0.4	pCi/g	
T1-06	12500	9500	OSDH	1-05	ALPHA	1.8	pCi/g	
T1-07	12500	9850	OSDH	1-05	ALPHA	-0.3	pCi/g	
T1-08	12600	10200	OSDH	1-05	ALPHA	-0.3	pCi/g	
T1-09	12600	10600	OSDH	1-05	ALPHA	1.6	pCi/g	
T1-11	12600	11300	OSDH	1-05	ALPHA	-0.3	pCi/g	
T1-12	12550	11900	OSDH	1-05	ALPHA	0.4	pCi/g	
T2-01	10750	6200	OSDH	1-05	ALPHA	0.1	pCi/g	
T2-02	10550	6800	OSDH	1-05	ALPHA	0.1	pCi/g	
T2-03	10650	7550	OSDH	1-05	ALPHA	132.0	pCi/g	
T2-04	10700	8400	OSDH	1-05	ALPHA	0.1	pCi/g	
T2-05	10800	9300	OSDH	1-05	ALPHA	0.1	pCi/g	
T2-06	11500	9850	OSDH	1-06	ALPHA	1.9	pCi/g	
T2-07	11500	10650	OSDH	1-06	ALPHA	3.0	pCi/g	
T2-08	11500	11650	OSDH	1-06	ALPHA	0.1	pCi/g	
T2-09	11350	12700	OSDH	1-06	ALPHA	1.2	pCi/g	
T2-10	11400	13700	OSDH	1-06	ALPHA	-0.3	pCi/g	
T3-01	8300	6250	OSDH	1-06	ALPHA	-0.3	pCi/g	
T3-02	8600	6950	OSDH	1-06	ALPHA	3.0	pCi/g	
T3-03	8650	9000	OSDH	1-06	ALPHA	-0.3	pCi/g	
T3-04	8350	10300	OSDH	1-06	ALPHA	-0.3	pCi/g	
T3-05	8350	11200	OSDH	1-06	ALPHA	0.9	pCi/g	
T3-06	8400	12050	OSDH	1-06	ALPHA	0.4	pCi/g	
T3-07	8550	13050	OSDH	1-06	ALPHA	0.1	pCi/g	
T5-01	17700	8700	OSDH	1-08	ALPHA	-0.3	pCi/g	
T5-03	16300	10350	OSDH	1-08	ALPHA	-0.3	pCi/g	
T6-01	13950	7700	OSDH	1-08	ALPHA	0.1	pCi/g	
T6-02	13900	8400	OSDH	1-08	ALPHA	-0.3	pCi/g	
T6-03	14650	8300	OSDH	1-08	ALPHA	0.4	pCi/g	
T6-04	14650	8700	OSDH	1-08	ALPHA	0.4	pCi/g	

Table 5.2.7.9A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
BETA IN SOIL SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
CARLILE	14250	15100	OSDH	1-05	BETA	-0.3	pCi/g	
CRES	6150	10750	OSDH	1-05	BETA	-0.0	pCi/g	
T1-01	12500	7200	OSDH	1-05	BETA	0.6	pCi/g	
T1-02	12500	8000	OSDH	1-05	BETA	0.4	pCi/g	
T1-03	12500	8550	OSDH	1-05	BETA	-0.0	pCi/g	
T1-04	12500	8900	OSDH	1-05	BETA	-0.1	pCi/g	
T1-05	12500	9200	OSDH	1-05	BETA	0.2	pCi/g	
T1-06	12500	9500	OSDH	1-05	BETA	-0.2	pCi/g	
T1-07	12500	9850	OSDH	1-05	BETA	-0.0	pCi/g	
T1-08	12600	10200	OSDH	1-05	BETA	-0.2	pCi/g	
T1-09	12600	10600	OSDH	1-05	BETA	-0.5	pCi/g	
T1-11	12600	11300	OSDH	1-05	BETA	-0.4	pCi/g	
T1-12	12550	11900	OSDH	1-05	BETA	0.2	pCi/g	
T2-01	10750	6200	OSDH	1-05	BETA	-0.5	pCi/g	
T2-02	10550	6800	OSDH	1-05	BETA	0.1	pCi/g	
T2-03	10650	7550	OSDH	1-05	BETA	23.0	pCi/g	
T2-04	10700	8400	OSDH	1-05	BETA	0.6	pCi/g	
T2-05	10800	9300	OSDH	1-05	BETA	0.7	pCi/g	
T2-06	11500	9850	OSDH	1-06	BETA	-0.7	pCi/g	
T2-07	11500	10650	OSDH	1-06	BETA	0.7	pCi/g	
T2-08	11500	11650	OSDH	1-06	BETA	0.4	pCi/g	
T2-09	11350	12700	OSDH	1-06	BETA	0.3	pCi/g	
T2-10	11400	13700	OSDH	1-06	BETA	0.6	pCi/g	
T3-01	8300	6250	OSDH	1-06	BETA	-0.2	pCi/g	
T3-02	8600	6950	OSDH	1-06	BETA	1.0	pCi/g	
T3-03	8650	9000	OSDH	1-06	BETA	1.0	pCi/g	
T3-04	8350	10300	OSDH	1-06	BETA	0.1	pCi/g	
T3-05	8350	11200	OSDH	1-06	BETA	0.4	pCi/g	
T3-06	8400	12050	OSDH	1-06	BETA	0.2	pCi/g	
T3-07	8550	13050	OSDH	1-06	BETA	-0.1	pCi/g	
T5-01	17700	8700	OSDH	1-08	BETA	0.6	pCi/g	
T5-03	16300	10350	OSDH	1-08	BETA	-0.2	pCi/g	
T6-01	13950	7700	OSDH	1-08	BETA	0.7	pCi/g	
T6-02	13900	8400	OSDH	1-08	BETA	-0.2	pCi/g	
T6-03	14650	8300	OSDH	1-08	BETA	-0.2	pCi/g	
T6-04	14650	8700	OSDH	1-08	BETA	-0.6	pCi/g	

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS BY MEDIA AND TYPE ANALYSIS

Table 5.2.7.10A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE ON VEGETATION SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
7C 6	T11N	7	C6	1-08	KMTC	10.0	PPM	J.GRASS
7F 7	T11N	7	F7	1-08	KMTC	20.0	PPM	WHEAT
7F 7	T11N	7	F7	1-08	KMTC	30.0	PPM	
11F 7	T11N	11	F7	1-08	KMTC	10.0	PPM	CAT LEAVES
11F 7	T11N	11	F7	1-08	KMTC	43.0	PPM	BEANS
11F 7	T11N	11	F7	1-08	KMTC	12.0	PPM	WILLOW
12N 8	T11N	12	N8	1-08	KMTC	5.0	PPM	
12N 8	T11N	12	N8	1-08	KMTC	7.0	PPM	CAT TIPS
12N 8	T11N	12	N8	1-08	KMTC	2.0	PPM	CEDAR
13B 1	T11N	13	B1	1-08	KMTC	4.0	PPM	
13G11	T11N	13	G11	1-09	KMTC	10.0	PPM	
14B 4	T11N	14	B4	1-08	KMTC	12.0	PPM	
14B 8	T11N	14	B8	1-08	KMTC	6.0	PPM	
14B12	T11N	14	B12	1-08	KMTC	5.0	PPM	FESCUE TIP
14B12	T11N	14	B12	1-08	KMTC	4.0	PPM	FESCUE
16B10	T11N	16	B10	1-09	KMTC	9.0	PPM	
16L12	T11N	16	L12	1-10	KMTC	50.0	PPM	
18B 4	T11N	18	B4	1-09	KMTC	30.0	PPM	
18H10	T11N	18	H10	1-09	KMTC	9.0	PPM	
1A11	T11N	1	A11	1-09	KMTC	40.0	PPM	
1H14	T11N	1	H14	1-08	KMTC	20.0	PPM	
22G14	T11N	22	G14	1-10	KMTC	1.0	PPM	
23A10	T11N	23	A10	1-08	KMTC	8.0	PPM	T11N
25E 8	T12N	25	E8	1-10	KMTC	10.0	PPM	
25H 3	T12N	25	H3	1-10	KMTC	9.0	PPM	
25H 3	T12N	25	H3	1-10	KMTC	10.0	PPM	
26G 1	T12N	26	G1	1-10	KMTC	10.0	PPM	
26G 8	T12N	26	G8	1-10	KMTC	20.0	PPM	
27A13	T12N	27	A13	1-08	KMTC	6.0	PPM	CEDAR
27A13	T12N	27	A13	1-08	KMTC	4.0	PPM	SMILAX
27D 1	T12N	27	D1	1-10	KMTC	80.0	PPM	
27H 9	T12N	27	H9	1-10	KMTC	10.0	PPM	
27H 9	T12N	27	H9	1-10	KMTC	20.0	PPM	
27K 4	T12N	27	K4	1-10	KMTC	20.0	PPM	
28G 4	T12N	28	G4	1-10	KMTC	1.0	PPM	
28G 4	T12N	28	G4	1-10	KMTC	20.0	PPM	
28J11	T12N	28	J11	1-10	KMTC	20.0	PPM	
28N 2	T12N	28	N2	1-10	KMTC	2.0	PPM	
28N 2	T12N	28	N2	1-10	KMTC	10.0	PPM	
29D 3	T12N	29	D3	1-10	KMTC	2.0	PPM	
2E14	T11N	2	E14	1-09	KMTC	20.0	PPM	
2L13	T11N	2	L13	1-09	KMTC	60.0	PPM	
2M 8	T11N	2	M8	1-09	KMTC	40.0	PPM	
30F 7	T12N	30	F7	1-10	KMTC	6.0	PPM	
30F 7	T12N	30	F7	1-10	KMTC	6.0	PPM	
31B10	T12N	31	B10	1-10	KMTC	10.0	PPM	
33B14	T12N	33	B14	1-10	KMTC	8.0	PPM	
33I 3	T12N	33	I3	1-10	KMTC	20.0	PPM	
33M14	T12N	33	M14	1-10	KMTC	6.0	PPM	

Table 5.2.7.10A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR FLUORIDE ON VEGETATION SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
33M14	T12N	33	M14	1-10	KMTC	5.0	PPM	
34D 7	T12N	34	D7	1-10	KMTC	30.0	PPM	
35A 9	T12N	35	A9	1-10	KMTC	6.0	PPM	
35A 9	T12N	35	A9	1-10	KMTC	11.0	PPM	
35B 1	T12N	35	B1	1-10	KMTC	9.0	PPM	
35B14	T12N	35	B14	1-10	KMTC	3.0	PPM	
35F10	T12N	35	F10	1-10	KMTC	20.0	PPM	
35L 5	T12N	35	L5	1-09	KMTC	5.0	PPM	
35L 5	T12N	35	L5	1-09	KMTC	8.0	PPM	
35L11	T12N	35	L11	1-10	KMTC	30.0	PPM	
35L11	T12N	35	L11	1-10	KMTC	<1	PPM	
36A13	T12N	36	A13	1-10	KMTC	20.0	PPM	
36G 5	T12N	36	G5	1-09	KMTC	20.0	PPM	
36H14	T12N	36	H14	1-10	KMTC	<1	PPM	
3F 7	T11N	3	F7	1-09	KMTC	8.0	PPM	
4A 1	T11N	4	A1	1-10	KMTC	6.0	PPM	
4A 3	T11N	4	A3	1-10	KMTC	20.0	PPM	
4A 6	T11N	4	A6	1-10	KMTC	60.0	PPM	
4J14	T11N	4	J14	1-09	KMTC	15.0	PPM	
4J14	T11N	4	J14	1-09	KMTC	6.0	PPM	
4N 7	T11N	4	N7	1-09	KMTC	30.0	PPM	
4N 8	T11N	4	N8	1-09	KMTC	6.0	PPM	
50/HWY	T12N	22	G1	1-06	KMTC	1500.0	PPM	CEDAR
5N 6	T11N	5	N6	1-09	KMTC	30.0	PPM	
6A 7	T11N	6	A7	1-09	KMTC	30.0	PPM	
6C14	T11N	6	C14	1-09	KMTC	10.0	PPM	
8A 1	T11N	8	A1	1-09	KMTC	8.0	PPM	
8J 7	T11N	8	J7	1-09	KMTC	10.0	PPM	
8M14	T11N	8	M14	1-09	KMTC	9.0	PPM	
9B 2	T11N	9	B2	1-09	KMTC	5.5	PPM	
BG 1/4	T12N	21	B13	1-06	KMTC	40.0	PPM	1/4 N.GATE
CRES08	T12N	27	K3	1-04	KMTC	42.0	PPM	CRES
DRES12	T12N	27	K4	1-04	KMTC	160.0	PPM	DRES/LEAVES
H-02	T12N	27	I2	1-04	KMTC	24.0	PPM	CEDAR
H-03	T12N	27	I2	1-04	KMTC	80.0	PPM	HRES
LRES04	T12N	28	I14	1-04	KMTC	3.0	PPM	TREE
RKRES15	T12N	34	A13	1-04	KMTC	32.0	PPM	RKRES/CEDAR
RRES18	T11N	34	B6	1-04	KMTC	7.0	PPM	RRES/CEDAR
SMRES21	T12N	26	K6	1-04	KMTC	5.0	PPM	SMRES/LEAVES
TRES53	T11N	23	M10	1-06	KMTC	23.0	PPM	TRES
YRES51	T11N	26	N3	1-05	KMTC	2600.0	PPM	YRES
BG 1/4	T12N	21	B13	1-06	ORNL	7.3	UG/G	
CARLILE	T12N	22	D14	1-05	ORNL	8.3	UG/G	
T4-01E	T11N	2	C11	1-06	ORNL	3.1	UG/G	
T4-02E	T11N	2	B8	1-06	ORNL	2.1	UG/G	
T4-03E	T12N	35	N5	1-06	ORNL	2.9	UG/G	
T4-04E	T12N	35	L3	1-06	ORNL	2.2	UG/G	
T4-04W	T12N	34	L13	1-06	ORNL	6.1	UG/G	
T4-05E	T12N	35	K1	1-06	ORNL	9.3	UG/G	

Table 5.2.7.10A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE ON VEGETATION SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
AB-01	T11N	17	A14	1-15	OSDH	2.72	MG/KG	
AB-02	T11N	16	A11	1-15	OSDH	1.68	MG/KG	
AB-03	T12N	32	N14	1-15	OSDH	3.28	MG/KG	
AB-04	T11N	9	B1	1-15	OSDH	1.52	MG/KG	
AB-05	T11N	4	C8	1-15	OSDH	2.64	MG/KG	
AB-06	T12N	29	N14	1-15	OSDH	1.68	MG/KG	
AB-07	T12N	31	A8	1-15	OSDH	2.40	MG/KG	
AB-08	T12N	19	N8	1-15	OSDH	1.60	MG/KG	
AB-09	T12N	18	M6	1-15	OSDH	3.60	MG/KG	
AB-10	T12N	13	G14	1-15	OSDH	2.96	MG/KG	
CARLILE	T12N	22	D14	1-05	OSDH	4.3	MG/KG	GRASS
CARLILE	T12N	22	D14	1-14	OSDH	2.56	MG/KG	
CNTRL01	T09N	16	-	1-06	OSDH	0.9	MG/KG	
CNTRL02	T10N	35	C14	1-06	OSDH	1.9	MG/KG	
CNTRL03	T11N	28	E10	1-06	OSDH	2.4	MG/KG	
CNTRL04	T11N	20	N10	1-06	OSDH	2.5	MG/KG	
CNTRL05	T11N	19	F13	1-06	OSDH	2.2	MG/KG	
CNTRL06	T09N	4	I13	1-06	OSDH	1.4	MG/KG	
CNTRL07	T11N	13	B7	1-06	OSDH	0.9	MG/KG	
CNTRL08	T10N	8	K8	1-06	OSDH	2.7	MG/KG	
CNTRL09	T11N	21	C12	1-06	OSDH	2.2	MG/KG	
CNTRL09	T11N	21	C12	1-06	OSDH	1.9	MG/KG	
CNTRL10	T11N	21	I13	1-06	OSDH	3.0	MG/KG	
CNTRL11	T12N	26	E3	1-06	OSDH	1.2	MG/KG	
CNTRL13	T11N	3	C2	1-06	OSDH	1.4	MG/KG	
CNTRL15	T09N	16	G13	1-06	OSDH	1.6	MG/KG	
CRES	T12N	27	K3	1-05	OSDH	32.0	MG/KG	GRASS
G-01	T12N	8	L5	1-15	OSDH	4.00	MG/KG	
G-02	T12N	8	B3	1-15	OSDH	8.00	MG/KG	
G-03	T12N	7	B13	1-15	OSDH	2.08	MG/KG	
G-04	T12N	7	K9	1-15	OSDH	3.04	MG/KG	
GL-01	T12N	16	F1	1-15	OSDH	2.16	MG/KG	
HC-01	T11N	23	N1	1-11	OSDH	2.48	MG/KG	
HC-02	T11N	22	N1	1-11	OSDH	1.04	MG/KG	
HC-03	T11N	20	N14	1-11	OSDH	2.00	MG/KG	
HC-04	T11N	21	A1	1-11	OSDH	1.28	MG/KG	
HC-05	T11N	15	N5	1-11	OSDH	2.24	MG/KG	
HC-07	T11N	26	N1	1-11	OSDH	2.00	MG/KG	
HC-08	T11N	28	M11	1-11	OSDH	2.32	MG/KG	
HC-09	T11N	32	A12	1-11	OSDH	1.52	MG/KG	
HC-10	T10N	4	N1	1-11	OSDH	2.24	MG/KG	
HC-11	T10N	4	N14	1-11	OSDH	1.60	MG/KG	
HC-11	T10N	4	N14	1-11	OSDH	1.52	MG/KG	
HC-12	T11N	22	A13	1-11	OSDH	0.90	MG/KG	
HC-13	T11N	26	A14	1-11	OSDH	3.60	MG/KG	
HC-14	T12N	25	A14	1-11	OSDH	1.28	MG/KG	
HC-15	T10N	3	A1	1-11	OSDH	4.08	MG/KG	
HC-16	T11N	33	N2	1-11	OSDH	5.76	MG/KG	
HC-17	T10N	9	A14	1-11	OSDH	2.80	MG/KG	

Table 5.2.7.10A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE ON VEGETATION SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
HC-18	T10N	10	A13	1-11	OSDH	3.60	MG/KG	
HC-19	T11N	29	A14	1-11	OSDH	6.40	MG/KG	
HC-20	T11N	30	A14	1-11	OSDH	2.88	MG/KG	
P-01	T12N	26	A11	1-13	OSDH	2.24	MG/KG	
P-02	T12N	25	H4	1-13	OSDH	<0.1	MG/KG	
P-03	T12N	36	A13	1-13	OSDH	1.36	MG/KG	
P-04	T12N	36	D10	1-13	OSDH	<0.1	MG/KG	
P-05	T11N	1	A11	1-13	OSDH	1.76	MG/KG	
P-06	T11N	1	A7	1-13	OSDH	2.24	MG/KG	
P-07	T12N	35	M10	1-13	OSDH	9.68	MG/KG	
P-08	T12N	35	D10	1-13	OSDH	6.80	MG/KG	
P-09	T12N	26	H6	1-13	OSDH	4.64	MG/KG	
S-01	T11N	34	A1	1-11	OSDH	2.8	MG/KG	
S-02	T11N	28	N1	1-11	OSDH	6.64	MG/KG	
S-03	T11N	30	N14	1-11	OSDH	3.92	MG/KG	
S-04	T11N	25	N14	1-11	OSDH	2.56	MG/KG	
S-05	T11N	36	A1	1-11	OSDH	3.52	MG/KG	
S-06	T11N	34	N14	1-11	OSDH	3.12	MG/KG	
S-07	T10N	2	A1	1-11	OSDH	3.04	MG/KG	
S-08	T11N	31	N1	1-11	OSDH	5.44	MG/KG	
S-09	T10N	6	A14	1-11	OSDH	2.16	MG/KG	
S-10	T10N	5	N1	1-11	OSDH	5.68	MG/KG	
S-11	T10N	9	A1	1-11	OSDH	5.04	MG/KG	
S-12	T10N	4	A1	1-11	OSDH	2.16	MG/KG	
S-13	T11N	33	N14	1-11	OSDH	4.96	MG/KG	
S-14	T10N	6	N1	1-11	OSDH	3.08	MG/KG	
S-15	T10N	2	N14	1-11	OSDH	2.88	MG/KG	
S-16	T10N	2	N1	1-11	OSDH	3.12	MG/KG	
T3-08	T12N	26	C12	1-14	OSDH	2.40	MG/KG	
T4-01E	T11N	2	C11	1-06	OSDH	2.6	MG/KG	EVERGREEN
T4-02E	T11N	2	B8	1-06	OSDH	2.7	MG/KG	EVERGREEN
T4-03E	T12N	35	N5	1-06	OSDH	3.5	MG/KG	EVERGREEN
T4-04E	T12N	35	L3	1-06	OSDH	1.8	MG/KG	EVERGREEN
T4-04W	T12N	34	L13	1-06	OSDH	54.0	MG/KG	LEAVES
T4-05E	T12N	35	K1	1-06	OSDH	11.2	MG/KG	EVERGREEN
WR-01	T11N	15	A1	1-15	OSDH	3.36	MG/KG	
WR-02	T11N	17	A14	1-15	OSDH	5.36	MG/KG	
WR-03	T11N	17	I14	1-15	OSDH	3.60	MG/KG	
WR-05	T11N	9	A1	1-15	OSDH	3.28	MG/KG	
WR-07	T11N	6	N14	1-15	OSDH	1.68	MG/KG	
WR-08	T11N	6	N7	1-15	OSDH	2.08	MG/KG	
WR-09	T11N	6	G1	1-15	OSDH	1.84	MG/KG	
WR-10	T11N	17	A1	1-15	OSDH	2.32	MG/KG	

Table 5.2.7.11A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE IN SOIL SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
1H14	T11N	1	H14	1-10	KMTC	60.0	PPM	
2E14	T11N	2	E14	1-10	KMTC	100.0	PPM	
4A 6	T11N	4	A6	1-10	KMTC	170.0	PPM	
4J14	T11N	4	J14	1-09	KMTC	220.0	PPM	
5N 6	T11N	5	N6	1-09	KMTC	160.0	PPM	
6A 7	T11N	6	A7	1-09	KMTC	180.0	PPM	
6C14	T11N	6	C14	1-09	KMTC	190.0	PPM	
6I11	T11N	6	I11	1-09	KMTC	130.0	PPM	
7C 6	T11N	7	C6	1-08	KMTC	130.0	PPM	
7F 7	T11N	7	F7	1-08	KMTC	120.0	PPM	
8A 1	T11N	8	A1	1-09	KMTC	140.0	PPM	
8J 7	T11N	8	J7	1-09	KMTC	50.0	PPM	
8M14	T11N	8	M14	1-09	KMTC	30.0	PPM	
9B 2	T11N	9	B2	1-09	KMTC	250.0	PPM	
9I 8	T11N	9	I8	1-09	KMTC	90.0	PPM	
10B 8	T11N	10	B8	1-09	KMTC	30.0	PPM	
10L 8	T11N	10	L8	1-08	KMTC	30.0	PPM	
10M10	T11N	10	M10	1-08	KMTC	30.0	PPM	
11F 7	T11N	11	F7	1-08	KMTC	50.0	PPM	
11N 6	T11N	11	N6	1-08	KMTC	50.0	PPM	
12F 7	T11N	12	F7	1-09	KMTC	50.0	PPM	
12N 8	T11N	12	N8	1-08	KMTC	130.0	PPM	
13B 1	T11N	13	B1	1-08	KMTC	50.0	PPM	
13G11	T11N	13	G11	1-09	KMTC	80.0	PPM	
13H 2	T11N	13	H2	1-08	KMTC	60.0	PPM	
14B 4	T11N	14	B4	1-08	KMTC	100.0	PPM	
14B 8	T11N	14	B8	1-08	KMTC	70.0	PPM	
14B12	T11N	14	B12	1-08	KMTC	60.0	PPM	
16B10	T11N	16	B10	1-09	KMTC	40.0	PPM	
16L 2	T11N	16	L2	1-10	KMTC	280.0	PPM	
16L12	T11N	16	L12	1-10	KMTC	120.0	PPM	
18B 4	T11N	18	B4	1-09	KMTC	60.0	PPM	
18H10	T11N	18	H10	1-09	KMTC	90.0	PPM	
1A11	T11N	1	A11	1-09	KMTC	90.0	PPM	
22G14	T11N	22	G14	1-10	KMTC	70.0	PPM	
23A10	T11N	23	A10	1-08	KMTC	50.0	PPM	T11N
25E 8	T12N	25	E8	1-10	KMTC	60.0	PPM	
25H 3	T12N	25	H3	1-10	KMTC	60.0	PPM	
25H14	T12N	25	H14	1-10	KMTC	80.0	PPM	
26G 1	T12N	26	G1	1-10	KMTC	60.0	PPM	
26G 8	T12N	26	G8	1-10	KMTC	70.0	PPM	
27A13	T12N	27	A13	1-08	KMTC	90.0	PPM	
27D 1	T12N	27	D1	1-10	KMTC	90.0	PPM	
27H 9	T12N	27	H9	1-10	KMTC	180.0	PPM	
27K 4	T12N	27	K4	1-10	KMTC	50.0	PPM	
28G 4	T12N	28	G4	1-10	KMTC	100.0	PPM	
28J11	T12N	28	J11	1-10	KMTC	140.0	PPM	
28N 2	T12N	28	N2	1-10	KMTC	170.0	PPM	
29D 3	T12N	29	D3	1-10	KMTC	50.0	PPM	

Table 5.2.7.11A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE IN SOIL SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
2L13	T11N	2	L13	1-09	KMTC	50.	PPM	
2M 8	T11N	2	M8	1-09	KMTC	50.0	PPM	
30F 7	T12N	30	F7	1-10	KMTC	60.0	PPM	
31B10	T12N	31	B10	1-10	KMTC	80.0	PPM	
33B14	T12N	33	B14	1-10	KMTC	170.0	PPM	
33I 3	T12N	33	I3	1-10	KMTC	130.0	PPM	
33M14	T12N	33	M14	1-10	KMTC	90.0	PPM	
34D 7	T12N	34	D7	1-10	KMTC	120.0	PPM	
35A 9	T12N	35	A9	1-10	KMTC	60.0	PPM	
35B 1	T12N	35	B1	1-10	KMTC	70.0	PPM	
35B14	T12N	35	B14	1-10	KMTC	70.0	PPM	
35F10	T12N	35	F10	1-10	KMTC	60.0	PPM	
35L 5	T12N	35	L5	1-09	KMTC	70.0	PPM	
35L11	T12N	35	L11	1-10	KMTC	210.0	PPM	
36A13	T12N	36	A13	1-10	KMTC	100.0	PPM	
36G 5	T12N	36	G5	1-09	KMTC	70.0	PPM	
36H14	T12N	36	H14	1-10	KMTC	160.0	PPM	
3F 7	T11N	3	F7	1-09	KMTC	90.0	PPM	
4A 1	T11N	4	A1	1-10	KMTC	140.0	PPM	
4N 7	T11N	4	N7	1-09	KMTC	90.0	PPM	
BG 1/4	T12N	21	B13	1-06	KMTC	220.0	PPM	
CRES10	T12N	27	K3	1-04	KMTC	190.0	PPM	CRES
DRES11	T12N	27	K4	1-04	KMTC	40.0	PPM	DRES
DRES13	T12N	27	K4	1-04	KMTC	60.0	PPM	DRES
HRES01	T12N	27	I2	1-04	KMTC	110.0	PPM	HRES
LRES05	T12N	28	I14	1-04	KMTC	120.0	PPM	LRES
LRES06	T12N	28	I14	1-04	KMTC	60.0	PPM	LRES
RKRES16	T12N	34	A13	1-04	KMTC	80.0	PPM	RKRES
RRES17	T11N	34	B6	1-04	KMTC	90.0	PPM	RRES
RRES19	T11N	34	B6	1-04	KMTC	100.0	PPM	RRES
SHRES14	T12N	27	N6	1-04	KMTC	80.0	PPM	SHRES
SMRES20	T12N	26	K6	1-04	KMTC	40.0	PPM	SMRES
TRES54	T11N	23	M10	1-06	KMTC	90.0	PPM	TRES
YRES52	T11N	26	N3	1-05	KMTC	100.0	PPM	YRES
BG 1/4	T12N	21	B13	1-06	ORNL	4.7	UG/G	DRY
BG 1/4	T12N	21	B13	1-06	ORNL	3.7	UG/G	WET
CARLILE	T12N	22	D14	1-05	ORNL	1.2	UG/G	DRY
CARLILE	T12N	22	D14	1-05	ORNL	0.8	UG/G	WET
CRES	T12N	27	K3	1-05	ORNL	2.8	UG/G	DRY
CRES	T12N	27	K3	1-05	ORNL	1.9	UG/G	WET
T4-01E	T11N	2	C11	1-06	ORNL	1.2	UG/G	DRY
T4-01E	T11N	2	C11	1-06	ORNL	1.0	UG/G	WET
T4-01W	T12N	27	N1	1-06	ORNL	0.7	UG/G	DRY
T4-01W	T12N	27	N1	1-06	ORNL	0.6	UG/G	WET
T4-02E	T11N	2	B8	1-06	ORNL	0.6	UG/G	DRY
T4-02E	T11N	2	B8	1-06	ORNL	0.5	UG/G	WET
T4-02W	T12N	33	L14	1-06	ORNL	0.7	UG/G	DRY
T4-02W	T12N	33	L14	1-06	ORNL	0.6	UG/G	WET

Table 5.2.7.11A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR FLUORIDE IN SOIL SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
T4-03E	T12N	35	N5	1-06	ORNL	1.3	UG/G	DRY
T4-03W	T12N	34	B6	1-06	ORNL	0.8	UG/G	DRY
T4-03W	T12N	34	B6	1-06	ORNL	0.7	UG/G	WET
T4-04E	T12N	35	L3	1-06	ORNL	0.9	UG/G	DRY
T4-04E	T12N	35	L3	1-06	ORNL	0.7	UG/G	WET
T4-04W	T12N	34	L13	1-06	ORNL	1.0	UG/G	DRY
T4-04W	T12N	34	L13	1-06	ORNL	0.8	UG/G	WET
T4-05E	T12N	35	K1	1-06	ORNL	0.7	UG/G	DRY
T4-05E	T12N	35	K1	1-06	ORNL	0.6	UG/G	WET
AB-01	T11N	17	A14	1-15	OSDH	0.64	MG/KG	
AB-02	T11N	16	A11	1-15	OSDH	0.68	MG/KG	
AB-03	T12N	32	N14	1-15	OSDH	0.44	MG/KG	
AB-04	T11N	9	B1	1-15	OSDH	0.56	MG/KG	
AB-05	T11N	4	C8	1-15	OSDH	0.52	MG/KG	
AB-06	T12N	29	N14	1-15	OSDH	0.80	MG/KG	
AB-07	T12N	31	A8	1-15	OSDH	0.40	MG/KG	
AB-08	T12N	19	N8	1-15	OSDH	<0.40	MG/KG	
AB-09	T12N	18	M6	1-15	OSDH	1.04	MG/KG	
AB-10	T12N	13	G14	1-15	OSDH	0.52	MG/KG	
CARLILE	T12N	22	D14	1-14	OSDH	1.24	MG/KG	
CARLILE	T12N	22	D14	1-05	OSDH	<0.4	MG/KG	
CNTRL01	T09N	16	-	1-06	OSDH	0.4	MG/KG	
CNTRL02	T10N	35	C14	1-06	OSDH	0.5	MG/KG	
CNTRL03	T11N	28	E10	1-06	OSDH	<0.4	MG/KG	
CNTRL04	T11N	20	N10	1-06	OSDH	0.7	MG/KG	
CNTRL05	T11N	19	F13	1-06	OSDH	0.9	MG/KG	
CNTRL07	T11N	13	B7	1-06	OSDH	<0.4	MG/KG	
CNTRL08	T10N	8	K8	1-06	OSDH	0.6	MG/KG	
CNTRL09	T11N	21	C12	1-06	OSDH	1.3	MG/KG	
CNTRL10	T11N	21	I13	1-06	OSDH	1.3	MG/KG	
CNTRL11	T12N	26	E3	1-06	OSDH	1.5	MG/KG	
CNTRL12	T11N	14	N6	1-06	OSDH	0.7	MG/KG	
CNTRL13	T11N	3	C2	1-06	OSDH	0.4	MG/KG	
CNTRL14	T11N	-	-	1-06	OSDH	0.5	MG/KG	S OF SALLISAW
CNTRL15	T09N	16	G13	1-06	OSDH	0.5	MG/KG	
CRES	T12N	27	K3	1-05	OSDH	0.6	MG/KG	
G-01	T12N	8	L5	1-15	OSDH	0.72	MG/KG	
G-02	T12N	8	B3	1-15	OSDH	1.84	MG/KG	
G-03	T12N	7	B13	1-15	OSDH	0.64	MG/KG	
G-04	T12N	7	K9	1-15	OSDH	1.52	MG/KG	
GL-01	T12N	16	F1	1-15	OSDH	0.52	MG/KG	
P-01	T12N	26	A11	1-13	OSDH	0.88	MG/KG	
P-02	T12N	25	H4	1-13	OSDH	0.50	MG/KG	
P-03	T12N	36	A13	1-13	OSDH	0.68	MG/KG	
P-04	T12N	36	D10	1-13	OSDH	0.96	MG/KG	
P-05	T11N	1	A11	1-13	OSDH	5.56	MG/KG	
P-06	T11N	1	A7	1-13	OSDH	0.52	MG/KG	
P-07	T12N	35	M10	1-13	OSDH	<0.1	MG/KG	
P-08	T12N	35	D10	1-13	OSDH	0.48	MG/KG	

Table 5.2.7.11A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE IN SOIL SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
P-09	T12N	26	H6	1-13	OSDH	1.16	MG/KG	
T3-08	T12N	26	C12	1-14	OSDH	1.24	MG/KG	
T4-01E	T11N	2	C11	1-06	OSDH	1.1	MG/KG	
T4-01W	T12N	27	N1	1-06	OSDH	1.1	MG/KG	
T4-02E	T11N	2	B8	1-06	OSDH	<0.8	MG/KG	
T4-02W	T12N	33	L14	1-06	OSDH	2.3	MG/KG	
T4-03E	T12N	35	N5	1-06	OSDH	<0.8	MG/KG	
T4-03W	T12N	34	B6	1-06	OSDH	1.6	MG/KG	
T4-04E	T12N	35	L3	1-06	OSDH	<0.8	MG/KG	
T4-04W	T12N	34	L13	1-06	OSDH	1.4	MG/KG	
T4-05E	T12N	35	K1	1-06	OSDH	1.2	MG/KG	
WR-01	T11N	15	A1	1-15	OSDH	1.40	MG/KG	
WR-02	T11N	17	A14	1-15	OSDH	1.64	MG/KG	
WR-03	T11N	17	I14	1-15	OSDH	1.12	MG/KG	
WR-05	T11N	9	A1	1-15	OSDH	1.28	MG/KG	
WR-07	T11N	6	N14	1-15	OSDH	<0.40	MG/KG	
WR-08	T11N	6	N7	1-15	OSDH	1.08	MG/KG	
WR-09	T11N	6	G1	1-15	OSDH	0.52	MG/KG	
WR-10	T11N	17	A1	1-15	OSDH	<0.40	MG/KG	

Table 5.2.7.12A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM ON VEGETATION SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
7C 6	T11N	7	C6	1-08	KMTC	1.2	PPM	J.GRASS
7F 7	T11N	7	F7	1-08	KMTC	3.9	PPM	WHEAT
7F 7	T11N	7	F7	1-08	KMTC	3.5	PPM	
11F 7	T11N	11	F7	1-08	KMTC	9.3	PPM	CAT LEAVES
11F 7	T11N	11	F7	1-08	KMTC	31.0	PPM	BEANS
11F 7	T11N	11	F7	1-08	KMTC	18.0	PPM	WILLOW
12N 8	T11N	12	N8	1-08	KMTC	5.9	PPM	CEDAR
12N 8	T11N	12	N8	1-08	KMTC	3.7	PPM	CAT TIPS
12N 8	T11N	12	N8	1-08	KMTC	2.6	PPM	
13B 1	T11N	13	B1	1-08	KMTC	2.2	PPM	
13G11	T11N	13	G11	1-09	KMTC	1.9	PPM	
14B 4	T11N	14	B4	1-08	KMTC	1.5	PPM	
14B 8	T11N	14	B8	1-08	KMTC	0.6	PPM	
14B12	T11N	14	B12	1-08	KMTC	8.1	PPM	FESCUE
14B12	T11N	14	B12	1-08	KMTC	7.8	PPM	FESCUE TIP
16B10	T11N	16	B10	1-09	KMTC	0.6	PPM	
16L12	T11N	16	L12	1-10	KMTC	1.1	PPM	
18B 4	T11N	18	B4	1-09	KMTC	0.7	PPM	
18H10	T11N	18	H10	1-09	KMTC	<0.5	PPM	
1A11	T11N	1	A11	1-09	KMTC	0.7	PPM	
1H14	T11N	1	H14	1-08	KMTC	1.4	PPM	
22G14	T11N	22	G14	1-10	KMTC	<0.5	PPM	
23A10	T11N	23	A10	1-08	KMTC	28.0	PPM	T11N
25E 8	T12N	25	E8	1-10	KMTC	1.2	PPM	
25H 3	T12N	25	H3	1-10	KMTC	<0.5	PPM	
25H 3	T12N	25	H3	1-10	KMTC	<0.5	PPM	
26G 1	T12N	26	G1	1-10	KMTC	<0.5	PPM	
26G 8	T12N	26	G8	1-10	KMTC	1.1	PPM	
27A13	T12N	27	A13	1-08	KMTC	4.5	PPM	SMILAX
27A13	T12N	27	A13	1-08	KMTC	5.7	PPM	CEDAR
27D 1	T12N	27	D1	1-10	KMTC	52.0	PPM	
27H 9	T12N	27	H9	1-10	KMTC	2.3	PPM	
27H 9	T12N	27	H9	1-10	KMTC	1.1	PPM	
27K 4	T12N	27	K4	1-10	KMTC	38.0	PPM	
28G 4	T12N	28	G4	1-10	KMTC	1.2	PPM	
28G 4	T12N	28	G4	1-10	KMTC	<0.5	PPM	
28J11	T12N	28	J11	1-10	KMTC	1.7	PPM	
28N 2	T12N	28	N2	1-10	KMTC	<0.5	PPM	
28N 2	T12N	28	N2	1-10	KMTC	6.6	PPM	
29D 3	T12N	29	D3	1-10	KMTC	<0.5	PPM	
2E14	T11N	2	E14	1-09	KMTC	<0.5	PPM	
2L13	T11N	2	L13	1-09	KMTC	5.5	PPM	
2M 8	T11N	2	M8	1-09	KMTC	55.0	PPM	
30F 7	T12N	30	F7	1-10	KMTC	<0.5	PPM	
30F 7	T12N	30	F7	1-10	KMTC	0.5	PPM	
31B10	T12N	31	B10	1-10	KMTC	<0.5	PPM	
33B14	T12N	33	B14	1-10	KMTC	<0.5	PP	
33I 3	T12N	33	I3	1-10	KMTC	<0.5	P	
33M14	T12N	33	M14	1-10	KMTC	<0.5	P	

Table 5.2.7.12A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM ON VEGETATION SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
33M14	T12N	33	M14	1-10	KMTC	<0.5	PPM	
34D 7	T12N	34	D7	1-10	KMTC	16.0	PPM	
35A 9	T12N	35	A9	1-10	KMTC	<0.5	PPM	
35A 9	T12N	35	A9	1-10	KMTC	0.8	PPM	
35B 1	T12N	35	B1	1-10	KMTC	<0.5	PPM	
35B14	T12N	35	B14	1-10	KMTC	<0.5	PPM	
35F10	T12N	35	F10	1-10	KMTC	0.6	PPM	
35L 5	T12N	35	L5	1-09	KMTC	<0.5	PPM	
35L 5	T12N	35	L5	1-09	KMTC	1.0	PPM	
35L11	T12N	35	L11	1-10	KMTC	<0.5	PPM	
35L11	T12N	35	L11	1-10	KMTC	1.2	PPM	
36A13	T12N	36	A13	1-10	KMTC	<0.5	PPM	
36G 5	T12N	36	G5	1-09	KMTC	0.9	PPM	
36H14	T12N	36	H14	1-10	KMTC	0.5	PPM	
3F 7	T11N	3	F7	1-09	KMTC	0.6	PPM	
4A 1	T11N	4	A1	1-10	KMTC	<0.5	PPM	
4A 3	T11N	4	A3	1-10	KMTC	<0.5	PPM	
4A 6	T11N	4	A6	1-10	KMTC	<0.5	PPM	
4J14	T11N	4	J14	1-09	KMTC	1.0	PPM	
4J14	T11N	4	J14	1-09	KMTC	<0.5	PPM	
4N 7	T11N	4	N7	1-09	KMTC	<0.5	PPM	
4N 8	T11N	4	N8	1-09	KMTC	<0.5	PPM	
50/HWY	T12N	22	G1	1-06	KMTC	17000.0	PPM	
5N 6	T11N	5	N6	1-09	KMTC	0.5	PPM	
6A 7	T11N	6	A7	1-09	KMTC	<0.5	PPM	
6C14	T11N	6	C14	1-09	KMTC	1.8	PPM	
8A 1	T11N	8	A1	1-09	KMTC	1.7	PPM	
8J 7	T11N	8	J7	1-09	KMTC	1.1	PPM	
8N14	T11N	8	N14	1-09	KMTC	<0.5	PPM	
9B 2	T11N	8	B2	1-09	KMTC	1.7	PPM	
BG 1/4	T12N	21	B13	1-06	KMTC	64.0	PPM	
CRES08	T12N	27	K3	1-04	KMTC	12.0	PPM	CRES
DRES12	T12N	27	K4	1-04	KMTC	220.0	PPM	DRES
H-02	T12N	27	I2	1-04	KMTC	32.0	PPM	CEDAR
H-03	T12N	27	I2	1-04	KMTC	0.95	PPM	HRES
LRES04	T12N	28	I14	1-04	KMTC	<0.4	PPM	LRES
RKRES15	T12N	34	A13	1-04	KMTC	0.6	PPM	RKRES
RRES18	T11N	34	B6	1-04	KMTC	2.7	PPM	RRES
SMRES21	T12N	26	K6	1-04	KMTC	0.6	PPM	SMRES
TRES53	T11N	23	M10	1-06	KMTC	16.0	PPM	
YRES51	T11N	26	N3	1-05	KMTC	8.1	PPM	
BG 1/4	T12N	21	B13	1-06	ORNL	3.91	PPM	
T4-01E	T11N	2	C11	1-06	ORNL	5.29	PPM	
T4-02E	T11N	2	B8	1-06	ORNL	1.99	PPM	
T4-03E	T12N	35	N5	1-06	ORNL	1.0	PPM	
T4-04E	T12N	35	L3	1-06	ORNL	0.807	PPM	
T4-04W	T12N	34	L13	1-06	ORNL	3.68	PPM	
T4-05E	T12N	35	K1	1-06	ORNL	19.6	PPM	

Table 5.2.7.13A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM IN SOIL SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
1H14	T11N	1	H14	1-10	KMTC	<10	PPM	
2E14	T11N	2	E14	1-10	KMTC	<10	PPM	
4A 6	T11N	4	A6	1-10	KMTC	<10	PPM	
4J14	T11N	4	J14	1-09	KMTC	<10	PPM	
5N 6	T11N	5	N6	1-09	KMTC	<10	PPM	
6A 7	T11N	6	A7	1-09	KMTC	<10	PPM	
6C14	T11N	6	C14	1-09	KMTC	<10	PPM	
6I11	T11N	6	I11	1-09	KMTC	<10	PPM	
7C 6	T11N	7	C6	1-08	KMTC	<10	PPM	
7F 7	T11N	7	F7	1-08	KMTC	<10	PPM	
8A 1	T11N	8	A1	1-09	KMTC	<10	PPM	
8J 7	T11N	8	J7	1-09	KMTC	<10	PPM	
8N14	T11N	8	M14	1-09	KMTC	20.0	PPM	
9B 2	T11N	9	B2	1-09	KMTC	<10	PPM	
9I 8	T11N	9	I8	1-09	KMTC	15.0	PPM	
10B 8	T11N	10	B8	1-09	KMTC	<10	PPM	
10L 8	T11N	10	L8	1-08	KMTC	<10	PPM	
10M10	T11N	10	M10	1-08	KMTC	<10	PPM	
11F 7	T11N	11	F7	1-08	KMTC	<10	PPM	
11N 6	T11N	11	N6	1-08	KMTC	<10	PPM	
12F 7	T11N	12	F7	1-09	KMTC	<10	PPM	
12N 8	T11N	12	N8	1-08	KMTC	<10	PPM	
13B 1	T11N	13	B1	1-08	KMTC	15.0	PPM	
13G11	T11N	13	G11	1-09	KMTC	15.0	PPM	
13H 2	T11N	13	H2	1-08	KMTC	15.0	PPM	
14B 4	T11N	14	B4	1-08	KMTC	<10	PPM	
14B 8	T11N	14	B8	1-08	KMTC	15.0	PPM	
14B12	T11N	14	B12	1-08	KMTC	15.0	PPM	
16B10	T11N	16	B10	1-09	KMTC	<10	PPM	
16L 2	T11N	16	L2	1-10	KMTC	<10	PPM	
16L12	T11N	16	L12	1-10	KMTC	<10	PPM	
18B 4	T11N	18	B4	1-09	KMTC	<10	PPM	
18H10	T11N	18	H10	1-09	KMTC	<10	PPM	
1A11	T11N	1	A11	1-09	KMTC	<10	PPM	
22G14	T11N	22	G14	1-10	KMTC	<10	PPM	
23A10	T11N	23	A10	1-08	KMTC	10.0	PPM	T11N
25E 8	T12N	25	E8	1-10	KMTC	15.0	PPM	
25H 3	T12N	25	H3	1-10	KMTC	15.0	PPM	
25H14	T12N	25	H14	1-10	KMTC	15.0	PPM	
26G 1	T12N	26	G1	1-10	KMTC	15.0	PPM	
26G 8	T12N	26	G8	1-10	KMTC	10.0	PPM	
27A13	T12N	27	A13	1-08	KMTC	10.0	PPM	
27D 1	T12N	27	D1	1-10	KMTC	15.0	PPM	
27H 9	T12N	27	H9	1-10	KMTC	<10	PPM	
27K 4	T12N	27	K4	1-10	KMTC	15.0	PPM	
28G 4	T12N	28	G4	1-10	KMTC	<10	PPM	
28J11	T12N	28	J11	1-10	KMTC	<10	PPM	
28N 2	T12N	28	N2	1-10	KMTC	<10	PPM	
29D 3	T12N	29	D3	1-10	KMTC	15.0	PPM	

Table 5.2.7.13A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM IN SOIL SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
2L13	T11N	2	L13	1-09	KMTC	<10	PPM	
2L13	T11N	2	L13	1-09	KMTC	<10	PPM	
2M 8	T11N	2	M8	1-09	KMTC	<10	PPM	
30F 7	T12N	30	F7	1-10	KMTC	15.0	PPM	
31B10	T12N	31	B10	1-10	KMTC	<10	PPM	
33B14	T12N	33	B14	1-10	KMTC	<10	PPM	
33I 3	T12N	33	I3	1-10	KMTC	<10	PPM	
33M14	T12N	33	M14	1-10	KMTC	<10	PPM	
34D 7	T12N	34	D7	1-10	KMTC	<10	PPM	
35A 9	T12N	35	A9	1-10	KMTC	15.0	PPM	
35B 1	T12N	35	B1	1-10	KMTC	10.0	PPM	
35B14	T12N	35	B14	1-10	KMTC	10.0	PPM	
35F10	T12N	35	F10	1-10	KMTC	15.0	PPM	
35L 5	T12N	35	L5	1-09	KMTC	10.0	PPM	
35L11	T12N	35	L11	1-10	KMTC	<10	PPM	
36A13	T12N	36	A13	1-10	KMTC	<10	PPM	
36G 5	T12N	36	G5	1-09	KMTC	<10	PPM	
36H14	T12N	36	H14	1-10	KMTC	<10	PPM	
3F 7	T11N	3	F7	1-09	KMTC	<10	PPM	
4A 1	T11N	4	A1	1-10	KMTC	<10	PPM	
4N 7	T11N	4	N7	1-09	KMTC	<10	PPM	
BG 1/4	T12N	21	B13	1-06	KMTC	<10	PPM	
CRES09	T12N	27	K3	1-04	KMTC	<10	PPM	CRES
CRES10	T12N	27	K3	1-04	KMTC	<10	PPM	CRES
DRES11	T12N	27	K4	1-04	KMTC	15.0	PPM	DRES
DRES13	T12N	27	K4	1-04	KMTC	13.0	PPM	DRES
HRES01	T12N	27	I2	1-04	KMTC	<10	PPM	HRES
LRES05	T12N	28	I14	1-04	KMTC	<10	PPM	LRES
LRES06	T12N	28	I14	1-04	KMTC	<10	PPM	LRES
RKRES16	T12N	34	A13	1-04	KMTC	<10	PPM	RKRES
RRES17	T11N	34	B6	1-04	KMTC	<10	PPM	RRES
RRES19	T11N	34	B6	1-04	KMTC	<10	PPM	RRES
SHRES14	T12N	27	N6	1-04	KMTC	<10	PPM	SHRES
SMRES20	T12N	26	K6	1-04	KMTC	11.0	PPM	SMRES
TRES54	T11N	23	M10	1-06	KMTC	<10	PPM	
YRES52	T11N	26	N3	1-05	KMTC	<10	PPM	
BG 1/4	T12N	21	B13	1-06	ORNL	7.88	PPM	DRY
BG 1/4	T12N	21	B13	1-06	ORNL	6.1	PPM	WET
CARLILE	T12N	22	D14	1-05	ORNL	3.7	PPM	DRY
CARLILE	T12N	22	D14	1-05	ORNL	2.7	PPM	WET
CRES	T12N	27	K3	1-05	ORNL	2.9	PPM	DRY
CRES	T12N	27	K3	1-05	ORNL	2.0	PPM	WET
T4-01E	T11N	2	C11	1-06	ORNL	3.72	PPM	DRY
T4-01E	T11N	2	C11	1-06	ORNL	3.1	PPM	WET
T4-01W	T12N	27	N1	1-06	ORNL	1.52	PPM	DRY
T4-01W	T12N	27	N1	1-06	ORNL	1.3	PPM	WET
T4-02E	T11N	2	B8	1-06	ORNL	3.59	PPM	DRY
T4-02E	T11N	2	B8	1-06	ORNL	3.0	PPM	WET
T4-02W	T12N	33	L14	1-06	ORNL	1.5	PPM	WET

Table 5.2.7.13A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM IN SOIL SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
T4-02W	T12N	33	L14	1-06	ORNL	1.67	PPM	DRY
T4-03E	T12N	35	N5	1-06	ORNL	3.8	PPM	DRY
T4-03E	T12N	35	N5	1-06	ORNL	2.9	PPM	WET
T4-03W	T12N	34	B6	1-06	ORNL	2.76	PPM	DRY
T4-03W	T12N	34	B6	1-06	ORNL	2.2	PPM	WET
T4-04E	T12N	35	L3	1-06	ORNL	3.73	PPM	DRY
T4-04E	T12N	35	L3	1-06	ORNL	3.0	PPM	WET
T4-04W	T12N	34	L13	1-06	ORNL	2.45	PPM	DRY
T4-04W	T12N	34	L13	1-06	ORNL	2.0	PPM	WET
T4-05E	T12N	35	K1	1-06	ORNL	2.29	PPM	DRY
T4-05E	T12N	35	K1	1-06	ORNL	1.9	PPM	WET

Table 5.2.7.14A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR ALPHA ON VEGETATION SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
CARLILE	T12N	22	D14	1-05	OSDH	0.8	PCI/G	GRASS
CNTRL01	T09N	16	-	1-06	OSDH	-0.4	PCI/G	
CNTRL02	T10N	35	C14	1-06	OSDH	0.2	PCI/G	
CNTRL03	T11N	28	E10	1-06	OSDH	0.1	PCI/G	
CNTRL04	T11N	20	N10	1-06	OSDH	0.5	PCI/G	
CNTRL05	T11N	19	F13	1-06	OSDH	-0.3	PCI/G	
CNTRL06	T09N	4	I13	1-06	OSDH	-0.4	PCI/G	
CNTRL07	T11N	13	B7	1-06	OSDH	-0.3	PCI/G	
CNTRL08	T10N	8	K8	1-06	OSDH	1.0	PCI/G	
CNTRL09	T11N	21	C12	1-06	OSDH	1.0	PCI/G	
CNTRL09	T11N	21	C12	1-06	OSDH	0.4	PCI/G	
CNTRL10	T11N	21	I13	1-06	OSDH	0.1	PCI/G	
CNTRL11	T12N	26	E3	1-06	OSDH	0.2	PCI/G	
CNTRL13	T11N	3	C2	1-06	OSDH	0.2	PCI/G	
CNTRL15	T09N	16	G13	1-06	OSDH	-0.3	PCI/G	
CRES	T12N	27	K3	1-05	OSDH	1.1	PCI/G	GRASS
HRES	T12N	27	I2		OSDH	5.0	PCI/G	
T4-01E	T11N	2	C11	1-06	OSDH	0.3	PCI/G	EVERGREEN
T4-02E	T11N	2	B8	1-06	OSDH	-0.2	PCI/G	EVERGREEN
T4-03E	T12N	35	N5	1-06	OSDH	-0.1	PCI/G	EVERGREEN
T4-04E	T12N	35	L3	1-06	OSDH	0.0	PCI/G	EVERGREEN
T4-04W	T12N	34	L13	1-06	OSDH	0.1	PCI/G	LEAVES
T4-05E	T12N	35	K1	1-06	OSDH	4.5	PCI/G	EVERGREEN

Table 5.2.7.15A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR BETA ON VEGETATION SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
CARLILE	T12N	22	D14	1-05	OSDH	0.7	PCI/G	GRASS
CNTRL01	T09N	16	-	1-06	OSDH	-0.1	PCI/G	
CNTRL02	T10N	35	C14	1-06	OSDH	2.0	PCI/G	
CNTRL03	T11N	28	E10	1-06	OSDH	0.3	PCI/G	
CNTRL04	T11N	20	N10	1-06	OSDH	0.3	PCI/G	
CNTRL05	T11N	19	F13	1-06	OSDH	0.2	PCI/G	
CNTRL06	T09N	4	I13	1-06	OSDH	0.6	PCI/G	
CNTRL07	T11N	13	B7	1-06	OSDH	0.8	PCI/G	
CNTRL08	T10N	8	K8	1-06	OSDH	0.7	PCI/G	
CNTRL09	T11N	21	C12	1-06	OSDH	7.0	PCI/G	
CNTRL09	T11N	21	C12	1-06	OSDH	-0.3	PCI/G	
CNTRL10	T11N	21	I13	1-06	OSDH	-0.2	PCI/G	
CNTRL11	T12N	26	E3	1-06	OSDH	0.1	PCI/G	
CNTRL13	T11N	3	C2	1-06	OSDH	3.0	PCI/G	
CNTRL15	T09N	16	G13	1-06	OSDH	0.3	PCI/G	
CRES	T12N	27	K3	1-05	OSDH	0.2	PCI/G	GRASS
HRES	T12N	27	I2	1/5	OSDH	1.9	PCI/G	
T4-01E	T11N	2	C11	1-06	OSDH	-0.2	PCI/G	EVERGREEN
T4-02E	T11N	2	B8	1-06	OSDH	-0.3	PCI/G	EVERGREEN
T4-03E	T12N	35	N5	1-06	OSDH	0.2	PCI/G	EVERGREEN
T4-04E	T12N	35	L3	1-06	OSDH	-0.2	PCI/G	EVERGREEN
T4-04W	T12N	34	L13	1-06	OSDH	0.4	PCI/G	LEAVES
T4-05E	T12N	35	K1	1-06	OSDH	0.8	PCI/G	EVERGREEN

Table 5.2.7.16A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR ALPHA ON SOIL SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
CARLILE	T12N	22	D14	1-05	OSDH	0.1	PCI/G	
CNTRL01	T09N	16	-	1-06	OSDH	0.8	PCI/G	
CNTRL02	T10N	35	C14	1-06	OSDH	0.4	PCI/G	
CNTRL03	T11N	28	E10	1-06	OSDH	-0.2	PCI/G	
CNTRL04	T11N	20	N10	1-06	OSDH	1.1	PCI/G	
CNTRL05	T11N	19	F13	1-06	OSDH	-0.3	PCI/G	
CNTRL07	T11N	13	B7	1-06	OSDH	-0.3	PCI/G	
CNTRL08	T10N	8	K8	1-06	OSDH	0.4	PCI/G	
CNTRL09	T11N	21	C12	1-06	OSDH	0.1	PCI/G	
CNTRL10	T11N	21	I13	1-06	OSDH	-0.3	PCI/G	
CNTRL11	T12N	26	E3	1-06	OSDH	-0.3	PCI/G	
CNTRL12	T11N	14	N6	1-06	OSDH	0.5	PCI/G	
CNTRL13	T11N	3	C2	1-06	OSDH	0.4	PCI/G	
CNTRL14	T11N	-	-	1-06	OSDH	0.7	PCI/G	S OF SALLISAW
CNTRL15	T09N	16	G13	1-06	OSDH	-0.3	PCI/G	
CRES	T12N	27	K3	1-05	OSDH	-0.1	PCI/G	
T4-01E	T11N	2	C11	1-06	OSDH	-0.3	PCI/G	
T4-01W	T12N	27	N1	1-06	OSDH	-0.2	PCI/G	
T4-02E	T11N	2	B8	1-06	OSDH	0.4	PCI/G	
T4-02W	T12N	33	L14	1-06	OSDH	0.7	PCI/G	
T4-03E	T12N	35	N5	1-06	OSDH	0.1	PCI/G	
T4-03W	T12N	34	B6	1-06	OSDH	0.1	PCI/G	
T4-04E	T12N	35	L3	1-06	OSDH	0.1	PCI/G	
T4-04W	T12N	34	L13	1-06	OSDH	0.1	PCI/G	
T4-05E	T12N	35	K1	1-06	OSDH	-0.3	PCI/G	

Table 5.2.7.17A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR BETA IN SOIL SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
CARLILE	T12N	22	D14	1-05	OSDH	-0.3	PCI/G	
CNTRL01	T09N	16	-	1-06	OSDH	-0.3	PCI/G	
CNTRL02	T10N	35	C14	1-06	OSDH	0.3	PCI/G	
CNTRL03	T11N	28	E10	1-06	OSDH	-0.0	PCI/G	
CNTRL04	T11N	20	N10	1-06	OSDH	-0.3	PCI/G	
CNTRL05	T11N	19	F13	1-06	OSDH	-0.0	PCI/G	
CNTRL07	T11N	13	B7	1-06	OSDH	0.5	PCI/G	
CNTRL08	T10N	8	K8	1-06	OSDH	-0.4	PCI/G	
CNTRL09	T11N	21	C12	1-06	OSDH	-0.3	PCI/G	
CNTRL10	T11N	21	I13	1-06	OSDH	0.3	PCI/G	
CNTRL11	T12N	26	E3	1-06	OSDH	-0.2	PCI/G	
CNTRL12	T11N	14	N6	1-06	OSDH	0.9	PCI/G	
CNTRL13	T11N	3	C2	1-06	OSDH	0.5	PCI/G	
CNTRL14	T11N	-	-	1-06	OSDH	0.6	PCI/G	S OF SALLISAW
CNTRL15	T09N	16	G13	1-06	OSDH	-0.4	PCI/G	
CRES	T12N	27	K3	1-05	OSDH	-0.0	PCI/G	
T4-01E	T11N	2	C11	1-06	OSDH	0.1	PCI/G	
T4-01W	T12N	27	N1	1-06	OSDH	-0.2	PCI/G	
T4-02E	T11N	2	B8	1-06	OSDH	-0.2	PCI/G	
T4-02W	T12N	33	L14	1-06	OSDH	0.1	PCI/G	
T4-03E	T12N	35	N5	1-06	OSDH	0.6	PCI/G	
T4-03W	T12N	34	B6	1-06	OSDH	-0.6	PCI/G	
T4-04E	T12N	35	L3	1-06	OSDH	0.1	PCI/G	
T4-04W	T12N	34	L13	1-06	OSDH	-0.4	PCI/G	
T4-05E	T12N	35	K1	1-06	OSDH	-0.4	PCI/G	

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS BY TYPE OF SAMPLE
SORTED BY LABEL

Table 5.2.7.18A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
1W	14500	14800	KMTC	1-06	WATER	0.1	mg/l	
2W	13250	13950	KMTC	1-06	WATER	0.1	mg/l	
3W	12750	11200	KMTC	1-06	WATER	0.2	mg/l	
4W	11700	11150	KMTC	1-06	WATER	0.2	mg/l	
5W	10100	10950	KMTC	1-06	WATER	0.4	mg/l	
6W	9850	9450	KMTC	1-06	WATER	0.1	mg/l	
7W	10600	7000	KMTC	1-06	WATER	0.2	mg/l	
8W	11800	7000	KMTC	1-06	WATER	0.3	mg/l	
10W	11800	6200	KMTC	1-06	WATER	0.1	mg/l	
11W	16350	9450	KMTC	1-06	WATER	<0.1	mg/l	
12W	6750	11050	KMTC	1-06	WATER	0.1	mg/l	
13W	7475	13350	KMTC	1-06	WATER	<0.1	mg/l	
14W	18450	6950	KMTC	1-06	WATER	<0.1	mg/l	
14W	18450	6950	KMTC	1-08	WATER	<0.1	mg/l	
15W	12900	5950	KMTC	1-06	WATER	<0.1	mg/l	
15W	12900	5950	KMTC	1-08	WATER	<0.1	mg/l	
17W	7650	4350	KMTC	1-06	WATER	0.2	mg/l	
18W	15100	10300	KMTC	1-08	WATER	0.1	mg/l	
19W	6850	9050	KMTC	1-08	WATER	0.2	mg/l	
20W	7750	17000	KMTC	1-08	WATER	0.1	mg/l	
103	13800	10200	KMTC	1-09	SOIL	120.0	ppm	
105	11700	8450	KMTC	1-09	VEG	20.0	ppm	
106	11700	8450	KMTC	1-09	SOIL	150.0	ppm	
108	10600	8750	KMTC	1-09	VEG	30.0	ppm	
109	10600	8750	KMTC	1-09	SOIL	160.0	ppm	
111	14250	8450	KMTC	1-09	VEG	40.0	ppm	
112	14250	8450	KMTC	1-09	SOIL	110.0	ppm	
115	11500	11600	KMTC	1-09	SOIL	100.0	ppm	
116	10650	12300	KMTC	1-09	VEG	10.0	ppm	
117	10650	12300	KMTC	1-09	SOIL	80.0	ppm	
118	9750	12450	KMTC	1-09	VEG	14.0	ppm	
119	9750	12450	KMTC	1-09	SOIL	110.0	ppm	
120	9700	8850	KMTC	1-09	VEG	20.0	ppm	
121	9700	8850	KMTC	1-09	SOIL	70.0	ppm	
122	9600	9900	KMTC	1-09	VEG	210.0	ppm	
123	9600	9900	KMTC	1-09	SOIL	130.0	ppm	
124	9700	10700	KMTC	1-09	VEG	100.0	ppm	
125	9700	10700	KMTC	1-09	SOIL	60.0	ppm	
126	9750	11850	KMTC	1-09	VEG	20.0	ppm	
127	9750	11850	KMTC	1-09	SOIL	90.0	ppm	
128	10650	11300	KMTC	1-09	VEG	35.0	ppm	
129	10650	11300	KMTC	1-09	SOIL	80.0	ppm	
130	10650	10350	KMTC	1-09	VEG	70.0	ppm	
131	10650	10350	KMTC	1-09	SOIL	70.0	ppm	
132	11600	10650	KMTC	1-09	VEG	80.0	ppm	
133	11600	10650	KMTC	1-09	SOIL	110.0	ppm	
134	9250	13150	KMTC	1-09	VEG	28.0	ppm	
135	9250	13150	KMTC	1-09	SOIL	90.0	ppm	

Table 5.2.7.18A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
136	9150	12050	KMTC	1-09	VEG	16.0	ppm	
137	9150	12050	KMTC	1-09	SOIL	150.0	ppm	
138	9200	11000	KMTC	1-09	VEG	90.0	ppm	
139	9200	11000	KMTC	1-09	SOIL	120.0	ppm	
141	9300	10100	KMTC	1-09	SOIL	160.0	ppm	
142	9150	9000	KMTC	1-09	VEG	15.0	ppm	
143	9150	9000	KMTC	1-09	SOIL	80.0	ppm	
144	10500	9700	KMTC	1-09	VEG	50.0	ppm	
145	10500	9700	KMTC	1-09	SOIL	100.0	ppm	
146	11600	9550	KMTC	1-09	VEG	73.0	ppm	
147	11600	9550	KMTC	1-09	SOIL	30.0	ppm	
149	11650	9900	KMTC	1-09	SOIL	160.0	ppm	
150	11450	9700	KMTC	1-09	VEG	640.0	ppm	
187	12600	7200	KMTC	1-14	SOIL	60.0	ppm	
190	14750	9500	KMTC	1-14	SOIL	70.0	ppm	
193	12550	10200	KMTC	1-14	SOIL	80.0	ppm	
196	12600	10750	KMTC	1-14	SOIL	70.0	ppm	
198	12550	11850	KMTC	1-14	VEG	I	ppm	
199	12550	11850	KMTC	1-14	SOIL	80.0	ppm	
201	13150	10200	KMTC	1-14	VEG	I	ppm	
202	13150	10200	KMTC	1-14	SOIL	100.0	ppm	
204	13150	11250	KMTC	1-14	VEG	I	ppm	
205	13150	11250	KMTC	1-14	SOIL	150.0	ppm	
208	12500	9900	KMTC	1-14	VEG	I	ppm	
209	12500	9900	KMTC	1-14	SOIL	80.0	ppm	
211	12500	9700	KMTC	1-14	VEG	I	ppm	
214	12500	9500	KMTC	1-14	VEG	I	ppm	
218	12500	9350	KMTC	1-14	SOIL	120.0	ppm	
221	12500	9100	KMTC	1-14	SOIL	90.0	ppm	
300	12450	9900	KMTC	1-06	WATER	0.3	mg/l	
301	12450	9900	KMTC	1-14	WATER	0.2	mg/l	
302	12550	9550	KMTC	1-06	WATER	1.6	mg/l	
303	12550	9550	KMTC	1-14	WATER	1.5	mg/l	
304	12550	9400	KMTC	1-06	WATER	2.0	mg/l	
305	12550	9400	KMTC	1-14	WATER	4.8	mg/l	
306	11450	9550	KMTC	1-06	WATER	0.5	mg/l	
307	11450	9550	KMTC	1-14	WATER	0.5	mg/l	
50	10750	10100	KMTC	1-06	VEG	1500.0	ppm	CEDAR
A-01	13130	9220	KMTC	1-06	VEG	2100.0	ppm	
A-01	13130	9220	KMTC	1-06	SOIL	250.0	ppm	
A-07	13130	9400	KMTC	1-06	VEG	2600.0	ppm	
A-07	13130	9400	KMTC	1-06	SOIL	410.0	ppm	
A-07	13130	9400	KMTC	1-09	SOIL	410.0	ppm	
A-13	13130	9580	KMTC	1-06	SOIL	320.0	ppm	
A-13	13130	9580	KMTC	1-06	VEG	3000.0	ppm	
A-13	13130	9580	KMTC	1-09	SOIL	140.0	ppm	
A-19	13130	9760	KMTC	1-06	VEG	230.0	ppm	
A-25	13130	9950	KMTC	1-06	VEG	35.0	ppm	

Table 5.2.7.18A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
A-25	13130	9950	KMTC	1-06	SOIL	110.0	ppm	
A-25	13130	9760	ORNL	1-06	SOIL	9.0	ug/g	WET
A-25	13130	9760	ORNL	1-06	SOIL	11.4	ug/g	DRY
A-25	13130	9950	ORNL	1-06	VEG	33.0	ug/g	
BG 1/4	14750	9500	ORNL	1-06	VEG	7.3	ug/g	
BG 1/4	14750	9500	ORNL	1-06	SOIL	3.7	ug/g	WET
BG 1/4	14750	9500	ORNL	1-06	SOIL	4.7	ug/g	DRY
BG 1/4	14750	9500	KMTC	1-06	VEG	40.0	ppm	1/4 N.GATE
BG 1/4	14750	9500	KMTC	1-06	SOIL	220.0	ppm	
CARLILE	14250	15100	ORNL	1-05	SOIL	1.2	ug/g	DRY
CARLILE	14250	15100	ORNL	1-05	SOIL	0.8	ug/g	WET
CARLILE	14250	15100	ORNL	1-05	VEG	8.3	ug/g	
CARLILE	14250	15100	OSDH	1-05	VEG	4.3	mg/kg	GRASS
CARLILE	14100	15300	OSDH	1-14	VEG	2.56	mg/kg	
CARLILE	14100	15300	OSDH	1-14	SOIL	1.24	mg/kg	
CARLILE	14250	15100	OSDH	1-05	SOIL	<0.4	mg/kg	
COMP-1	11800	9500	OSDH	1-16	VEG	488.0	mg/kg	LAB COMPARISON
COMP-1	11800	9500	OSDH	1-16	SOIL	5.44	mg/kg	LAB COMPARISON
COMP-2	8800	10100	OSDH	1-16	VEG	164.0	mg/kg	LAB COMPARISON
COMP-2	8800	10100	OSDH	1-16	SOIL	2.76	mg/kg	LAB COMPARISON
COMP-3	10050	10700	OSDH	1-16	VEG	128.0	mg/kg	LAB COMPARISON
COMP-3	10050	10700	OSDH	1-16	SOIL	1.96	mg/kg	LAB COMPARISON
COMP-3	10050	10700	OSDH	1-16	WATER	0.45	mg/l	LAB COMPARISON
COMP-4	14450	14800	OSDH	1-16	VEG	7.36	mg/kg	LAB COMPARISON
COMP-4	14450	14800	OSDH	1-16	SOIL	1.48	mg/kg	LAB COMPARISON
COMP-4	14450	14800	OSDH	1-16	WATER	0.27	mg/l	LAB COMPARISON
COMP-5	12700	11200	OSDH	1-16	VEG	1080	mg/kg	LAB COMPARISON
COMP-5	12700	11200	OSDH	1-16	SOIL	5.6	mg/kg	LAB COMPARISON
COMP-5	12700	11200	OSDH	1-16	WATER	0.24	mg/l	LAB COMPARISON
CRES	6150	10750	OSDH	1-05	VEG	32.0	mg/kg	GRASS
CRES	6150	10800	OSDH	1-05	WATER	0.19	mg/l	
CRES	6150	10800	ORNL	1-05	WATER	0.09	ug/ml	
CRES	6150	10750	ORNL	1-05	SOIL	1.9	ug/g	WET
CRES	6150	10750	ORNL	1-05	SOIL	2.8	ug/g	DRY
CRES	6150	10800	ORNL	1-05	VEG	16.2	ug/g	
CRES	6150	10750	OSDH	1-05	SOIL	0.6	mg/kg	
CRES08	6150	10750	KMTC	1-03	VEG	42.0	ppm	CRES
CRES09	6150	10750	KMTC	1-04	S-V	90.0	ppm	MIX SOIL/VEG
CRES10	6150	10750	KMTC	1-04	SOIL	190.0	ppm	CRES
DRES11	6100	11100	KMTC	1-04	SOIL	40.0	ppm	
DRES12	6100	11100	KMTC	1-04	VEG	160.0	ppm	DRY LEAVES
DRES13	6100	11100	KMTC	1-04	SOIL	60.0	ppm	
E-01	13000	9230	KMTC	1-06	VEG	700.0	ppm	
E-01	13000	9230	KMTC	1-06	SOIL	100.0	ppm	
E-01	13000	9230	KMTC	1-09	SOIL	180.0	ppm	
E-07	13000	9410	KMTC	1-06	VEG	3100.0	ppm	
E-07	13000	9410	KMTC	1-06	SOIL	170.0	ppm	

Table 5.2.7.18A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
E-07	13000	9410	KMTC	1-09	SOIL	170.0	ppm	
E-13	13000	9600	KMTC	1-06	VEG	3700.0	ppm	
E-13	13000	9600	KMTC	1-06	SOIL	230.0	ppm	
E-13	13000	9600	KMTC	1-09	SOIL	150.0	ppm	
E-19	13000	9770	KMTC	1-06	SOIL	40.0	ppm	
E-19	13000	9770	KMTC	1-06	VEG	760.0	ppm	
E-25	13000	9950	KMTC	1-06	VEG	80.0	ppm	
E-25	13000	9950	KMTC	1-06	SOIL	170.0	ppm	
E-25	13000	9950	ORNL	1-06	SOIL	7.4	ug/g	WET
E-25	13000	9950	ORNL	1-06	SOIL	8.6	ug/g	DRY
E-25	13000	9950	ORNL	1-06	VEG	58.0	ug/g	
HRES	6950	10650	OSDH	1-08	VEG	24.0	mg/kg	
HRES01	6950	10650	KMTC	1-04	SOIL	110.0	ppm	
HRES02	6950	10650	KMTC	1-04	VEG	24.0	ppm	
HRES03	6950	10650	KMTC	1-04	VEG	80.0	ppm	
J-07	12840	9410	KMTC	1-06	VEG	870.0	ppm	
J-07	12840	9410	KMTC	1-06	SOIL	150.0	ppm	
J-07	12840	9410	KMTC	1-09	SOIL	180.0	ppm	
J-13	12840	9600	KMTC	1-06	SOIL	220.0	ppm	
J-13	12840	9600	KMTC	1-06	VEG	1700.0	ppm	
J-13	12840	9600	KMTC	1-09	SOIL	200.0	ppm	
J-19	12840	9780	KMTC	1-06	VEG	1300.0	ppm	
J-19	12840	9780	KMTC	1-06	SOIL	90.0	ppm	
J-25	12840	9950	KMTC	1-06	VEG	140.0	ppm	
J-25	12840	9950	KMTC	1-06	SOIL	110.0	ppm	
J-25	12840	9950	ORNL	1-06	SOIL	8.3	ug/g	WET
J-25	12840	9950	ORNL	1-06	SOIL	11.2	ug/g	DRY
J-25	12840	9950	ORNL	1-06	VEG	150.0	ug/g	
KM H20	13250	9400	OSDH	1-17	WATER	0.24	mg/l	
LAGOON	12800	9200	OSDH	1-17	WATER	4.40	mg/l	
LAGOON	12800	9200	KMTC	1-17	WATER	3.9	mg/l	
LR-01	7300	10450	OSDH	1-11	SOIL	0.88	mg/kg	
LR-01	7300	10450	OSDH	1-11	VEG	56.8	mg/kg	
LR-01	7300	10450	OSDH	1-11	VEG	56.8	mg/kg	
LR-01	7300	10450	OSDH	1-11	SOIL	0.88	mg/kg	
LR-02	6000	10000	OSDH	1-11	SOIL	1.36	mg/kg	
LR-02	6000	10000	OSDH	1-11	VEG	2.96	mg/kg	
LR-02	6000	10000	OSDH	1-11	SOIL	1.36	mg/kg	
LR-02	6000	10000	OSDH	1-11	VEG	2.96	mg/kg	
LR-03	6000	10800	OSDH	1-11	SOIL	1.68	mg/kg	
LR-03	6000	10800	OSDH	1-11	VEG	56.00	mg/kg	
LR-03	6000	10800	OSDH	1-11	SOIL	1.68	mg/kg	
LR-03	6000	10800	OSDH	1-11	VEG	56.00	mg/kg	
LR-04	5800	12100	OSDH	1-11	SOIL	1.12	mg/kg	
LR-04	5800	12100	OSDH	1-11	VEG	5.60	mg/kg	
LR-04	5800	12100	OSDH	1-11	SOIL	1.12	mg/kg	
LR-04	5800	12100	OSDH	1-11	VEG	5.60	mg/kg	
LR-05	5975	13950	OSDH	1-11	SOIL	1.92	mg/kg	

Table 5.2.7.18A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
LR-05	5975	13950	OSDH	1-11	VEG	7.12	mg/kg	
LR-05	5975	13950	OSDH	1-11	SOIL	1.92	mg/kg	
LR-05	5975	13950	OSDH	1-11	VEG	7.12	mg/kg	
LR-05A	6100	14450	OSDH	1-14	VEG	13.20	mg/kg	
LR-05A	6100	14450	OSDH	1-14	VEG	13.20	mg/kg	
LR-05A	6100	14450	OSDH	1-14	SOIL	1.36	mg/kg	
LR-06	6000	15600	OSDH	1-14	VEG	4.48	mg/kg	
LR-06	6000	15600	OSDH	1-14	SOIL	1.12	mg/kg	
LRES04	6950	9900	KMTC	1-04	VEG	3.0	ppm	TREE ?DATA DRCT
LRES05	6950	9900	KMTC	1-04	SOIL	120.0	ppm	
LRES06	6950	9900	KMTC	1-04	SOIL	60.0	ppm	
LRES07	6950	9900	KMTC	1-04	WATER	<0.1	mg/l	RAIN BARREL
P-01	12670	9230	KMTC	1-06	VEG	270.0	ppm	
P-07	12670	9410	KMTC	1-06	VEG	2600.0	ppm	
P-07	12670	9410	KMTC	1-06	SOIL	300.0	ppm	
P-07	12670	9410	KMTC	1-09	SOIL	170.0	ppm	
P-12	12670	0	KMTC	1-06	VEG	450.0	ppm	
P-13	12670	9600	KMTC	1-06	SOIL	50.0	ppm	
P-13	12670	9600	KMTC	1-06	VEG	2900.0	ppm	AVERAGE VALUE
P-13	12670	9600	KMTC	1-09	SOIL	290.0	ppm	
P-19	12670	9780	KMTC	1-06	SOIL	210.0	ppm	
P-19	12670	9600	ORNL	1-06	SOIL	28.7	ug/g	WET
P-19	12670	9600	ORNL	1-06	SOIL	32.8	ug/g	DRY
P-19	12670	9780	ORNL	1-06	VEG	2900.0	ug/g	
P-19A	12670	0	KMTC	1-06	VEG	450.0	ppm	
P-25	12670	9950	KMTC	1-06	VEG	320.0	ppm	
P-25	12670	9950	KMTC	1-06	SOIL	90.0	ppm	
P-25	12670	9780	ORNL	1-06	SOIL	14.2	ug/g	WET
P-25	12670	9780	ORNL	1-06	SOIL	21.0	ug/g	DRY
P-25	12670	9950	ORNL	1-06	VEG	280.0	ug/g	
PW 1632	13250	9400	KMTC	1-15	WATER	<0.1	mg/l	
R-01	11750	10700	OSDH	1-11	VEG	33.60	mg/kg	
R-01	11750	10700	OSDH	1-11	SOIL	3.32	mg/kg	
R-02	10800	10700	OSDH	1-11	VEG	84.00	mg/kg	
R-02	10800	10700	OSDH	1-11	SOIL	2.64	mg/kg	
R-03	10750	11550	OSDH	1-11	VEG	6.80	mg/kg	
R-03	10750	11550	OSDH	1-11	SOIL	4.00	mg/kg	
R-15	6050	13750	KMTC	1-04	VEG	32.0	ppm	
R-16	6050	13750	KMTC	1-04	SOIL	80.0	ppm	
RD-01	8150	10550	OSDH	1-16	VEG	40.00	mg/kg	
RD-01	8150	10550	OSDH	1-16	SOIL	5.20	mg/kg	
RD-02	7400	10750	OSDH	1-16	VEG	46.40	mg/kg	
RD-02	7400	10750	OSDH	1-16	SOIL	2.96	mg/kg	
RD-03	6700	10750	OSDH	1-16	VEG	53.60	mg/kg	
RD-03	6700	10750	OSDH	1-16	SOIL	0.48	mg/kg	
RD-03	6600	10800	OSDH	1-16	WATER	0.22	mg/l	
RD-04	6300	10750	OSDH	1-16	VEG	64.00	mg/kg	

Table 5.2.7.18A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
RD-04	6300	10750	OSDH	1-16	SOIL	8.80	mg/kg	
RD-04	6350	10750	OSDH	1-16	WATER	0.30	mg/l	
RD-05	6200	10850	OSDH	1-16	WATER	0.17	mg/l	
RD-06	6900	10200	OSDH	1-16	WATER	0.19	mg/l	
RD-07	10100	10700	OSDH	1-16	WATER	0.32	mg/l	
RD-08	9900	9450	OSDH	1-16	WATER	0.20	mg/l	
SM-20	7450	17250	KMTC	1-04	SOIL	40.0	ppm	
SM-21	7450	17250	KMTC	1-04	VEG	5.0	ppm	LEAVES
STRM GH	12650	9550	OSDH	1-16	WATER	7.00	mg/l	
T1-01	12500	7200	OSDH	1-05	SOIL	0.8	mg/kg	
T1-01	12500	7200	OSDH	1-05	VEG	1.2	mg/kg	EVERGREEN
T1-01	12500	7200	OSDH	1-14	VEG	3.68	mg/kg	
T1-01	12500	7200	ORNL	1-05	SOIL	3.1	ug/g	DRY
T1-01	12500	7200	ORNL	1-05	SOIL	2.3	ug/g	WET
T1-01	12500	7200	ORNL	1-05	VEG	1.7	ug/g	
T1-01	12500	7200	ORNL	1-05	VEG	1.7	ug/g	
T1-02	12500	8000	OSDH	1-05	SOIL	<0.4	mg/kg	
T1-02	12500	8000	OSDH	1-05	VEG	1.8	mg/kg	GRASS
T1-02	12500	8000	OSDH	1-14	SOIL	0.92	mg/kg	
T1-02	12500	8000	ORNL	1-05	SOIL	1.4	ug/g	DRY
T1-02	12500	8000	ORNL	1-05	SOIL	1.2	ug/g	WET
T1-02	12500	8000	ORNL	1-05	VEG	1.2	ug/g	
T1-03	12500	8550	OSDH	1-05	SOIL	1.3	mg/kg	
T1-03	12500	8550	OSDH	1-05	VEG	2.6	mg/kg	GRASS
T1-03	12500	8550	ORNL	1-05	SOIL	4.2	ug/g	DRY
T1-03	12500	8550	ORNL	1-05	SOIL	3.4	ug/g	WET
T1-03	12500	8550	ORNL	1-05	VEG	4.7	ug/g	
T1-03&4	12500	8750	OSDH	1-14	WATER	0.23	mg/l	
T1-04	12500	8900	OSDH	1-05	SOIL	0.9	mg/kg	
T1-04	12500	8900	OSDH	1-05	VEG	10.4	mg/kg	EVERGREEN
T1-04	12500	8900	OSDH	1-14	VEG	4.96	mg/kg	
T1-04	12500	8900	OSDH	1-14	SOIL	1.84	mg/kg	
T1-04	12500	8900	ORNL	1-05	SOIL	7.5	ug/g	DRY
T1-04	12500	8900	ORNL	1-05	SOIL	5.7	ug/g	WET
T1-04	12500	8900	ORNL	1-05	VEG	19.2	ug/g	
T1-05	12500	9200	OSDH	1-05	SOIL	4.8	mg/kg	
T1-05	12500	9200	OSDH	1-05	VEG	408.0	mg/kg	EVERGREEN
T1-05	12500	9200	OSDH	1-14	VEG	28.8	mg/kg	
T1-05	12500	9200	OSDH	1-14	SOIL	4.08	mg/kg	
T1-05	12500	9200	ORNL	1-05	SOIL	23.5	ug/g	DRY
T1-05	12500	9200	ORNL	1-05	SOIL	17.7	ug/g	WET
T1-05	12500	9200	ORNL	1-05	VEG	1800.0	ug/g	
T1-06	12500	9500	OSDH	1-05	SOIL	3.6	mg/kg	
T1-06	12500	9500	OSDH	1-05	VEG	500.0	mg/kg	GRASS

Table 5.2.7.18A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
T1-06	12500	9500	OSDH	1-14	VEG	1320.0	mg/kg	
T1-06	12500	9500	OSDH	1-14	SOIL	3.64	mg/kg	
T1-06	12500	9500	OSDH	1-14	WATER	1.80	mg/l	
T1-06	12500	9500	ORNL	1-05	SOIL	22.5	ug/g	WET
T1-06	12500	9500	ORNL	1-05	SOIL	26.3	ug/g	DRY
T1-06	12500	9500	ORNL	1-05	VEG	930.0	ug/g	
T1-07	12500	9850	OSDH	1-05	SOIL	2.0	mg/kg	
T1-07	12500	9850	OSDH	1-05	VEG	216.0	mg/kg	GRASS
T1-07	12500	9850	OSDH	1-14	VEG	240.0	mg/kg	
T1-07	12500	9850	OSDH	1-14	SOIL	3.00	mg/kg	
T1-07	12500	9850	ORNL	1-05	SOIL	12.2	ug/g	WET
T1-07	12500	9850	ORNL	1-05	SOIL	22.8	ug/g	DRY
T1-07	12500	9850	ORNL	1-05	VEG	750.0	ug/g	
T1-08	12600	10200	OSDH	1-05	SOIL	0.8	mg/kg	
T1-08	12600	10200	OSDH	1-05	VEG	55.0	mg/kg	GRASS
T1-08	12600	10200	OSDH	1-14	VEG	20.0	mg/kg	
T1-08	12600	10200	OSDH	1-14	SOIL	2.20	mg/kg	
T1-08	12600	10200	ORNL	1-05	SOIL	6.6	ug/g	DRY
T1-08	12600	10200	ORNL	1-05	SOIL	5.1	ug/g	WET
T1-08	12600	10200	ORNL	1-05	VEG	44.6	ug/g	
T1-09	12600	10600	OSDH	1-05	SOIL	0.6	mg/kg	
T1-09	12600	10600	OSDH	1-05	VEG	20.0	mg/kg	GRASS
T1-09	12600	10600	OSDH	1-14	VEG	17.6	mg/kg	
T1-09	12600	10600	OSDH	1-14	SOIL	1.96	mg/kg	
T1-09	12600	10600	ORNL	1-05	SOIL	2.1	ug/g	DRY
T1-09	12600	10600	ORNL	1-05	SOIL	1.7	ug/g	WET
T1-09	12600	10600	ORNL	1-05	VEG	17.5	ug/g	
T1-10	12750	11100	OSDH	1-05	WATER	0.2	mg/l	
T1-10	12750	11100	ORNL	1-05	WATER	0.21	ug/ml	
T1-10	12750	11100	ORNL	1-05	WATER	0.19	ug/ml	
T1-11	12600	11300	OSDH	1-05	SOIL	1.0	mg/kg	
T1-11	12600	11300	OSDH	1-05	VEG	11.3	mg/kg	GRASS
T1-11	12600	11300	ORNL	1-05	SOIL	7.6	ug/g	DRY
T1-11	12600	11300	ORNL	1-05	SOIL	4.6	ug/g	WET
T1-11	12600	11300	ORNL	1-05	VEG	8.8	ug/g	
T1-12	12550	11900	OSDH	1-05	SOIL	0.8	mg/kg	
T1-12	12550	11900	OSDH	1-05	VEG	9.9	mg/kg	EVERGREEN
T1-12	12550	11900	OSDH	1-14	VEG	7.36	mg/kg	
T1-12	12550	11900	OSDH	1-14	SOIL	3.76	mg/kg	
T1-12	12550	11900	ORNL	1-05	SOIL	2.4	ug/g	DRY
T1-12	12550	11900	ORNL	1-05	SOIL	1.4	ug/g	WET
T1-12	12550	11900	ORNL	1-05	VEG	10.2	ug/g	
T1-13	12650	13200	OSDH	1-14	VEG	2.56	mg/kg	
T1-13	12650	13200	OSDH	1-14	SOIL	0.48	mg/kg	
T1-13	12200	13150	OSDH	1-14	WATER	0.41	mg/l	
T1-14	13200	14100	OSDH	1-14	VEG	5.92	mg/kg	
T1-14	13200	14100	OSDH	1-14	SOIL	0.96	mg/kg	
T1-14	13250	14000	OSDH	1-14	WATER	0.29	mg/l	

Table 5.2.7.18A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
T2-01	10750	6200	ORNL	1-05	SOIL	1.1	ug/g	DRY
T2-01	10750	6200	ORNL	1-05	SOIL	0.9	ug/g	WET
T2-01	10750	6200	ORNL	1-05	VEG	4.7	ug/g	
T2-01	10750	6200	OSDH	1-05	SOIL	<0.4	mg/kg	
T2-01	10750	6200	OSDH	1-05	VEG	4.0	mg/kg	
T2-02	10550	6800	ORNL	1-05	SOIL	2.9	ug/g	DRY
T2-02	10550	6800	ORNL	1-05	SOIL	2.5	ug/g	WET
T2-02	10550	6800	OSDH	1-14	SOIL	1.0	mg/kg	
T2-02	10550	6800	OSDH	1-05	SOIL	0.48	mg/kg	
T2-02	10550	6800	OSDH	1-14	VEG	2.16	mg/kg	
T2-03	10650	7550	OSDH	1-05	VEG	1.6	mg/kg	
T2-03	10650	7550	ORNL	1-05	VEG	5.2	ug/g	
T2-03	10650	7550	ORNL	1-05	SOIL	I	ug/g	WET
T2-03	10650	7550	ORNL	1-05	SOIL	I	ug/g	DRY
T2-03	10650	7550	OSDH	1-14	SOIL	1.2	mg/kg	
T2-03	10650	7550	OSDH	1-05	SOIL	1.6	mg/kg	
T2-03	10650	7550	OSDH	1-14	VEG	3.12	mg/kg	
T2-04	10350	8400	ORNL	1-05	WATER	0.15	ug/ml	
T2-04	10700	8400	ORNL	1-05	SOIL	15.1	ug/g	DRY
T2-04	10700	8400	ORNL	1-05	SOIL	13.9	ug/g	WET
T2-04	10700	8400	OSDH	1-14	SOIL	0.76	mg/kg	
T2-04	10700	8400	OSDH	1-05	SOIL	1.96	mg/kg	
T2-04	10700	8400	OSDH	1-14	VEG	4.72	mg/kg	
T2-04	10350	8650	OSDH	1-14	WATER	0.36	mg/l	
T2-04	10350	8400	OSDH	1-05	WATER	0.26	mg/l	
T2-05	10800	9300	ORNL	1-05	SOIL	1.4	ug/g	DRY
T2-05	10800	9300	ORNL	1-05	SOIL	1.2	ug/g	WET
T2-05	10800	9300	ORNL	1-05	VEG	250.0	ug/g	
T2-05	10800	9300	OSDH	1-14	SOIL	0.8	mg/kg	
T2-05	10800	9300	OSDH	1-05	SOIL	0.4	mg/kg	
T2-05	10800	9300	OSDH	1-14	VEG	21.6	mg/kg	
T2-05	10800	9300	OSDH	1-05	VEG	91.3	mg/kg	
T2-06	11450	9950	ORNL	1-05	WATER	0.46	ug/ml	
T2-06	11450	9950	ORNL	1-05	SOIL	21.4	ug/g	DRY
T2-06	11450	9950	ORNL	1-05	SOIL	20.2	ug/g	WET
T2-06	11450	9950	ORNL	1-05	VEG	290.0	ug/g	
T2-06	11500	9850	OSDH	1-14	SOIL	1.4	mg/kg	
T2-06	11500	9850	OSDH	1-06	SOIL	1.12	mg/kg	
T2-06	11500	9850	OSDH	1-14	VEG	584.0	mg/kg	
T2-06	11500	9850	OSDH	1-06	VEG	122.2	mg/kg	
T2-06	11500	9950	OSDH	1-06	WATER	0.37	mg/l	
T2-07	11700	11100	ORNL	1-06	WATER	0.09	ug/ml	
T2-07	11500	10650	ORNL	1-06	SOIL	14.9	ug/g	DRY
T2-07	11500	10650	ORNL	1-06	SOIL	14.3	ug/g	WET
T2-07	11500	10650	OSDH	1-14	SOIL	0.92	mg/kg	
T2-07	11500	10650	OSDH	1-06	SOIL	6.72	mg/kg	

Table 5.2.7.18A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
T2-07	11500	10650	OSDH	1-14	VEG	22.4	mg/kg	
T2-07	11500	10650	OSDH	1-05	WATER	0.23	mg/l	
T2-08	11500	11650	OSDH	1-06	VEG	3.1	mg/kg	
T2-08	11500	11650	OSDH	1-16	WATER	0.17	mg/l	
T2-08	11500	11650	ORNL	1-06	SOIL	13.9	ug/g	DRY
T2-08	11500	11650	ORNL	1-06	SOIL	10.2	ug/g	WET
T2-08	11500	11650	ORNL	1-06	VEG	2.3	ug/g	
T2-08	11500	11650	OSDH	1-14	SOIL	11.2	mg/kg	
T2-08	11500	11650	OSDH	1-06	SOIL	3.12	mg/kg	
T2-08	11500	11650	OSDH	1-14	VEG	18.8	mg/kg	
T2-09	11350	12700	OSDH	1-06	VEG	<0.8	mg/kg	
T2-09	11350	12700	ORNL	1-06	SOIL	0.6	ug/g	DRY
T2-09	11350	12700	ORNL	1-06	SOIL	0.5	ug/g	WET
T2-09	11350	12700	ORNL	1-06	VEG	2.3	ug/g	
T2-09	11350	12700	OSDH	1-06	SOIL	<0.8	mg/kg	
T2-10	11400	13700	OSDH	1-06	VEG	1.6	mg/kg	
T2-10	11400	13700	OSDH	1-16	WATER	0.16	mg/l	
T2-10	11400	13700	ORNL	1-06	SOIL	4.1	ug/g	WET
T2-10	11400	13700	ORNL	1-06	SOIL	6.5	ug/g	DRY
T2-10	11400	13700	ORNL	1-06	VEG	2.7	ug/g	
T2-10	11400	13700	OSDH	1-14	SOIL	1.32	mg/kg	
T2-10	11400	13700	OSDH	1-06	SOIL	1.6	mg/kg	
T2-10	11400	13700	OSDH	1-14	VEG	5.52	mg/kg	
T3-01	8300	6250	OSDH	1-06	SOIL	0.8	mg/kg	
T3-01	8300	6250	OSDH	1-06	VEG	4	mg/kg	EVERGREEN
T3-01	8300	6250	OSDH	1-14	VEG	2.48	mg/kg	
T3-01	8300	6250	OSDH	1-14	SOIL	1.32	mg/kg	
T3-01	8300	6250	ORNL	1-06	SOIL	1.1	ug/g	DRY
T3-01	8300	6250	ORNL	1-06	SOIL	0.9	ug/g	WET
T3-01	8300	6250	ORNL	1-06	VEG	4.7	ug/g	
T3-02	8600	6950	OSDH	1-06	SOIL	1.2	mg/kg	
T3-02	8600	6950	OSDH	1-06	VEG	2.4e	mg/kg	EVERGREEN
T3-02	8600	6950	ORNL	1-06	SOIL	3.4	ug/g	DRY
T3-02	8600	6950	ORNL	1-06	SOIL	2.9	ug/g	WET
T3-02	8600	6950	ORNL	1-06	VEG	3.0	ug/g	
T3-02A	8250	8750	OSDH	1-16	VEG	1.76	mg/kg	
T3-02A	8250	8750	OSDH	1-16	SOIL	3.00	mg/kg	
T3-03	8650	9000	OSDH	1-06	SOIL	2.5	mg/kg	
T3-03	8650	9000	OSDH	1-06	VEG	8.8	mg/kg	EVERGREEN
T3-03	8650	9000	OSDH	1-14	VEG	9.28	mg/kg	
T3-03	8650	9000	OSDH	1-14	SOIL	2.36	mg/kg	
T3-03	8650	9000	ORNL	1-06	SOIL	3.2	ug/g	DRY
T3-03	8650	9000	ORNL	1-06	SOIL	2.8	ug/g	WET
T3-03	8650	9000	ORNL	1-06	VEG	7.2	ug/g	
T3-03A	8500	9550	OSDH	1-16	VEG	5.92	mg/kg	
T3-03A	8500	9550	OSDH	1-16	SOIL	21.60	mg/kg	
T3-03B	8300	9950	OSDH	1-16	VEG	41.60	mg/kg	

Table 5.2.7.18A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
T3-03B	8300	9950	OSDH	1-16	SOIL	5.56	mg/kg	
T3-03C	8800	10050	OSDH	1-16	VEG	13.68	mg/kg	
T3-03C	8800	10050	OSDH	1-16	SOIL	<0.40	mg/kg	
T3-04	8350	10300	OSDH	1-06	SOIL	<0.8	mg/kg	
T3-04	8350	10300	OSDH	1-06	VEG	102.0	mg/kg	EVRGRN/LEAVES
T3-04	8350	10300	OSDH	1-14	VEG	4.00	mg/kg	
T3-04	8350	10300	OSDH	1-14	SOIL	0.52	mg/kg	
T3-04	8350	10700	OSDH	1-16	VEG	73.60	mg/kg	
T3-04	8350	10300	ORNL	1-06	SOIL	1.4	ug/g	DRY
T3-04	8350	10300	ORNL	1-06	SOIL	1.3	ug/g	WET
T3-04	8350	10300	ORNL	1-06	VEG	420.0	ug/g	
T3-04A	8350	10700	OSDH	1-16	SOIL	8.80	mg/kg	
T3-04A	8150	10800	OSDH	1-16	WATER	0.12	mg/l	
T3-04B	8350	11000	OSDH	1-16	VEG	72.00	mg/kg	
T3-04B	8350	11000	OSDH	1-16	SOIL	1.68	mg/kg	
T3-05	8350	11200	OSDH	1-06	SOIL	1.2	mg/kg	
T3-05	8350	11200	OSDH	1-06	VEG	93.0	mg/kg	EVERGREEN
T3-05	8350	11200	OSDH	1-14	VEG	30.4	mg/kg	
T3-05	8350	11200	OSDH	1-14	SOIL	0.84	mg/kg	
T3-05	8350	11200	ORNL	1-06	SOIL	2.2	ug/g	DRY
T3-05	8350	11200	ORNL	1-06	SOIL	1.6	ug/g	WET
T3-05	8350	11200	ORNL	1-06	VEG	67.0	ug/g	
T3-06	8400	12050	OSDH	1-06	SOIL	1.4	mg/kg	
T3-06	8400	12050	OSDH	1-06	VEG	5.8	mg/kg	EVERGREEN
T3-06	8400	12050	OSDH	1-14	VEG	5.84	mg/kg	
T3-06	8400	12050	OSDH	1-14	SOIL	0.76	mg/kg	
T3-06	8400	12050	ORNL	1-06	SOIL	2.1	ug/g	DRY
T3-06	8400	12050	ORNL	1-06	SOIL	1.7	ug/g	WET
T3-06	8400	12050	ORNL	1-06	VEG	7.0	ug/g	
T3-07	8550	13050	OSDH	1-06	SOIL	<0.8	mg/kg	
T3-07	8550	13050	OSDH	1-06	VEG	4.2	mg/kg	GRASS
T3-07	8550	13050	OSDH	1-14	VEG	8.48	mg/kg	
T3-07	8550	13050	OSDH	1-14	SOIL	0.64	mg/kg	
T3-07	8550	13050	ORNL	1-06	SOIL	2.0	ug/g	DRY
T3-07	8550	13050	ORNL	1-06	SOIL	1.4	ug/g	WET
T3-07	8550	13050	ORNL	1-06	VEG	3.6	ug/g	
T5-01	17700	8700	OSDH	1-15	VEG	5.92	mg/kg	
T5-01	17700	8700	OSDH	1-15	SOIL	1.84	mg/kg	
T5-01	17700	8700	OSDH	1-08	SOIL	0.68	mg/kg	
T5-01	17700	8700	OSDH	1-08	VEG	2.48	mg/kg	
T5-02	16500	10000	OSDH	1-08	VEG	4.56	mg/kg	
T5-02	16500	10000	OSDH	1-08	VEG	1.76	mg/kg	
T5-03	16300	10350	OSDH	1-08	SOIL	<0.4	mg/kg	
T5-03	16300	10350	OSDH	1-08	VEG	3.6	mg/kg	
T5-04	15500	8500	OSDH	1-08	VEG	2.56	mg/kg	
T5-04	1550	8500	OSDH	1-08	WATER	0.32	mg/l	
T6-01	13950	7700	OSDH	1-08	SOIL	3.56	mg/kg	
T6-01	13950	7700	OSDH	1-08	VEG	28.8	mg/kg	

Table 5.2.7.18A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR FLUORIDE SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
T6-02	13900	8400	OSDH	1-08	SOIL	9.0	mg/kg	
T6-02	13900	8400	OSDH	1-08	VEG	48.0	mg/kg	
T6-03	14650	8300	OSDH	1-08	SOIL	2.28	mg/kg	
T6-03	14650	8300	OSDH	1-08	VEG	10.48	mg/kg	
T6-04	14650	8700	OSDH	1-08	SOIL	1.8	mg/kg	
T6-05	14450	9550	OSDH	1-08	VEG	15.84	mg/kg	

Table 5.2.7.19A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
1W	14500	14800	KMTC	1-06	WATER	0.11	mg/l	
2W	13250	13950	KMTC	1-06	WATER	0.23	mg/l	
3W	12750	11200	KMTC	1-06	WATER	0.19	mg/l	
4W	11700	11150	KMTC	1-06	WATER	<0.002	mg/l	
5W	10100	10950	KMTC	1-06	WATER	0.011	mg/l	
6W	9850	9450	KMTC	1-06	WATER	<0.002	mg/l	
7W	10600	7000	KMTC	1-06	WATER	0.32	mg/l	
8W	11800	7000	KMTC	1-06	WATER	0.6	mg/l	
10W	11800	6200	KMTC	1-06	WATER	<0.002	mg/l	
11W	16350	9450	KMTC	1-06	WATER	<0.002	mg/l	
12W	6750	11050	KMTC	1-06	WATER	0.003	mg/l	
13W	7475	13350	KMTC	1-06	WATER	<0.002	mg/l	
14W	18450	6950	KMTC	1-06	WATER	<0.002	mg/l	
14W	18450	6950	KMTC	1-08	WATER	0.003	mg/l	
15W	12900	5950	KMTC	1-06	WATER	0.018	mg/l	
15W	12900	5950	KMTC	1-08	WATER	0.013	mg/l	
17W	7650	4350	KMTC	1-06	WATER	0.006	mg/l	
18W	15100	10300	KMTC	1-08	WATER	0.002	mg/l	
19W	6850	9050	KMTC	1-08	WATER	0.004	mg/l	
20W	7750	17000	KMTC	1-08	WATER	<0.002	mg/l	
103	13800	10200	KMTC	1-09	SOIL	20.0	ppm	
105	11700	8450	KMTC	1-09	VEG	5.3	ppm	
106	11700	8450	KMTC	1-09	SOIL	<10	ppm	
108	10600	8750	KMTC	1-09	VEG	5.2	ppm	
109	10600	8750	KMTC	1-09	SOIL	<10	ppm	
111	14250	8450	KMTC	1-09	VEG	120.0	ppm	
112	14250	8450	KMTC	1-09	SOIL	290.0	ppm	
115	11500	11600	KMTC	1-09	SOIL	<10	ppm	
116	10650	12300	KMTC	1-09	VEG	9.2	ppm	
117	10650	12300	KMTC	1-09	SOIL	20.0	ppm	
118	9750	12450	KMTC	1-09	VEG	2.7	ppm	
119	9750	12450	KMTC	1-09	SOIL	20.0	ppm	
120	9700	8850	KMTC	1-09	VEG	7.7	ppm	
121	9700	8850	KMTC	1-09	SOIL	20.0	ppm	
122	9600	9900	KMTC	1-09	VEG	480.0	ppm	
123	9600	9900	KMTC	1-09	SOIL	25.0	ppm	
124	9700	10700	KMTC	1-09	VEG	110.0	ppm	
125	9700	10700	KMTC	1-09	SOIL	20.0	ppm	
126	9750	11850	KMTC	1-09	VEG	4.6	ppm	
127	9750	11850	KMTC	1-09	SOIL	<10	ppm	
128	10650	11300	KMTC	1-09	VEG	22.0	ppm	
129	10650	11300	KMTC	1-09	SOIL	<10	ppm	
130	10650	10350	KMTC	1-09	VEG	71.0	ppm	
131	10650	10350	KMTC	1-09	SOIL	30.0	ppm	
132	11600	10650	KMTC	1-09	VEG	25.0	ppm	
133	11600	10650	KMTC	1-09	SOIL	15.0	ppm	
134	9250	13150	KMTC	1-09	VEG	5.4	ppm	
135	9250	13150	KMTC	1-09	SOIL	<10	ppm	

Table 5.2.7.19A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR URANIUM SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
136	9150	12050	KMTC	1-09	VEG	7.2	ppm	
137	9150	12050	KMTC	1-09	SOIL	<10	ppm	
138	9200	11000	KMTC	1-09	VEG	69.0	ppm	
139	9200	11000	KMTC	1-09	SOIL	<10	ppm	
141	9300	10100	KMTC	1-09	SOIL	15.0	ppm	
142	9150	9000	KMTC	1-09	VEG	3.2	ppm	
143	9150	9000	KMTC	1-09	SOIL	<10	ppm	
144	10500	9700	KMTC	1-09	VEG	92.0	ppm	
145	10500	9700	KMTC	1-09	SOIL	30.0	ppm	
146	11600	9550	KMTC	1-09	VEG	130.0	ppm	
147	11600	9550	KMTC	1-09	SOIL	35.0	ppm	
149	11650	9900	KMTC	1-09	SOIL	95.0	ppm	
150	11450	9700	KMTC	1-09	VEG	1400.0	ppm	
187	12600	7200	KMTC	1-14	SOIL	20.0	ppm	
190	14750	9500	KMTC	1-14	SOIL	50.0	ppm	
193	12550	10200	KMTC	1-14	SOIL	30.0	ppm	
196	12600	10750	KMTC	1-14	SOIL	20.0	ppm	
198	12550	11850	KMTC	1-14	VEG	2.6	ppm	
199	12550	11850	KMTC	1-14	SOIL	10.0	ppm	
201	13150	10200	KMTC	1-14	VEG	9.1	ppm	
202	13150	10200	KMTC	1-14	SOIL	30.0	ppm	
204	13150	11250	KMTC	1-14	VEG	1.6	ppm	
205	13150	11250	KMTC	1-14	SOIL	<10	ppm	
208	12500	9900	KMTC	1-14	VEG	540.0	ppm	
209	12500	9900	KMTC	1-14	SOIL	140.0	ppm	
211	12500	9700	KMTC	1-14	VEG	360.0	ppm	
214	12500	9500	KMTC	1-14	VEG	1530.0	ppm	
218	12500	9350	KMTC	1-14	SOIL	220.0	ppm	
221	12500	9100	KMTC	1-14	SOIL	40.0	ppm	
300	12450	9900	KMTC	1-06	WATER	0.042	mg/l	
301	12450	9900	KMTC	1-14	WATER	0.017	mg/l	
302	12550	9550	KMTC	1-06	WATER	0.94	mg/l	
303	12550	9550	KMTC	1-14	WATER	1.1	mg/l	
304	12550	9400	KMTC	1-06	WATER	1.2	mg/l	
305	12550	9400	KMTC	1-14	WATER	2.6	mg/l	
306	11450	9550	KMTC	1-14	WATER	0.25	mg/l	
306	11450	9550	KMTC	1-06	WATER	0.25	mg/l	
307	11450	9550	KMTC	1-14	WATER	0.21	mg/l	
50	10750	10100	KMTC	1-06	VEG	17000.0	ppm	
A-01	13130	9220	KMTC	1-06	VEG	4200.0	ppm	
A-01	13130	9220	KMTC	1-06	SOIL	2180.0	ppm	
A-07	13130	9400	KMTC	1-06	VEG	8000.0	ppm	
A-07	13130	9400	KMTC	1-09	SOIL	590.0	ppm	
A-07	13130	9400	KMTC	1-06	SOIL	730.0	ppm	
A-13	13130	9580	KMTC	1-06	SOIL	655.0	ppm	
A-13	13130	9580	KMTC	1-06	VEG	6200.0	ppm	
A-13	13130	9580	KMTC	1-09	SOIL	200.0	ppm	
A-19	13130	9760	KMTC	1-06	VEG	7150.0	ppm	

Table 5.2.7.19A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
A-25	13130	9950	KMTC	1-06	VEG	49.0	ppm	
A-25	13130	9950	KMTC	1-06	SOIL	25.0	ppm	
A-25	13130	9760	ORNL	1-06	SOIL	10.5	ppm	WET
A-25	13130	9760	ORNL	1-06	SOIL	13.2	ppm	DRY
A-25	13130	9950	ORNL	1-06	VEG	11.8	ppm	
BG 1/4	14750	9500	ORNL	1-06	VEG	3.91	ppm	
BG 1/4	14750	9500	ORNL	1-06	SOIL	6.1	ppm	WET
BG 1/4	14750	9500	ORNL	1-06	SOIL	7.88	ppm	DRY
BG 1/4	14750	9500	KMTC	1-06	VEG	64.0	ppm	
BG 1/4	14750	9500	KMTC	1-06	SOIL	<10	ppm	
CARLILE	14250	15100	ORNL	1-05	SOIL	2.7	ppm	WET
CARLILE	14250	15100	ORNL	1-05	SOIL	3.7	ppm	DRY
CARLILE	14250	15100	ORNL	1-05	VEG	0.188	ppm	
COMB ST	12600	8650	KMTC	1-07	WATER	0.29	mg/l	
COMB ST	12600	8650	KMTC	1-06	WATER	0.95	mg/l	
COMB ST	12600	8650	KMTC	1-05	WATER	0.36	mg/l	
COMB ST	12600	8650	KMTC	1-04	WATER	0.36	mg/l	
COMB ST	12600	8650	KMTC	1-03	WATER	0.61	mg/l	
COMB ST	12600	8650	KMTC	1-02	WATER	0.57	mg/l	
COMB ST	12600	8650	KMTC	1-01	WATER	0.43	mg/l	
CRES	6150	10800	ORNL	1-05	WATER	0.05	ug/ml	
CRES	6150	10750	ORNL	1-05	SOIL	2.9	ppm	DRY
CRES	6150	10750	ORNL	1-05	SOIL	2.0	ppm	WET
CRES	6150	10800	ORNL	1-05	VEG	13.8	ppm	
CRES08	6150	10750	KMTC	1-04	VEG	12.0	ppm	
CRES09	6150	10750	KMTC	1-04	S-V	<10	ppm	
CRES10	6150	10750	KMTC	1-04	SOIL	<10	ppm	
DRES11	6100	11100	KMTC	1-04	SOIL	15.0	ppm	
DRES12	6100	11100	KMTC	1-04	VEG	220.0	ppm	
DRES13	6100	11100	KMTC	1-04	SOIL	13.0	ppm	
E-01	13000	9230	KMTC	1-06	VEG	1340.0	ppm	
E-01	13000	9230	KMTC	1-06	SOIL	210.0	ppm	
E-01	13000	9230	KMTC	1-09	SOIL	300.0	ppm	
E-07	13000	9410	KMTC	1-06	VEG	14200.0	ppm	
E-07	13000	9410	KMTC	1-06	SOIL	465.0	ppm	
E-07	13000	9410	KMTC	1-09	SOIL	380.0	ppm	
E-13	13000	9600	KMTC	1-06	VEG	7420.0	ppm	
E-13	13000	9600	KMTC	1-06	SOIL	130.0	ppm	
E-13	13000	9600	KMTC	1-09	SOIL	130.0	ppm	
E-19	13000	9770	KMTC	1-06	SOIL	15.0	ppm	
E-19	13000	9770	KMTC	1-06	VEG	21600.0	ppm	
E-25	13000	9950	KMTC	1-06	VEG	40.0	ppm	
E-25	13000	9950	KMTC	1-06	SOIL	20.0	ppm	
E-25	13000	9950	ORNL	1-06	SOIL	8.9	ppm	WET
E-25	13000	9950	ORNL	1-06	SOIL	10.3	ppm	DRY
E-25	13000	9950	ORNL	1-06	VEG	24.2	ppm	
HRES01	6950	10650	KMTC	1-04	SOIL	<10	ppm	
HRES02	6950	10650	KMTC	1-04	VEG	32.0	ppm	

Table 5.2.7.19A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR URANIUM SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
HRES03	6950	10650	KMTC	1-04	VEG	0.95	ppm	
J-07	12840	9410	KMTC	1-06	VEG	1520.0	ppm	
J-07	12840	9410	KMTC	1-06	SOIL	125.0	ppm	
J-07	12840	9410	KMTC	1-09	SOIL	250.0	ppm	
J-13	12840	9600	KMTC	1-06	SOIL	200.0	ppm	
J-13	12840	9600	KMTC	1-06	VEG	6640.0	ppm	
J-13	12840	9600	KMTC	1-09	SOIL	125.0	ppm	
J-19	12840	9780	KMTC	1-06	VEG	3220.0	ppm	
J-19	12840	9780	KMTC	1-06	SOIL	165.0	ppm	
J-25	12840	9950	KMTC	1-06	VEG	210.0	ppm	
J-25	12840	9950	KMTC	1-06	SOIL	20.0	ppm	
J-25	12840	9950	ORNL	1-06	SOIL	9.8	ppm	WET
J-25	12840	9950	ORNL	1-06	SOIL	13.1	ppm	DRY
J-25	12840	9950	ORNL	1-06	VEG	148.0	ppm	
LAGOON	12800	9200	KMTC	1-17	WATER	I	mg/l	
LRES04	6950	9900	KMTC	1-04	VEG	<0.4	ppm	
LRES05	6950	9900	KMTC	1-04	SOIL	<10	ppm	
LRES06	6950	9900	KMTC	1-04	SOIL	<10	ppm	
LRES07	6950	9900	KMTC	1-04	WATER	<0.002	mg/l	FRONT PORCH
P-01	12670	9230	KMTC	1-06	VEG	5300.0	ppm	
P-07	12670	9410	KMTC	1-06	VEG	4480.0	ppm	
P-07	12670	9410	KMTC	1-06	SOIL	235.0	ppm	
P-07	12670	9410	KMTC	1-09	SOIL	90.0	ppm	
P-12	12670	0	KMTC	1-06	VEG	5940.0	ppm	
P-13	12670	9600	KMTC	1-06	VEG	3800.0	ppm	
P-13	12670	9600	KMTC	1-06	SOIL	55.0	ppm	
P-13	12670	9600	KMTC	1-09	SOIL	175.0	ppm	
P-19	12670	9780	KMTC	1-06	SOIL	90.0	ppm	
P-19	12670	9600	ORNL	1-06	SOIL	135.0	ppm	WET
P-19	12670	9600	ORNL	1-06	SOIL	154.0	ppm	DRY
P-19	12670	9780	ORNL	1-06	VEG	3600.0	ppm	
P-25	12670	9950	KMTC	1-06	VEG	360.0	ppm	
P-25	12670	9950	KMTC	1-06	SOIL	40.0	ppm	
P-25	12670	9780	ORNL	1-06	SOIL	19.2	ppm	WET
P-25	12670	9780	ORNL	1-06	SOIL	28.4	ppm	DRY
P-25	12670	9950	ORNL	1-06	VEG	186.0	ppm	
PW 1632	13250	9400	KMTC	1-15	WATER	<0.002	mg/l	
R-15	6050	13750	KMTC	1-04	VEG	0.6	ppm	
R-16	6050	13750	KMTC	1-04	SOIL	<10	ppm	
SM-20	7450	17250	KMTC	1-04	SOIL	11.0	ppm	
SM-21	7450	17250	KMTC	1-04	VEG	0.6	ppm	
T1-01	12500	7200	ORNL	1-05	SOIL	4.6	ppm	WET
T1-01	12500	7200	ORNL	1-05	SOIL	6.2	ppm	DRY
T1-02	12500	8000	ORNL	1-05	SOIL	5.7	ppm	DRY
T1-02	12500	8000	ORNL	1-05	SOIL	4.5	ppm	WET
T1-03	12500	8550	ORNL	1-05	SOIL	5.7	ppm	WET

Table 5.2.7.19A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR URANIUM SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
T1-03	12500	8550	ORNL	1-05	SOIL	7.0	ppm	DRY
T1-04	12500	8900	ORNL	1-05	SOIL	13.0	ppm	WET
T1-04	12500	8900	ORNL	1-05	SOIL	17.3	ppm	DRY
T1-05	12500	9200	ORNL	1-05	SOIL	34.0	ppm	WET
T1-05	12500	9200	ORNL	1-05	SOIL	45.1	ppm	DRY
T1-06	12500	9500	ORNL	1-05	SOIL	90.7	ppm	DRY
T1-06	12500	9500	ORNL	1-05	SOIL	77.6	ppm	WET
T1-07	12500	9850	ORNL	1-05	SOIL	33.7	ppm	WET
T1-07	12500	9850	ORNL	1-05	SOIL	62.7	ppm	DRY
T1-08	12600	10200	ORNL	1-05	SOIL	7.3	ppm	DRY
T1-08	12600	10200	ORNL	1-05	SOIL	5.7	ppm	WET
T1-09	12600	10600	ORNL	1-05	SOIL	4.5	ppm	DRY
T1-09	12600	10600	ORNL	1-05	SOIL	3.6	ppm	WET
T1-10	12750	11100	ORNL	1-05	WATER	0.15	ug/ml	
T1-10	12750	11100	ORNL	1-05	WATER	0.026	ug/ml	
T1-11	12600	11300	ORNL	1-05	SOIL	6.0	ppm	DRY
T1-11	12600	11300	ORNL	1-05	SOIL	3.7	ppm	WET
T1-12	12550	11900	ORNL	1-05	SOIL	6.0	ppm	DRY
T1-12	12550	11900	ORNL	1-05	SOIL	3.5	ppm	WET
T2-01	10750	6200	ORNL	1-05	SOIL	2.9	ppm	WET
T2-01	10750	6200	ORNL	1-05	SOIL	3.5	ppm	DRY
T2-02	10550	6800	ORNL	1-05	SOIL	2.6	ppm	DRY
T2-02	10550	6800	ORNL	1-05	SOIL	2.2	ppm	WET
T2-03	10650	7550	ORNL	1-05	SOIL	3.2	ppm	WET
T2-03	10650	7550	ORNL	1-05	SOIL	3.9	ppm	DRY
T2-04	10350	8400	ORNL	1-05	WATER	0.003	ug/ml	
T2-04	10700	8400	ORNL	1-05	SOIL	4.1	ppm	DRY
T2-04	10700	8400	ORNL	1-05	SOIL	3.2	ppm	WET
T2-05	10800	9300	ORNL	1-05	SOIL	4.5	ppm	DRY
T2-05	10800	9300	ORNL	1-05	SOIL	3.9	ppm	WET
T2-05	10800	9300	ORNL	1-05	VEG	393.0	ppm	
T2-06	11450	9950	ORNL	1-05	WATER	0.27	ug/ml	
T2-06	11450	9950	ORNL	1-05	SOIL	25.9	ppm	DRY
T2-06	11450	9950	ORNL	1-05	SOIL	24.4	ppm	WET
T2-06	11450	9950	ORNL	1-05	VEG	285.0	ppm	
T2-07	11700	11100	ORNL	1-06	WATER	0.03	ug/ml	
T2-07	11500	10650	ORNL	1-06	SOIL	5.23	ppm	DRY
T2-07	11500	10650	ORNL	1-06	SOIL	5.0	ppm	WET
T2-08	11500	11650	ORNL	1-06	SOIL	5.21	ppm	DRY
T2-08	11500	11650	ORNL	1-06	SOIL	3.8	ppm	WET
T2-08	11500	11650	ORNL	1-06	VEG	0.633	ppm	
T2-09	11350	12700	ORNL	1-06	SOIL	3.95	ppm	DRY
T2-09	11350	12700	ORNL	1-06	SOIL	3.0	ppm	WET
T2-09	11350	12700	ORNL	1-06	VEG	1.53	ppm	
T2-10	11400	13700	ORNL	1-06	SOIL	2.4	ppm	WET
T2-10	11400	13700	ORNL	1-06	SOIL	3.86	ppm	DRY
T2-10	11400	13700	ORNL	1-06	VEG	0.596	ppm	
T3-01	8300	6250	ORNL	1-06	SOIL	4.34	ppm	DRY

Table 5.2.7.19A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR URANIUM SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
T3-01	8300	6250	ORNL	1-06	SOIL	3.3	ppm	WET
T3-01	8300	6250	ORNL	1-06	VEG	5.03	ppm	
T3-02	8600	6950	ORNL	1-06	SOIL	3.86	ppm	DRY
T3-02	8600	6950	ORNL	1-06	SOIL	3.3	ppm	WET
T3-02	8600	6950	ORNL	1-06	VEG	3.21	ppm	
T3-03	8650	9000	ORNL	1-06	SOIL	5.34	ppm	DRY
T3-03	8650	9000	ORNL	1-06	SOIL	4.7	ppm	WET
T3-03	8650	9000	ORNL	1-06	VEG	3.39	ppm	
T3-04	8350	10300	ORNL	1-06	SOIL	4.28	ppm	DRY
T3-04	8350	10300	ORNL	1-06	SOIL	3.9	ppm	WET
T3-04	8350	10300	ORNL	1-06	VEG	624.0	ppm	
T3-05	8350	11200	ORNL	1-06	SOIL	4.0	ppm	DRY
T3-05	8350	11200	ORNL	1-06	SOIL	3.0	ppm	WET
T3-05	8350	11200	ORNL	1-06	VEG	177.0	ppm	
T3-06	8400	12050	ORNL	1-06	SOIL	4.88	ppm	DRY
T3-06	8400	12050	ORNL	1-06	SOIL	3.9	ppm	WET
T3-06	8400	12050	ORNL	1-06	VEG	6.0	ppm	
T3-07	8550	13050	ORNL	1-06	SOIL	3.9	ppm	DRY
T3-07	8550	13050	ORNL	1-06	SOIL	2.8	ppm	WET
T3-07	8550	13050	ORNL	1-06	VEG	35.6	ppm	

Table 5.2.7.20A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR ALPHA SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
CARLILE	14250	15100	OSDH	1-05	VEG	0.8	pCi/g	GRASS
CARLILE	14250	15100	OSDH	1-05	SOIL	0.1	pCi/g	
CRES	6150	10750	OSDH	1-05	SOIL	-0.1	pCi/g	
CRES	6150	10750	OSDH	1-05	VEG	1.1	pCi/g	GRASS
CRES	6150	10800	OSDH	1-05	WATER	0.0	pCi/l	
HRES	6950	10650	OSDH	1-08	VEG	5.0	pCi/g	
T1-01	12500	7200	OSDH	1-05	SOIL	0.1	pCi/g	
T1-01	12500	7200	OSDH	1-05	VEG	1.4	pCi/g	EVERGREEN
T1-02	12500	8000	OSDH	1-05	SOIL	0.1	pCi/g	
T1-02	12500	8000	OSDH	1-05	VEG	0.1	pCi/g	GRASS
T1-03	12500	8550	OSDH	1-05	SOIL	0.4	pCi/g	
T1-03	12500	8550	OSDH	1-05	VEG	0.5	pCi/g	GRASS
T1-04	12500	8900	OSDH	1-05	SOIL	0.9	pCi/g	
T1-04	12500	8900	OSDH	1-05	VEG	1.3	pCi/g	EVERGREEN
T1-05	12500	9200	OSDH	1-05	SOIL	0.4	pCi/g	
T1-05	12500	9200	OSDH	1-05	VEG	4020.0	pCi/g	EVERGREEN
T1-06	12500	9500	OSDH	1-05	SOIL	1.8	pCi/g	
T1-06	12500	9500	OSDH	1-05	VEG	1220.0	pCi/g	GRASS
T1-07	12500	9850	OSDH	1-05	SOIL	-0.3	pCi/g	
T1-07	12500	9850	OSDH	1-05	VEG	124.0	pCi/g	GRASS
T1-08	12600	10200	OSDH	1-05	SOIL	-0.3	pCi/g	
T1-08	12600	10200	OSDH	1-05	VEG	1.0	pCi/g	GRASS
T1-09	12600	10600	OSDH	1-05	SOIL	1.6	pCi/g	
T1-09	12600	10600	OSDH	1-05	VEG	0.0	pCi/g	GRASS
T1-10	12750	11100	OSDH	1-05	WATER	100.0	pCi/l	
T1-11	12600	11300	OSDH	1-05	SOIL	-0.3	pCi/g	
T1-11	12600	11300	OSDH	1-05	VEG	1.3	pCi/g	GRASS
T1-12	12550	11900	OSDH	1-05	SOIL	0.4	pCi/g	
T1-12	12550	11900	OSDH	1-05	VEG	0.0	pCi/g	EVERGREEN
T2-01	10750	6200	OSDH	1-05	SOIL	0.1	pCi/g	
T2-01	10750	6200	OSDH	1-05	VEG	-0.2	pCi/g	
T2-02	10550	6800	OSDH	1-05	SOIL	0.1	pCi/g	
T2-03	10650	7550	OSDH	1-05	SOIL	132.0	pCi/g	
T2-03	10650	7550	OSDH	1-05	VEG	-0.4	pCi/g	
T2-04	10700	8400	OSDH	1-05	SOIL	0.1	pCi/g	
T2-04	10350	8400	OSDH	1-05	WATER	150.0	pCi/l	
T2-05	10800	9300	OSDH	1-05	SOIL	0.1	pCi/g	
T2-05	10800	9300	OSDH	1-05	VEG	78.0	pCi/g	
T2-06	11500	9850	OSDH	1-06	SOIL	1.9	pCi/g	
T2-06	11500	9850	OSDH	1-06	VEG	41.0	pCi/g	
T2-06	11500	9950	OSDH	1-06	WATER	124.0	pCi/l	
T2-07	11500	10650	OSDH	1-06	SOIL	3.0	pCi/g	
T2-08	11500	11650	OSDH	1-06	SOIL	0.1	pCi/g	
T2-08	11500	11650	OSDH	1-06	VEG	-0.5	pCi/g	
T2-09	11350	12700	OSDH	1-06	SOIL	1.2	pCi/g	
T2-09	11350	12700	OSDH	1-06	VEG	0.1	pCi/g	
T2-10	11400	13700	OSDH	1-06	SOIL	-0.3	pCi/g	
T2-10	11400	13700	OSDH	1-06	VEG	0.3	pCi/g	

Table 5.2.7.20A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR ALPHA SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
T3-01	8300	6250	OSDH	1-06	SOIL	-0.3	pCi/g	
T3-01	8300	6250	OSDH	1-06	VEG	1.6	pCi/g	EVERGREEN
T3-02	8600	6950	OSDH	1-06	SOIL	3.0	pCi/g	
T3-02	8600	6950	OSDH	1-06	VEG	1.0	pCi/g	EVERGREEN
T3-03	8650	9000	OSDH	1-06	SOIL	-0.3	pCi/g	
T3-03	8650	9000	OSDH	1-06	VEG	0.6	pCi/g	EVERGREEN
T3-04	8350	10300	OSDH	1-06	SOIL	-0.3	pCi/g	
T3-04	8350	10300	OSDH	1-06	VEG	1070.0	pCi/g	EVRGRN/LEAVES
T3-05	8350	11200	OSDH	1-06	SOIL	0.9	pCi/g	
T3-05	8350	11200	OSDH	1-06	VEG	27.0	pCi/g	EVERGREEN
T3-06	8400	12050	OSDH	1-06	SOIL	0.4	pCi/g	
T3-06	8400	12050	OSDH	1-06	VEG	0.7	pCi/g	EVERGREEN
T3-07	8550	13050	OSDH	1-06	SOIL	0.1	pCi/g	
T3-07	8550	13050	OSDH	1-06	VEG	0.6	pCi/g	GRASS
T5-01	17700	8700	OSDH	1-08	SOIL	-0.3	pCi/g	
T5-01	17700	8700	OSDH	1-08	VEG	0.2	pCi/g	
T5-02	16500	10000	OSDH	1-08	VEG	-0.2	pCi/g	
T5-02	16500	10000	OSDH	1-08	VEG	0.0	pCi/g	
T5-03	16300	10350	OSDH	1-08	SOIL	-0.3	pCi/g	
T5-03	16300	10350	OSDH	1-08	VEG	0.0	pCi/g	
T5-04	15500	8500	OSDH	1-08	VEG	0.2	pCi/g	
T5-04	1550	8500	OSDH	1-08	WATER	7.0	pCi/l	
T6-01	13950	7700	OSDH	1-08	SOIL	0.1	pCi/g	
T6-01	13950	7700	OSDH	1-08	VEG	1.2	pCi/g	
T6-02	13900	8400	OSDH	1-08	SOIL	-0.3	pCi/g	
T6-02	13900	8400	OSDH	1-08	VEG	2.5	pCi/g	
T6-03	14650	8300	OSDH	1-08	SOIL	0.4	pCi/g	
T6-03	14650	8300	OSDH	1-08	VEG	1.0	pCi/g	
T6-04	14650	8700	OSDH	1-08	SOIL	0.4	pCi/g	
T6-05	14450	9550	OSDH	1-08	VEG	0.9	pCi/g	

Table 5.2.7.21A

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR BETA SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
CARLILE	14250	15100	OSDH	1-05	VEG	0.7	pCi/g	GRASS
CARLILE	14250	15100	OSDH	1-05	SOIL	-0.3	pCi/g	
CRES	6150	10750	OSDH	1-05	SOIL	-0.0	pCi/g	
CRES	6150	10750	OSDH	1-05	VEG	0.2	pCi/g	GRASS
CRES	6150	10800	OSDH	1-05	WATER	-1.0	pCi/l	
HRES	6950	10650	OSDH	1-08	VEG	1.9	pCi/g	
T1-01	12500	7200	OSDH	1-05	SOIL	0.6	pCi/g	
T1-01	12500	7200	OSDH	1-05	VEG	1.0	pCi/g	EVERGREEN
T1-02	12500	8000	OSDH	1-05	SOIL	0.4	pCi/g	
T1-02	12500	8000	OSDH	1-05	VEG	1.2	pCi/g	GRASS
T1-03	12500	8550	OSDH	1-05	SOIL	-0.0	pCi/g	
T1-03	12500	8550	OSDH	1-05	VEG	1.1	pCi/g	GRASS
T1-04	12500	8900	OSDH	1-05	SOIL	-0.1	pCi/g	
T1-04	12500	8900	OSDH	1-05	VEG	0.1	pCi/g	EVERGREEN
T1-05	12500	9200	OSDH	1-05	SOIL	0.2	pCi/g	
T1-05	12500	9200	OSDH	1-05	VEG	110.0	pCi/g	EVERGREEN
T1-06	12500	9500	OSDH	1-05	SOIL	-0.2	pCi/g	
T1-06	12500	9500	OSDH	1-05	VEG	95.0	pCi/g	GRASS
T1-07	12500	9850	OSDH	1-05	SOIL	-0.0	pCi/g	
T1-07	12500	9850	OSDH	1-05	VEG	23.0	pCi/g	GRASS
T1-08	12600	10200	OSDH	1-05	SOIL	-0.2	pCi/g	
T1-08	12600	10200	OSDH	1-05	VEG	5.0	pCi/g	GRASS
T1-09	12600	10600	OSDH	1-05	SOIL	-0.5	pCi/g	
T1-09	12600	10600	OSDH	1-05	VEG	0.5	pCi/g	GRASS
T1-10	12750	11100	OSDH	1-05	WATER	12.0	pCi/l	
T1-11	12600	11300	OSDH	1-05	SOIL	-0.4	pCi/g	
T1-11	12600	11300	OSDH	1-05	VEG	1.7	pCi/g	GRASS
T1-12	12550	11900	OSDH	1-05	SOIL	0.2	pCi/g	
T1-12	12550	11900	OSDH	1-05	VEG	0.3	pCi/g	EVERGREEN
T2-01	10750	6200	OSDH	1-05	SOIL	-0.5	pCi/g	
T2-01	10750	6200	OSDH	1-05	VEG	0.7	pCi/g	
T2-02	10550	6800	OSDH	1-05	SOIL	0.1	pCi/g	
T2-03	10650	7550	OSDH	1-05	SOIL	23.0	pCi/g	
T2-03	10650	7550	OSDH	1-05	VEG	3.1	pCi/g	
T2-04	10700	8400	OSDH	1-05	SOIL	0.6	pCi/g	
T2-04	10350	8400	OSDH	1-05	WATER	9.0	pCi/l	
T2-05	10800	9300	OSDH	1-05	SOIL	0.7	pCi/g	
T2-05	10800	9300	OSDH	1-05	VEG	7.0	pCi/g	
T2-06	11500	9850	OSDH	1-06	SOIL	-0.7	pCi/g	
T2-06	11500	9850	OSDH	1-06	VEG	6.0	pCi/g	
T2-06	11500	9950	OSDH	1-06	WATER	26.0	pCi/l	
T2-07	11500	10650	OSDH	1-06	SOIL	0.7	pCi/g	
T2-08	11500	11650	OSDH	1-06	SOIL	0.4	pCi/g	
T2-08	11500	11650	OSDH	1-06	VEG	6.0	pCi/g	
T2-09	11350	12700	OSDH	1-06	SOIL	0.3	pCi/g	
T2-09	11350	12700	OSDH	1-06	VEG	2.3	pCi/g	
T2-10	11400	13700	OSDH	1-06	SOIL	0.6	pCi/g	
T2-10	11400	13700	OSDH	1-06	VEG	0.3	pCi/g	

Table 5.2.7.21A (Continued)

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR BETA SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
T3-01	8300	6250	OSDH	1-06	SOIL	-0.2	pCi/g	
T3-01	8300	6250	OSDH	1-06	VEG	0.6	pCi/g	EVERGREEN
T3-02	8600	6950	OSDH	1-06	SOIL	1.0	pCi/g	
T3-02	8600	6950	OSDH	1-06	VEG	0.4	pCi/g	EVERGREEN
T3-03	8650	9000	OSDH	1-06	SOIL	1.0	pCi/g	
T3-03	8650	9000	OSDH	1-06	VEG	0.0	pCi/g	EVERGREEN
T3-04	8350	10300	OSDH	1-06	SOIL	0.1	pCi/g	
T3-04	8350	10300	OSDH	1-06	VEG	77.0	pCi/g	EVRGRN/LEAVES
T3-05	8350	11200	OSDH	1-06	SOIL	0.4	pCi/g	
T3-05	8350	11200	OSDH	1-06	VEG	8.0	pCi/g	EVERGREEN
T3-06	8400	12050	OSDH	1-06	SOIL	0.2	pCi/g	
T3-06	8400	12050	OSDH	1-06	VEG	-0.1	pCi/g	EVERGREEN
T3-07	8550	13050	OSDH	1-06	SOIL	-0.1	pCi/g	
T3-07	8550	13050	OSDH	1-06	VEG	-0.1	pCi/g	GRASS
T5-01	17700	8700	OSDH	1-08	SOIL	0.6	pCi/g	
T5-01	17700	8700	OSDH	1-08	VEG	-0.0	pCi/g	
T5-02	16500	10000	OSDH	1-08	VEG	-0.2	pCi/g	
T5-02	16500	10000	OSDH	1-08	VEG	-0.1	pCi/g	
T5-03	16300	10350	OSDH	1-08	SOIL	-0.2	pCi/g	
T5-03	16300	10350	OSDH	1-08	VEG	-0.3	pCi/g	
T5-04	15500	8500	OSDH	1-08	VEG	-0.1	pCi/g	
T5-04	1550	8500	OSDH	1-08	WATER	5.0	pCi/l	
T6-01	13950	7700	OSDH	1-08	SOIL	0.7	pCi/g	
T6-01	13950	7700	OSDH	1-08	VEG	0.7	pCi/g	
T6-02	13900	8400	OSDH	1-08	SOIL	-0.2	pCi/g	
T6-02	13900	8400	OSDH	1-08	VEG	1.1	pCi/g	
T6-03	14650	8300	OSDH	1-08	SOIL	-0.2	pCi/g	
T6-03	14650	8300	OSDH	1-08	VEG	0.3	pCi/g	
T6-04	14650	8700	OSDH	1-08	SOIL	-0.6	pCi/g	
T6-05	14450	9550	OSDH	1-08	VEG	-0.5	pCi/g	

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS BY SAMPLE ANALYSIS SORTED BY LABEL

Table 5.2.7.22A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR FLUORIDE SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
16W	T11N	R21E	34	B6	KMTC	1-06	WATER	0.2	MG/L	
1H14	T11N	R21E	1	H14	KMTC	1-10	SOIL	60.0	PPM	
2E14	T11N	R21E	2	E14	KMTC	1-10	SOIL	100.0	PPM	
4A 6	T11N	R21E	4	A6	KMTC	1-10	SOIL	170.0	PPM	
4J14	T11N	R21E	4	J14	KMTC	1-09	SOIL	220.0	PPM	
5N 6	T11N	R22E	5	N6	KMTC	1-09	SOIL	160.0	PPM	
6A 7	T11N	R22E	6	A7	KMTC	1-09	SOIL	130.0	PPM	
6C14	T11N	R22E	6	C14	KMTC	1-09	SOIL	190.0	PPM	
6I11	T11N	R22E	6	I11	KMTC	1-09	SOIL	130.0	PPM	
7C 6	T11N	R22E	7	C6	KMTC	1-08	SOIL	130.0	PPM	
7C 6	T11N	R22E	7	C6	KMTC	1-08	VEG	10.0	PPM	J.GRASS
7F 7	T11N	R22E	7	F7	KMTC	1-08	SOIL	120.0	PPM	
7F 7	T11N	R22E	7	F7	KMTC	1-08	VEG	20.0	PPM	WHEAT
7F 7	T11N	R22E	7	F7	KMTC	1-08	VEG	30.0	PPM	
8A 1	T11N	R22E	8	A1	KMTC	1-09	SOIL	140.0	PPM	
8J 7	T11N	R21E	8	J7	KMTC	1-09	SOIL	50.0	PPM	
8M14	T11N	R22E	8	M14	KMTC	1-09	SOIL	30.0	PPM	
9B 2	T11N	R21E	9	B2	KMTC	1-09	SOIL	250.0	PPM	
9I 8	T11N	R21E	9	I8	KMTC	1-09	SOIL	90.0	PPM	
10B 8	T11N	R21E	10	B8	KMTC	1-09	SOIL	30.0	PPM	
10L 8	T11N	R21E	10	L8	KMTC	1-08	SOIL	30.0	PPM	
10M10	T11N	R21E	10	M10	KMTC	1-08	SOIL	30.0	PPM	
11F 7	T11N	R21E	11	F7	KMTC	1-08	SOIL	50.0	PPM	
11F 7	T11N	R21E	11	F7	KMTC	1-08	VEG	10.0	PPM	CAT LEAVES
11F 7	T11N	R21E	11	F7	KMTC	1-08	VEG	43.0	PPM	BEANS
11F 7	T11N	R21E	11	F7	KMTC	1-08	VEG	12.0	PPM	WILLOW
11N 6	T11N	R21E	11	N6	KMTC	1-08	SOIL	50.0	PPM	
12F 7	T11N	R21E	12	F7	KMTC	1-09	SOIL	50.0	PPM	
12N 8	T11N	R21E	12	N8	KMTC	1-08	SOIL	130.0	PPM	
12N 8	T11N	R21E	12	N8	KMTC	1-08	VEG	5.0	PPM	
12N 8	T11N	R21E	12	N8	KMTC	1-08	VEG	7.0	PPM	CAT TIPS
12N 8	T11N	R21E	12	N8	KMTC	1-08	VEG	2.0	PPM	CEDAR
13B 1	T11N	R21E	13	B1	KMTC	1-08	SOIL	50.0	PPM	
13B 1	T11N	R21E	13	B1	KMTC	1-08	VEG	4.0	PPM	
13G11	T11N	R21E	13	G11	KMTC	1-09	SOIL	80.0	PPM	
13G11	T11N	R21E	13	G11	KMTC	1-09	VEG	10.0	PPM	
13H 2	T11N	R21E	13	H2	KMTC	1-08	SOIL	60.0	PPM	
14B 4	T11N	R21E	14	B4	KMTC	1-08	SOIL	100.0	PPM	
14B 4	T11N	R21E	14	B4	KMTC	1-08	VEG	12.0	PPM	
14B 8	T11N	R21E	14	B8	KMTC	1-08	SOIL	70.0	PPM	
14B 8	T11N	R21E	14	B8	KMTC	1-08	VEG	6.0	PPM	
14B12	T11N	R21E	14	B12	KMTC	1-08	SOIL	60.0	PPM	
14B12	T11N	R21E	14	B12	KMTC	1-08	VEG	5.0	PPM	FESCUE TIP
14B12	T11N	R21E	14	B12	KMTC	1-08	VEG	4.0	PPM	FESCUE
16B10	T11N	R21E	16	B10	KMTC	1-09	SOIL	40.0	PPM	
16B10	T11N	R21E	16	B10	KMTC	1-09	VEG	9.0	PPM	
16L 2	T11N	R21E	16	L2	KMTC	1-10	SOIL	280.0	PPM	
16L12	T11N	R21E	16	L12	KMTC	1-10	SOIL	120.0	PPM	
16L12	T11N	R21E	16	L12	KMTC	1-10	VEG	50.0	PPM	
18B 4	T11N	R22E	18	B4	KMTC	1-09	SOIL	60.0	PPM	

Table 5.2.7.22A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
18B 4	T11N	R22E	18	B4	KMTC	1-09	VEG	30.0	PPM	
18H10	T11N	R22E	18	H10	KMTC	1-09	SOIL	90.0	PPM	
18H10	T11N	R22E	18	H10	KMTC	1-09	VEG	9.0	PPM	
1A11	T11N	R21E	1	A11	KMTC	1-09	SOIL	90.0	PPM	
1A11	T11N	R21E	1	A11	KMTC	1-09	VEG	40.0	PPM	
1H14	T11N	R21E	1	H14	KMTC	1-08	VEG	20.0	PPM	
22G14	T11N	R21E	22	G14	KMTC	1-10	SOIL	70.0	PPM	
22G14	T11N	R21E	22	G14	KMTC	1-10	VEG	1.0	PPM	
23A10	T11N	R21E	23	A10	KMTC	1-08	SOIL	50.0	PPM	T11N
23A10	T11N	R21E	23	A10	KMTC	1-08	VEG	8.0	PPM	T11N
25E 8	T12N	R21E	25	E8	KMTC	1-10	SOIL	60.0	PPM	
25E 8	T12N	R21E	25	E8	KMTC	1-10	VEG	10.0	PPM	
25H 3	T12N	R21E	25	H3	KMTC	1-10	SOIL	60.0	PPM	
25H 3	T12N	R21E	25	H3	KMTC	1-10	VEG	9.0	PPM	
25H 3	T12N	R21E	25	H3	KMTC	1-10	VEG	10.0	PPM	
25H14	T12N	R21E	25	H14	KMTC	1-10	SOIL	80.0	PPM	
25L14	T12N	R21E	25	L14	KMTC	1-14	WATER	<0.1	MG/L	
26E 7	T12N	R21E	26	E7	KMTC	1-14	WATER	<0.1	MG/L	
26F 6	T12N	R21E	26	F6	KMTC	1-14	WATER	<0.1	MG/L	SURFACE WATER
26G 1	T12N	R21E	26	G1	KMTC	1-10	SOIL	60.0	PPM	
26G 1	T12N	R21E	26	G1	KMTC	1-10	VEG	10.0	PPM	
26G 8	T12N	R21E	26	G8	KMTC	1-10	SOIL	70.0	PPM	
26G 8	T12N	R21E	26	G8	KMTC	1-10	VEG	20.0	PPM	
26L 1	T12N	R21E	26	L1	KMTC	1-14	WATER	<0.1	MG/L	SURFACE (POND)
27A13	T12N	R21E	27	A13	KMTC	1-08	SOIL	90.0	PPM	
27A13	T12N	R21E	27	A13	KMTC	1-08	VEG	6.0	PPM	CEDAR
27A13	T12N	R21E	27	A13	KMTC	1-08	VEG	4.0	PPM	SMILAX
27D 1	T12N	R21E	27	D1	KMTC	1-10	SOIL	90.0	PPM	
27D 1	T12N	R21E	27	D1	KMTC	1-10	VEG	80.0	PPM	
27H 9	T12N	R21E	27	H9	KMTC	1-10	SOIL	180.0	PPM	
27H 9	T12N	R21E	27	H9	KMTC	1-10	VEG	10.0	PPM	
27H 9	T12N	R21E	27	H9	KMTC	1-10	VEG	20.0	PPM	
27I 0	T12N	R21E	27	I0	KMTC	1-14	WATER	<0.1	MG/L	SURFACE WATER
27K 4	T12N	R21E	27	K4	KMTC	1-10	SOIL	50.0	PPM	
27K 4	T12N	R21E	27	K4	KMTC	1-10	VEG	20.0	PPM	
27L 1	T12N	R21E	27	L1	KMTC	1-14	WATER	0.1	MG/L	
27L 4	T12N	R21E	27	L4	KMTC	1-14	WATER	0.1	MG/L	SURFACE WATER
27L 8	T12N	R21E	27	L8	KMTC	1-14	WATER	<0.1	MG/L	SURFACE WATER
28G 4	T12N	R21E	28	G4	KMTC	1-10	SOIL	100.0	PPM	
28G 4	T12N	R21E	28	G4	KMTC	1-10	VEG	1.0	PPM	
28G 4	T12N	R21E	28	G4	KMTC	1-10	VEG	20.0	PPM	
28H14	T12N	R21E	28	H14	KMTC	1-14	WATER	0.1	MG/L	SURFACE WATER
28J11	T12N	R21E	28	J11	KMTC	1-10	SOIL	140.0	PPM	
28J11	T12N	R21E	28	J11	KMTC	1-10	VEG	20.0	PPM	
28N 2	T12N	R21E	28	N2	KMTC	1-10	SOIL	170.0	PPM	
28N 2	T12N	R21E	28	N2	KMTC	1-10	VEG	2.0	PPM	
28N 2	T12N	R21E	28	N2	KMTC	1-10	VEG	10.0	PPM	
29D 3	T12N	R22E	29	D3	KMTC	1-10	SOIL	50.0	PPM	
29D 3	T12N	R22E	29	D3	KMTC	1-10	VEG	2.0	PPM	

Table 5.2.7.22A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
2E14	T11N	R21E	2	E14	KMTC	1-09	VEG	20.0	PPM	
2L13	T11N	R21E	2	L13	KMTC	1-09	SOIL	50.	PPM	
2L13	T11N	R21E	2	L13	KMTC	1-09	VEG	60.0	PPM	
2M 8	T11N	R21E	2	M8	KMTC	1-09	SOIL	50.0	PPM	
2M 8	T11N	R21E	2	M8	KMTC	1-09	VEG	40.0	PPM	
30F 7	T12N	R22E	30	F7	KMTC	1-10	SOIL	60.0	PPM	
30F 7	T12N	R22E	30	F7	KMTC	1-10	VEG	6.0	PPM	
30F 7	T12N	R22E	30	F7	KMTC	1-10	VEG	6.0	PPM	
31B10	T12N	R22E	31	B10	KMTC	1-10	SOIL	80.0	PPM	
31B10	T12N	R22E	31	B10	KMTC	1-10	VEG	10.0	PPM	
33B14	T12N	R21E	33	B14	KMTC	1-10	SOIL	170.0	PPM	
33B14	T12N	R21E	33	B14	KMTC	1-10	VEG	8.0	PPM	
33I 3	T12N	R21E	33	I3	KMTC	1-10	SOIL	130.0	PPM	
33I 3	T12N	R21E	33	I3	KMTC	1-10	VEG	20.0	PPM	
33M14	T12N	R21E	33	M14	KMTC	1-10	SOIL	90.0	PPM	
33M14	T12N	R21E	33	M14	KMTC	1-10	VEG	6.0	PPM	
33M14	T12N	R21E	33	M14	KMTC	1-10	VEG	5.0	PPM	
34D 7	T12N	R21E	34	D7	KMTC	1-10	SOIL	120.0	PPM	
34D 7	T12N	R21E	34	D7	KMTC	1-10	VEG	30.0	PPM	
35A 9	T12N	R21E	35	A9	KMTC	1-10	SOIL	60.0	PPM	
35A 9	T12N	R21E	35	A9	KMTC	1-10	VEG	6.0	PPM	
35A 9	T12N	R21E	35	A9	KMTC	1-10	VEG	11.0	PPM	
35B 1	T12N	R21E	35	B1	KMTC	1-10	SOIL	70.0	PPM	
35B 1	T12N	R21E	35	B1	KMTC	1-10	VEG	9.0	PPM	
35B14	T12N	R21E	35	B14	KMTC	1-10	SOIL	70.0	PPM	
35B14	T12N	R21E	35	B14	KMTC	1-10	VEG	3.0	PPM	
35F10	T12N	R21E	35	F10	KMTC	1-10	SOIL	60.0	PPM	
35F10	T12N	R21E	35	F10	KMTC	1-10	VEG	20.0	PPM	
35L 5	T12N	R21E	35	L5	KMTC	1-09	SOIL	70.0	PPM	
35L 5	T12N	R21E	35	L5	KMTC	1-09	VEG	5.0	PPM	
35L 5	T12N	R21E	35	L5	KMTC	1-09	VEG	8.0	PPM	
35L11	T12N	R21E	35	L11	KMTC	1-10	SOIL	210.0	PPM	
35L11	T12N	R21E	35	L11	KMTC	1-10	VEG	30.0	PPM	
35L11	T12N	R21E	35	L11	KMTC	1-10	VEG	<1	PPM	
36A13	T12N	R21E	36	A13	KMTC	1-10	SOIL	100.0	PPM	
36A13	T12N	R21E	36	A13	KMTC	1-10	VEG	20.0	PPM	
36D11	T12N	R21E	36	D11	KMTC	1-14	WATER	<0.1	MG/L	
36G 5	T12N	R21E	36	G5	KMTC	1-09	SOIL	70.0	PPM	
36G 5	T12N	R21E	36	G5	KMTC	1-09	VEG	20.0	PPM	
36H14	T12N	R21E	36	H14	KMTC	1-10	SOIL	160.0	PPM	
36H14	T12N	R21E	36	H14	KMTC	1-10	VEG	<1	PPM	
36L 5	T12N	R21E	36	L5	KMTC	1-14	WATER	<0.1	MG/L	
36M10	T12N	R21E	36	M10	KMTC	1-14	WATER	<0.1	MG/L	SURFACE WATER
3F 7	T11N	R21E	3	F7	KMTC	1-09	SOIL	90.0	PPM	
3F 7	T11N	R21E	3	F7	KMTC	1-09	VEG	8.0	PPM	
4A 1	T11N	R21E	4	A1	KMTC	1-10	SOIL	140.0	PPM	
4A 1	T11N	R21E	4	A1	KMTC	1-10	VEG	6.0	PPM	
4A 3	T11N	R21E	4	A3	KMTC	1-10	VEG	20.0	PPM	
4A 6	T11N	R21E	4	A6	KMTC	1-10	VEG	60.0	PPM	

Table 5.2.7.22A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR FLUORIDE SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
4J14	T11N	R21E	4	J14	KMTC	1-09	VEG	15.0	PPM	
4J14	T11N	R21E	4	J14	KMTC	1-09	VEG	6.0	PPM	
4N 7	T11N	R21E	4	N7	KMTC	1-09	SOIL	90.0	PPM	
4N 7	T11N	R21E	4	N7	KMTC	1-09	VEG	30.0	PPM	
4N 8	T11N	R21E	4	N8	KMTC	1-09	VEG	6.0	PPM	
50/HWY	T12N	R21E	22	G1	KMTC	1-06	VEG	1500.0	PPM	CEDAR
5N 6	T11N	R22E	5	N6	KMTC	1-09	VEG	30.0	PPM	
6A 7	T11N	R22E	6	A7	KMTC	1-09	VEG	30.0	PPM	
6C14	T11N	R22E	6	C14	KMTC	1-09	VEG	10.0	PPM	
8A 1	T11N	R22E	8	A1	KMTC	1-09	VEG	8.0	PPM	
8J 7	T11N	R21E	8	J7	KMTC	1-09	VEG	10.0	PPM	
8M14	T11N	R22E	8	M14	KMTC	1-09	VEG	9.0	PPM	
9B 2	T11N	R21E	9	B2	KMTC	1-09	VEG	5.5	PPM	
AB-01	T11N	R21E	17	A14	OSDH	1-15	SOIL	0.64	MG/KG	
AB-01	T11N	R21E	17	A14	OSDH	1-15	VEG	2.72	MG/KG	
AB-02	T11N	R21E	16	A11	OSDH	1-15	SOIL	0.68	MG/KG	
AB-02	T11N	R21E	16	A11	OSDH	1-15	VEG	1.68	MG/KG	
AB-03	T12N	R21E	32	N14	OSDH	1-15	SOIL	0.44	MG/KG	
AB-03	T12N	R21E	32	N14	OSDH	1-15	VEG	3.28	MG/KG	
AB-04	T11N	R21E	9	B1	OSDH	1-15	SOIL	0.56	MG/KG	
AB-04	T11N	R21E	9	B1	OSDH	1-15	VEG	1.52	MG/KG	
AB-05	T11N	R21E	4	C8	OSDH	1-15	SOIL	0.52	MG/KG	
AB-05	T11N	R21E	4	C8	OSDH	1-15	VEG	2.64	MG/KG	
AB-06	T12N	R21E	29	N14	OSDH	1-15	SOIL	0.80	MG/KG	
AB-06	T12N	R21E	29	N14	OSDH	1-15	VEG	1.68	MG/KG	
AB-07	T12N	R21E	31	A8	OSDH	1-15	SOIL	0.40	MG/KG	
AB-07	T12N	R21E	31	A8	OSDH	1-15	VEG	2.40	MG/KG	
AB-08	T12N	R21E	19	N8	OSDH	1-15	SOIL	<0.40	MG/KG	
AB-08	T12N	R21E	19	N8	OSDH	1-15	VEG	1.60	MG/KG	
AB-09	T12N	R21E	18	M6	OSDH	1-15	SOIL	1.04	MG/KG	
AB-09	T12N	R21E	18	M6	OSDH	1-15	VEG	3.60	MG/KG	
AB-10	T12N	R20E	13	G14	OSDH	1-15	SOIL	0.52	MG/KG	
AB-10	T12N	R20E	13	G14	OSDH	1-15	VEG	2.96	MG/KG	
BG 1/4	T12N	R21E	21	B13	ORNL	1-06	SOIL	4.7	UG/G	DRY
BG 1/4	T12N	R21E	21	B13	ORNL	1-06	SOIL	3.7	UG/G	WET
BG 1/4	T12N	R21E	21	B13	KMTC	1-06	SOIL	220.0	PPM	
BG 1/4	T12N	R21E	21	B13	ORNL	1-06	VEG	7.3	UG/G	
BG 1/4	T12N	R21E	21	B13	KMTC	1-06	VEG	40.0	PPM	1/4 N.GATE
CARLILE	T12N	R21E	22	D14	ORNL	1-05	SOIL	1.2	UG/G	DRY
CARLILE	T12N	R21E	22	D14	ORNL	1-05	SOIL	0.8	UG/G	WET
CARLILE	T12N	R21E	22	D14	OSDH	1-14	SOIL	1.24	MG/KG	
CARLILE	T12N	R21E	22	D14	OSDH	1-05	SOIL	<0.4	MG/KG	
CARLILE	T12N	R21E	22	D14	OSDH	1-05	VEG	4.3	GRASS	
CARLILE	T12N	R21E	22	D14	ORNL	1-05	VEG	8.3	UG/G	
CARLILE	T12N	R21E	22	D14	OSDH	1-14	VEG	2.56	MG/KG	
CNTRL01	T09N	R24E	16	-	OSDH	1-06	SOIL	0.4	MG/KG	
CNTRL01	T09N	R24E	16	-	OSDH	1-06	VEG	0.9	MG/KG	
CNTRL02	T10N	R22E	35	C14	OSDH	1-06	SOIL	0.5	MG/KG	
CNTRL02	T10N	R22E	35	C14	OSDH	1-06	VEG	1.9	MG/KG	

Table 5.2.7.22A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
CNTRL03	T11N	R22E	28	E10	OSDH	1-06	SOIL	<0.4	MG/KG	
CNTRL03	T11N	R22E	28	E10	OSDH	1-06	VEG	2.4	MG/KG	
CNTRL04	T11N	R22E	20	N10	OSDH	1-06	SOIL	0.7	MG/KG	
CNTRL04	T11N	R22E	20	N10	OSDH	1-06	VEG	2.5	MG/KG	
CNTRL05	T11N	R22E	19	F13	OSDH	1-06	SOIL	0.9	MG/KG	
CNTRL05	T11N	R22E	19	F13	OSDH	1-06	VEG	2.2	MG/KG	
CNTRL06	T09N	R22E	4	I13	OSDH	1-06	VEG	1.4	MG/KG	
CNTRL07	T11N	R21E	13	B7	OSDH	1-06	SOIL	<0.4	MG/KG	
CNTRL07	T11N	R21E	13	B7	OSDH	1-06	VEG	0.9	MG/KG	
CNTRL08	T10N	R22E	8	K8	OSDH	1-06	SOIL	0.6	MG/KG	
CNTRL08	T10N	R22E	8	K8	OSDH	1-06	VEG	2.7	MG/KG	
CNTRL09	T11N	R20E	21	C12	OSDH	1-06	SOIL	1.3	MG/KG	
CNTRL09	T11N	R20E	21	C12	OSDH	1-06	VEG	2.2	MG/KG	
CNTRL09	T11N	R20E	21	C12	OSDH	1-06	VEG	1.9	MG/KG	
CNTRL10	T11N	R20E	21	I13	OSDH	1-06	SOIL	1.3	MG/KG	
CNTRL10	T11N	R20E	21	I13	OSDH	1-06	VEG	3.0	MG/KG	
CNTRL11	T12N	R19E	26	E3	OSDH	1-06	SOIL	1.5	MG/KG	
CNTRL11	T12N	R19E	26	E3	OSDH	1-06	VEG	1.2	MG/KG	
CNTRL12	T11N	R20E	14	N6	OSDH	1-06	SOIL	0.7	MG/KG	
CNTRL13	T11N	R23E	3	C2	OSDH	1-06	SOIL	0.4	MG/KG	
CNTRL13	T11N	R23E	3	C2	OSDH	1-06	VEG	1.4	MG/KG	
CNTRL14	T11N	R23E	-	-	OSDH	1-06	SOIL	0.5	MG/KG	S OF SALLISAW
CNTRL15	T09N	R20E	16	G13	OSDH	1-06	SOIL	0.5	MG/KG	
CNTRL15	T09N	R20E	16	G13	OSDH	1-06	VEG	1.6	MG/KG	
CRES	T12N	R21E	27	K3	OSDH	1-05	SOIL	0.6	MG/KG	
CRES	T12N	R21E	27	K3	ORNL	1-05	SOIL	2.8	UG/G	DRY
CRES	T12N	R21E	27	K3	ORNL	1-05	SOIL	1.9	UG/G	WET
CRES	T12N	R21E	27	K3	OSDH	1-05	VEG	32.0	MG/KG	GRASS
CRES	T12N	R21E	27	K3	OSDH	1-05	WATER	0.19	MG/L	
CRES	T12N	R21E	27	K3	ORNL	1-05	WATER	0.09	UM/ML	
CRES08	T12N	R21E	27	K3	KMTC	1-04	VEG	42.0	PPM	CRES
CRES09	T12N	R21E	27	K3	KMTC	1-04	S/V	90.0	PPM	MIX LEAVES/DIF
CRES10	T12N	R21E	27	K3	KMTC	1-04	SOIL	190.0	PPM	CRES
DIRTYCR	T11N	R21E	6	F9	OSDH	1-14	WATER	0.32	MG/L	
DRES11	T12N	R21E	27	K4	KMTC	1-04	SOIL	40.0	PPM	DRES
DRES12	T12N	R21E	27	K4	KMTC	1-04	VEG	160.0	PPM	DRES/LEAVES
DRES13	T12N	R21E	27	K4	KMTC	1-04	SOIL	60.0	PPM	DRES
G-01	T12N	R21E	8	L5	OSDH	1-15	SOIL	0.72	MG/KG	
G-01	T12N	R21E	8	L5	OSDH	1-15	VEG	4.00	MG/KG	
G-02	T12N	R21E	8	B3	OSDH	1-15	SOIL	1.84	MG/KG	
G-02	T12N	R21E	8	B3	OSDH	1-15	VEG	8.00	MG/KG	
G-03	T12N	R21E	7	B13	OSDH	1-15	SOIL	0.64	MG/KG	
G-03	T12N	R21E	7	B13	OSDH	1-15	VEG	2.08	MG/KG	
G-04	T12N	R21E	7	K9	OSDH	1-15	SOIL	1.52	MG/KG	
G-04	T12N	R21E	7	K9	OSDH	1-15	VEG	3.04	MG/KG	
GL-01	T12N	R21E	16	F1	OSDH	1-15	SOIL	0.52	MG/KG	
GL-01	T12N	R21E	16	F1	OSDH	1-15	VEG	2.16	MG/KG	
H-02	T12N	R21E	27	I2	KMTC	1-04	VEG	24.0	PPM	CEDAR
H-03	T12N	R21E	27	I2	KMTC	1-04	VEG	80.0	PPM	HRES

Table 5.2.7.22A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR FLUORIDE SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
HC-01	T11N	R21E	23	N1	OSDH	1-11	VEG	2.48	MG/KG	
HC-02	T11N	R21E	22	N1	OSDH	1-11	VEG	1.04	MG/KG	
HC-03	T11N	R21E	20	N14	OSDH	1-11	VEG	2.00	MG/KG	
HC-04	T11N	R21E	21	A1	OSDH	1-11	VEG	1.28	MG/KG	
HC-05	T11N	R21E	15	N5	OSDH	1-11	VEG	2.24	MG/KG	
HC-07	T11N	R21E	26	N1	OSDH	1-11	VEG	2.00	MG/KG	
HC-08	T11N	R21E	28	M11	OSDH	1-11	VEG	2.32	MG/KG	
HC-09	T11N	R21E	32	A12	OSDH	1-11	VEG	1.52	MG/KG	
HC-10	T10N	R21E	4	N1	OSDH	1-11	VEG	2.24	MG/KG	
HC-11	T10N	R21E	4	N14	OSDH	1-11	VEG	1.60	MG/KG	
HC-11	T10N	R21E	4	N14	OSDH	1-11	VEG	1.52	MG/KG	
HC-12	T11N	R21E	22	A13	OSDH	1-11	VEG	0.90	MG/KG	
HC-13	T11N	R21E	26	A14	OSDH	1-11	VEG	3.60	MG/KG	
HC-14	T12N	R21E	25	A14	OSDH	1-11	VEG	1.28	MG/KG	
HC-15	T10N	R21E	3	A1	OSDH	1-11	VEG	4.08	MG/KG	
HC-16	T11N	R21E	33	N2	OSDH	1-11	VEG	5.76	MG/KG	
HC-17	T10N	R22E	9	A14	OSDH	1-11	VEG	2.80	MG/KG	
HC-18	T10N	R22E	10	A13	OSDH	1-11	VEG	3.60	MG/KG	
HC-19	T11N	R22E	29	A14	OSDH	1-11	VEG	6.40	MG/KG	
HC-20	T11N	R22E	30	A14	OSDH	1-11	VEG	2.88	MG/KG	
HRES01	T12N	R21E	27	I2	KMTC	1-04	SOIL	110.0	PPM	HRES
LRES04	T12N	R21E	28	I14	KMTC	1-04	VEG	3.0	PPM	TREE
LRES05	T12N	R21E	28	I14	KMTC	1-04	SOIL	120.0	PPM	LRES
LRES06	T12N	R21E	28	I14	KMTC	1-04	SOIL	60.0	PPM	LRES
LRES07	T12N	R21E	28	I14	KMTC	1-04	WATER	<0.1	MG/L	RAIN BARREL
P-01	T12N	R21E	26	A11	OSDH	1-13	SOIL	0.88	MG/KG	
P-01	T12N	R21E	26	A11	OSDH	1-13	VEG	2.24	MG/KG	
P-01	T12N	R21E	26	A11	OSDH	1-13	WATER	0.23	MG/L	
P-02	T12N	R21E	25	H4	OSDH	1-13	SOIL	0.50	MG/KG	
P-02	T12N	R21E	25	H4	OSDH	1-13	VEG	<0.1	MG/KG	
P-03	T12N	R21E	36	A13	OSDH	1-13	SOIL	0.68	MG/KG	
P-03	T12N	R21E	36	A13	OSDH	1-13	VEG	1.36	MG/KG	
P-04	T12N	R21E	36	D10	OSDH	1-13	SOIL	0.96	MG/KG	
P-04	T12N	R21E	36	D10	OSDH	1-13	VEG	<0.1	MG/KG	
P-05	T11N	R21E	1	A11	OSDH	1-13	SOIL	5.56	MG/KG	
P-05	T11N	R21E	1	A11	OSDH	1-13	VEG	1.76	MG/KG	
P-06	T11N	R21E	1	A7	OSDH	1-13	SOIL	0.52	MG/KG	
P-06	T11N	R21E	1	A7	OSDH	1-13	VEG	2.24	MG/KG	
P-07	T12N	R21E	35	M10	OSDH	1-13	SOIL	<0.1	MG/KG	
P-07	T12N	R21E	35	M10	OSDH	1-13	VEG	9.68	MG/KG	
P-08	T12N	R21E	35	D10	OSDH	1-13	SOIL	0.48	MG/KG	
P-08	T12N	R21E	35	D10	OSDH	1-13	VEG	6.80	MG/KG	
P-09	T12N	R21E	26	H6	OSDH	1-13	SOIL	1.16	MG/KG	
P-09	T12N	R21E	26	H6	OSDH	1-13	VEG	4.64	MG/KG	
P-10	T12N	R21E	28	F14	OSDH	1-13	WATER	0.49	MG/L	
REDHILL	T11N	R21E	9	H4	OSDH	1-14	WATER	0.15	MG/L	
RKRES15	T12N	R21E	34	A13	KMTC	1-04	VEG	32.0	PPM	RKRES/CEDAR
RKRES16	T12N	R21E	34	A13	KMTC	1-04	SOIL	80.0	PPM	RKRES
RRES17	T11N	R21E	34	B6	KMTC	1-04	SOIL	90.0	PPM	RRES

Table 5.2.7.22A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
RRES18	T11N	R21E	34	B6	KMTC	1-04	VEG	7.0	PPM	RRES/CEDAR
RRES19	T11N	R21E	34	B6	KMTC	1-04	SOIL	100.0	PPM	RRES
S-01	T11N	R22E	34	A1	OSDH	1-11	VEG	2.8	MG/KG	
S-02	T11N	R22E	28	N1	OSDH	1-11	VEG	6.64	MG/KG	
S-03	T11N	R22E	30	N14	OSDH	1-11	VEG	3.92	MG/KG	
S-04	T11N	R21E	25	N14	OSDH	1-11	VEG	2.56	MG/KG	
S-05	T11N	R21E	36	A1	OSDH	1-11	VEG	3.52	MG/KG	
S-06	T11N	R21E	34	N14	OSDH	1-11	VEG	3.12	MG/KG	
S-07	T10N	R21E	2	A1	OSDH	1-11	VEG	3.04	MG/KG	
S-08	T11N	R22E	31	N1	OSDH	1-11	VEG	5.44	MG/KG	
S-09	T10N	R22E	6	A14	OSDH	1-11	VEG	2.16	MG/KG	
S-10	T10N	R22E	5	N1	OSDH	1-11	VEG	5.68	MG/KG	
S-11	T10N	R22E	9	A1	OSDH	1-11	VEG	5.04	MG/KG	
S-12	T10N	R22E	4	A1	OSDH	1-11	VEG	2.16	MG/KG	
S-13	T11N	R22E	33	N14	OSDH	1-11	VEG	4.96	MG/KG	
S-14	T10N	R22E	6	N1	OSDH	1-11	VEG	3.68	MG/KG	
S-15	T10N	R21E	2	N14	OSDH	1-11	VEG	2.88	MG/KG	
S-16	T10N	R21E	2	N1	OSDH	1-11	VEG	3.12	MG/KG	
SHRES14	T12N	R21E	27	N6	KMTC	1-04	SOIL	80.0	PPM	SHRES
SMRES20	T12N	R21E	26	K6	KMTC	1-04	SOIL	40.0	PPM	SMRES
SMRES21	T12N	R21E	26	K6	KMTC	1-04	VEG	5.0	PPM	SMRES/LEAVES
STRM GH	T11N	R21E	4	K0	OSDH	1-16	WATER	7.00	MG/L	
SWR PND	T11N	R21E	4	K0	OSDH	1-14	WATER	0.18	MG/L	
T3-08	T12N	R21E	26	C12	OSDH	1-14	SOIL	1.24	MG/KG	
T3-08	T12N	R21E	26	C12	OSDH	1-14	VEG	2.40	MG/KG	
T4-01E	T11N	R21E	2	C11	OSDH	1-06	SOIL	1.1	MG/KG	
T4-01E	T11N	R21E	2	C11	ORNL	1-06	SOIL	1.2	UG/G	DRY
T4-01E	T11N	R21E	2	C11	ORNL	1-06	SOIL	1.0	UG/G	WET
T4-01E	T11N	R21E	2	C11	OSDH	1-06	VEG	2.6	MG/KG	EVERGREEN
T4-01E	T11N	R21E	2	C11	ORNL	1-06	VEG	3.1	UG/G	
T4-01W	T12N	R21E	27	N1	OSDH	1-06	SOIL	1.1	MG/KG	
T4-01W	T12N	R21E	27	N1	ORNL	1-06	SOIL	0.7	UG/G	DRY
T4-01W	T12N	R21E	27	N1	ORNL	1-06	SOIL	0.6	UG/G	WET
T4-02E	T11N	R21E	2	B8	OSDH	1-06	SOIL	<0.8	MG/KG	
T4-02E	T11N	R21E	2	B8	ORNL	1-06	SOIL	0.6	UG/G	DRY
T4-02E	T11N	R21E	2	B8	ORNL	1-06	SOIL	0.5	UG/G	WET
T4-02E	T11N	R21E	2	B8	OSDH	1-06	VEG	2.7	MG/KG	EVERGREEN
T4-02E	T11N	R21E	2	B8	ORNL	1-06	VEG	2.1	UG/G	
T4-02W	T12N	R21E	33	L14	OSDH	1-06	SOIL	2.3	MG/KG	
T4-02W	T12N	R21E	33	L14	ORNL	1-06	SOIL	0.7	UG/G	DRY
T4-02W	T12N	R21E	33	L14	ORNL	1-06	SOIL	0.6	UG/G	WET
T4-03E	T12N	R21E	35	N5	OSDH	1-06	SOIL	<0.8	MG/KG	
T4-03E	T12N	R21E	35	N5	ORNL	1-06	SOIL	?	UG/G	WET
T4-03E	T12N	R21E	35	N5	ORNL	1-06	SOIL	1.3	UG/G	DRY
T4-03E	T12N	R21E	35	N5	OSDH	1-06	VEG	3.5	MG/KG	EVERGREEN
T4-03E	T12N	R21E	35	N5	ORNL	1-06	VEG	2.9	UG/G	
T4-03W	T12N	R21E	34	B6	OSDH	1-06	SOIL	1.6	MG/KG	
T4-03W	T12N	R21E	34	B6	ORNL	1-06	SOIL	0.8	UG/G	DRY
T4-03W	T12N	R21E	34	B6	ORNL	1-06	SOIL	0.7	UG/G	WET

Table 5.2.7.22A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR FLUORIDE SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
T4-03W	T12N	R21E	34	C7	OSDH	1-06	WATER	0.17	MG/KG	
T4-04E	T12N	R21E	35	L3	OSDH	1-06	SOIL	<0.8	MG/KG	
T4-04E	T12N	R21E	35	L3	ORNL	1-06	SOIL	0.9	UG/G	DRY
T4-04E	T12N	R21E	35	L3	ORNL	1-06	SOIL	0.7	UG/G	WET
T4-04E	T12N	R21E	35	L3	OSDH	1-06	VEG	1.8	MG/KG	EVERGREEN
T4-04E	T12N	R21E	35	L3	ORNL	1-06	VEG	2.2	UG/G	
T4-04W	T12N	R21E	34	L13	OSDH	1-06	SOIL	1.4	MG/KG	
T4-04W	T12N	R21E	34	L13	ORNL	1-06	SOIL	1.0	UG/G	DRY
T4-04W	T12N	R21E	34	L13	ORNL	1-06	SOIL	0.8	UG/G	WET
T4-04W	T12N	R21E	34	L13	OSDH	1-06	VEG	54.0	MG/KG	LEAVES
T4-04W	T12N	R21E	34	L13	ORNL	1-06	VEG	6.1	UG/G	
T4-05E	T12N	R21E	35	K1	OSDH	1-06	SOIL	1.2	MG/KG	
T4-05E	T12N	R21E	35	K1	ORNL	1-06	SOIL	0.7	UG/G	DRY
T4-05E	T12N	R21E	35	K1	ORNL	1-06	SOIL	0.6	UG/G	WET
T4-05E	T12N	R21E	35	K1	OSDH	1-06	VEG	11.2	MG/KG	EVERGREEN
T4-05E	T12N	R21E	35	K1	ORNL	1-06	VEG	9.3	UG/G	
TRES53	T11N	R21E	23	M10	KMTC	1-06	VEG	23.0	PPM	TRES
TRES54	T11N	R21E	23	M10	KMTC	1-06	SOIL	90.0	PPM	TRES
WR-01	T11N	R22E	15	A1	OSDH	1-15	SOIL	1.40	MG/KG	
WR-01	T11N	R22E	15	A1	OSDH	1-15	VEG	3.36	MG/KG	
WR-01	T11N	R22E	9	N13	OSDH	1-15	WATER	0.18	MG/L	
WR-02	T11N	R22E	17	A14	OSDH	1-15	SOIL	1.64	MG/KG	
WR-02	T11N	R22E	17	A14	OSDH	1-15	VEG	5.36	MG/KG	
WR-02	T11N	R22E	9	N2	OSDH	1-15	WATER	0.26	MG/L	
WR-03	T11N	R22E	17	I14	OSDH	1-15	SOIL	1.12	MG/KG	
WR-03	T11N	R22E	17	I14	OSDH	1-15	VEG	3.60	MG/KG	
WR-04	T11N	R22E	8	L14	OSDH	1-15	WATER	0.1	MG/L	
WR-05	T11N	R22E	9	A1	OSDH	1-15	SOIL	1.28	MG/KG	
WR-05	T11N	R22E	9	A1	OSDH	1-15	VEG	3.28	MG/KG	
WR-06	T11N	R22E	5	N3	OSDH	1-15	WATER	0.26	MG/L	
WR-07	T11N	R22E	6	N14	OSDH	1-15	SOIL	<0.40	MG/KG	
WR-07	T11N	R22E	6	N14	OSDH	1-15	VEG	1.68	MG/KG	
WR-08	T11N	R22E	6	N7	OSDH	1-15	SOIL	1.08	MG/KG	
WR-08	T11N	R22E	6	N7	OSDH	1-15	VEG	2.08	MG/KG	
WR-09	T11N	R22E	6	G1	OSDH	1-15	SOIL	0.52	MG/KG	
WR-09	T11N	R22E	6	G1	OSDH	1-15	VEG	1.84	MG/KG	
WR-10	T11N	R22E	17	A1	OSDH	1-15	SOIL	<0.40	MG/KG	
WR-10	T11N	R22E	17	A1	OSDH	1-15	VEG	2.32	MG/KG	
YRES51	T11N	R21E	26	N3	KMTC	1-05	VEG	2600.0	PPM	YRES
YRES52	T11N	R21E	26	N3	KMTC	1-05	SOIL	100.0	PPM	YRES

Table 5.2.7.23A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
16W	T11N	R21E	34	B6	KMTC	1-06	WATER	0.006	MG/L	
1H14	T11N	R21E	1	H14	KMTC	1-10	SOIL	<10	PPM	
2E14	T11N	R21E	2	E14	KMTC	1-10	SOIL	<10	PPM	
4A 6	T11N	R21E	4	A6	KMTC	1-10	SOIL	<10	PPM	
4J14	T11N	R21E	4	J14	KMTC	1-09	SOIL	<10	PPM	
5N 6	T11N	R22E	5	N6	KMTC	1-09	SOIL	<10	PPM	
6A 7	T11N	R22E	6	A7	KMTC	1-09	SOIL	<10	PPM	
6C14	T11N	R22E	6	C14	KMTC	1-09	SOIL	<10	PPM	
6I11	T11N	R22E	6	I11	KMTC	1-09	SOIL	<10	PPM	
7C 6	T11N	R22E	7	C6	KMTC	1-08	SOIL	<10	PPM	
7C 6	T11N	R22E	7	C6	KMTC	1-08	VEG	1.2	PPM	J.GRASS
7F 7	T11N	R22E	7	F7	KMTC	1-08	SOIL	<10	PPM	
7F 7	T11N	R22E	7	F7	KMTC	1-08	VEG	3.9	PPM	WHEAT
7F 7	T11N	R22E	7	F7	KMTC	1-08	VEG	3.5	PPM	
8A 1	T11N	R22E	8	A1	KMTC	1-09	SOIL	<10	PPM	
8J 7	T11N	R21E	8	J7	KMTC	1-09	SOIL	<10	PPM	
8N14	T11N	R22E	8	M14	KMTC	1-09	SOIL	20.0	PPM	
9B 2	T11N	R21E	9	B2	KMTC	1-09	SOIL	<10	PPM	
9I 8	T11N	R21E	9	I8	KMTC	1-09	SOIL	15.0	PPM	
10B 8	T11N	R21E	10	B8	KMTC	1-09	SOIL	<10	PPM	
10L 8	T11N	R21E	10	L8	KMTC	1-08	SOIL	<10	PPM	
10M10	T11N	R21E	10	M10	KMTC	1-08	SOIL	<10	PPM	
11F 7	T11N	R21E	11	F7	KMTC	1-08	SOIL	<10	PPM	
11F 7	T11N	R21E	11	F7	KMTC	1-08	VEG	9.3	PPM	CAT LEAVES
11F 7	T11N	R21E	11	F7	KMTC	1-08	VEG	31.0	PPM	BEANS
11F 7	T11N	R21E	11	F7	KMTC	1-08	VEG	18.0	PPM	WILLOW
11N 6	T11N	R21E	11	N6	KMTC	1-08	SOIL	<10	PPM	
12F 7	T11N	R21E	12	F7	KMTC	1-09	SOIL	<10	PPM	
12N 8	T11N	R21E	12	N8	KMTC	1-08	SOIL	<10	PPM	
12N 8	T11N	R21E	12	N8	KMTC	1-08	VEG	5.9	PPM	CEDAR
12N 8	T11N	R21E	12	N8	KMTC	1-08	VEG	3.7	PPM	CAT TIPS
12N 8	T11N	R21E	12	N8	KMTC	1-08	VEG	2.6	PPM	
13B 1	T11N	R21E	13	B1	KMTC	1-08	SOIL	15.0	PPM	
13B 1	T11N	R21E	13	B1	KMTC	1-08	VEG	2.2	PPM	
13G11	T11N	R21E	13	G11	KMTC	1-09	SOIL	15.0	PPM	
13G11	T11N	R21E	13	G11	KMTC	1-09	VEG	1.9	PPM	
13H 2	T11N	R21E	13	H2	KMTC	1-08	SOIL	15.0	PPM	
14B 4	T11N	R21E	14	B4	KMTC	1-08	SOIL	<10	PPM	
14B 4	T11N	R21E	14	B4	KMTC	1-08	VEG	1.5	PPM	
14B 8	T11N	R21E	14	B8	KMTC	1-08	SOIL	15.0	PPM	
14B 8	T11N	R21E	14	B8	KMTC	1-08	VEG	0.6	PPM	
14B12	T11N	R21E	14	B12	KMTC	1-08	SOIL	15.0	PPM	
14B12	T11N	R21E	14	B12	KMTC	1-08	VEG	8.1	PPM	FESCUE
14B12	T11N	R21E	14	B12	KMTC	1-08	VEG	7.8	PPM	FESCUE TIP
16B10	T11N	R21E	16	B10	KMTC	1-09	SOIL	<10	PPM	
16B10	T11N	R21E	16	B10	KMTC	1-09	VEG	0.6	PPM	
16L 2	T11N	R21E	16	L2	KMTC	1-10	SOIL	<10	PPM	
16L12	T11N	R21E	16	L12	KMTC	1-10	SOIL	<10	PPM	
16L12	T11N	R21E	16	L12	KMTC	1-10	VEG	1.1	PPM	

Table 5.2.7.23A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
18B 4	T11N	R22E	18	B4	KMTC	1-09	SOIL	<10	PPM	
18B 4	T11N	R22E	18	B4	KMTC	1-09	VEG	0.7	PPM	
18H10	T11N	R22E	18	H10	KMTC	1-09	SOIL	<10	PPM	
18H10	T11N	R22E	18	H10	KMTC	1-09	VEG	<0.5	PPM	
1A11	T11N	R21E	1	A11	KMTC	1-09	SOIL	<10	PPM	
1A11	T11N	R21E	1	A11	KMTC	1-09	VEG	0.7	PPM	
1H14	T11N	R21E	1	H14	KMTC	1-08	VEG	1.4	PPM	
22G14	T11N	R21E	22	G14	KMTC	1-10	SOIL	<10	PPM	
22G14	T11N	R21E	22	G14	KMTC	1-10	VEG	<0.5	PPM	
23A10	T11N	R21E	23	A10	KMTC	1-08	SOIL	10.0	PPM	T11N
23A10	T11N	R21E	23	A10	KMTC	1-08	VEG	28.0	PPM	T11N
25E 8	T12N	R21E	25	E8	KMTC	1-10	SOIL	15.0	PPM	
25E 8	T12N	R21E	25	E8	KMTC	1-10	VEG	1.2	PPM	
25H 3	T12N	R21E	25	H3	KMTC	1-10	SOIL	15.0	PPM	
25H 3	T12N	R21E	25	H3	KMTC	1-10	VEG	<0.5	PPM	
25H 3	T12N	R21E	25	H3	KMTC	1-10	VEG	<0.5	PPM	
25H14	T12N	R21E	25	H14	KMTC	1-10	SOIL	15.0	PPM	
25L14	T12N	R21E	25	L14	KMTC	1-14	WATER	<0.002	MG/L	
26E 7	T12N	R21E	26	E7	KMTC	1-14	WATER	0.006	MG/L	
26F 6	T12N	R21E	26	F6	KMTC	1-14	WATER	0.003	MG/L	SURFACE WATER
26G 1	T12N	R21E	26	G1	KMTC	1-10	SOIL	15.0	PPM	
26G 1	T12N	R21E	26	G1	KMTC	1-10	VEG	<0.5	PPM	
26G 8	T12N	R21E	26	G8	KMTC	1-10	SOIL	10.0	PPM	
26G 8	T12N	R21E	26	G8	KMTC	1-10	VEG	1.1	PPM	
26L 1	T12N	R21E	26	L1	KMTC	1-14	WATER	0.003	MG/L	
27A13	T12N	R21E	27	A13	KMTC	1-08	SOIL	10.0	PPM	
27A13	T12N	R21E	27	A13	KMTC	1-08	VEG	4.5	PPM	SMILAX
27A13	T12N	R21E	27	A13	KMTC	1-08	VEG	5.7	PPM	CEDAR
27D 1	T12N	R21E	27	D1	KMTC	1-10	SOIL	15.0	PPM	
27D 1	T12N	R21E	27	D1	KMTC	1-10	VEG	52.0	PPM	
27H 9	T12N	R21E	27	H9	KMTC	1-10	SOIL	<10	PPM	
27H 9	T12N	R21E	27	H9	KMTC	1-10	VEG	2.3	PPM	
27H 9	T12N	R21E	27	H9	KMTC	1-10	VEG	1.1	PPM	
27I 0	T12N	R21E	27	I0	KMTC	1-14	WATER	<0.002	MG/L	SURFACE WATER
27K 4	T12N	R21E	27	K4	KMTC	1-10	SOIL	15.0	PPM	
27K 4	T12N	R21E	27	K4	KMTC	1-10	VEG	38.0	PPM	
27L 1	T12N	R21E	27	L1	KMTC	1-14	WATER	<0.002	MG/L	
27L 4	T12N	R21E	27	L4	KMTC	1-14	WATER	<0.002	MG/L	SURFACE WATER
27L 8	T12N	R21E	27	L8	KMTC	1-14	WATER	0.004	MG/L	SURFACE WATER
28G 4	T12N	R21E	28	G4	KMTC	1-10	SOIL	<10	PPM	
28G 4	T12N	R21E	28	G4	KMTC	1-10	VEG	1.2	PPM	
28G 4	T12N	R21E	28	G4	KMTC	1-10	VEG	<0.5	PPM	
28H14	T12N	R21E	28	H14	KMTC	1-14	WATER	<0.002	MG/L	SURFACE WATER
28J11	T12N	R21E	28	J11	KMTC	1-10	SOIL	<10	PPM	
28J11	T12N	R21E	28	J11	KMTC	1-10	VEG	1.7	PPM	
28N 2	T12N	R21E	28	N2	KMTC	1-10	SOIL	<10	PPM	
28N 2	T12N	R21E	28	N2	KMTC	1-10	VEG	<0.5	PPM	
28N 2	T12N	R21E	28	N2	KMTC	1-10	VEG	6.6	PPM	
29D 3	T12N	R22E	29	D3	KMTC	1-10	SOIL	15.0	PPM	

Table 5.2.7.23A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
29D 3	T12N	R22E	29	D3	KMTC	1-10	VEG	<0.5	PPM	
2E14	T11N	R21E	2	E14	KMTC	1-09	VEG	<0.5	PPM	
2L13	T11N	R21E	2	L13	KMTC	1-09	SOIL	<10	PPM	
2L13	T11N	R21E	2	L13	KMTC	1-09	SOIL	<10	PPM	
2L13	T11N	R21E	2	L13	KMTC	1-09	VEG	5.5	PPM	
2M 8	T11N	R21E	2	M8	KMTC	1-09	SOIL	<10	PPM	
2M 8	T11N	R21E	2	M8	KMTC	1-09	VEG	55.0	PPM	
30F 7	T12N	R22E	30	F7	KMTC	1-10	SOIL	15.0	PPM	
30F 7	T12N	R22E	30	F7	KMTC	1-10	VEG	<0.5	PPM	
30F 7	T12N	R22E	30	F7	KMTC	1-10	VEG	0.5	PPM	
31B10	T12N	R22E	31	B10	KMTC	1-10	SOIL	<10	PPM	
31B10	T12N	R22E	31	B10	KMTC	1-10	VEG	<0.5	PPM	
33B14	T12N	R21E	33	B14	KMTC	1-10	SOIL	<10	PPM	
33B14	T12N	R21E	33	B14	KMTC	1-10	VEG	<0.5	PPM	
33I 3	T12N	R21E	33	I3	KMTC	1-10	SOIL	<10	PPM	
33I 3	T12N	R21E	33	I3	KMTC	1-10	VEG	<0.5	PPM	
33M14	T12N	R21E	33	M14	KMTC	1-10	SOIL	<10	PPM	
33M14	T12N	R21E	33	M14	KMTC	1-10	VEG	<0.5	PPM	
33M14	T12N	R21E	33	M14	KMTC	1-10	VEG	<0.5	PPM	
34D 7	T12N	R21E	34	D7	KMTC	1-10	SOIL	<10	PPM	
34D 7	T12N	R21E	34	D7	KMTC	1-10	VEG	16.0	PPM	
35A 9	T12N	R21E	35	A9	KMTC	1-10	SOIL	15.0	PPM	
35A 9	T12N	R21E	35	A9	KMTC	1-10	VEG	<0.5	PPM	
35A 9	T12N	R21E	35	A9	KMTC	1-10	VEG	0.8	PPM	
35B 1	T12N	R21E	35	B1	KMTC	1-10	SOIL	10.0	PPM	
35B 1	T12N	R21E	35	B1	KMTC	1-10	VEG	<0.5	PPM	
35B14	T12N	R21E	35	B14	KMTC	1-10	SOIL	10.0	PPM	
35B14	T12N	R21E	35	B14	KMTC	1-10	VEG	<0.5	PPM	
35F10	T12N	R21E	35	F10	KMTC	1-10	SOIL	15.0	PPM	
35F10	T12N	R21E	35	F10	KMTC	1-10	VEG	0.6	PPM	
35L 5	T12N	R21E	35	L5	KMTC	1-09	SOIL	10.0	PPM	
35L 5	T12N	R21E	35	L5	KMTC	1-09	VEG	<0.5	PPM	
35L 5	T12N	R21E	35	L5	KMTC	1-09	VEG	1.0	PPM	
35L11	T12N	R21E	35	L11	KMTC	1-10	SOIL	<10	PPM	
35L11	T12N	R21E	35	L11	KMTC	1-10	VEG	<0.5	PPM	
35L11	T12N	R21E	35	L11	KMTC	1-10	VEG	1.2	PPM	
36A13	T12N	R21E	36	A13	KMTC	1-10	SOIL	<10	PPM	
36A13	T12N	R21E	36	A13	KMTC	1-10	VEG	<0.5	PPM	
36D11	T12N	R21E	36	D11	KMTC	1-14	WATER	0.004	MG/L	
36G 5	T12N	R21E	36	G5	KMTC	1-09	SOIL	<10	PPM	
36G 5	T12N	R21E	36	G5	KMTC	1-09	VEG	0.9	PPM	
36H14	T12N	R21E	36	H14	KMTC	1-10	SOIL	<10	PPM	
36H14	T12N	R21E	36	H14	KMTC	1-10	VEG	0.5	PPM	
36L 5	T12N	R21E	36	L5	KMTC	1-14	WATER	0.003	MG/L	
36M10	T12N	R21E	36	M10	KMTC	1-14	WATER	<0.002	MG/L	
3F 7	T11N	R21E	3	F7	KMTC	1-09	SOIL	<10	PPM	
3F 7	T11N	R21E	3	F7	KMTC	1-09	VEG	0.6	PPM	
4A 1	T11N	R21E	4	A1	KMTC	1-10	SOIL	<10	PPM	
4A 1	T11N	R21E	4	A1	KMTC	1-10	VEG	<0.5	PPM	
4A 3	T11N	R21E	4	A3	KMTC	1-10	VEG	<0.5	PPM	

Table 5.2.7.23A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR URANIUM SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
4A 6	T11N	R21E	4	A6	KMTC	1-10	VEG	<0.5	PPM	
4J14	T11N	R21E	4	J14	KMTC	1-09	VEG	1.0	PPM	
4J14	T11N	R21E	4	J14	KMTC	1-09	VEG	<0.5	PPM	
4N 7	T11N	R21E	4	N7	KMTC	1-09	SOIL	<10	PPM	
4N 7	T11N	R21E	4	N7	KMTC	1-09	VEG	<0.5	PPM	
4N 8	T11N	R21E	4	N8	KMTC	1-09	VEG	<0.5	PPM	
50/HWY	T12N	R21E	22	G1	KMTC	1-06	VEG	17000.0	PPM	
5N 6	T11N	R22E	5	N6	KMTC	1-09	VEG	0.5	PPM	
6A 7	T11N	R22E	6	A7	KMTC	1-09	VEG	<0.5	PPM	
6C14	T11N	R22E	6	C14	KMTC	1-09	VEG	1.8	PPM	
8A 1	T11N	R22E	8	A1	KMTC	1-09	VEG	1.7	PPM	
8J 7	T11N	R21E	8	J7	KMTC	1-09	VEG	1.1	PPM	
8N14	T11N	R22E	8	N14	KMTC	1-09	VEG	<0.5	PPM	
9B 2	T11N	R21E	8	B2	KMTC	1-09	VEG	1.7	PPM	
BG 1/4	T12N	R21E	21	B13	ORNL	1-06	SOIL	7.88	PPM	DRY
BG 1/4	T12N	R21E	21	B13	ORNL	1-06	SOIL	6.1	PPM	WET
BG 1/4	T12N	R21E	21	B13	KMTC	1-06	SOIL	<10	PPM	
BG 1/4	T12N	R21E	21	B13	ORNL	1-06	VEG	3.91	PPM	
BG 1/4	T12N	R21E	21	B13	KMTC	1-06	VEG	64.0	PPM	
CARLILE	T12N	R21E	22	D14	ORNL	1-05	SOIL	3.7	PPM	DRY
CARLILE	T12N	R21E	22	D14	ORNL	1-05	SOIL	2.7	PPM	WET
CRES	T12N	R21E	27	K3	ORNL	1-05	SOIL	2.9	PPM	DRY
CRES	T12N	R21E	27	K3	ORNL	1-05	SOIL	2.0	PPM	WET
CRES	T12N	R21E	27	K3	ORNL	1-05	WATER	0.05	UM/ML	
CRES08	T12N	R21E	27	K3	KMTC	1-04	VEG	12.0	PPM	CRES
CRES09	T12N	R21E	27	K3	KMTC	1-04	SOIL	<10	PPM	CRES
CRES10	T12N	R21E	27	K3	KMTC	1-04	SOIL	<10	PPM	CRES
DRES11	T12N	R21E	27	K4	KMTC	1-04	SOIL	15.0	PPM	DRES
DRES12	T12N	R21E	27	K4	KMTC	1-04	VEG	220.0	PPM	DRES
DRES13	T12N	R21E	27	K4	KMTC	1-04	SOIL	13.0	PPM	DRES
H-02	T12N	R21E	27	I2	KMTC	1-04	VEG	32.0	PPM	CEDAR
H-03	T12N	R21E	27	I2	KMTC	1-04	VEG	0.95	PPM	HRES
HRES01	T12N	R21E	27	I2	KMTC	1-04	SOIL	<10	PPM	HRES
LRES04	T12N	R21E	28	I14	KMTC	1-04	VEG	<0.4	PPM	LRES
LRES05	T12N	R21E	28	I14	KMTC	1-04	SOIL	<10	PPM	LRES
LRES06	T12N	R21E	28	I14	KMTC	1-04	SOIL	<10	PPM	LRES
LRES07	T12N	R21E	28	I14	KMTC	1-04	WATER	<0.002	MG/L	FRONT PORCH
RKRES15	T12N	R21E	34	A13	KMTC	1-04	VEG	0.6	PPM	RKRES
RKRES16	T12N	R21E	34	A13	KMTC	1-04	SOIL	<10	PPM	RKRES
RRES17	T11N	R21E	34	B6	KMTC	1-04	SOIL	<10	PPM	RRES
RRES18	T11N	R21E	34	B6	KMTC	1-04	VEG	2.7	PPM	RRES
RRES19	T11N	R21E	34	B6	KMTC	1-04	SOIL	<10	PPM	RRES
SHRES14	T12N	R21E	27	N6	KMTC	1-04	SOIL	<10	PPM	RRES
SMRES20	T12N	R21E	26	K6	KMTC	1-04	SOIL	11.0	PPM	SMRES
SMRES21	T12N	R21E	26	K6	KMTC	1-04	VEG	0.6	PPM	SMRES
T4-01E	T11N	R21E	2	C11	ORNL	1-06	SOIL	3.72	PPM	DRY
T4-01E	T11N	R21E	2	C11	ORNL	1-06	SOIL	3.1	PPM	WET
T4-01E	T11N	R21E	2	C11	ORNL	1-06	VEG	5.29	PPM	
T4-01W	T12N	R21E	27	N1	ORNL	1-06	SOIL	1.52	PPM	DRY
T4-01W	T12N	R21E	27	N1	ORNL	1-06	SOIL	1.3	PPM	WET
T4-02E	T11N	R21E	2	B8	ORNL	1-06	SOIL	3.59	PPM	DRY

Table 5.2.7.23A (Continued)

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR URANIUM SAMPLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
T4-02E	T11N	R21E	2	B8	ORNL	1-06	SOIL	3.0	PPM	WET
T4-02E	T11N	R21E	2	B8	ORNL	1-06	VEG	1.99	PPM	
T4-02W	T12N	R21E	33	L14	ORNL	1-06	SOIL	1.5	PPM	WET
T4-02W	T12N	R21E	33	L14	ORNL	1-06	SOIL	1.67	PPM	DRY
T4-03E	T12N	R21E	35	N5	ORNL	1-06	SOIL	3.8	PPM	DRY
T4-03E	T12N	R21E	35	N5	ORNL	1-06	SOIL	2.9	PPM	WET
T4-03E	T12N	R21E	35	N5	ORNL	1-06	VEG	1.0	PPM	
T4-03W	T12N	R21E	34	B6	ORNL	1-06	SOIL	2.76	PPM	DRY
T4-03W	T12N	R21E	34	B6	ORNL	1-06	SOIL	2.2	PPM	WET
T4-04E	T12N	R21E	35	L3	ORNL	1-06	SOIL	3.73	PPM	DRY
T4-04E	T12N	R21E	35	L3	ORNL	1-06	SOIL	3.0	PPM	WET
T4-04E	T12N	R21E	35	L3	ORNL	1-06	VEG	0.807	PPM	
T4-04W	T12N	R21E	34	L13	ORNL	1-06	SOIL	2.45	PPM	DRY
T4-04W	T12N	R21E	34	L13	ORNL	1-06	SOIL	2.0	PPM	WET
T4-04W	T12N	R21E	34	L13	ORNL	1-06	VEG	3.68	PPM	
T4-05E	T12N	R21E	35	K1	ORNL	1-06	SOIL	2.29	PPM	DRY
T4-05E	T12N	R21E	35	K1	ORNL	1-06	SOIL	1.9	PPM	WET
T4-05E	T12N	R21E	35	K1	ORNL	1-06	VEG	19.6	PPM	
TRES53	T11N	R21E	23	M10	KMTC	1-06	VEG	16.0	PPM	
TRES54	T11N	R21E	23	M10	KMTC	1-06	SOIL	<10	PPM	
YRES51	T11N	R21E	26	N3	KMTC	1-05	VEG	8.1	PPM	
YRES52	T11N	R21E	26	N3	KMTC	1-05	SOIL	<10	PPM	

Table 5.2.7.24A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR ALPHA PARTICLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
CARLILE	T12N	R21E	22	D14	OSDH	1-05	SOIL	0.1	PCI/G	
CARLILE	T12N	R21E	22	D14	OSDH	1-05	VEG	0.8	PCI/G	GRASS
CNTRL01	T09N	R24E	16	-	OSDH	1-06	SOIL	0.8	PCI/G	
CNTRL01	T09N	R24E	16	-	OSDH	1-06	VEG	-0.4	PCI/G	
CNTRL02	T10N	R22E	35	C14	OSDH	1-06	SOIL	0.4	PCI/G	
CNTRL02	T10N	R22E	35	C14	OSDH	1-06	VEG	0.2	PCI/G	
CNTRL03	T11N	R22E	28	E10	OSDH	1-06	SOIL	-0.2	PCI/G	
CNTRL03	T11N	R22E	28	E10	OSDH	1-06	VEG	0.1	PCI/G	
CNTRL04	T11N	R22E	20	N10	OSDH	1-06	SOIL	1.1	PCI/G	
CNTRL04	T11N	R22E	20	N10	OSDH	1-06	VEG	0.5	PCI/G	
CNTRL05	T11N	R22E	19	F13	OSDH	1-06	SOIL	-0.3	PCI/G	
CNTRL05	T11N	R22E	19	F13	OSDH	1-06	VEG	-0.3	PCI/G	
CNTRL06	T09N	R22E	4	I13	OSDH	1-06	VEG	-0.4	PCI/G	
CNTRL07	T11N	R21E	13	B7	OSDH	1-06	SOIL	-0.3	PCI/G	
CNTRL07	T11N	R21E	13	B7	OSDH	1-06	VEG	-0.3	PCI/G	
CNTRL08	T10N	R22E	8	K8	OSDH	1-06	SOIL	0.4	PCI/G	
CNTRL08	T10N	R22E	8	K8	OSDH	1-06	VEG	1.0	PCI/G	
CNTRL09	T11N	R20E	21	C12	OSDH	1-06	SOIL	0.1	PCI/G	
CNTRL09	T11N	R20E	21	C12	OSDH	1-06	VEG	1.0	PCI/G	
CNTRL09	T11N	R20E	21	C12	OSDH	1-06	VEG	0.4	PCI/G	
CNTRL10	T11N	R20E	21	I13	OSDH	1-06	SOIL	-0.3	PCI/G	
CNTRL10	T11N	R20E	21	I13	OSDH	1-06	VEG	0.1	PCI/G	
CNTRL11	T12N	R19E	26	E3	OSDH	1-06	SOIL	-0.3	PCI/G	
CNTRL11	T12N	R19E	26	E3	OSDH	1-06	VEG	0.2	PCI/G	
CNTRL12	T11N	R20E	14	N6	OSDH	1-06	SOIL	0.5	PCI/G	
CNTRL13	T11N	R23E	3	C2	OSDH	1-06	SOIL	0.4	PCI/G	
CNTRL13	T11N	R23E	3	C2	OSDH	1-06	VEG	0.2	PCI/G	
CNTRL14	T11N	R23E	-	-	OSDH	1-06	SOIL	0.7	PCI/G	S OF SALLISAW
CNTRL15	T09N	R20E	16	G13	OSDH	1-06	SOIL	-0.3	PCI/G	
CNTRL15	T09N	R20E	16	G13	OSDH	1-06	VEG	-0.3	PCI/G	
CRES	T12N	R21E	27	K3	OSDH	1-05	SOIL	-0.1	PCI/G	
CRES	T12N	R21E	27	K3	OSDH	1-05	VEG	1.1	PCI/G	GRASS
CRES	T12N	R21E	27	K3	OSDH	1-05	WATER	0.0	PCI/L	
HRES	T12N	R21E	27	I2	OSDH		VEG	5.0	PCI/G	
T4-01E	T11N	R21E	2	C11	OSDH	1-06	SOIL	-0.3	PCI/G	
T4-01E	T11N	R21E	2	C11	OSDH	1-06	VEG	0.3	PCI/G	EVERGREEN
T4-01W	T12N	R21E	27	N1	OSDH	1-06	SOIL	-0.2	PCI/G	
T4-02E	T11N	R21E	2	B8	OSDH	1-06	SOIL	0.4	PCI/G	
T4-02E	T11N	R21E	2	B8	OSDH	1-06	VEG	-0.2	PCI/G	EVERGREEN
T4-02W	T12N	R21E	33	L14	OSDH	1-06	SOIL	0.7	PCI/G	
T4-03E	T12N	R21E	35	N5	OSDH	1-06	SOIL	0.1	PCI/G	
T4-03E	T12N	R21E	35	N5	OSDH	1-06	VEG	-0.1	PCI/G	EVERGREEN
T4-03W	T12N	R21E	34	B6	OSDH	1-06	SOIL	0.1	PCI/G	
T4-04E	T12N	R21E	35	L3	OSDH	1-06	SOIL	0.1	PCI/G	
T4-04E	T12N	R21E	35	L3	OSDH	1-06	VEG	0.0	PCI/G	EVERGREEN
T4-04W	T12N	R21E	34	L13	OSDH	1-06	SOIL	0.1	PCI/G	
T4-04W	T12N	R21E	34	L13	OSDH	1-06	VEG	0.1	PCI/G	LEAVES
T4-05E	T12N	R21E	35	K1	OSDH	1-06	SOIL	-0.3	PCI/G	
T4-05E	T12N	R21E	35	K1	OSDH	1-06	VEG	4.5	PCI/G	EVERGREEN

Table 5.2.7.25A

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR BETA PARTICLES

LABEL	TOWNSHP	RANGE	SECTION	SUBSECT	LAB	DATE	MEDIA	RESULTS	UNITS	COMMENTS
CARLILE	T12N	R21E	22	D14	OSDH	1-05	SOIL	-0.3	PCI/G	
CARLILE	T12N	R21E	22	D14	OSDH	1-05	VEG	0.7	PCI/G	GRASS
CNTRL01	T09N	R24E	16	-	OSDH	1-06	SOIL	-0.3	PCI/G	
CNTRL01	T09N	R24E	16	-	OSDH	1-06	VEG	-0.1	PCI/G	
CNTRL02	T10N	R22E	35	C14	OSDH	1-06	SOIL	0.3	PCI/G	
CNTRL02	T10N	R22E	35	C14	OSDH	1-06	VEG	2.0	PCI/G	
CNTRL03	T11N	R22E	28	E10	OSDH	1-06	SOIL	-0.0	PCI/G	
CNTRL03	T11N	R22E	28	E10	OSDH	1-06	VEG	0.3	PCI/G	
CNTRL04	T11N	R22E	20	N10	OSDH	1-06	SOIL	-0.3	PCI/G	
CNTRL04	T11N	R22E	20	N10	OSDH	1-06	VEG	0.3	PCI/G	
CNTRL05	T11N	R22E	19	F13	OSDH	1-06	SOIL	-0.0	PCI/G	
CNTRL05	T11N	R22E	19	F13	OSDH	1-06	VEG	0.2	PCI/G	
CNTRL06	T09N	R22E	4	I13	OSDH	1-06	VEG	0.6	PCI/G	
CNTRL07	T11N	R21E	13	B7	OSDH	1-06	SOIL	0.5	PCI/G	
CNTRL07	T11N	R21E	13	B7	OSDH	1-06	VEG	0.8	PCI/G	
CNTRL08	T10N	R22E	8	K8	OSDH	1-06	SOIL	-0.4	PCI/G	
CNTRL08	T10N	R22E	8	K8	OSDH	1-06	VEG	0.7	PCI/G	
CNTRL09	T11N	R20E	21	C12	OSDH	1-06	SOIL	-0.3	PCI/G	
CNTRL09	T11N	R20E	21	C12	OSDH	1-06	VEG	7.0	PCI/G	
CNTRL09	T11N	R20E	21	C12	OSDH	1-06	VEG	-0.3	PCI/G	
CNTRL10	T11N	R20E	21	I13	OSDH	1-06	SOIL	0.3	PCI/G	
CNTRL10	T11N	R20E	21	I13	OSDH	1-06	VEG	-0.2	PCI/G	
CNTRL11	T12N	R19E	26	E3	OSDH	1-06	SOIL	-0.2	PCI/G	
CNTRL11	T12N	R19E	26	E3	OSDH	1-06	VEG	0.1	PCI/G	
CNTRL12	T11N	R20E	14	N6	OSDH	1-06	SOIL	0.9	PCI/G	
CNTRL13	T11N	R23E	3	C2	OSDH	1-06	SOIL	0.5	PCI/G	
CNTRL13	T11N	R23E	3	C2	OSDH	1-06	VEG	3.0	PCI/G	
CNTRL14	T11N	R23E	-	-	OSDH	1-06	SOIL	0.6	PCI/G	S OF SALLISAW
CNTRL15	T09N	R20E	16	G13	OSDH	1-06	SOIL	-0.4	PCI/G	
CNTRL15	T09N	R20E	16	G13	OSDH	1-06	VEG	0.3	PCI/G	
CRES	T12N	R21E	27	K3	OSDH	1-05	SOIL	-0.0	PCI/G	
CRES	T12N	R21E	27	K3	OSDH	1-05	VEG	0.2	PCI/G	GRASS
CRES	T12N	R21E	27	K3	OSDH	1-05	WATER	-1.0	PCI/L	
HRES	T12N	R21E	27	I2	OSDH	1/5	VEG	1.9	PCI/G	
T4-01E	T11N	R21E	2	C11	OSDH	1-06	SOIL	0.1	PCI/G	
T4-01E	T11N	R21E	2	C11	OSDH	1-06	VEG	-0.2	PCI/G	EVERGREEN
T4-01W	T12N	R21E	27	N1	OSDH	1-06	SOIL	-0.2	PCI/G	
T4-02E	T11N	R21E	2	B8	OSDH	1-06	SOIL	-0.2	PCI/G	
T4-02E	T11N	R21E	2	B8	OSDH	1-06	VEG	-0.3	PCI/G	EVERGREEN
T4-02W	T12N	R21E	33	L14	OSDH	1-06	SOIL	0.1	PCI/G	
T4-03E	T12N	R21E	35	N5	OSDH	1-06	SOIL	0.6	PCI/G	
T4-03E	T12N	R21E	35	N5	OSDH	1-06	VEG	0.2	PCI/G	EVERGREEN
T4-03W	T12N	R21E	34	B6	OSDH	1-06	SOIL	-0.6	PCI/G	
T4-04E	T12N	R21E	35	L3	OSDH	1-06	SOIL	0.1	PCI/G	
T4-04E	T12N	R21E	35	L3	OSDH	1-06	VEG	-0.2	PCI/G	EVERGREEN
T4-04W	T12N	R21E	34	L13	OSDH	1-06	SOIL	-0.4	PCI/G	
T4-04W	T12N	R21E	34	L13	OSDH	1-06	VEG	0.4	PCI/G	LEAVES
T4-05E	T12N	R21E	35	K1	OSDH	1-06	SOIL	-0.4	PCI/G	
T4-05E	T12N	R21E	35	K1	OSDH	1-06	VEG	0.8	PCI/G	EVERGREEN

APPENDIX 5.3.1

RAW SURFACE WATER DATA

APPENDIX 5.3.1

Surface waters were sampled by both SFC and OSDH. Sampling locations are shown in Appendix 5.2.1 and in Section 5.3.1. Sampling locations and results are listed in the tables which follow.

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE IN WATER SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
1W	14500	14800	KMTC	1-06	F	0.1	mg/l	
2W	13250	13950	KMTC	1-06	F	0.1	mg/l	
3W	12750	11200	KMTC	1-06	F	0.2	mg/l	
4W	11700	11150	KMTC	1-06	F	0.2	mg/l	
5W	10100	10950	KMTC	1-06	F	0.4	mg/l	
6W	9850	9450	KMTC	1-06	F	0.1	mg/l	
7W	10600	7000	KMTC	1-06	F	0.2	mg/l	
8W	11800	7000	KMTC	1-06	F	0.3	mg/l	
10W	11800	6200	KMTC	1-06	F	0.1	mg/l	
11W	16350	9450	KMTC	1-06	F	<0.1	mg/l	
12W	6750	11050	KMTC	1-06	F	0.1	mg/l	
13W	7475	13350	KMTC	1-06	F	<0.1	mg/l	
14W	18450	6950	KMTC	1-06	F	<0.1	mg/l	
14W	18450	6950	KMTC	1-08	F	<0.1	mg/l	
15W	12900	5950	KMTC	1-06	F	<0.1	mg/l	
15W	12900	5950	KMTC	1-08	F	<0.1	mg/l	
17W	7650	4350	KMTC	1-06	F	0.2	mg/l	
18W	15100	10300	KMTC	1-08	F	0.1	mg/l	
19W	6850	9050	KMTC	1-08	F	0.2	mg/l	
20W	7750	17000	KMTC	1-08	F	0.1	mg/l	
300	12450	9900	KMTC	1-06	F	0.3	mg/l	
301	12450	9900	KMTC	1-14	F	0.2	mg/l	
302	12550	9550	KMTC	1-06	F	1.6	mg/l	
303	12550	9550	KMTC	1-14	F	1.5	mg/l	
304	12550	9400	KMTC	1-06	F	2.0	mg/l	
305	12550	9400	KMTC	1-14	F	4.8	mg/l	
306	11450	9550	KMTC	1-06	F	0.5	mg/l	
307	11450	9550	KMTC	1-14	F	0.5	mg/l	
LAGOON	12800	9200	KMTC	1-17	F	3.9	mg/l	
LRES07	6950	9900	KMTC	1-04	F	<0.1	mg/l	RAIN BARREL
PW 1632	13250	9400	KMTC	1-15	F	<0.1	mg/l	
CRES	6150	10800	ORNL	1-05	F	0.09	ug/ml	
T1-10	12750	11100	ORNL	1-05	F	0.21	ug/ml	
T1-10	12750	11100	ORNL	1-05	F	0.19	ug/ml	
T2-04	10350	8400	ORNL	1-05	F	0.15	ug/ml	
T2-06	11450	9950	ORNL	1-05	F	0.46	ug/ml	
T2-07	11700	11100	ORNL	1-06	F	0.09	ug/ml	
COMP-3	10050	10700	OSDH	1-16	F	0.45	mg/l	LAB COMPARISON
COMP-4	14450	14800	OSDH	1-16	F	0.27	mg/l	LAB COMPARISON
COMP-5	12700	11200	OSDH	1-16	F	0.24	mg/l	LAB COMPARISON
CRES	6150	10800	OSDH	1-05	F	0.19	mg/l	
KM H20	13250	9400	OSDH	1-17	F	0.24	mg/l	
LAGOON	12800	9200	OSDH	1-17	F	4.40	mg/l	
RD-03	6600	10800	OSDH	1-16	F	0.22	mg/l	
RD-04	6350	10750	OSDH	1-16	F	0.30	mg/l	
RD-05	6200	10850	OSDH	1-16	F	0.17	mg/l	
RD-06	6900	10200	OSDH	1-16	F	0.19	mg/l	

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FLUORIDE IN WATER SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
RD-07	10100	10700	OSDH	1-16	F	0.32	mg/l	
RD-08	9900	9450	OSDH	1-16	F	0.20	mg/l	
STRM GH	12650	9550	OSDH	1-16	F	7.00	mg/l	
T1-03&4	12500	8750	OSDH	1-14	F	0.23	mg/l	
T1-06	12500	9500	OSDH	1-14	F	1.80	mg/l	
T1-10	12750	11100	OSDH	1-05	F	0.2	mg/l	
T1-13	12200	13150	OSDH	1-14	F	0.41	mg/l	
T1-14	13250	14000	OSDH	1-14	F	0.29	mg/l	
T2-04	10350	8650	OSDH	1-14	F	0.36	mg/l	
T2-04	10350	8400	OSDH	1-05	F	0.26	mg/l	
T2-06	11500	9950	OSDH	1-06	F	0.37	mg/l	
T2-07	11500	10650	OSDH	1-05	F	0.23	mg/l	
T2-08	11500	11650	OSDH	1-16	F	0.17	mg/l	
T2-10	11400	13700	OSDH	1-16	F	0.16	mg/l	
T3-04A	8150	10800	OSDH	1-16	F	0.12	mg/l	
T5-04	1550	8500	OSDH	1-08	F	0.32	mg/l	

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
URANIUM IN WATER SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
1W	14500	14800	KMTC	1-06	U	0.11	mg/l	
2W	13250	13950	KMTC	1-06	U	0.23	mg/l	
3W	12750	11200	KMTC	1-06	U	0.19	mg/l	
4W	11700	11150	KMTC	1-06	U	<0.002	mg/l	
5W	10100	10950	KMTC	1-06	U	0.011	mg/l	
6W	9850	9450	KMTC	1-06	U	<0.002	mg/l	
7W	10600	7000	KMTC	1-06	U	0.32	mg/l	
8W	11800	7000	KMTC	1-06	U	0.6	mg/l	
10W	11800	6200	KMTC	1-06	U	<0.002	mg/l	
11W	16350	9450	KMTC	1-06	U	<0.002	mg/l	
12W	6750	11050	KMTC	1-06	U	0.003	mg/l	
13W	7475	13350	KMTC	1-06	U	<0.002	mg/l	
14W	18450	6950	KMTC	1-06	U	<0.002	mg/l	
14W	18450	6950	KMTC	1-08	U	0.003	mg/l	
15W	12900	5950	KMTC	1-06	U	0.018	mg/l	
15W	12900	5950	KMTC	1-08	U	0.013	mg/l	
17W	7650	4350	KMTC	1-06	U	0.006	mg/l	
18W	15100	10300	KMTC	1-08	U	0.002	mg/l	
19W	6850	9050	KMTC	1-08	U	0.004	mg/l	
20W	7750	17000	KMTC	1-08	U	<0.002	mg/l	
300	12450	9900	KMTC	1-06	U	0.042	mg/l	
301	12450	9900	KMTC	1-14	U	0.017	mg/l	
302	12550	9550	KMTC	1-06	U	0.94	mg/l	
303	12550	9550	KMTC	1-14	U	1.1	mg/l	
304	12550	9400	KMTC	1-06	U	1.2	mg/l	
305	12550	9400	KMTC	1-14	U	2.6	mg/l	
306	11450	9550	KMTC	1-14	U	0.25	mg/l	
306	11450	9550	KMTC	1-06	U	0.25	mg/l	
307	11450	9550	KMTC	1-14	U	0.21	mg/l	
COMB ST	12600	8650	KMTC	1-07	U	0.29	mg/l	
COMB ST	12600	8650	KMTC	1-06	U	0.95	mg/l	
COMB ST	12600	8650	KMTC	1-05	U	0.36	mg/l	
COMB ST	12600	8650	KMTC	1-04	U	0.36	mg/l	
COMB ST	12600	8650	KMTC	1-03	U	0.61	mg/l	
COMB ST	12600	8650	KMTC	1-02	U	0.57	mg/l	
COMB ST	12600	8650	KMTC	1-01	U	0.43	mg/l	
LAGOON	12800	9200	KMTC	1-17	U	I	mg/l	
LRES07	6950	9900	KMTC	1-04	U	<0.002	mg/l	FRONT PORCH
PW 1632	13250	9400	KMTC	1-15	U	<0.002	mg/l	
CRES	6150	10800	ORNL	1-05	U	0.05	ug/ml	
T1-10	12750	11100	ORNL	1-05	U	0.15	ug/ml	
T1-10	12750	11100	ORNL	1-05	U	0.026	ug/ml	
T2-04	10350	8400	ORNL	1-05	U	0.003	ug/ml	
T2-06	11450	9950	ORNL	1-05	U	0.27	ug/ml	
T2-07	11700	11100	ORNL	1-06	U	0.03	ug/ml	

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
ALPHA IN WATER SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
CRES	6150	10800	OSDH	1-05	ALPHA	0.0	pCi/l	
T1-10	12750	11100	OSDH	1-05	ALPHA	100.0	pCi/l	
T2-04	10350	8400	OSDH	1-05	ALPHA	150.0	pCi/l	
T2-06	11500	9950	OSDH	1-06	ALPHA	124.0	pCi/l	
T5-04	1550	8500	OSDH	1-08	ALPHA	7.0	pCi/l	

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
BETA IN WATER SAMPLES

LABEL	NORTH	EAST	LAB	DATE	TYPE	RESULT	UNITS	COMMENTS
CRES	6150	10800	OSDH	1-05	BETA	-1.0	pCi/l	
T1-10	12750	11100	OSDH	1-05	BETA	12.0	pCi/l	
T2-04	10350	8400	OSDH	1-05	BETA	9.0	pCi/l	
T2-06	11500	9950	OSDH	1-06	BETA	26.0	pCi/l	
T5-04	1550	8500	OSDH	1-08	BETA	5.0	pCi/l	

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS FOR FLUORIDE IN WATER SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
16W	T11N	34	B6	1-06	KMTC	0.2	MG/L	
25L14	T12N	25	L14	1-14	KMTC	<0.1	MG/L	
26E 7	T12N	26	E7	1-14	KMTC	<0.1	MG/L	
26F 6	T12N	26	F6	1-14	KMTC	<0.1	MG/L	SURFACE WATER
26L 1	T12N	26	L1	1-14	KMTC	<0.1	MG/L	SURFACE (POND)
27I 0	T12N	27	I0	1-14	KMTC	<0.1	MG/L	SURFACE WATER
27L 1	T12N	27	L1	1-14	KMTC	0.1	MG/L	
27L 4	T12N	27	L4	1-14	KMTC	0.1	MG/L	SURFACE WATER
27L 8	T12N	27	L8	1-14	KMTC	<0.1	MG/L	SURFACE WATER
28H14	T12N	28	H14	1-14	KMTC	0.1	MG/L	SURFACE WATER
36D11	T12N	36	D11	1-14	KMTC	<0.1	MG/L	
36L 5	T12N	36	L5	1-14	KMTC	<0.1	MG/L	
36M10	T12N	36	M10	1-14	KMTC	<0.1	MG/L	SURFACE WATER
LRES07	T12N	28	I14	1-04	KMTC	<0.1	MG/L	RAIN BARREL
CRES	T12N	27	K3	1-05	ORNL	0.09	UM/ML	
CRES	T12N	27	K3	1-05	OSDH	0.19	MG/L	
DIRTYCR	T11N	6	F9	1-14	OSDH	0.32	MG/L	
P-01	T12N	26	A11	1-13	OSDH	0.23	MG/L	
P-10	T12N	28	F14	1-13	OSDH	0.49	MG/L	
REDHILL	T11N	9	H4	1-14	OSDH	0.15	MG/L	
STRM GH	T11N	4	K0	1-16	OSDH	7.00	MG/L	
SWR PND	T11N	4	K0	1-14	OSDH	0.18	MG/L	
T4-03W	T12N	34	C7	1-06	OSDH	0.17	MG/KG	
WR-01	T11N	9	N13	1-15	OSDH	0.18	MG/L	
WR-02	T11N	9	N2	1-15	OSDH	0.26	MG/L	
WR-04	T11N	8	L14	1-15	OSDH	0.1	MG/L	
WR-06	T11N	5	N3	1-15	OSDH	0.26	MG/L	

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR URANIUM IN WATER SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
16W	T11N	34	B6	1-06	KMTC	0.006	MG/L	
25L14	T12N	25	L14	1-14	KMTC	<0.002	MG/L	
26E 7	T12N	26	E7	1-14	KMTC	0.006	MG/L	
26F 6	T12N	26	F6	1-14	KMTC	0.003	MG/L	SURFACE WATER
26L 1	T12N	26	L1	1-14	KMTC	0.003	MG/L	
27I 0	T12N	27	I0	1-14	KMTC	<0.002	MG/L	SURFACE WATER
27L 1	T12N	27	L1	1-14	KMTC	<0.002	MG/L	
27L 4	T12N	27	L4	1-14	KMTC	<0.002	MG/L	SURFACE WATER
27L 8	T12N	27	L8	1-14	KMTC	0.004	MG/L	SURFACE WATER
28H14	T12N	28	H14	1-14	KMTC	<0.002	MG/L	SURFACE WATER
36D11	T12N	36	D11	1-14	KMTC	0.004	MG/L	
36L 5	T12N	36	L5	1-14	KMTC	0.003	MG/L	
36M10	T12N	36	M10	1-14	KMTC	<0.002	MG/L	
LRES07	T12N	28	I14	1-04	KMTC	<0.002	MG/L	
CRES	T12N	27	K3	1-05	ORNL	0.05	UM/ML	

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR ALPHA IN WATER SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
CRES	T12N	27	K3	1-05	OSDH	0.0	PCI/L	

FAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR BETA IN WATER SAMPLES

LABEL	TOWNSHIP	SECTION	SUBSECT	DATE	LAB	RESULTS	UNITS	COMMENTS
CRES	T12N	27	K3	1-05	OSDH	-1.0	PCI/L	

APPENDIX 5.4.1

AN AERIAL RADIOLOGICAL SURVEY OF THE KERR-MCGEE FACILITY AND SURROUNDING AREA

EG&G
ENERGY MEASUREMENTS GROUP

THE
REMOTE
SENSING
LABORATORY
OF THE UNITED STATES
DEPARTMENT OF ENERGY

EG&G SURVEY REPORT
NRC-8105
JULY 1981

AN AERIAL RADIOLOGICAL SURVEY OF THE

KERR — McGEE FACILITY

AND SURROUNDING AREA

GORE, OKLAHOMA   DATES OF SURVEY: 25-30 JULY 1980

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E. L. Feimster
Project Scientist

REVIEWED BY

W. J. Tipton
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Radiation Sciences Section

This Document is UNCLASSIFIED

GP Stobie
G. P. Stobie
Classification Officer

This work was performed by EG&G for the United States Nuclear Regulatory Commission through an EAO transfer of funds to Contract Number DE-AC08-76NV01183 with the United States Department of Energy.

ABSTRACT

An aerial radiological survey was conducted over a 17 km^2 area, centered on the Kerr-McGee facility at Gore, Oklahoma, during 25-30 July 1980. An isoradiation contour map was produced that shows the distribution of exposure rates (at the 1 m level) due to terrestrial gamma ray activity within the surveyed area. These results showed several areas directly over the Kerr-McGee facility with radiation levels significantly above natural background. Spectral analysis revealed the presence of protactinium-234, a daughter of separated uranium-238 (^{226}Ra and daughters removed). Bismuth-214, a daughter of the natural uranium-238 decay chain, was also present. The estimated maximum exposure rate range over this facility was 220-320 μR/h. The typical background ranges were 4 to 6.5 μR/h over vegetation and 6.5 to 9.0 μR/h over cultivated land areas. These exposure rate ranges are from terrestrial sources only. An additional 4 μR/h due to cosmic ray contributions must be added to obtain the total external exposure rate.

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Sections

Figures

1.0 INTRODUCTION

The United States Department of Energy (DOE) maintains an aerial surveillance operation called the Aerial Measuring Systems (AMS). AMS is operated for the DOE by EG&G, Inc. This continuing nationwide program, started in 1958, involves surveys to monitor and document background radiation levels throughout the United States. At the request of the DOE or other federal and state agencies (such as the United States Nuclear Regulatory Commission), the AMS is deployed for various aerial survey operations. This report is the result of a survey requested by the NRC for the Kerr-McGee facility located at Gore, Oklahoma.

Aerial radiological detection systems average the radiation levels due to gamma-emitting radionuclides existing over an area of several acres. The systems are capable of detecting anomalous gamma count rates and determining the specific radionuclides causing the anomalies; however, because of averaging, they tend to underestimate the magnitude of localized sources as compared with ground-based readings. As such, the indicated radiation levels in the vicinity of anomalies are not definitive. Ground surveys are required for accurate definition of the extent and intensity of such anomalies.

The results of the survey are reported as radiation exposure rates in microroentgens per hour (μR/h) at 1 meter above the ground surface. Approximate annual radiation dose levels expressed as millirem per year (mrem/y) are obtained by multiplying μR/h by 8.76. This conversion number applies only to the external radiation dose component.

Natural background radiation originates from radioactive elements present in the earth and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma rays originate primarily from the uranium decay chain, the thorium decay chain, and radioactive potassium. Local concentrations of these nuclides produce radiation levels at the surface of the earth ranging from 1 to 15 μR/h (9 to 130 mrem/y). Some areas with high uranium and thorium concentrations in surface minerals exhibit even higher radiation levels, especially in the western states. For example, in the Colorado Plateau area the average radition level is above 200 mrem/y. At some locations in Brazil and India, the natural radiation level is above 1000 mrem/y. One member of each of the uranium and thorium decay chains is a noble gas which can both diffuse through soil and be borne by air to other locations. Thus, the level of this airborne radiation depends on the meteorological conditions, the mineral content of the soil, the soil permeability, and other conditions existing at each location at any particular time. The airborne radiation contributes from 1 to 10% of the natural background radiation levels.

Cosmic rays, the space component, interact in a complicated manner with the elements of the earth's atmosphere and the soil. These interactions produce an additional natural source of gamma radiation. Radiation levels due to cosmic rays vary with altitude and geomagnetic latitude: they range from 3.7 to 23 μR/h (up to 200 mrem/y).[1]

2.0 SITE DESCRIPTION

The Kerr-McGee facility is located approximately 4.5 km southeast of the towns of Webber Falls and Gore, Oklahoma; its boundaries cover approximately 2000 acres. Most of the land area is covered with vegetation or cultivated for agricultural use. The site is bordered on the west by the Illinois River (Figure 1).

The primary operation at this facility is the conversion of the uranium compound U_3O_8 (referred to as "yellow cake") to UF_6, uranium hexaflouride. The raw material, U_3O_8, is stored on site; however, the refined product, UF_6, is shipped immediately to its various users.

3.0 SURVEY PROCEDURES AND EQUIPMENT

An aerial photograph was used to define the area to be surveyed. Parallel lines spaced at 76 m intervals were flown at 76 m altitude.

The survey vehicle, a Hughes H-500 helicopter, carried a pilot, an equipment operator and a lightweight version of a specialized data recording system. Two detector pods were mounted on the sides of the helicopter; each pod contained ten sodium iodide, NaI (Tl), detectors. The crystal in each detector was 12.7 cm in diameter and 5.1 cm in height. Gamma ray signals from the twenty detectors were summed and routed through an analog-to-digital converter and pulse height analyzer. Gamma ray counting rates and energy spectral data were accumulated in 1-second intervals and recorded on magnetic tape.

The helicopter position was established with two systems: a Microwave Ranging System (MRS) and a radio altimeter. The MRS master station, mounted in the helicopter, interrogated two remote transceivers mounted at stationary positions overlooking the survey area. By measuring the round trip propagation time between the master and remote stations, the master computed the distance to each. These distances were also recorded on magnetic tape each second. In subsequent computer processing, they were converted to position coordinates.

The radio altimeter determined the aircraft altitude by connecting the time of a round trip pulsed signal to distance between the aircraft and the ground. These data were also recorded on magnetic tape so that any variations in gamma signal strength caused by altitude fluctuation could be compensated accurately.

The detectors and electronic systems that accumulate and record the data are described in detail in previous reports.[2,3]

Data processing was done primarily with a computer based analysis laboratory mounted in a mobile van. An extensive collection of software routines was available for data processing. The first data processing that was accomplished produced terrestrial exposure rate isoradiation contours. These contours were constructed from gross count rate numbers, which refer to integral count rates in that portion of the gamma ray energy spectrum between 0.05 and 3.0 MeV. These count rates were converted to exposure rates at 1 m above the ground using a factor of 940 counts per second per μR/h, a number obtained from calibration data over a test range. The exposure rate isoradiation contours shown in Figure 1 are from terrestrial sources only. A total exposure rate can be obtained by adding an average cosmic ray value of 4 μR/h.

4.0 DISCUSSION AND RESULTS

Results of the aerial survey are shown in Figure 1 in the form of exposure rate contours superimposed on a photograph of the survey area.

Several areas of localized activity significantly higher than background activity were encountered directly over the Kerr-McGee facility. The rapidly changing radiation levels over the site preclude accurate extrapolation of the aerial data to ground level exposure rates in the near vicinity of the site. The maximum estimated exposure rate (220-320 μR/h) over the localized areas may be an underestimate of the actual exposure rate as measured on the ground. In areas where heavy vegetation, such as trees, covered the terrain, the background exposure rate was in the range of 4-6.5 μR/h. In bare ground areas, cultivated fields, and areas with minimum vegetation the background was 6.5-9.0 μR/h. One small area of cultivated land on the western boundary of the survey showed an exposure rate in the range of 9-13 μR/h. A gamma ray spectrum typical of the area is shown in Figure 2.

Spectral analysis of the anomalous areas indicated the presence of large quantities of natural uranium and seperated uranium (^{226}Ra and daughters removed). Spectra accumulated over all the elevated activity areas showed photopeaks of protactinium-234 and bismuth-214 (Figure 3); these are daughter products associated with seperated uranium-238 and normal uranium-238, respectively.

The exposure rates quoted here and shown in Figure 1 are from terrestrial sources only. Cosmic ray radiation contributes an additional exposure rate of approximately 4 μR/h to the total exposure rate.

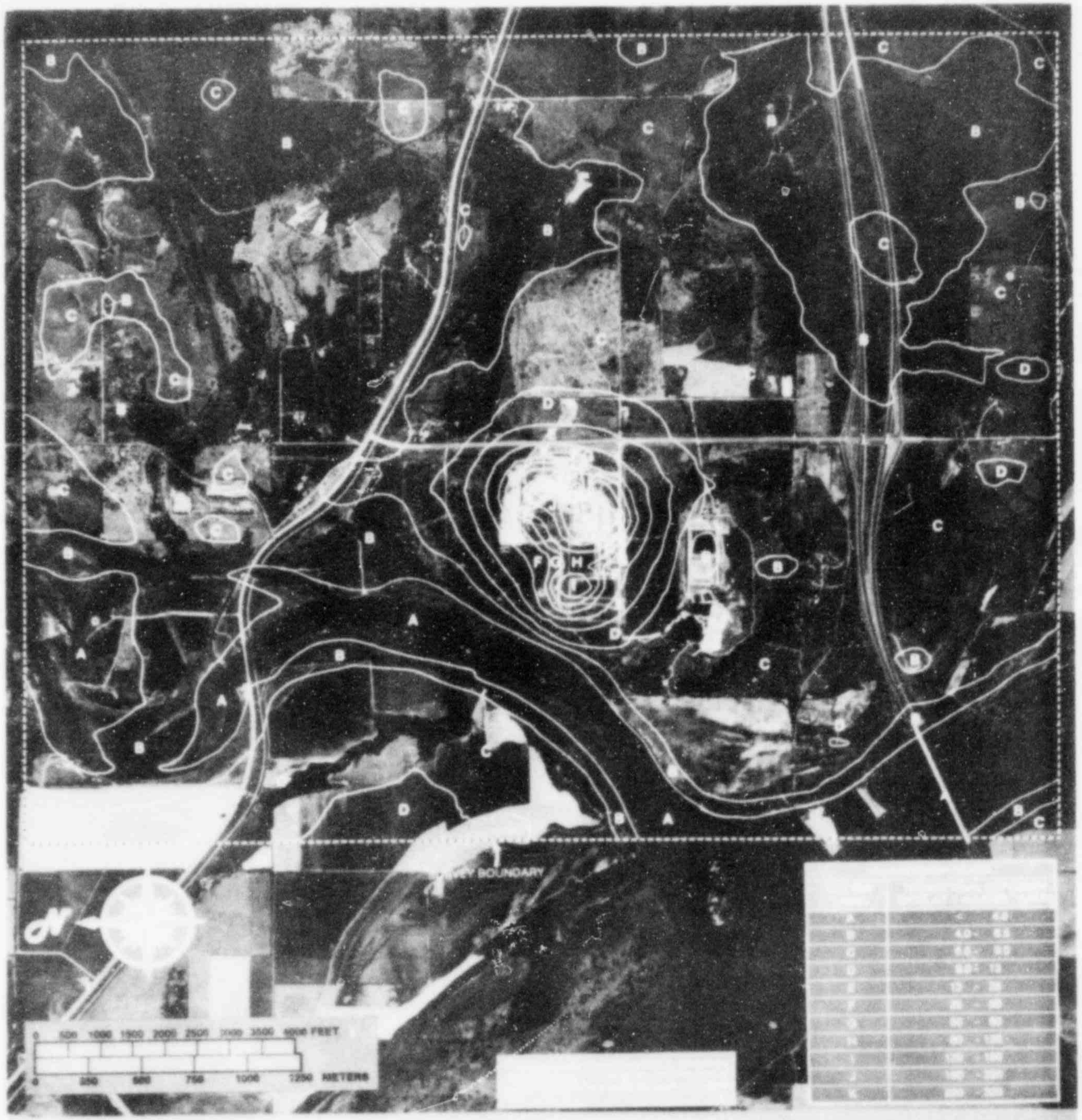

Figure 1. *EXPOSURE RATE ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTOGRAPH. The area surveyed is included within the dashed line.*

7

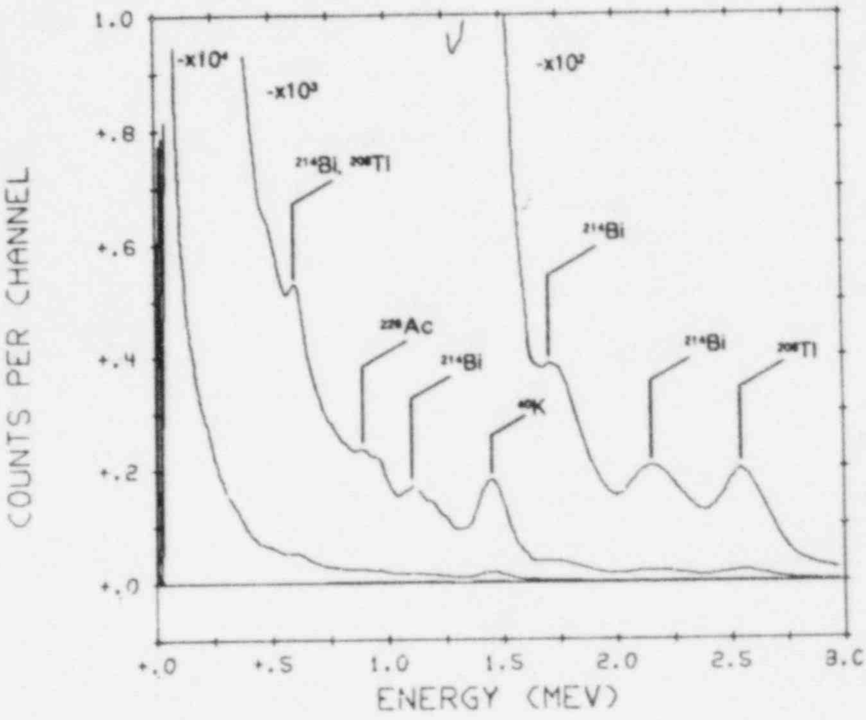

Figure 2. *GAMMA PULSE HEIGHT SPECTRUM TYPICAL OF NATURAL BACKGROUND*

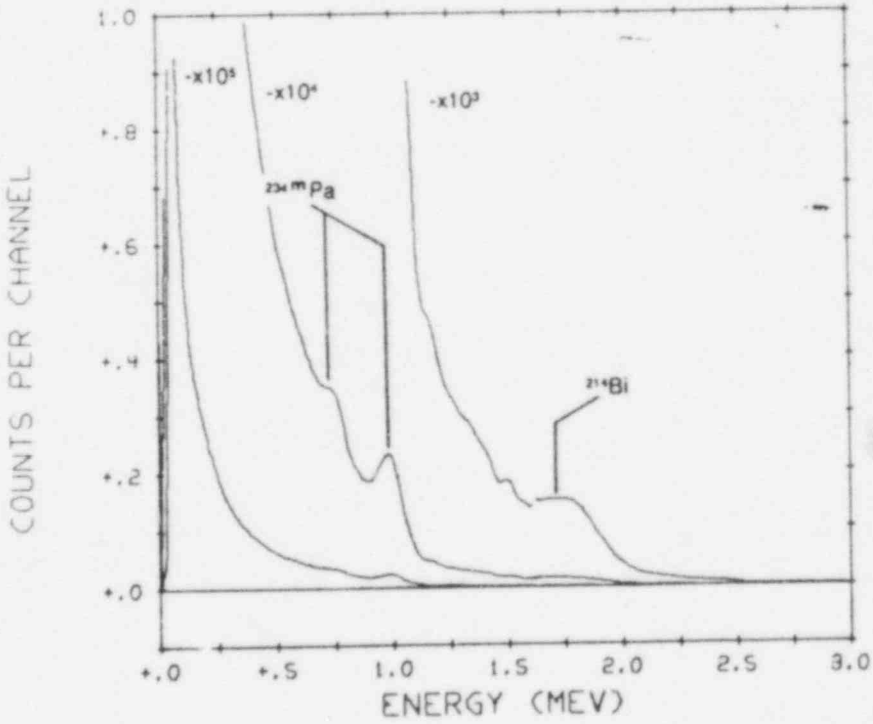

Figure 3. *GAMMA PULSE HEIGHT SPECTRUM INDICATING THE PRESENCE OF ANOMALOUS CONCENTRATIONS OF SEPARATED U-238 AND RADIUM DAUGHTERS FROM THE NORMAL URANIUM-238 DECAY CHAIN*

APPENDIX: SURVEY PARAMETERS

Location: Gore, Oklahoma and surrounding area, centered on the Kerr-McGee facility

Survey Coverage: 17 km^2

Survey Date: 25-30 July 1980

Project Scientist: E. L. Feimster

Survey Altitude: 76 m (250 feet)

Line Spacing: 76 m (250 feet)

Detector Array: 20 Na. (Tl)

Acquisition System: REDAR III

Aircraft: Hughes H-500 Helicopter

Data Processing:

A. Gross Counts

Window: 0.05 - 3.0 MeV

Conversion Factor: 940 cps/μR/h

Cosmic ray contribution: 4 μR/h

REFERENCES

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KERR—MCGEE FACILITY
NRC-8105
DATES OF SURVEY: 25-30 JULY 1980
DATE OF REPORT: JULY 1981

APPENDIX 5.5.1

RESULTS OF HPGE IN SITU MEASUREMENTS

APPENDIX 5.5.1

EG&G, Inc. performed a survey of locations using an intrinsic germanium detector, as described in Section 5.5.1. Results are shown in Figure 5.5.1. Figure 5.5.1A in this Appendix shows the measurement locations with their labels. Table 5.5.1A is a listing of the measurement results; it lists them as results for Pa-234m samples because Pa-234m peaks in the gamma spectrum were used for the measurement.

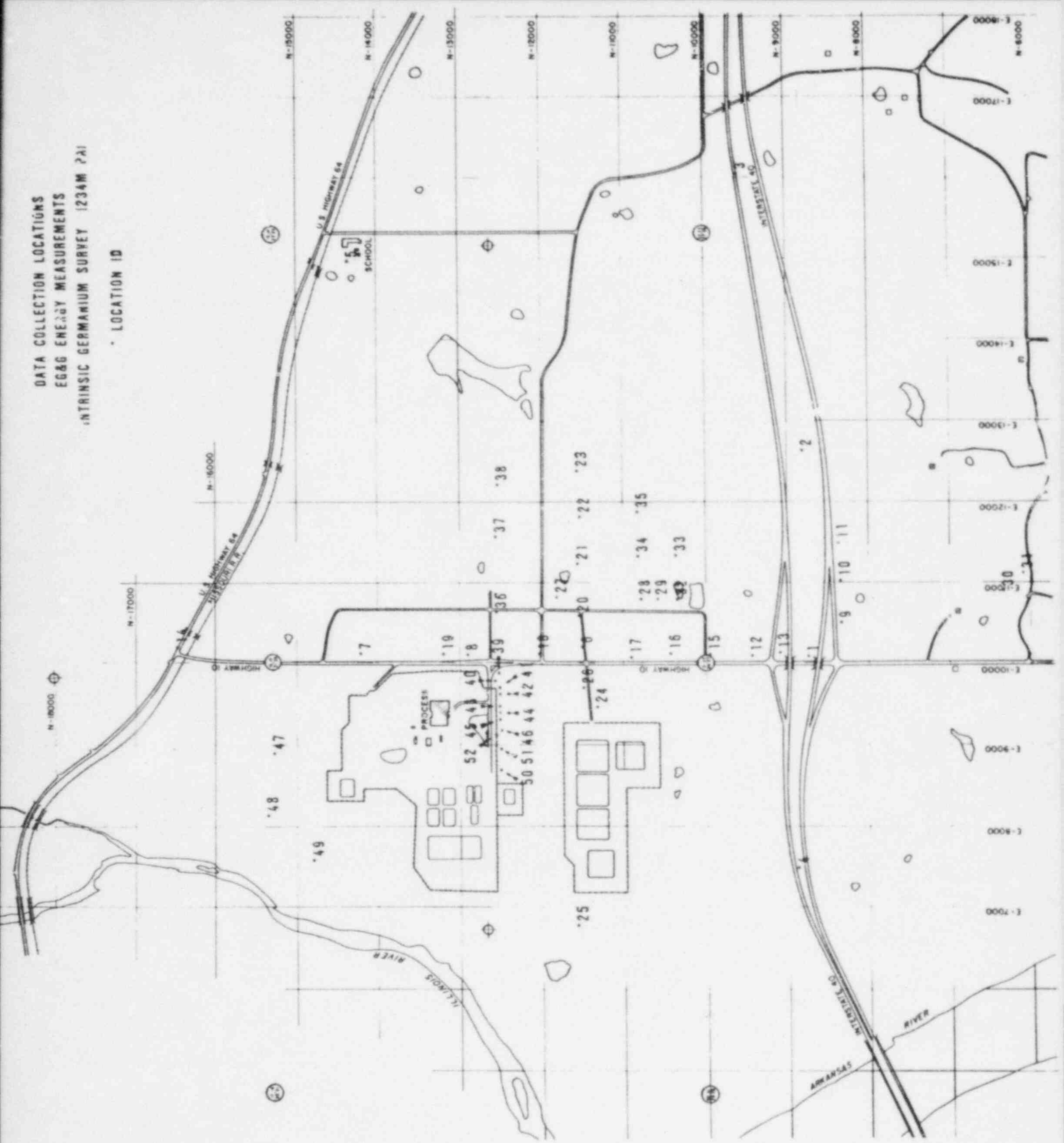

Figure 5.5.1.A Data collection locations

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR Pa-234m SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
Z 01	8750	10100	EG&G	1-07	DEPO	<90	nCi/m2	
Z 02	8800	12600	EG&G	1-07	DEPO	<90	nCi/m2	
Z 03	9550	16050	EG&G	1-07	DEPO	<90	nCi/m2	
Z 04	8850	7450	EG&G	1-07	DEPO	<90	nCi/m2	
Z 05	14350	14950	EG&G	1-08	DEPO	<90	nCi/m2	
Z 06	11500	10200	EG&G	1-08	DEPO	95.3	nCi/m2	
Z 07	14200	10100	EG&G	1-08	DEPO	<90	nCi/m2	
Z 08	12900	10100	EG&G	1-08	DEPO	126.5	nCi/m2	
Z 09	8300	10500	EG&G	1-09	DEPO	<90	nCi/m2	
Z 10	8350	11050	EG&G	1-09	DEPO	<90	nCi/m2	
Z 11	8350	11450	EG&G	1-09	DEPO	<90	nCi/m2	
Z 12	9450	10100	EG&G	1-09	DEPO	<90	nCi/m2	
Z 13	9100	10100	EG&G	1-09	DEPO	<90	nCi/m2	
Z 14	16500	10200	EG&G	1-09	DEPO	<90	nCi/m2	
Z 15	9950	10100	EG&G	1-09	DEPO	<90	nCi/m2	
Z 16	10400	10100	EG&G	1-09	DEPO	94.9	nCi/m2	
Z 17	10900	10050	EG&G	1-09	DEPO	106.8	nCi/m2	
Z 18	12050	10100	EG&G	1-09	DEPO	108.2	nCi/m2	
Z 19	13200	10100	EG&G	1-09	DEPO	96.8	nCi/m2	
Z 20	11550	10600	EG&G	1-10	DEPO	<90	nCi/m2	
Z 21	11550	11200	EG&G	1-10	DEPO	<90	nCi/m2	
Z 22	11550	11800	EG&G	1-10	DEPO	100.0	nCi/m2	
Z 23	11550	12350	EG&G	1-10	DEPO	<90	nCi/m2	
Z 24	11350	9450	EG&G	1-10	DEPO	107.5	nCi/m2	
Z 25	11600	6750	EG&G	1-10	DEPO	<90	nCi/m2	
Z 26	11500	9700	EG&G	1-10	DEPO	173.5	nCi/m2	
Z 27	11800	10800	EG&G	1-10	DEPO	<90	nCi/m2	
Z 28	10750	10800	EG&G	1-10	DEPO	96.4	nCi/m2	
Z 29	10550	10800	EG&G	1-10	DEPO	100.85	nCi/m2	
Z 30	6300	10850	EG&G	1-10	DEPO	<90	nCi/m2	
Z 31	6050	11100	EG&G	1-10	DEPO	<90	nCi/m2	
Z 32	10350	10800	EG&G	1-11	DEPO	105.5	nCi/m2	
Z 33	10350	11300	EG&G	1-11	DEPO	103.3	nCi/m2	
Z 34	10800	11300	EG&G	1-11	DEPO	<90	nCi/m2	
Z 35	10800	11850	EG&G	1-11	DEPO	<90	nCi/m2	
Z 36	12550	10650	EG&G	1-11	DEPO	<90	nCi/m2	
Z 37	12600	11550	EG&G	1-11	DEPO	109.5	nCi/m2	
Z 38	12550	12200	EG&G	1-11	DEPO	106.0	nCi/m2	
Z 39	12500	9850	EG&G	1-11	DEPO	210.5	nCi/m2	
Z 40	12550	9750	EG&G	1-11	DEPO	297.0	nCi/m2	
Z 41	12500	9700	EG&G	1-11	DEPO	383.0	nCi/m2	
Z 42	12500	9600	EG&G	1-11	DEPO	652.5	nCi/m2	
Z 43	12500	9450	EG&G	1-11	DEPO	465.0	nCi/m2	
Z 44	12500	9350	EG&G	1-11	DEPO	332.5	nCi/m2	
Z 45	12500	9250	EG&G	1-11	DEPO	395.0	nCi/m2	
Z 46	12500	9150	EG&G	1-11	DEPO	465.5	nCi/m2	

NEAR FIELD ENVIRONMENTAL SAMPLING RESULTS
FOR Pa-234m SAMPLES

LABEL	NORTH	EAST	LAB	DATE	MEDIA	RESULT	UNITS	COMMENTS
Z 47	15300	8850	EG&G	1-12	DEPO	111.5	nCi/m2	
Z 48	15400	8100	EG&G	1-12	DEPO	95.8	nCi/m2	
Z 49	14800	7550	EG&G	1-12	DEPO	<90	nCi/m2	
Z 50	12500	8650	EG&G	1-12	DEPO	<90	nCi/m2	
Z 51	12500	8950	EG&G	1-12	DEPO	<90	nCi/m2	WASHED DWN PRIOR
Z 52	12550	9100	EG&G	1-12	DEPO	<90	nCi/m2	WASHED DWN PRIOR

APPENDIX 5.6.1

MEDICAL EXAMINATION AND DIAGNOSIS FOR ONSITE WORKERS

SEQUOYAH FUELS CORPORATION
P.O. BOX 610 • GORE, OKLAHOMA 74435

February 13, 1986

Dr. Donald A. Cool
Uranium Fuels Licensing Branch
Division of Fuel Cycle & Material Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

RE: Interagency Meeting
February 6, 1986

Dear Dr. Cool:

At the Interagency Meeting of February 6, 1986 your subcommittee on UF_6 Assessment Task Group requested the following information on individuals by code designation:

1. Identification of employees who responded to the emergency to cool the ruptured UF_6 cylinder and minimize the spread of UF_6 into the atmosphere.
2. Identify employees sent to the hospital(s) and indicate the treatment received.
3. Identify subcontractor and/or other outside individuals sent to the hospital(s) for examination and treatment.

In response to this request, we supplied the following information:

I. Employees responding to the emergency who used water spray to cool and control UF_6 vapors. (Response was from upwind from the UF_6 vapors.)

5E, 7E, 8E, 11E, 16E, 20E, 25E, and 29E.

A total of 8 employees.

II. Employees examined at the Sequoyah Memorial Hospital in Sallisaw, Okla. and retained overnight for observation.

14E, 22E, 27E, and 31E.

A total of 4 employees.

A SUBSIDIARY OF KERR-McGEE CORPORATION

III. Employees examined at the Sequoyah Memorial Hospital in Sallisaw and retained more than 24 hours for observation and "Alka-Seltzer" treatment.

1E, 2E, 6E, 8E, 9E, 12E, 16E, 17E, 20E, 23E, 25E, 26E, 28E, and 29E.

A total of 14 employees.

IV. Employees examined first at Sequoyah Memorial Hospital, Sallisaw, Okla. then transferred to Sparks Memorial Hospital, Ft. Smith, Arkansas for observation relative to possible lung irritation and/or damage from HF exposure.

5E, 15E, 18E.

A total of three employees.

V. Subcontractor and other outside personnel examined at Sequoyah Memorial Hospital, Sallisaw, Okla. and retained overnight for observation. (i.e. same category as employees in II above.)

5C, 6C, 9C, and 52P.

A total of 4 persons.

Only one person, 25E, was treated for skin irritation and burn from HF.

In addition to the above categories 10 employees were examined at Sequoyah Memorial Hospital and immediately released and 6 subcontractor personnel upwind of the UF_6 cylinder rupture, but on site, were examined at the same hospital and immediately released.

Your subcommittee also asked for the medical diagnosis for the employees in Category IV above and we received the following information from the hospital for all three individuals:

Diagnosis: Toxic inhalation exposure; medical code 506.3.

The employee fatality is not included in the above summary; the cause of death was also medical code 506.3.

Sincerely,

William L. Utnage

W. L. Utnage
Sequoyah Facility Manager

WLU:dd

APPENDIX 5.6.2

URANIUM BIOASSAY RESULTS FOR SFC WORKERS AND OFFSITE INDIVIDUALS

CLASSIFICATION: SFC EMPLOYEES ONSITE DURING RELEASE

			U (ug/l)						FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC			PEMBROOK	ORNL			BNL	PNL	ORNL	AVERAGE
1E	01/04/86	1548	6900			6500	5240	5300		11.7	15.5	11.8	13.0
	01/05/86	0400	990			950	994						
	01/06/86	1156	90										
	01/07/86	0612	210										
	01/08/86	0612	84										
	01/09/86	0600	95										
	01/10/86	0012	36										
	01/11/86	0745	28										
	01/13/86	0600	32										
	01/11/86	0910							.58				
2E	01/04/86	1600	7400			6500	6820	6800		19.1	26.0	15.4	20.17
	01/05/85	0400	2800			1500	3100						
	01/06/86	0600	180										
	01/07/86	0500	91										
	01/08/86	0600	48										
	01/09/86	0600	34										
	01/10/86	1500	5										
	01/11/86	1000							.48				
3E	01/04/86	1915	983			825	810			2.8	4.6	3.5	3.63
	01/06/86	0600	110										
	01/07/86	0600	40										
	01/08/86	0600	24										
	01/10/86	0600	13										
	01/11/8	0530	12										
	01/12/86	0730	12	15									
	01/13/86	0600	6										
4E	01/04/86	2000	<2			10	10			0.1777	0.55	0.61	0.45
	01/05/86	0700	<2			13							
	01/05/86	2200	15										
	01/06/86	2200	18										
	01/07/86	0600	56										
	01/09/86	2200	5										
	01/13/86	0600	7										
5E	01/04/86	1630	9200	9400	9000					20.8	25.3	16.5	20.87
	01/04/86	2100	2600	3100	3500								
	01/05/86	0600	1300	1400									
	01/07/86	0700	210										
	01/08/86	0630	110										
	01/09/86	0605	82										
6E	01/04/86	1600	1300			1000	1500			9.91	6.9	3.1	6.64
	01/05/86	0400	230			200							
	01/08/86	0700	19										
	01/09/86	0630	19										
	01/10/86	0730	9										
	01/11/86	0700	14										
	01/12/86	0730	<2										
	01/13/86	0730	9										

CLASSIFICATION: SFC EMPLOYEES ONSITE DURING RELEASE

			U (ug/l)					FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC		PEMBROOK	ORNL			BNL	PNL	ORNL	AVERAGE
7E	01/04/86	1700	3800		4000	2840			11.4	15.1	9.6	12.03
	01/05/86	0800	820		775	757						
	01/06/86	2000	15									
	01/07/86	0600	54									
	01/08/86	0600	36									
	01/12/86	0600	17									
	01/18/86	1200						.28				
8E	01/02/86	1500	<2						1.21	1.60	1.2	1.34
	01/04/86	2015	540		500	497	500					
	01/04/86	2315	310		250	290						
	01/05/86	0300	110									
	01/06/86	1100	8									
	01/07/86	0630	12									
	01/08/86	1500	<2									
	01/12/86	0630	6									
9E	01/04/86	1950	1600		1650	1210	1200		5.96	7.5	5.6	6.35
	01/05/86	0500	640		600	789						
	01/06/86	0600	180									
	01/07/86	0630	130									
	01/08/86	0630	84	73								
	01/09/86	0630	30									
	01/10/86	0645	34									
10E	01/04/86	1700	640									
	01/05/86	1700	130									
	01/07/86	0830	22									
	01/08/86	0630	10									
	01/10/86	0600	7									
	01/13/86	0700	<2									
11E	01/04/86	2230	540		500	472			1.80	1.7	1.3	1.60
	01/05/86	0400	270		150	162	160					
	01/05/86	1900	7									
	01/06/86	0600	13									
	01/06/86	0930	15									
	01/07/86	0600	11									
	01/08/86	0600	7									
	01/09/86	0600	<2									
	01/12/86	0600	5									
	01/13/86	0600	<2									
12E	01/04/86	1835	1600			2280			6.56	8.3	5.5	6.79
	01/05/86	0600	630		625	582						
	01/06/86	2130	28									
	01/07/86	2240	57									

CLASSIFICATION: SFC EMPLOYEES ONSITE DURING RELEASE

			U (ug/l)					FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC		PEMBROOK	ORNL			BNL	PNL	ORNL	AVERAGE
13E	01/04/86	1740	700		775	486			2.31	2.7	2.1	2.37
	01/05/86	0400	300									
	01/05/86	1330	95									
	01/06/86	1300	63									
	01/08/86	1000	27									
	01/09/86	0830	17									
	01/09/86	1230	10									
	01/10/86	0930	23									
	01/10/86	1230	5									
14E	01/04/86	2215	2500		2150	3030			8.18	7.6	5.8	7.19
	01/05/86	0400	390		400	495						
	01/05/86	1330	52									
	01/06/86	1900	39									
	01/08/86	0630	28									
	01/09/86	0630	18									
	01/10/86	0600	15									
	01/11/86	0630	9									
	01/11/86	1000	25									
	01/13/86	0630	8									
15E	01/04/86	2300	190		200	153			1.04	1.5	0.99	1.18
	01/05/86		18									
	01/06/86	1000	11									
	01/07/86	0600	9									
	01/07/86	0730	17									
	01/07/86	2315	6									
	01/08/86	0430	7									
	01/08/86		4									
	01/09/86	1500	6									
	01/10/86	1030	<2									
16E	01/04/86	1845	3500		3250	2520			14.3	14.2	8.9	12.47
	01/05/86	0400	720		400	740						
	01/07/86	1800	42									
	01/10/86	1000	15									
	01/11/86	0900	10									
	01/13/86	0530	17									
	01/12/86	0700						.19				
17E	01/04/86	1600	11000	13000	13000	2250	2200		26.5	34.2	22.2	27.63
	01/05/86	0400	3200			3940						
	01/06/86	0800	110									
	01/07/86	0700	120									
	01/08/86	1500	93									
	01/09/86	0800	36									
	01/10/86	1039	20									
	01/11/86	0700	67									

CLASSIFICATION: SFC EMPLOYEES ONSITE DURING RELEASE

			U (ug/l)					FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC		PEMBROOK	ORNL			BNL	PNL	ORNL	AVERAGE
18E	01/02/86	2300	<2									
	01/04/86	1600	3200	2700	3100	2540	2500		4.20	11.2	9.6	8.33
	01/06/86		312									
	01/07/86	0800	131									
	01/08/86	1000	6									
	01/09/86	0800	46									
	01/10/86	0800	8									
	01/11/86	0700	21									
	01/12/86	0800	31									
	01/13/86	0700	8									
19E	01/04/86	1700	620						1.37	1.6	1.1	1.36
	01/05/86	1300	64									
	01/07/86	0600	21									
	01/09/86	0600	3									
	01/10/86	0600	29									
	01/13/86	0600	<2									
20E	01/04/86	1700	250						1.03	1.6	2.0	1.54
	01/04/86	2245	140		180	124	120					
	01/05/86	0400	170		110	166	170					
	01/06/86	0730	27									
	01/08/86	0600	18									
	01/09/86	0600	12									
	01/10/86	0600	13									
	01/11/86	1600	23									
	01/12/86		10									
21E	01/04/86	1700	62	67	50	84			0.138	0.32	0.32	0.26
	01/04/86	2000	47									
	01/05/86	1300	3									
	01/06/86	0615	5									
	01/06/86	2100	17									
	01/07/86	2100	9									
	01/12/86	0630	3									
22E	01/04/86	1700	730			700			1.25	1.8	2.1	1.72
	01/04/86	1950	200									
	01/04/86				140	150						
	01/05/86	0400	38									
	01/05/86				17							
	01/05/86	1300	610									
	01/05/86	1400	12									
	01/06/86	0600	44									
	01/07/86	0700	42									
	01/09/86	0700	6									
	01/10/86	0822	7									
	01/11/86	0600	10									
	01/12/86	0600	5									

CLASSIFICATION: SFC EMPLOYEES ONSITE DURING RELEASE

			U (ug/l)				FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC	PEMBROOK	ORNL			BNL	PNL	ORNL	AVERAGE
23E	01/04/86	1945	4400					23.1	24.8	16.1	21.33
	01/04/86	2000	5500		5340						
	01/04/86	2330	3900	3500							
	01/04/86			2400							
	01/05/86	0300	1100		2170						
	01/07/86	0905	147								
	01/08/86	0700	71								
	01/09/86	0705	46								
	01/10/86	0700	27								
	01/11/86	0805	39								
	01/12/86	0700	400								
	01/12/86	0900	48								
	01/11/86	2335					1.4				
24E	01/04/86	1900	90	8	68			0.455	0.550	0.33	0.45
	01/05/86				28						
	01/06/86		8								
25E	01/04/86	1745	760	700	742			3.28	4.6	3.0	3.63
	01/05/86	0800	370	200	286						
	01/06/86	1545	12								
	01/09/86	0800	5								
	01/09/86	0810	2								
	01/09/86	1647	12								
26E	01/04/86	2130	7400	8000	5960	6000		6.97	9.1	15.0	10.36
	01/05/86	0400	1500								
	01/06/86	1000	110								
	01/08/86	1320	92								
	01/11/86	1315	73								
	01/12/86	1425					.41				
27E	01/04/86	0600	12	10				6.25	6.7	4.8	5.92
	01/04/86	1700	2500								
	01/04/86	2000	1100	1650	1360	1400					
	01/05/86	0400	780		526						
	01/06/86	0600	96								
	01/07/86	0600	39								
	01/08/86	0600	30								
	01/09/86	0600	33								
	01/12/86	1800	9								
	01/13/86	0600	17								
28E	01/04/86	1700	1500	1400	1510			2.93	4.2	2.4	3.18
	01/05/86	1300	22								
	01/08/86	1300	11								
	01/09/86	0800	8								
	01/09/86	1500	15								
	01/10/86	1400	6								

CLASSIFICATION: SFC EMPLOYEES ONSITE DURING RELEASE

			U (ug/l)					FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC		PEMBROOK	ORNL			BNL	PNL	ORNL	AVERAGE
29E	01/03/86		13						27.7	24.0	5.9	19.20
	01/04/86	1620	4600	4400	6000	3620	3600					
	01/05/86	0400	430			560						
	01/06/86		22									
	01/07/86		31									
	01/08/86		49									
	01/09/86	1600	29									
	01/10/86		6									
	01/11/86		9									
30E	01/04/86	1700	100						0.509	0.68	0.99	0.73
	01/04/86	1900	30		24	14						
	01/05/86	0400	150	151	130	150						
	01/05/86	1300	<2									
	01/06/86	0700	44									
	01/07/86	2130	19									
	01/13/86	0700	19									
31E	01/04/86	1700	2300	1400	1200	1010	1000		2.29	4.1	4.6	3.66
	01/04/86	1730	1800									
	01/04/86					1220						
	01/06/86	1600	16									
	01/07/86	0600	72									
	01/08/86	0700	69									
	01/09/86	0700	19									

CLASSIFICATION: NON SFC EMPLOYEES ONSITE DURING RELEASE

			U (ug/l)					FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC		PEMBROOK	ORNL			BNL	PNL	ORNL	AVERAGE
1C	01/04/86	1930	<4		<4	<5			0.0201	0.0244	0.0154	0.0200
	01/05/86	0400	<2		<5	<5						
2C	01/04/86		<2						---	---	0.0595	.0595
	01/05/86		5			<5						
3C	RESULTS PENDING											
4C	01/04/86	1547	2600			7560	7600					
	01/05/86		470		1050	966						
5C	01/04/86	0600	1230									
	01/04/86		1700									
	01/05/86		690									
6C	01/04/86	1535	1500	1400	1500	850			5.78	7.748	9.66	7.73
	01/05/86		1300									
	01/05/86				500							
	01/05/86					1250						
7C	01/04/86	1930	4			14			0.0201	0.0245	0.0154	0.0200
	01/05/86	0400	<2									
8C	01/04/86	1700	120									
	01/04/86	1800	98		49							
	01/05/86	0400	41		7	8						
	01/05/86	1300	4									
	01/06/86	1700	7									
	01/07/86	1500	<2									
	01/11/86	1330	7									
9C	01/04/86	1555	230			230						
	01/05/86		44									
10C	01/04/86	1515	7		<5	<5			0.0196	0.0768	0.0167	0.0377
	01/05/86	0400	<2									

CLASSIFICATION: OFFSITE RESIDENTS

			U (ug/l)					FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC			PEMBROOK	ORNL		BNL	PNL	ORNL	AVERAGE
1P	01/07/86	1535	3									
2P	01/07/86	1535	11									
3P	01/05/86	2200	12									
4P	01/05/86	0400	<2			<5	<5					
5P	01/05/86	1200	<2									
6P	01/05/86		12									
7P	01/07/86	0345	<2									
8P	01/05/86		<2									
9P	01/06/86	1200	<2									
10P			<3									
11P			3									
12P	01/04/86	1530	93			110	92		0.429	0.463	0.291	0.39
	01/05/86	0500 est.	65	69	26	30	39					
13P	01/04/86	1530	240			240	170		0.862	1.183	0.729	0.92
	01/05/86	0400est.	110			60	83					
14P	01/04/86		<2									
	01/04/86	1930	4			9	<5					
15P	01/04/86	1930	37						0.189	0.227	0.142	0.19
			15			<5	<5					
	01/13/86	0630	<2									
16P	01/07/86		<2									
17P	NO RESULTS											
18P	01/06/86		11									
19P			6									
	01/04/86		4			<5	<5					
20P	01/04/86	1540	7			15	10					
	01/05/86		16			11	<5					
	01/08/86	1710	<2									
21P	01/04/86	2400	<2									

CLASSIFICATION: OFFSITE RESIDENTS

			U (ug/l)				FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC		PEMBROOK	ORNL		BNL	PNL	ORNL	AVERAGE
22P	01/07/86		<2								
23P	01/06/86	1400	<2								
24P	01/07/86	0935	<2								
25P	01/05/86		53		32	20					
26P	01/05/86		47		19	20					
27P	01/07/86	1530	2								
28P	01/07/86	1530	2								
29P	01/07/86	1530	<2								
30P			10								
31P			9								
32P	01/05/86	1930	8								
33P	01/07/86		<2								
34P	01/06/86		<3								
35P	01/07/86		<2								
36P	01/05/86		<2								
37P	01/05/86		3								
38P	01/04/86	1620	<2								
39P	01/06/86	1715	<2								
40P			0								
41P	01/04/86	1900	<4	5		6					
42P	01/06/86		8								
43P	01/06/86		8		<5	<5					
44P			19								
45P	01/05/86	2315	<3								
	01/06/86	1000	18								

CLASSIFICATION: OFFSITE RESIDENTS

			U (ug/l)				Intake (mg-U)			
ID NO;	SAMPLE DATE	VOID TIME	SFC	PEMBROOK	ORNL	FECAL(ppm)	BNL	PNL	ORNL	AVERAGE
46P	01/05/86	2330	<2		<5					
	01/06/86	0900	<2		<5					
	01/06/86	1830	<2							
	01/07/86	0615	3							
47P	01/05/86	1045	7	<5	<5					
48P	01/08/86		<2							
	01/10/86		<2							
49P	01/06/86	1015	7							
50P	01/06/86	1015	<2							
51P	01/05/86	1630	6							
52P	01/04/86	1700	<7	<5	<5					
	01/04/86	1900	<7							
53P	01/04/86	2245	14	<5	17					
	01/05/86	1600	15		<5					
54P		0400	<2							
		2040	12							
55P	01/05/86	1845	10							
56P	01/07/86	1115	<2							
57P	01/07/86	1115	<2							
58P	01/08/86		<2							
59P	01/06/86	1455	<2							
60P	NO RESULTS									
61P	NO RESULTS									
62P	01/06/86	1030	4							
63P	01/06/86	0030	6							
64P	01/07/86		<2							
65P	01/06/86	1520	<2							
	01/06/86	1520	<2							
66P			7							

CLASSIFICATION: OFFSITE RESIDENTS

ID NO:	SAMPLE DATE	VOID TIME	U (ug/l) SFC	U (ug/l) PEMBROOK	U (ug/l) ORNL	FECAL(ppm)	Intake (mg-U) BNL	Intake (mg-U) PNL	Intake (mg-U) ORNL	Intake (mg-U) AVERAGE
67P	01/07/86	0820	10							
68P	01/07/86	1300	6							
69P	01/06/86	1700	<2							
70P	01/07/86		<2							
71P			<2							
	01/04/86	1930	4	6	<5					
72P			27							
	01/04/86	1930	6	<5	<5					
73P	NO RESULTS									
74P	NO RESULTS									
75P	NO RESULTS									
76P	01/05/86		49							
77P	01/07/86	0600	14							
78P	01/04/86		15	13	16					
	01/05/86	0400	27		7					
79P	01/04/86	1745	15	8	<5					
	01/05/86	0400	17	7						
80P	01/06/86	1410	4							
81P	01/08/86		77							
82P	01/07/86		<2							
83P	01/04/86	1515	<7		<5		0.0326	0.0374	0.0184	0.03
84P	NO RESULTS									
85P	01/06/86	1030	8							
86P	01/07/86	1535	<2							
87P	01/09/86	1300	<2							
88P	01/04/86		17							
	01/05/86	0400	<2		<5					
89P	01/04/36	1600	13	<5	23					
	01/05/86	1600	5		<5					

CLASSIFICATION: OFFSITE RESIDENTS

			U (ug/l)				FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC		PEMBROOK	ORNL		BNL	PNL	ORNL	AVERAGE
90P	01/04/86	1650	<4		<5	<5					
	01/04/86		2								
91P	01/08/86		7								
92P	01/04/86	2315	<2		<5	<5					
	01/05/86	0420	<2		<5	<12					
93P	01/06/86	1215	7								
94P		0400	13								
	01/04/86	1830	<4								
95P	01/08/86		<2								
96P	01/06/86	0950	5								
97P	NO RESULTS										
98P	NO RESULTS										
99P			<2								
			<2								
	01/04/86		<4		<5	<5					
100P	01/04/86		<2		<5	<5					
	01/04/86		4		<5	82					
101P	01/04/86		<2								
	01/04/86		4		<5	<5					
102P	01/04/86	1930	4			14					
	01/05/86	0400	<2		<5	<5					
103P	01/07/86	1440	<2								
104P	01/07/86		<2								
105P	01/07/86	1735	<2								
106P	01/04/86	1900	<4	8	<5	11					
107P	01/04/86	1930	<4	18	<5	<5					
108P	01/04/86		<2		<5	<5					
	01/04/86	1900	8		<5	<5					
109P	01/04/86		<2								
	01/04/86	1900	8		<5	<5					

CLASSIFICATION: OFFSITE RESIDENTS

			U (ug/l)				FECAL(ppm)	Intake (mg-U)			
ID NO:	SAMPLE DATE	VOID TIME	SFC		PEMBROOK	ORNL		BNL	PNL	ORNL	AVERAGE
110P	01/04/86		<2								
	01/04/86	1930	4		<5	<5					
111P			<2								
	01/04/86	1900	<4		<5	<5					
112P	01/07/86		6								
113P	01/04/86	1818	5		<5	<5					
	01/05/86	0400	<2		<5	<5					
114P	01/04/86		9								
115P	01/04/86	2230	10		<5	<5					
	01/05/86		6		<5	<5					
116P	01/04/86	2230	5		15	<5					
117P	01/05/86	1000	19		<5	<5					
118P			16								
119P	01/05/86	1600	<5		<5	<5					
120P	01/07/86		<2								
121P	01/04/86	1600	43	35	20	14		0.204	0.229	0.116	0.18
122P	01/04/86	1800	20		31	20	16	0.0988	0.122	0.0663	0.10
123P			20		8	16		0.192	0.213	0.116	0.17
	01/04/86	1645	40		31	20					
124P			15		10	36					
125P	01/05/86		12								
126P	01/05/86		4								
127P	01/06/86	1310	<2								
128P			<2								
129P	01/07/86		<2								
130P			<2								
	01/04/86	1920	6		6	<5					
131P	01/04/86	1910	10		<5	<5					
132P	01/06/86	1600	<2								
	01/07/86	0800	6								

APPENDIX 5.6.3

INTAKE CALCULATION MODELS AND ASSUMPTIONS

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

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Safety & Environmental Protection Division

(516) 282
FTS 666 4250

January 17, 1986

Dr. Allen Brodsky
Senior Health Physicist
Division of Radiation Programs
and Earth Sciences
Office of Nuclear Regulatory Research
Washington, D. C. 20555

SUBJECT: Estimate of Intake Post UF6 Release at Sequoyah Fuels Corporation

Dear Dr. Brodsky:

This is a letter to report results of estimates of intake, based on preliminary bioassay data sent to me on January 14, 1986. This letter briefly outlines the methods used to interpret the bioassay measurements, and additional details will be reported in the monthly report for FIN No. A-3289. The bioassay data are that reported to the Nuclear Regulatory Commission by Sequoyah Fuels Corporation, and the estimates of intake, which I computed from this bioassay data, are tabulated on the attachment.

In order to interpret the data, I assumed that urine was excreted at the rate of 1.4 liters per day, and from this assumption, I estimated the accumulated amount of uranium in urine. I based this on the reported times of sample, or the reported time of the single exposure to UF6, from which I estimated the volume of urine in each sample. Based on this volume and the reported uranium concentration, I estimated the micrograms of uranium excreted, from the point in time of a previous urine sample, up to the time of the sample under consideration. From this, I estimated the total micrograms of uranium excreted, from exposure up to the time of sample, and it was this estimate which led me to compute the estimated intake, which is reported in column 5 of the attachment.

The estimate of intake, in column 5, was based on the fraction of intake excreted to urine, up to the time of sample, and the estimate of total uranium excreted through the urine pathway, up to the time of sample. The fraction of intake was based on lung, GI tract, and systemic models, which were given in ICRP Publication 30. An inhalation intake of class D aerosols, with an AMAD of 1 micron, was assumed. An exposed person's estimate of intake showed some variation from sample to sample. Some of this variation was due to biological variables, and some was due to physical variables, such as those associated with sample collection and measurement, and those associated with computation and transcription of the results. The last column, on the attachment, repre-

TELEX: 96-7703 CABLE BROOKLAB UPTONNY

sents the best estimate of intake, and it was based on the least squares method of fitting data.

If you have any questions, please do not hesitate to call.

Sincerely,

Edward T. Lessard

Edward T. Lessard
Program Manager,
Interpretation of Bioassay
Measurements

ETL/cjl

cc: J. Baum

Attachment*

*Note: The data in this attachment has been summarized in Appendix 5.6.2.

Calculation of Intakes (estimated) and Organ Doses for UF_6 at Km.

Assumptions:

1. Time of intake = 1130 hrs, Jan. 4, 1986.
2. UF_6 = Class D solubility, natural uranium.
3. Applied ICRP-30 metabolic rate constants, and assumed an aerosol with AMAD = 1.0 µm.
4. Standard man parameters (ICRP-23). Daily urinary output = 1.4 L
5. Each urinalysis weighted equally. For duplicate samples, the mean assay was used as a single urinalysis.
6. Conversion factors:
   0.6866 µCi / g U_{nat}, 2.543 x 10^4 Bq / g U_{nat}.
7. Method of Calculation: Computer code GENMOD, by J.R. Johnson and D.W. Dunford, Chalk River Nuclear Labs., Ontario, Canada.
8. Subjects excrete 1.4 L urine per day.

Procedure:

1. Times (tenths of a day) post-exposure were determined for each urinalysis
2. A value of Uranium excretion (µg/day) was determined for each sample assuming a daily urinary excretion of 1.4 L.
3. The expected fraction of uranium in urine for various times post exposu was obtained from GENMOD. The ratio of the assay (µg/day) to th expected excretion fraction, from GENMOD, was determined. The averag fraction for all bioassays of an individual was calculated. This was the assumed intake, in µg U_{nat}.
4. The assumed intake for each individual was converted to Becquerel units, and dose values were obtained from the GENMOD output tables.

Darrell R. Fisher 1-16-

Model by J. Johnson of Chalk River Canada

Allen – A copy with the references added and some text changes –
KF Eckerman

⑤

ESTIMATES OF INTAKE OF URANIUM BY PERSONS NEAR ACCIDENTAL RELEASE AT KERR-McGEE SITE

K. F. Eckerman and R. W. Leggett
Health and Safety Research Division
Oak Ridge National Laboratory

Estimates of uranium intake have been made for several persons on or near the site of the recent accident at the Kerr-McGee plant in Oklahoma. These estimates were based on uranium concentrations in urine of the subjects at times from a few hours to a few days after exposure.

Various excretion models have been applied to the general problem of estimating uranium uptake to blood based on the level of uranium in urine. Bernard and Struxness (1957) determined a best-fitting power function for urinary excretion data for patients injected with uranium nitrate:

$$Y_u(t) = 34.3\ t^{-1.5},$$

where Y_u is the excretion rate in %/h and t is measured in hours. This function is not a good approximation to the data for the first day after injection and hence is not suitable for the present analysis.

The alternate function

$$Y_u(t) = 80\%\ \text{(first day)}$$

$$Y_u(t) = 20\%\ t^{-1.5},$$

where t is in days, was later adopted by the ICRP (1968). This function is not suitable for use in the present situation because of the lack of detail offered for the first day after exposure. Moreover, this function may overestimate urinary excretion at early times.

A third approach is to combine the uranium retention functions and the generic clearance rate from the transfer compartment as given in ICRP 30 (1979). This approach yields seemingly reasonable excretion rates at early times when combined with the ICRP lung model for class D material (the classification for uranium hexafluoride given in ICRP 30). This is fortuitous, however, since the ICRP generic clearance rate from the transfer compartment appears to be a poor approximation for uranium, and the ICRP 30 retention models for uranium do not include consideration of the early times after exposure. (Errors involved in the blood clearance rate may be offset somewhat by errors in the lung model as applied to soluble uranium.) In general, the use of ICRP 30 retention models for estimation of excretion rates should be avoided because the ICRP 30 retention models were not designed or intended for analysis of short-term retention of radionuclides.

We appealed to the original injection data for the "Boston patients" considered by Bernard and Struxness (1957), combined with injection data on healthy persons and persons with osteoporosis (see Hursh and Spoor 1973) to derive an excretion function for uranium that has reached blood. The function

$$Y(t) = 7.3\ e^{-0.2t} + 2.4\ e^{-0.075t} + 0.08\ e^{-0.011t} + 0.004\ e^{-0.0014t}$$

where Y_u is the %/h excreted in urine and t is in hours, appears to approximate these combined data closely for times from 30 minutes to

Received 2/4/86
A. Brodsky

several days after injection.

The data provided to us on the Kerr-McGee subjects include only the concentration of uranium and the date/time of the urine sample. Some assumptions had to be made in order to relate our theoretical blood-to-urine clearance curve to the concentrations of uranium in urine reported for various times of voiding. We assumed that the average urinary excretion rate for each subject is 1.4 liters of urine per day, or 0.058 liters per hour. For a given sample it was assumed that the measured concentration represented an integrated value for all urine formed since the time of the preceding sample, unless that was more than 5 hours. If the time since the preceding reported sample was more than 5 hours, we assumed that the measured concentration represented an integrated value for urine formed over the preceding 3 hours.

There remained the troublesome problem of determining the delay time of UF_6 and resulting compounds in the respiratory tract. Analysis of data of Boback (1975), Chalabreysse (1970), and Moore and Kathren (1985) for persons accidentally exposed to uranium hexafluoride indicate that any of three different patterns of excretion may be observed. The excretion rates for some persons appear to be the same as if there were almost no delay of material in the lungs, since the pattern of urinary excretion was very similar to our blood-to-urine model given above. Other persons exhibited a slight extention of urinary excretion of uranium, as if there were a brief delay (with $T_{1/2}$ of perhaps 0.5 day or greater) in the lungs. For a third small group of persons, there appeared a nearly bimodal distribution of the uranium excretion rates, with high initial rates falling quickly toward zero after a few days and later rising abruptly, sometimes to levels approaching the initial excretion rates. The bimodel distribution of excretion rates appears to be fairly unusual and was not considered in the present analysis.

In ICRP 30 it is recommended that inhaled uranium hexafluoride be considered as a class D compound. The ICRP lung model for class D compounds is intended only as a first approximation for a large class of soluble materials that actually have a fairly wide distribution of clearance times, varying up to several days. It is evident from the published data on uranium hexafluoride mentioned above that a substantial portion of inhaled uranium hexafluoride (much more than would be predicted by the ICRP lung model) must reach the blood fairly rapidly.

We specialized the ICRP lung model for class D materials to uranium hexafluoride and to the present exposure situation by choosing two fractions, one clearing rapidly and the other more slowly, in such a way as to "stabilize" our estimates of intake. (In agreement with the ICRP model for class D material, "rapid" was taken to mean $T_{1/2}$=0.01 days and "more slowly" was taken to mean $T_{1/2}$=0.5 days.) Suppose, for example, that there are six urine samples for subject A, taken at various times. Given a lung retention model and our blood-to-urine model, the concentration of uranium in each sample can be used to estimate an intake at time 0. Uncertainties associated with our blood-to-urine model appear small compared with those associated with the delay in the lungs. Thus, a large variance in the six estimates would suggest to us that we have incorrectly estimated delay in the respiratory tract, while stable estimates (a small variance) would suggest that the delay has been estimated reasonably well. There is no single lung model that would yield most stable estimates for all subjects. For most subjects, estimates were stabilized reasonably well by assuming that 30% of the activity enters blood with half-time 0.01 days and 20% enters blood with half-time 0.5 days; the total amount assumed to enter blood (50%) agrees with the ICRP lung model for class D material. Our specialized lung model was used for all subjects. We note that estimates were stabilized nearly as well and fairly similar estimates were obtained by assuming no delay at all in the lungs and 50% clearance to blood. Estimates became very unstable if long-term delays in the lung were assumed.

Estimates for all 45 subjects are summarized in the attached table. The best choice of a lung model, and the subsequent estimates of intake, are expected to vary somewhat as more data on urinary excretion are collected.

REFERENCES

[1] Bernard SR and Struxness EG, 1957, *A Study of the Distribution and Excretion of Uranium in Man*, ORNL 2304.

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[3] Hursh JB and Spoor NL, 1973, Data on man, in Hodge HC, Stannard JN, Hursh JB (eds.), *Uranium, Plutonium, Transplutonic Elements*, New York: Springer-Verlag, pp. 197-239.

[4] International Commission on Radiological Protection, 1968, Publication 10, *Report on Evaluation of Radiation Doses to Body Tissues from Internal Contamination due to Occupational Exposure*. Oxford: Permagon Press.

[5] International Commission on Radiological Protection, 1979, Publication 30, *Limits for Intakes of Radionuclides by Workers*, Oxford: Permagon Press.

[6] Moore RH and Kathren RL, 1985, A World War II uranium hexafluoride inhalation event with pulmonary implications for today, *J. Occup. Med*. 27, 753-756.

[7] Chalabreysse J, 1970, Etude et resultats d'examens effectues a la suite d'une inhalation de composes dits solubles d'uranium naturel, *Radioprotection* 5, 1-17.

APPENDIX 5.6.4

CHEMICAL BIOASSAY RESULTS FOR SFC WORKERS

Name (ID)	Sex	Weight	Date	Time	Osmolality (MOS/KG)	Creatinine (MG/DL)	Protein (MG/DL)	Glucose (MG/DL)	LDH (MU/24HR)	Albumin (MG/L)	(β-M) (ng/ml)	(NAG) (nmol/min/ml)
1E	M	145	01/23/86	1510	965	473.1	5	18	21	<68	244	9.05
			01/24/86	0715	513	96.6	ND	4	5	<68	247	3.86
			01/25/86	0800	467	96.1	1	2.9	3	<68	278	2.69
2E	M	208	01/23/86	0800	562	135.4	1	6	5	<68	160	7.78
			01/24/86	0600	299	83.6	ND	4	4	<68	144	7.44
3E	M	260	01/23/86	0900	998	182.9	ND	9	9	<68	244	10.23
			01/24/86	0530	714	146.3	1	6	5	<68	133	5.02
			01/25/86	0700	728	152.5	1	6	8	<68	173	6.38
4E	M		01/23/86	1115	258	34.5	ND	2	2	<68	40	1.24
			01/24/86	1210	261	36.5	ND	2	1	<68	57	1.71
			01/25/85	0900	629	142.1	1	5	8	<68	142	4.54
5E	M	207	01/23/86	0800	1021	267.0	4	11	10	<68	189	5.72
			01/24/86	1120	858	161.1	ND	7	7	<68	156	2.98
			01/25/86	0600	1029	234.0	2	7	10	<68	169	1.61
6E	F	202	01/23/86	0800	237	46.6	4	9	2	<68	20	5.25
			01/24/86	0730	410	34.1	1	1462	2	<68	80	3.91
			01/25/86	0730	228	38.2	2	6	1	<68	20	4.06
7E	M	170	01/23/86	?	496	137.0	5	0.2	7	<68	400	7.41
			01/24/86	?	605	144.3	9	6	5	<68	889	4.55
			01/25/86	1000	352	100.0	9	3.2	6	<68	256	2.35
8E	M	190	01/23/86	1030	778	268.0	2	8	11	<68	120	6.23
			01/24/86	1100	361	105.9	ND	4	5	<68	84	3.03
			01/25/86	0900	800	312.6	5	11	13	<68	187	9.23
9E	F	123	01/23/86	0845	281	31.3	ND	1	1	<68	20	1.08
			01/24/86	0905	463	134.6	ND	8	6	<68	289	4.01
			01/25/86	0750	398	123.2	1	4.9	5	<68	244	3.06
10E	M	190	01/23/86	1145	875	226.0	ND	13	12	<68	100	3.06
			01/24/86	1357	743	253.6	3	14	11	<68	256	2.28
			01/25/86	1025	400	69.4	ND	13.4	3	<68	51	0.63
11E	M	145	01/23/86	1000	750	148.0	3	5	8	<68	120	4.25
			01/24/86	1100		146.0	ND	7	7	<68	196	5.29
			01/25/86	1000	789	169.3	1	6	8	<68	187	6.12
12E	M	210	01/23/86	1030	1114	446.0	ND	13	19	<68	156	12.66
			01/24/86	1010	990	352.8	3	9	12	<68	220	6.78
			01/25/86	?	890	181.0	2	7	11	<68	164	2.88
14E	M	178	01/23/86	1530	246	35.5	ND	3	2	<68	80	3.56
			01/24/86	1300	371	65.2	ND	5	5	<68	256	6.72
			01/25/86	1130	153	15.6	ND	0.4	1	<68	36	1.5
15E	F	155	01/23/86	?	215	35.5	5	2	3	<68	30	3.64
			01/24/86	?	320	43.0	1	12	2	<68	109	1.98
			01/25/86	?	433	60.0	1	0.1	4	<68	151	1.95
16E	M	155	01/23/86	0920	1014	212.0	4	20	11	<68	267	8.78
			01/24/86	0855	982	244.4	8	18	14	<68	700	13.65

Name (ID)	Sex	Weight	Date	Time	Osmolality (MOS/KG)	Creatinine (MG/DL)	Protein (MG/DL)	Glucose (MG/DL)	LDH (MU/24HR)	Albumin (MG/L)	(β-M) (ng/ml)	(NAG) (nmol/min/ml)
17E	M	210	01/23/86	0830	218	29.0	ND	3	1	<68	43	1.29
			01/24/86	1000	260	27.3	ND	2	2	<68	43	1.09
			01/25/86	0600	481	69.4	1	2.9	4	<68	311	2.35
18E	M	170	01/23/86	1605	347	60.0	ND	3	5	<68	66	1.16
			01/24/86	1530	232	18.4	ND	2	0	<68	32	0.57
			01/25/86	0900	437	158.1	1	5	7	<68	222	5.91
19E	M	210	01/23/86	0923	459	69.9	2	4	2	<68	89	4.62
			01/24/86	0850	870	319.2	9	15	16	69	236	21
			01/25/86	0935	538	50.5	2	3	4	<68	58	4.64
20E	M	155	01/23/86	0925	382	55.8	ND	4	3	<68	116	1.16
			01/24/86	0855	395	64.8	ND	3	4	<68	89	2.19
			01/25/86	1145	192	17.2	ND	1	1	<68	36	1.29
21E	M	180	01/23/86	1118	756	140.7	1	7	6	<68	124	3.59
			01/24/86	0800	316	42.7	1	3	3	<68	72	1.43
			01/25/86	0730	858	151.9	11	5.7	6	<68	367	6.46
22E	M	187	01/23/86	1100	494	74.5	ND	4	5	<68	22	1.64
			01/24/86	0855	462	80.6	ND	5	4	<68	33	0.64
			01/25/86	0875	579	88.1	ND	4.2	3	<68	98	1.89
23E	M	190	01/23/86	1145	730	327.0	7	15	14	<68	278	10.39
			01/24/86	1235	828	237.8	ND	67	10	<68	256	4.97
			01/25/86	1040	389	168.0	1	15	9	<68	278	2.91
25E	M	274	01/23/86	1100	715	241.8	ND	5	9	<68	109	2.43
			01/24/86	0905	966	368.1	5	9	16	<68	267	2.62
			01/25/86	0400	362	100.3	1	3.5	7	<68	151	2.32
26E	F	182	01/23/86	1120	937	223.0	17	22	24	<68	100	10.63
			01/24/86	1130	360	101.7	ND	9	18	<68	200	7.52
			01/25/86	0430	497	116.0	1	6.1	17	<68	322	6.75
27E	M	172	01/23/86	1050	319	43.1	3	1	3	<68	40	1.29
			01/24/86	0905	430	73.7	ND	7	3	<68	67	1.76
			01/25/86	0715	741	154.4	1	12	8	<68	129	2.53
28E	M	210	01/23/86	0900	806	158.6	2	9	8	<68	105	2.53
			01/24/86	1100	612	156.6	2	6	8	<68	189	3.61
			01/25/86	?						<68		
29E	M	190	01/23/86	?	718	128.3	3	7	5	<68	61	0.95
			01/24/86	?	769	161.4	5	8	7	<68	156	3.96
			01/25/86	?	903	186.8	5	7.4	9	<68	344	2.98
30E	M	118	01/23/86	?	693	272.0	ND	12	13	<68	116	9.79
			01/24/86	1025	410	84.0	ND	2	3	<68	82	2.15
			01/25/86	0830	471		1	3		<68	128	4.64
31E	M	153	01/23/86	0915	946	175.4	15	7	11	<68	10	0.74
			01/24/86	0930	1019	232.7	1	8	18	<68	124	4.35
			01/25/86	0915	927	228.0	4	6.1	14	<68	324	3.61
8C	M	220	01/23/86	?	679	158.3	ND	15	7	<68	129	7.22
			01/24/86	1230	716	209.8	4	15	12	<68	249	5.74
			01/25/86	1015	763	189.9	ND	18.2	12	<68	356	5.88

APPENDIX 5.6.5

CREATININE CORRECTION METHODOLOGY AND FACTORS

Creatinine Correction

The following calculations of 24-hour creatinine excretion values are based on a 1.25 l/day average urine volume, the measured creatinine values, and the body weight data provided. On the basis of the mg creatinine/day/kg body weight estimates, all urinary indicator values were normalized by determining the ratio of each estimate to a normal value of 23 mg creatinine/day/kg body whenever the estimate lay outside a normal range of creatinine excretion values, viz., 16 to 30 mg creatinine/day/kg. Each ratio is listed as the creatinine correction. Two examples of the application of the creatinine correction to the urinary-injury indicator measurements follow the tabulation.

Creatinine Data

Date	Subject	mg/l	mg/day	mg/day/kg body wt	creatinine correction
1/23/86	1E	4731	5914	90	0.26
1/24/86		966	1208	18	(1)
1/25/86		961	1201	18	(1)
	2E	1354	1693	18	(1)
		836	1045	11	2.1
		--	--	--	--
	3E	1829	2286	19	(1)
		1463	1829	16	(1)
		1525	1906	16	(1)
	4E	345	431	--	--
		365	456	--	--
		1421	1776	--	--
	5E	2670	3338	35	0.66
		1611	2014	22	(1)
		2340	2925	32	0.72
	6E	466	583	6	3.8
		341	426	5	4.6
		382	478	5	4.6
	7E	1370	1713	22	(1)
		1443	1804	23	(1)
		1000	1250	16	(1)
	8E	2680	3350	39	0.60
		1059	1324	15	1.5
		3129	3911	45	2.0
	9E	313	391	7	3.3
		1346	1683	30	(1)
		1232	1540	28	(1)
	10E	2260	2825	33	0.70
		2536	3170	37	0.62
		694	868	10	2.3

Creatinine (continued)

11E	1480	1850	28	(1)
	1460	1825	28	(1)
	1693	2116	32	0.72
12E	4460	5575	59	0.39
	3528	4410	46	0.50
	1810	2263	24	(1)
13E	--	--	--	--
	--	--	--	--
	--	--	--	--
14E	355	444	6	3.8
	652	815	10	2.3
	156	195	2	11
15E	355	444	6	3.8
	430	538	8	2.9
	600	750	11	2.1
16E	2120	2650	39	0.60
	2440	3050	44	0.52
	--	--	--	--
17E	290	363	4	5.8-
	273	341	4	5.8
	694	668	9	2.6
18E	600	750	10	2.3
	184	230	3	7.7
	1581	1976	26	(1)
19E	699	874	9	2.6
	3192	3990	42	0.55
	505	621	7	3.3
20E	558	698	10	2.3
	648	810	12	1.9
	172	215	3	7.7
21E	1407	1759	21	(1)
	427	534	7	3.3
	1519	1899	23	(1)

Creatinine (continued)

22E	745	931	11	2.1
	806	1008	12	1.9
	881	1101	13	1.8
23E	3270	4088	48	0.48
	2378	2973	35	1.5
	1680	2100	24	(1)
24E	--	--	--	--
	--	--	--	--
	--	--	--	--
25E	2418	3023	24	(1)
	3681	4601	37	0.62
	1003	1254	10	2.3
26E	2230	2788	34	0.68
	1017	1271	15	(1)
	1160	1450	17	(1)
27E	431	539	7	3.3
	737	921	12	1.9
	1544	1930	25	(1)
28E	1586	1983	21	(1)
	1566	1958	21	(1)
	--	--	--	--
29E	1283	1604	19	(1)
	1614	2018	23	(1)
	1868	2335	27	(1)
30E	2720	3400	63	0.37
	840	1050	19	(1)
	--	--	--	--
31E	1754	2193	31	0.74
	2327	2909	42	0.55
	2280	2850	41	0.56
8C	1583	1979	20	(1)
	2098	2623	26	(1)
	1899	2374	24	(1)

Examples of the Application of the Creatinine Correction to Urinary Measurements from Subject 5E and 6E

Subject 5E

Measured Values	Re-expressed Values	Creatinine Corrected Values
NAG 1.24 nmoles/min/ml	1.24 nmoles/min/ml	0.82 nmoles/min/ml
1.71	1.71	1.71
4.54	4.54	3.27
BMG 189 ng/ml	189 µg/l	125 µg/l
156	156	156
169	169	122
Protein 4 mg/dl	0.53 mg/day/kg	0.35 mg/day/kg
--	--	--
2	0.27	0.19
Glucose 11 mg/dl	110 mg/l	73 mg/l
7	70	70
7	70	50

Subject 6E

Measured Values	Re-expressed Values	Creatinine Corrected Values
NAG 5.25 nmoles/min/ml	5.25 nmoles/min/ml	20.0 nmoles/min/ml
3.91	3.91	18.0
4.06	4.06	18.7
BMG 20 ng/ml	20 µg/l	70 µg/l
80	80	368 µg/l
20	20	92 µg/l
Protein 4 mg/dl	0.55 mg/day/kg	2.1 mg/day/kg
1	0.13	0.6
2	0.27	1.2
Glucose 9 mg/dl	90 mg/l	342 mg/l
1462	14620	67000
6	60	276

APPENDIX 6.1.2.1

SUMMARY OF DOSE CONVERSION FACTORS AND INTAKE PARAMETERS USED FOR RADIOLOGICAL DOSE CALCULATION

APPENDIX 6.1.2.1

External Dose Conversion Factors

Releases of radioactive gases and particulates to the atmosphere may result in external doses by exposure to and/or immersion in the plume and by exposure to contaminated land surfaces. The dose conversion factors are summarized by Kocher in ORNL/MUREG-70, and those used in this report are shown in Table 6.1.2.1.1. Usage factors are given in Table 6.1.2.1.4.

Table 6.1.2.1.1 Dose conversion factors for external exposure pathways

Radionuclide	Organ			
	Total body	Bone	Kidney	Lungs
	Exposure to ground surfaces (millirem/year per $\mu Ci/cm^2$)			
^{234}U	7.1×10^2	3.0×10^2	1.0×10^2	1.7×10^2
^{235}U	1.5×10^5	2.1×10^5	1.3×10^5	1.4×10^5
^{238}U	5.7×10^2	2.1×10^2	5.9×10^1	1.2×10^2
	Immersion in air (millirem/year per $\mu Ci/cm^3$)			
^{234}U	6.8×10^5	7.1×10^5	3.7×10^5	4.1×10^5
^{235}U	6.8×10^8	9.4×10^8	5.9×10^8	1.2×10^8
^{238}U	4.6×10^5	4.5×10^5	2.2×10^5	2.5×10^5

Source: D. C. Kocher, Dose-Rate Conversion Factors for External Exposure to Photons and Electrons, ORNL/NUREG-79, Oak Ridge National Laboratory, August 1981.

Table 6.1.2.1.2 Dose conversion factors for inhalation exposure pathways--AMAD = 1 μm

Radionuclide	Committed dose equivalent (rem/μCi)			
	Total body	Bone	Kidneys	Lungs
		Class D		
^{234}U	2.5	7.7×10^1	1.6×10^2	9.4×10^{-1}
^{235}U	2.2	6.9×10^1	1.5×10^1	8.5×10^{-1}
^{238}U	2.1	6.8×10^1	1.5×10^1	8.3×10^{-1}

Source: D. E. Dunning, Jr., G. G. Killough, S. R. Bernard, J. G. Pleasant, and P. J. Walsh, Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclide Occurring in Routine Releases From Nuclear Fuel Cycle Facilities. Vol. III, OTNL/NUREG/TM-190/V3, Oak Ridge National Laboratory, October 1981.

Table 6.1.2.1.1 Dose conversion factors for external exposure pathways

Radionuclide	Committed dose equivalent (rem/μCi)			
	Total body	Bone	Kidneys	Lungs
		Class D		
^{234}U	2.6×10^{-1}	7.8	1.7	1.7×10^{-2}
^{235}U	2.2×10^{-1}	7.1	1.5	1.6×10^{-2}
^{238}U	2.2×10^{-1}	7.0	1.5	1.5×10^{-2}

Source: D. E. Dunning, Jr., G. G. Killough, S. R. Bernard, J. G. Pleasant, and P. J. Walsh, Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclide Occurring in Routine Releases From Nuclear Fuel Cycle Facilities. Vol. III, OTNL/NUREG/TM-190/V3, Oak Ridge National Laboratory, October 1981.

Table 6.1.2.1.4 Intake parameters (adult) used in lieu of site-specific data

Pathway	Exposed individual
Vegetables, kg/year	94
Milk, L/year	310
Meat, kg/year	110
Inhalation, m^3/year	8000

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16. ABSTRACT *(200 words or less)*

Following the accidental release of UF_6 from the Sequoyah Fuels Facility on January 4, 1986, an Ad Hoc Interagency Public Health Assessment Task Force was established. The Task Force consists of technical staff members from various agencies who have prepared this assessment of the public health impact associated with the accidental release.

The assessment is based on data from the accident available as of February 14, 1986, and describes the chemical and radiological effects from the intake of uranium and fluoride.

Volume 1 of the report describes the effects from the intake of uranium and fluoride and summarizes the findings and recommendations of the Task Force.

Volume 2 of the report consists of Appendices which provide more detailed information used in the assessment.

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