Health Assessment for

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KERR-MCGEE RADIATION AREAS

WEST CHICAGO, DUPAGE COUNTY, ILLINOIS

KRESS CREEK - CERCLIS NO. ILD980823991
REED-KEPPLER PARK - CERCLIS NO. ILD980824007
RESIDENTIAL AREAS - CERCLIS NO. ILD980824015
SEWAGE TREATMENT PLANT - CERCLIS NO. ILD980824031

NOVEMBER 14, 1994

[illegible] DEPARTMENT OF HEALTH & HUMAN SERVICES
[illegible] Public Health Service
[illegible]

THE ATSDR HEALTH ASSESSMENT: A NOTE OF EXPLANATION

Section 104 (i) (6) (F) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, states "...the term 'health assessment' shall include preliminary assessments of potential risks to human health posed by individual sites and facilities, based on such factors as the nature and extent of contamination, the existence of potential pathways of human exposure (including ground or surface water contamination, air emissions, and food chain contamination), the size and potential susceptibility of the community within the likely pathways of exposure, the comparison of expected human exposure levels to the short-term and long-term health effects associated with identified hazardous substances and any available recommended exposure or tolerance limits for such hazardous substances, and the comparison of existing morbidity and mortality data on diseases that may be associated with the observed levels of exposure. The Administrator of ATSDR shall use appropriate data, risks assessments, risk evaluations and studies available from the Administrator of EPA."

In accordance with the CERCLA section cited, this Health Assessment has been conducted using available data. Additional Health Assessments may be conducted for this site as more information becomes available.

The conclusions and recommendations presented in this Health Assessment are the result of site specific analyses and are not to be cited or quoted for other evaluations or Health Assessments.

Use of trade names is for identification only and does not constitute endorsement by the Public Health Service or the U.S. Department of Health and Human Services.

FINAL RELEASE

PUBLIC HEALTH ASSESSMENT

KERR MCGEE RADIATION AREAS

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Prepared by:

Illinois Department of Public Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations 42 C.F.R. Part 90). In preparing this document ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30 day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, is an agency of the U.S. Public Health Service. It was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National riorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. (The legal definition of a health assessment is included on the inside front cover.) If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is ıot enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists then evaluate whether or not there will be any harmful effects from these exposures. The report focuses on public health, or the health impact on the community as a whole, rather than on individual risks. Again, ATSDR generally makes use of existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further research studies are needed.

Conclusions: The report presents conclusions about the level of health threat, if any, posed by a site and recommends ways to stop or reduce exposure in its public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions

of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Interactive Process: The health assessment is an interactive process. ATSDR solicits and evaluates information from numerous city, state and federal agencies, the companies responsible for cleaning up the site, and the community. It then shares its conclusions with them. Agencies are asked to respond to an early version of the report to make sure that the data they have provided is accurate and current. When informed of ATSDR's conclusions and recommendations, sometimes the agencies will begin to act on them before the final release of the report.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E-56), Atlanta, GA 30333.

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SUMMARY

The Kerr-McGee radiation areas consist of the Kerr-McGee Facility (Illinois Department of Nuclear Safety jurisdiction) and National Priorities List (NPL) areas in and around West Chicago, Illinois: (1) Reed-Keppler Park, (2) the West Chicago Regional Wastewater Treatment Plant (WTP), (3) residential areas, (4) Kress Creek, and (5) the West Branch of the DuPage River (included with the WTP or Kress Creek areas for the NPL listings). Chemicals of concern include radon, radium, thorium, uranium, antimony, arsenic, barium, boron, cadmium, fluoride, lead, manganese, nickel, nitrate, selenium, silver, vanadium, zinc, and possibly chromium and polychlorinated biphenyls (PCBs). Many of the radioactive elements in the wastes emit gamma radiation.

The Kerr-McGee Facility has disposal ponds, ores, waste tailings, and other chemicals from a plant which extracted rare earth and thorium compounds from 1932 to 1973. The plant caused extensive groundwater contamination, and hydraulic pathways exist between the wastes and nearby private wells. Waste tailings from the plant were used as fill at Reed-Keppler Park, the WTP, and over 150 residential properties (many remediated). Kress Creek and properties along it have been contaminated by runoff from the Kerr-McGee Facility. The West Branch of the DuPage River and associated properties have been polluted by erosion of tailings along its bank at the WTP and by Kress Creek, which flows into it. At all of the areas, contaminants can be transported in air as gases or on dust. Houses with tailings along foundations may be at increased risk of having elevated radon levels.

Homes are close to the Kerr-McGee Facility, Reed-Keppler Park, and WTP. There are also homes along Kress Creek and the West Branch of the DuPage River.

The main health concern of people in West Chicago is the cancer risk from the radioactive wastes. Other concerns include (1) a proposed plan to permanently bury the wastes at the Kerr-McGee Facility will not lessen this risk, (2) groundwater pollution, and (3) direct radiation from the Kerr-McGee Facility.

Exposure pathways include the inhalation of contaminated dust and gases; the ingestion of dust, groundwater, soil, sediments, and surface water; and dermal contact with dust, sediments, soil, and surface water.

The Kerr-McGee Facility, residential areas, Reed-Keppler Park, the WTP, Kress Creek, and the West Branch of the DuPage River are considered a public health hazard because of the risk to human health from past, present, and/or potential future exposure to radioactive and nonradioactive substances at levels that may cause adverse health effects.

The Agency for Toxic Substances and Disease Registry's (ATSDR) Health Activities Recommendation Panel and the Illinois Department of Public Health (IDPH) have evaluated the six Kerr-McGee areas for appropriate follow-up with respect to health actions. The Panel determined that Kerr-McGee workers and members of the public have been exposed to contaminants from the areas. Action should be taken to reduce public exposure in residential areas which still have tailings, including properties along Kress Creek and the West Branch

of the DuPage River. If no permanent solution is available, interim measures should be taken. The results of the epidemiologic studies of workers and people in yards with tailings showed no conclusive relationship between radiation exposure and types of cancer which may be caused by radioactive materials. If the completed Remedial Investigation suggests exposure to hazardous substances has occurred at levels which may cause adverse health effects, IDPH, in conjunction with ATSDR, will reevaluate these six areas for any indicated follow-up.

As part of the ATSDR Physician Education Cooperative Agreement, IDPH will inform area health professionals of the public health implications associated with these six areas and others in the vicinity.

BACKGROUND

A. SITE DESCRIPTION AND HISTORY

The Kerr-McGee radiation areas consist of the Kerr-McGee Facility (Sections 9 and 16; Illinois Department of Nuclear Safety (IDNS) jurisdiction), and U.S. Environmental Protection Agency (USEPA) National Priority List (NPL) areas in T39N, R8E (Figure 1): (1) Reed-Keppler Park (Section 4), (2) the West Chicago Regional Wastewater Treatment Plant (WTP; Section 15), (3) residential areas (Sections 3, 4, 9, 10, 15, and 16, (4) Kress Creek (Sections 16 and 22), and (5) the West Branch of the DuPage River (Sections 15, 22, and possibly further downstream). The USEPA has included the part of the West Branch of the DuPage River upstream from its confluence with Kress Creek in the WTP NPL area, while the part of the river below the confluence is included in the Kress Creek NPL area. On August 28, 1990, Reed-Keppler Park, the WTP, and the residential areas were placed on the NPL. In February 1991, Kress Creek and the West Branch of the DuPage River were added to the NPL. The Kerr-McGee Facility was under jurisdiction of the Nuclear Regulatory Commission (NRC; formerly the Atomic Energy Commission, AEC), and control of it was recently given to the State of Illinois, with the Illinois Department of Nuclear Safety (IDNS) as the regulatory agency. Groundwater pollution from the Kerr-McGee Facility is under IDNS jurisdiction.

KERR-MCGEE FACILITY

The Kerr-McGee Facility (Figure 2) includes (1) the eight acre Factory Area, which includes(d) the demolished factory and associated buildings; (2) the Kerr-McGee Disposal Area, which consists of 27 acres used for waste disposal; and (3) the Intermediate Area, which consists of about eight acres between the Factory and Kerr-McGee Disposal Areas.

From the mid-1880's to 1931, the Union Tool Company made drilling equipment on a five acre part of the Factory Area. In 1931, the property was bought by the Lindsay Light Company, and in 1932, they began producing thorium and other rare earth materials. They were the major supplier of thorium for Welsbach mantles (for gas lights) and also produced thorium for early nuclear weapon research by the U.S. Government (USEPA, 1986). In 1958, the American Potash and Chemical Corporation purchased the Lindsay Light Company property, and in 1967, it was bought by Kerr-McGee, the current owner. The operating license was then transferred to Kerr-McGee (USEPA, 1986).

Most of the rare earth and thorium products were extracted from monazite ore. It contains silica, about four to six percent thorium oxide, 40 to 50 percent mixed rare earths, radium oxide, phosphorus oxide, and 0.15 to 0.4 percent uranium oxide (USEPA, 1986; Kerr-McGee, 1975; Butler, 1965). During the 42 years of operation, about 130,000 to 141,000 tons of monazite were processed (USEPA, 1986), although Kerr-McGee now

estimates only 111,000 tons of ore were used. Other thorium sources included odd lots of thorium-bearing residues, minor ores such as thorite, and the repurchase of thorium-containing wastes (largely Welsbach mantle scraps). Bastnasite ore, which was processed beginning in 1954, contains fluorocarbonates and about 54 percent rare earth oxides, but no thorium over background levels. Between 1954 and 1973, about 13,000 tons of bastnasite was processed. From 1954 to 1963, the plant was expanded to produce thorium nitrate for the U.S. Government (USEPA, 1986; Stauter, 1982). In later years, however, the rare earths became more valuable than thorium, which became more abundant in the waste (USEPA, 1986). When it was operating, the plant was the largest producer of rare earth and thorium compounds in the world (Butler, 1965). In the plant, the various ores were mechanically reduced in size and extracted with chemicals including hydrochloric, hydrofluoric, nitric, phosphoric, and sulfuric acids. Also used were organic substances such as tributyl phosphate, organic solvents, and small amounts of analytical reagents. The factory products were thorium compounds, including chlorides, fluorides, and oxides and mixed rare earths including cerium oxide and lanthanum oxide (Table 1). About 75 percent of the thorium dioxide and rare earths were removed by various separation processes, and the remaining 25 percent ended up in the waste (Rhinelander, 1983; Butler, 1965). According to the IDNS, because the extraction procedures concentrated the radioactive materials into a small volume, the waste has up to 20 times the radioactivity of the original ore (Ed, 1990). According to Kerr-McGee, however, the level of thorium in the wastes is about half that in the monazite ore (Kerr-McGee, 1994). In many cases, the wastes were diluted with clean soil during disposal, reducing radiation levels (Jensen, 1993). About 330 tons of uranium oxide were processed, and 33 tons remain in the waste, but the fate of the rest is unknown (USEPA, 1986). Kerr-McGee believes that most of it ended up in the liquid waste effluent (Vreeland, 1975a). Because many different processes were used to extract thorium and rare earths from the ores, the waste composition was extremely variable (Butler, 1965).

After precipitation of the rare earths and thorium in factory tanks, the remaining liquid waste was pumped into one of several solid retention ponds, which were maintained at approximately pH 2 (USEPA, 1986). From June 26 to July 24, 1964, an average of around 230,000 gallons of waste per day were pumped into the operating disposal pond (Butler, 1965). In 1973, about 200,000 to 250,000 gallons of waste per day were pumped into the ponds (USEPA, 1986). The ponds were unlined, and the liquid seeped into the surrounding glacial material, causing extensive groundwater pollution. Before 1952, the liquid waste was pumped into a small pond in the Factory Area. In 1952 and 1953, the Lindsay Light Company bought additional land (the Kerr-McGee Disposal Area) for waste disposal (USEPA, 1986). In the 1950's, two disposal ponds (1 and 2) were built on the Kerr-McGee Disposal Area, and the small Factory Area pond was abandoned. Sludge from this pond was later moved to the Kerr-McGee Disposal Area. About 1966, Pond 3 was constructed and operated in series with either Pond 1 or 2. In 1970, the operation of Ponds 4 and 5 in series downstream of Pond 3 was begun. The largely insoluble fluoride, phosphate, and carbonate compounds of thorium and rare earths precipitated in Ponds 1 and 2. In later years, when sediments nearly filled Pond 1, some solids overflowed into Pond 3; however, little or no

solids reached Ponds 4 or 5 (Kerr-McGee, 1975). Butler (1965) reported that a pond behind the Bowling Green Sports Center received wastewater from the Kerr-McGee Facility. The property owner said the pond was on a nine hole golf course, and while it may have received Kerr-McGee Facility runoff, it did not receive waste effluent. According to him, the pond sediments were not contaminated with radioactive materials, and in the mid- to late- 1960's, the sediments were excavated and the pond was filled (Stahelin, 1990). However, Butler (1965) found the water of this pond was contaminated; consequently, the removed sediments may have also been affected.

Solid wastes from the extraction process, which consisted of a filtered cake of insoluble ore gangue and unreacted ore, were initially stored at the Factory Area and were later transferred to the Kerr-McGee Disposal Area. The Kerr-McGee Disposal Area was also used for the storage of ore, process intermediates, and solid chemicals (Kerr-McGee, 1975).

The area west of the Kerr-McGee Facility fence was once used to unload monazite ore from rail cars. Presently, groundhogs inhabit the area.

During plant operations, airborne hydrofluoric acid emissions killed trees and shrubs around the factory (Allan, 1967; Resources Research, Incorporated, 1967a,b), with damage reported as early as 1941. On June 5, 1967, after an accidental release of about 116 pounds of hydrogen fluoride, moderate to severe vegetation damage occurred in an area about four to five blocks long and two to two and one-half blocks wide near the factory (Resources Research, Incorporated, 1967a,b).

In 1970, a resident on Joliet Street reported he had to abandon his private well and hook up to city water because of groundwater contamination attributed to Kerr-McGee. He also reported that contaminated water from the disposal ponds had seeped to the surface of his property, killing about 50 small evergreen trees and his garden (Byram, 1970).

Between 1956 and 1983, the Lindsay Light and Chemical Company (to 1958), American Potash and Chemical Company (1958 to 1967), or Kerr-McGee (1967 to present) were cited for numerous violations of AEC/NRC regulations at the Kerr-McGee Facility, including:

1. Failure to fence off radioactive storage areas (1957);
2. Failure to post areas as containing radiation hazards (1961, 1962, 1964, 1965, 1976);
3. Exposure of workers to radiation levels above AEC/NRC standards (1957, 1958, 1961, 1962, 1965, 1970, 1976);
4. Failure to notify workers of exposure to radiation levels above AEC/NRC standards (1970, 1976);
5. Radiation levels outside the fenceline above AEC/NRC standards (1962, 1963, 1964, 1982, 1983);
6. Lack of worker safety programs (1961, 1962);
7. Failure to conduct adequate radiation surveys and personal

monitoring (1962, 1965);
8. Improper waste disposal (1965, 1970); and
9. Failure to provide safety equipment, showering, or laundry facilities to workers (1961, 1964); and
10. Eating and drinking in a potentially contaminated area (1982).

The fact that fenceline radiation levels were exceeded and workers reportedly went home without showering or changing, were not monitored for contamination, and washed work clothes at home (Hind, 1984; AEC Inspection Reports 1957-70; NRC Inspection Reports, 1976-83) indicates workplace practices may have lead to contamination of residences. Written safety procedures were provided in 1964 and laundry facilities were provided by 1983. Also, according to AEC inspection reports (1957-70), before 1957, the Kerr-McGee Facility was unfenced on the western side, making it readily accessible. In the 1980's, the NRC cited Kerr-McGee for excessive air emissions from the waste piles and required them to cover the piles (Jensen, 1993b).

By 1973, the Illinois Environmental Protection Agency (IEPA) had denied the request of Kerr-McGee for an operating permit because they did not supply the required data to show they would be in compliance with pollution regulations (Craig, 1973; Lock, 1973). In 1973, as a result of cost-benefit analysis, Kerr-McGee halted production at the factory rather than install pollution control equipment (Kerr-McGee, 1994; USEPA, 1986). Subsequently, nearly all of the ores, ore residues, and wastes at the Factory Area were moved to the Kerr-McGee Disposal Area. Also, almost all of the processing equipment in the factory (leachate tanks, reaction vessels, etc.) were taken to the Kerr-McGee Disposal Area or decontaminated, salvaged, and removed from the Kerr-McGee Facility (USEPA, 1986).

In 1974, Kerr-McGee sold two-hundred 30 gallon fiberboard drums overpacked into 55 gallon drums to the Marvin Moore Chemical Company, Andres, Illinois. The contents were supposed to be nonradioactive neodymium neocarbonate; however, it was later discovered that thorium had accidently been placed in some of the drums. Furthermore, the Marvin Moore Chemical Company may have used some of this radioactive material before the mistake was discovered. Inside the storage shed at the chemical company, the level of radon-220 (also called thoron), 29.5 picoCuries per liter, exceeded the 10 picoCuries per liter NRC radon-220 standard. The drums had holes, and some of the radioactive materials had spilled onto the floor. The most radioactive material, which averaged 25 millirems per hour, was placed in 55 gallon drums and shipped to the Sheffield, Illinois disposal site (Axelson and Borst, 1977; Atcor, 1977).

In 1977, about 18,000 cubic feet of thorium ore were removed from a Kerr-McGee Facility warehouse and shipped to the Sheffield, Illinois disposal site. This was done because the old warehouse was considered a fire hazard, and contaminants could have been dispersed through the air had a fire occurred (Meline, 1977).

In 1980, Kerr-McGee applied to the NRC for a license amendment to use an incinerator to decrease the volume of thorium-containing material (Shelly, 1983). By 1983, the incinerator was completed and testing was about to begin (Damlos, 1983). According to Kerr-McGee (1994), it had a high efficiency particulate (HEPA) filter, which effectively removed 99.95 percent of particulate matter. The incinerator was required to release less than 10 kilograms per year, and radiation in the stack effluent, which was monitored, had to be below 0.0015 picoCuries per liter for any 24 hour period.

The two waste piles on the Kerr-McGee Facility remained uncovered until July 1983, when an asphalt suppression system was installed in response to a NRC citation for excessive radon-220 decay product emissions. This consisted of a "light coat" of asphalt emulsion, overlaid by a nonwoven geotechnical fabric, which was then covered with a "relatively thick" top coat of asphalt emulsion (Jensen, 1993b; Hind, 1984).

There has been much controversy over the disposal method for the radioactive wastes. Kerr-McGee favors permanent burial on the Kerr-McGee Disposal Area because it would be cheaper. Between 1979 and 1989, Kerr-McGee submitted several proposals to the NRC for disposal at the Kerr-McGee Disposal Area. On February 13, 1990, the Atomic Safety and Licensing Board (ASLB) of the NRC approved one of these plans. The ASLB directed the NRC to issue Kerr-McGee a license for disposal, which was granted on February 23, 1990. The proposed disposal cell would be above ground, 4.5 stories high, and cover 27 acres. This plan was criticized by the Illinois State Attorney General, the IDNS, the IEPA, the USEPA, and the Illinois State Geological Survey (NRC, 1989b). Concerns of these agencies have included: (1) the location in a heavily populated area, (2) possible further groundwater contamination, which may affect private and municipal wells, (3) groundwater mounding, and (4) the cap may not withstand the effects of erosion. Two USEPA-contracted engineering studies, Bernhardt et al. (1990) and NUS Corporation (1990) concluded the proposed cell may not withstand the effects of erosion. Currently, much of the wastes are below grade, additional radioactive material would be brought to the Kerr-McGee Disposal Area, and construction of the proposed above-ground cell could cause additional elevated gamma radiation levels around the Kerr-McGee Disposal Area by direct shine (Ed, 1990).

On August 31, 1990, the State of Illinois and City of West Chicago filed a motion to vacate the ASLB decision. On October 22, 1990, the City and State filed a motion to vacate the ASLB decision because regulatory authority of the Kerr-McGee Facility was about to be transferred to the State. On February 28, 1991, after hearings, motions, and counter motions by the State, City, NRC, and Kerr-McGee, the ASLB Appeal Panel vacated the ASLB decision and ordered the NRC to revoke the disposal license. On March 22, 1991, the NRC revoked the license (Allen, 1992).

On October 17, 1990, the NRC Licensing Board gave the State of Illinois jurisdiction over the Kerr-McGee Facility, effective November 1, 1990, with the IDNS as the regulatory agency (Allen, 1992).

In spring 1991, a bill was introduced into the state legislature which, if passed, would charge Kerr-McGee a $2 per cubic foot annual storage fee for wastes at the Kerr-McGee Facility. On May 14, 1991, Kerr-McGee agreed to move all of the wastes to a yet-to-be-determined out-of-state disposal facility and contribute to a fund for cleanup. The IDNS has proposed shipping the material to a remote location in Utah. Before that site can accept the wastes, however, it must be granted a license by the NRC (Bennetti, 1990). A local citizen action group opposed to disposal at the Kerr-McGee Facility, the Thorium Action Group (TAG), has accused Kerr-McGee of trying to block the NRC licensure of the Utah site in an effort to eliminate the alternative of off-site disposal (TAG, 1992). On September 6, 1992, Governor Edgar signed legislation which will charge Kerr-McGee an estimated $17 million per year storage fee beginning in 1994 if the thorium wastes are not removed from the Kerr-McGee Facility (Kerr-McGee, 1994; McCoppin, 1992b; Curry, 1992). The IDNS hopes that the NRC license for the Utah disposal site will be approved by September 1994, so Kerr-McGee can begin removal of the wastes in late September or early October 1994 (Allen, 1994). Kerr-McGee has signed a contract with EnviroCare for disposal, and claims they are now committed to sending the wastes to Utah (Kerr-McGee, 1994). Activities in summer 1994 include replacing old water and sewer lines which would not withstand heavy equipment, as well as construction of access roads, buildings for trailers, a parking area, and a railroad spur (all removal will be by rail; Allen, 1994).

REED-KEPPLER PARK

In the first two decades of Lindsay Light and Chemical Company operations, tailings were used as fill around the vicinity because of their good bearing strength. The exact dates of this practice are uncertain, but it probably occurred before the 1956 AEC license. The largest of these fill areas is in Reed-Keppler Park (owned by the City of West Chicago), where most of the tailings are in an unimproved spoil area (Figure 3). This area was a gravel pit which was filled with tailings and other unknown material from before 1939 and to 1967. Tailing disposal is thought to have occurred from the 1930's to the 1940's (Booth et al., 1982). Some additional disposal of unknown types of wastes, however, may have occurred at this location up to 1974 (Booth et al., 1982). The spoil area with radioactive materials is about 100,000 square feet (2 acres) in size, and a smaller area of waste tailings was east of and partially under the tennis courts. Tailings from part of the latter area were removed in July 1976 and placed in the spoil portion of the park. In 1977, a security fence was installed around the spoil area at the 0.2 milliroentgen per hour isodose line (Booth et al., 1982). In spite of the fence, trespassing has occurred (Jensen, 1992).

The City of West Chicago closed the park swimming pool after the 1989 season because it was in poor condition. The city planned to construct a new pool (McCoppin, 1992d) just to the west of the existing one; however, the plan was rejected by the USEPA after a consultant found 230 cubic yards of buried tailings in the proposed pool area (Szymczak and Baker, date unknown).

WEST CHICAGO REGIONAL WASTEWATER TREATMENT PLANT

A smaller amount of tailings was used for fill at the WTP (owned by the City of West Chicago; Figure 4). There is no contamination of sewage sludge by thorium wastes, although it is radioactive from naturally-occurring radium in the water of West Chicago. Aside from fill around the sewage plant, tailings were used along 320 feet of the adjacent bank of the West Branch of the DuPage River, and some of this waste has been eroded and washed downstream. Kerr-McGee signed a consent decree with the City of West Chicago to remove radioactive wastes from the plant and transport them to the Kerr-McGee Disposal Area; however, this agreement did not include tailings along the West Branch of the DuPage River. In late May 1986, Kerr-McGee began removing tailings from the WTP (USEPA, 1986). In 1986-7, Kerr-McGee reportedly removed 57,000 cubic yards of thorium-contaminated soil from the WTP and took it to the Kerr-McGee Facility. The upcoming USEPA Remedial Investigation will assess the adequacy of this past removal and identify any remaining contamination (Shafer, 1992).

RESIDENTIAL AREAS

Tailings were also used for fill in residential areas in and around West Chicago. In some cases, the same trucks were used to carry tailings and topsoil, causing the contamination of gardens and yards which did not receive tailings (Frigerio et al., 1978). In some cases, tailings were mixed with concrete and used for foundations, and some of the contaminated areas were from spills along roadways during transport, especially at corners (Frigerio et al., 1978). A 1978 study by Argonne National Laboratory (Frigerio et al., 1978) found 77 places in and around West Chicago contaminated by thorium. A later survey of 2726 properties by Kerr-McGee found 117 contaminated areas (4.3 percent of the surveyed properties) inside the City, and these included all but 4 of the places found in 1978 (Kerr-McGee, 1994; USEPA, 1986). In 1985, Kerr-McGee remediated 116 of the 117 radioactive residential properties within the City limits. One property owner refused access to Kerr-McGee for removal of the waste. Areas with tailings outside of the City of West Chicago have been surveyed by Kerr-McGee (USEPA, 1986), but to date, only one of them has been remediated (IDNS, 1991a). In June 1989, six new areas were identified outside of the city limits (TAG, 1990). On September 20, 1989, Kerr-McGee began excavating soil from one of the contaminated yards outside of the city limits, but was forced to stop after the City of West Chicago adopted an ordinance prohibiting transportation of the material on city streets. They removed about 75 cubic yards of the 270 cubic yards of contaminated material before they stopped (Kelma, 1990). A federal judge banned enforcement of the ordinance (Allen, 1992). Subsequently, the City reached an agreement with Kerr-McGee to allow them to remediate residential properties outside the city limits (Kelma, 1990), but as of 1990, no more waste had been removed (Shafer, 1990). In 1990, Kerr-McGee was supposed to remediate 20 properties and re-examine 17 others (TAG, 1990). On April 24, 1990, Kerr-McGee filed a request with DuPage County for an excavation permit for the first of several residential clean-ups (Kerr, 1990). However, Kerr-McGee still lacks an IDNS license amendment to accept material from residential properties on the Kerr-McGee Facility

(Allen, 1994; Allen, 1992). On June 16, 1991, the Agency for Toxic Substances and Disease Registry (ATSDR 1991a) recommended that seven properties be remediated within the calendar year. As of July 1991, only one of them had been remediated (IDNS, 1991a).

In April or May 1992, tailings were found in a small mound at the future site of a new West Chicago Library, but the levels of radioactivity were below levels of concern (McCoppin, 1992c).

KRESS CREEK

Runoff from the Kerr-McGee Facility discharges through a storm sewer and a ditch along the railroad tracks west of the fenceline. The water then flows through a drain under Roosevelt Road and discharges into Kress Creek. This has contaminated its sediments and adjacent soil (including residential yards). At the Kerr-McGee Facility, the 1976 construction of a berm to reduce runoff from the waste piles and the 1983 covering of the waste piles with asphalt probably decreased contaminant transport to the storm sewer and Kress Creek.

The stream ranges from about 10 to 49 feet in width, averages 1 foot deep, and the banks range from low and flat to high and steep. During periods of average rainfall, the stream is relatively slow-moving; however, erosion on its banks indicates flooding can occur. The stream bed is composed of sand and rocks, with some areas of hard clay. Vascular aquatic vegetation is sparse, but there is abundant algal growth. Carp, shiners, and suckers inhabit the stream, and a fish kill occurred just before July 29, 1981; however, the cause was unknown (Frame, 1984; Frame, 1981).

WEST BRANCH OF THE DUPAGE RIVER

The West Branch of the DuPage River has become contaminated from two sources: (1) tailings washed into the stream from the river bank by the WTP and (2) Kress Creek, which flows into it about 1.4 miles downstream of the Kerr-McGee storm outfall.

Sometime in or after 1984, because of concerns about radioactive contamination, the DuPage County Forest Preserve District closed part of the West Branch of the DuPage River to the public. The restricted area was posted and extended from the confluence with Kress Creek to Butterfield Road and was 50 yards wide on each side of the river (Presecky, date unknown).

LEGAL HISTORY

Plaintiffs in a 1941 lawsuit against the Lindsay Light and Chemical Company were concerned about damage to vegetation and possible health effects. The company agreed to

replace the vegetation, but the judge ruled there was no evidence the factory was harmful to public health. The plaintiffs were each awarded one dollar (Holloway, 1990).

On October 28, 1981, a lawsuit alleging exposure to radioactive materials was filed against Kerr-McGee by the owners (and others) of a building at 185 W Washington Street. This building, Bolles Opera House, formerly housed a Kerr-McGee laboratory. In 1976, Kerr-McGee sold it to the present owner after the building was decontaminated, formally released from the AEC license, and approved by the State of Illinois. This building is currently used for office(s).

In 1980, the Illinois Attorney General filed a lawsuit which attempted to block a proposed plan of Kerr-McGee to permanently bury the wastes at the Kerr-McGee Facility. This lawsuit was dismissed, and in 1986, the decision was appealed. In response to the 1990 transfer of regulatory authority over the Kerr-McGee Facility from the NRC to the IDNS, Kerr-McGee filed lawsuits to block this action (Associated Press, 1990; Pearson, 1991). On May 14, 1991, Kerr-McGee agreed to off-site disposal, and as part of the agreement, all ongoing litigation concerning the Kerr-McGee areas would be dropped (Culloton, 1991).

In the 1980's, a woman with Hodgkin's disease who attributed her cancer to tailings in her back yard filed suit against Kerr-McGee. The case was settled out-of-court. The woman died in 1992 at the age of 34 (McCoppin, 1992a).

On January 13, 1992, a Joy Street Subdivision resident filed a class action suit against Kerr-McGee and the City of West Chicago for damages, medical monitoring, costs, and other relief for failure to clean up their contaminated property(ies). On April 16, 1992, Kerr-McGee filed an answer and counterclaim against the City and mayor of West Chicago, the USEPA, the USEPA Administrator, the NRC, the NRC Chairperson, the IDNS, the IDNS Director, DuPage County, and the DuPage County Board Chairperson. The counterclaim was for judgement against the counter-defendants to permit Kerr-McGee to clean up residential properties and store excavated wastes at the Kerr-McGee Facility (Allen, 1992).

In 1992, two West Chicago parents filled suit against Kerr-McGee alleging that radioactive wastes from the areas had caused aplastic anemia in their two daughters (Janota, 1992).

On November 25, 1992, the USEPA sent a letter to the City of West Chicago requesting access to Reed-Keppler Park and the WTP. The City denied access and on January 6, 1993, the USEPA issued a Unilateral Order for Access (Shafer, 1993). On January 7, 1993, the city agreed to give the USEPA access to Reed-Keppler Park and the WTP (McCoppin, 1993b).

On February 12, 1993, Kerr-McGee filed suit against the governor, the Illinois State Attorney General, and the IDNS Director to stop the state from charging Kerr-McGee an estimated $17 million dollar per year storage fee for wastes buried in West Chicago. Money generated by this fee would be set aside to pay for cleanup costs (Rodriguez, 1993).

B. SITE VISITS

Site visits were performed on May 23, 1989, June 4, 1990, July 24, 1991, June 20, 1994, and several other dates by Illinois Department of Public Health staff, West Chicago Regional Office.

KERR-MCGEE FACILITY

The Kerr-McGee Facility is surrounded by a six to eight foot tall chain-link fence which is topped by barbed wire. It has many radioactive material and no trespassing signs, and is intact, but heavily patched. On May 23, 1989 and June 4, 1990, the bottoms of some gates were high enough that small children could crawl under them and enter the area. However, by July 24, 1991, dirt fill had been used to correct this problem. There are piles of rusty metal on each section of the Kerr-McGee Facility, especially at the Factory Area. Overall, the Disposal and Intermediate Areas are well-vegetated with grass, but have some bare patches. The Factory Area was poorly vegetated and had a lot of bare ground, as well as exposed concrete slabs. By June 20, 1994, however, vegetation had been established between the slabs. Each section of the Kerr-McGee Facility has dirt lanes, which were presumably used for the transport of chemicals, ores, and wastes. The disposal pond used in the Factory Area before 1952 no longer exists and has been filled. East of the Factory Area, a former Kerr-McGee parking lot remediated in the 1980's is now roped off with a single low chain. There are houses about 100 to 150 feet east of the Kerr-McGee Facility. To the west, homes are about 400 feet from the Kerr-McGee Facility and are separated from it by the Elgin, Joliet, and Eastern Railroad (EJ&E) tracks and a field. The homes around the Kerr-McGee Facility are small and fairly typical of the blue-collar community of West Chicago. The lots are small and the density of dwellings is high. South of the Kerr-McGee Disposal Area, some offices are within 75 feet of the area. Near the railroad tracks, about one-half to one mile north and northeast of the Factory Area, the houses are larger, older ones. The area is now attracting more professional people, and some larger homes have been built in and around the city. The area behind the Bowling Green Sports Center, south of the Kerr-McGee Facility, is no longer a golf course, but is now occupied by office buildings. One of these buildings, Number 6, may have been built over a pond which Butler (1965) found was contaminated.

On June 20, 1994, the Kerr-McGee Facility was being prepared for removal activities. Construction was occurring in the southwestern and southeastern parts of the Kerr-McGee Disposal Area. The southern two disposal ponds had been filled, and in the southwestern part of the Disposal Area, a sewer line was about to be replaced. There were two large mounds of dirt covered with plastic, one against the southern side of the Disposal Area tailings pile and the other in the Intermediate Area. Construction activities were also occurring in the Intermediate Area, where a sewer line was about to be replaced and a staging area was being prepared for removal activities.

REED-KEPPLER PARK

At Reed-Keppler Park, the spoil area containing most of the contaminated material is surrounded by a chain-link fence topped by barbed wire. It is intact and has numerous radioactive material warning signs. The spoil area is thickly vegetated, mostly with trees 30 to 45 feet high. One large tree on the perimeter is about 60 feet high, and there is some brush and a few small grassy areas. Across the road east of the spoil area are tennis courts, and there are homes and a public swimming pool about 100 yards from the fence. A football field is about 100 yards north of the fenced area, and baseball diamonds are 100 or more yards north and northwest of it. About 200 yards west of the spoil area is a West Chicago Park District maintenance building. In June 1990, a house was being constructed about 1000 feet northwest of the fenced area.

WEST CHICAGO REGIONAL WASTEWATER TREATMENT PLANT

While the WTP is accessible, few, if any, people would be attracted by it. Immediately north of the WTP is the West DuPage Woods Forest Preserve, and one of its hiking trails is adjacent to the northern fence of the plant. This side of the WTP is bordered by a chain-linked fence topped by barbed wire. The remainder of the WTP is surrounded by a fence, but much of it lacks barbed wire and parts of it are in a state of disrepair.

KRESS CREEK

Kress Creek flows through the Joy Street Subdivision after it passes the Kerr-McGee storm outfall and becomes contaminated with radioactive materials. In this subdivision, the stream is slow, and its banks are gradual. The stream has some marshy areas with cattails, but is readily accessible and bordered by back yards. The banks along these back yards have obviously been regraded. The homes are mostly small, with a few medium-sized, middle-income ones. The lots, however, are larger than those near the Kerr-McGee Facility, and the density of homes is lower.

WEST BRANCH OF THE DUPAGE RIVER

East of the WTP, the banks of the West Branch of the DuPage River are thickly vegetated along the western side, and the river itself is about 30 to 40 feet wide, with a few spots up to 70 feet across. During dry periods (usually July into fall), the river can become quite shallow, with some riffles being only a few inches deep. On the northern side of Roosevelt Road, immediately downstream from the contaminated river bank, several homes have yards bordered by the eastern bank of the river. There is an apartment complex about 2000 feet downstream from the contaminated bank by the WTP. Part of the complex is adjacent to the West Branch of the DuPage River, with part of the river bank readily accessible. The

apartments by the river are mostly inhabited by Hispanics (at least 80 percent), with other ethnic minorities (Asian and black), as well as Caucasians represented. Most of the occupants are families with small children, and both adults and children have occasionally been seen fishing in the river near these apartments. Children, probably from the apartment complex, have also been seen playing in the river by Gary's Mill Road, where the water can be very shallow during periods of low flow.

The apartment complex, some houses, a tree nursery, and a church are along the river upstream of Gary's Mill Road and the confluence with Kress Creek. Downstream of Gary's Mill Road, the West Branch of the DuPage River flows through the Blackwell Forest Preserve and along some additional residential properties both upstream and downstream of the confluence. One park trail goes within 30 feet of the river, and part of this trail is downstream of its confluence with Kress Creek. In spring 1990, a 3.5 inch rainfall on already saturated ground caused the river to flood a 100 foot long section of this trail, which was upstream of the confluence. Downstream from the confluence, the trail is higher in elevation, farther from the river (at least 200 feet), and less likely to be flooded. There are a few side trails that go to the river upstream of its confluence with Kress Creek, but not downstream of that point. Below the confluence, the West Branch of the DuPage River is no longer posted as closed to the public. Downstream of the confluence, on the southern side of Mack Road, there is a public canoe access ramp on the eastern side of the river. In mid- to late-summer, the river generally becomes too shallow for canoeing.

C. DEMOGRAPHICS, LAND USE, AND NATURAL RESOURCE USE

KERR-MCGEE FACILITY

The Kerr-McGee Facility is surrounded by residences on three sides and offices on the southern one. The locations and types of houses and other buildings were described in the Site Visit section of this report. There are six schools (including one preschool and day care center) within 0.5 mile of the Kerr-McGee Facility. In the past, children have been seen on the Kerr-McGee Facility, and in 1976, the IEPA reported that some of them often went through holes in the fence to cross the area on their way to school (Child, 1976). With the currently high citizen concern about the area, this is hopefully no longer occurring.

The geology of the Kerr-McGee Facility consists of glacial deposits 71 to 90 feet thick, with three sand and gravel strata separated by clay layers, overlying Silurian dolomite bedrock (NRC, 1989a). Groundwater and contaminants flow most easily through sand and gravel, and their movement is slowed by clay. Enough deep borings have not yet been made to establish the continuity and extent of clay layers under and, especially, around the Kerr-McGee Facility. The upper clay layer is apparently thin to absent in the Intermediate Area. No deep borings have been made in the Factory Area, so the continuity of the deep clay under it is unknown. Also, in one deep boring, this layer was only a few feet thick,

indicating it can be thin and suggesting it may not be continuous under and around the entire area. The deep clay also often has sand and gravel layers, which would promote the lateral movement of groundwater and associated contaminants. From well logs, the deep clay is absent in some areas around the Kerr-McGee Facility, including (1) about 2400 feet south of the Kerr-McGee Facility (NRC, 1989a), (2) about one mile east of the Kerr-McGee Facility, (3) just east of the Kerr-McGee Facility (southwestern corner of Section 10), (4) near the junction of Roosevelt Road and Route 59, (5) one well on Pearl Road, and (6) about one mile northwest of the Kerr-McGee Facility (ISGS well logs, 1990). In all of these cases, the deep clay is present at other nearby wells, sometimes up to 80 feet thick. Consequently, the extent and thickness of the deep clay are extremely variable. The upper 15 to 30 feet of the dolomite bedrock has many irregularly distributed fissures, joints, and solution cavities, which form the shallow dolomite aquifer. This aquifer supplies about 68% of the groundwater used in DuPage County, while around 30% of it comes from deeper rock formations, and only 2% of it is taken from the glacial till. From well logs (ISGS well logs, 1990), most private wells in the area draw from the shallow dolomite aquifer.

When the factory was operating, it discharged 200,000 to 250,000 gallons of wastewater per day into the disposal ponds, which likely caused considerable groundwater mounding, probably altering the direction(s) of groundwater flow. Through a limited number of measurements, Butler (1965) found the flow of groundwater in the shallow dolomite aquifer north of Disposal Pond 2 was radially away from the pond. This, coupled with the fact that Butler (1965) also found chloride, sulfate, and hardness were about equally elevated in all directions from Disposal Pond 2, suggest the direction of groundwater flow may have been more or less radially away from the Disposal Pond 2. However, because few groundwater measurements were taken, the geology was not well-understood by Butler (1965), and the glacial till is variable, this is far from certain. The groundwater flow during plant operations is mostly unknown.

When the plant was operating, the high temperature of the disposal pond(s) would have increased the solubility of most dissolved substances and promoted their movement into groundwater. In addition, the low pH of the ponds would have enhanced the solubility of heavy metals and increased their movement into groundwater.

From measurements made in 1986 by Kerr-McGee, groundwater in the upper sand and gravel stratum flows to the south-southwest, and the water table is 6 to 18 feet beneath the surface. In the middle sand and gravel layer, groundwater flow is to the southeast. Hydraulic gradients suggest groundwater in the upper and middle sand and gravel strata tends to move downward (NRC, 1989a). Where clay layers do not inhibit this downward flow (e.g., the Intermediate Area for the upper clay layer), this movement would tend to carry contaminants downward. In one area, the deep clay was thin, and its continuity under and around the Kerr-McGee Facility is uncertain (especially in the Factory Area, where no deep borings have been made). Improperly constructed wells and improperly sealed abandoned wells can act as conduits for shallow groundwater contaminants to reach deeper layers, but it is unknown whether they exist in the vicinity. The bottom sand and gravel stratum is

hydraulically connected to the shallow dolomite aquifer. Consequently, contaminants may move downward into the shallow dolomite aquifer. In both of these aquifers, groundwater flow is shown in Figure 14.

The overall flow of groundwater beyond the boundary of the Kerr-McGee Facility is unknown. However, if water in the shallow dolomite aquifer continues to move in the same general direction, the private wells along Pearl Road are generally downgradient. At one location in this area, the deep clay is absent, so contamination of the shallow dolomite aquifer is possible. The geology and hydrogeology of the other five areas have yet to be investigated, aside from shallow borings and monitoring wells at Reed-Keppler Park and the WTP, which were not used for hydrogeological evaluation.

REED-KEPPLER PARK

At Reed-Keppler Park, the nearest homes are about 300 feet east and southeast of the fenced waste spoil area, and the density of houses is high at 10 or more dwellings per block. The area immediately north, south, and west of the spoil area is largely undeveloped. To the south, the nearest residence is about 1000 feet from the park boundary, and houses are infrequent up to about 0.6 miles. There is a railroad track approximately 1000 feet west of the park, and the closest residences in this direction are about 0.5 miles away. The area north of the spoil area has some farms, and some farm houses are about 0.25 miles north and northeast of the park (Booth et al., 1982).

WEST CHICAGO REGIONAL WASTEWATER TREATMENT PLANT

The WTP has a residential area to the west, a forest preserve to the north, an apartment complex to the south (across Roosevelt Road), and scattered residences to the south and east. The nearest house is about 300 feet east of the West Chicago Wastewater Treatment Plant, and less than 20 dwellings are within 1000 feet east of it (USEPA, 1986).

RESIDENTIAL AREAS

Homes within the City of West Chicago are served by a municipal water supply; however, some residents may still use wells for purposes such as washing cars and laundry, and this needs to be investigated. West of the Kerr-McGee Facility, houses on Pearl Road are in an unincorporated area served by private wells. The unincorporated Joy Street Subdivision south of Roosevelt Road is also served by private wells. Kress Creek flows through this subdivision of single family homes after it passes the Kerr-McGee storm water outfall and becomes contaminated with radioactive materials. An unincorporated residential area east of Route 59 and north of the West DuPage Woods Forest Preserve is served by private wells.

The presence and use of any other wells in the vicinity are unknown, but unincorporated residences are normally served by them.

The City of West Chicago obtains water from 6 municipal wells (Figure 5). Wells 3, 4, and 5 are deep wells cased to 380 to 672 feet, so they do not draw water from the shallow dolomite aquifer. Wells 6, 7, and 8, however, are cased to the top of the dolomite bedrock (IEPA Well and Public Water Supply files, 1990), so some of their water is drawn from the shallow dolomite aquifer. Wells 6, 7, and 8 are all over one mile from the Kerr-McGee Facility.

KRESS CREEK

The Kerr-McGee storm outfall empties into the stream just east of the EJ&E Railroad tracks, and the creek begins to flow to the southwest (Figure 6). For about the next 330 feet, the stream flows through undeveloped property covered mostly with trees and brush. Kress Creek then flows through the Joy Street Subdivision, where it broadens to form Gunness Lake in the back yards of single family homes. South of Joy Street, the stream mainly flows through an open field (Manfred Oaks Forest Preserve, City of West Chicago) until reaching Wilson Road. In the next 660 feet, the stream banks are covered by dense brush and trees. It then mainly flows through open fields until it reaches Route 59, but some areas of brush and trees exist on the western bank. Between Route 59 and the West Branch of the DuPage River, the eastern bank of Kress Creek is bordered by the Blackwell Forest Preserve, while the western bank is bordered by the back yards of several homes. The confluence with the West Branch of the DuPage River is about 1.4 miles downstream from the Kerr-McGee storm outfall. The width of Kress Creek varies from about 10 to 49 feet (widest at Gunness Lake). Its average depth is one foot, and it is rarely greater than two feet. Flooding of the stream is common and has been observed up to about 100 feet from the western bank of the stream (Frame, 1984).

WEST BRANCH OF THE DUPAGE RIVER

The West Branch of the DuPage River is used for canoeing and fishing, and it is about 30 to 40 feet wide and two to three feet deep (USEPA, 1986). However, the water becomes shallow in some areas during periods of low flow. After passing the apartment complex, tree nursery, and church described in the Site Visit section of this report, the West Branch of the DuPage River passes through the 1235 acre Blackwell Forest Preserve, which received an estimated 105,000 visits in 1989 (DuPage County Forest Preserve District, 1990) and 250,000 visits in 1991 (USEPA, 1992). Kress Creek joins the West Branch of the DuPage River at the edge of this park. There are homes with lots adjacent to Kress Creek above the confluence, and they are also along the West Branch of the DuPage River above and below the confluence. Downstream of the Blackwell Forest Preserve and about 1 mile below the confluence, the river flows through the Village of Warrenville.

D. COMMUNITY HEALTH CONCERNS

This is a highly emotionally and politically charged site in the Chicago area. The citizens of West Chicago are opposed to any Kerr-McGee Facility disposal plan and want all of the radioactive wastes removed from their community. A local nonprofit citizen group, the Thorium Action Group (TAG), has been very active at distributing information to the public, lecturing in local schools, lobbying politicians, organizing protests ranging in size from 75 to 500 people, researching the problem, and trying to get county-wide support. Many of the local, state, and federal politicians representing or hoping to represent the people of the area have stated their opposition to the Kerr-McGee Facility disposal plan.

The main health concern of the people of West Chicago is that the radioactive wastes will increase their risk of cancer, and they are also concerned the proposed Kerr-McGee Facility disposal cell will not alleviate this risk. Many people also incorrectly believe that radium in the deep groundwater used by the municipal water supply of West Chicago came from Kerr-McGee, while it is actually naturally-occurring. The IDPH and USEPA have received numerous calls from prospective home buyers who want to know if it would be safe to live in a house in West Chicago. People near the Kerr-McGee Facility have reportedly had difficulty selling their houses, and are concerned the value of their properties will diminish if the proposed Kerr-McGee Facility disposal cell is built. Concerns about property values are not within the scope of this report, which addresses health effects.

ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

The tables in this section list the contaminants of concern. These contaminants will be further evaluated in the remaining sections of this health assessment to determine if they pose a threat to public health. **The listing of a contaminant or radiation on the following tables does not necessarily mean it poses a threat to public health.** The selection of these contaminants is based on the following factors:

1. Concentrations of contaminants in each of the six areas of concern (Kerr-McGee Facility, Reed-Keppler Park, WTP, Residential Areas, Kress Creek, and West Branch of the DuPage River).

2. Data quality, both in the field and in the laboratory, and the sampling plan design.

3. Comparison of contaminant concentrations and background concentrations with health assessment comparison values for both carcinogenic and noncarcinogenic endpoints (discussed further below).

4. Community health concerns.

Comparison values for a health assessment are levels used to select contaminants for further evaluation. These values, prioritized below, include Environmental Media Evaluation Guides (EMEG's), Cancer Risk Evaluation Guides (CREG's), Reference Dose Media Evaluation Guides (RMEG's), Lifetime Health Advisories (LTHA's), and Maximum Contaminant Levels (MCL's). If a site-related contaminant is found at levels above any of these comparison values or if no comparison value exists for the chemical in that medium (air, water, soil), it will be investigated further in the remaining sections of the health assessment to determine if it poses a significant threat to public health. Known or suspected human carcinogens with no carcinogenic comparison value will also be listed as a contaminant of concern and will be evaluated in the remaining sections of this health assessment.

EMEG's are comparison values developed for chemicals that are relatively toxic, frequently encountered at NPL sites, and present a potential for human exposure. They are derived to protect the most sensitive members of the population (e.g., children) and are not cut-off levels, but rather comparison values. They do not consider carcinogenic effects, chemical interactions, multiple route exposure, or other media-specific routes of exposure, and are very conservative concentration values designed to protect the public.

CREG's are estimated contaminant concentrations based on one excess cancer in a million persons exposed to a chemical over a lifetime (70 years). These are also very conservative values designed to protect sensitive members of the population.

RMEG's are estimates of a daily oral or inhalation exposure to a particular chemical that is unlikely to produce any noncarcinogenic adverse health effects over a lifetime. They are conservative values designed to protect sensitive members of the population.

LTHA's are estimated water concentrations an individual can drink for 70 years without experiencing noncarcinogenic health effects. These numbers contain a margin of safety to protect sensitive members of the population. These values are considered only if no EMEG, CREG, or RfD are available for the chemical.

MCL's have been established by the USEPA for public water supplies to reduce the chances of adverse health effects from contaminated drinking water. These standards are well below levels associated with health effects and take into account the financial feasibility of achieving specific contaminant levels. These are enforceable limits that public water supplies must meet. These values are considered only if no EMEG, CREG, RfD, or LTHA are available for the chemical.

Radiation

Radioactive elements are unstable and decay into other isotopes or elements by emitting radiation. The radioactive half-life is the time needed for half of a radioactive substance to decay. Another type of half-life is the biological half-life, which is the time needed for half

of a compound to be eliminated from a cell, tissue, organ, or entire body. Radionuclides with shorter radioactive half-lives have more disintegrations per unit of time and thus emit more radiation per unit mass than those with longer half-lives. The radionuclides in the Kerr-McGee wastes do not occur independently, but are produced by three decay series (Figure 7). While the three decay series ultimately decay into stable forms of lead, the amount of lead produced is far too small to contribute measurably to lead contamination. Lead in the wastes evidently came from another source(s).

The forms of radiation emitted by the Kerr-McGee wastes include alpha particles, beta particles, and gamma radiation.

1. An alpha particle is the same as a helium nucleus, and it consists of two protons and two neutrons.

2. A beta particle is an electron emitted from the nucleus of some atoms.

3. Gamma radiation is similar to x-rays, but is emitted from the nucleus of some atoms. It has a higher frequency and usually has greater energy. Nearly all of the radionuclides in the thorium and uranium decay chains produce gamma radiation.

A. KERR-MCGEE FACILITY

The Kerr-McGee Facility contains most of the radioactive and nonradioactive contaminants. For study purposes only, this area was subdivided into three areas, the Factory Area, Intermediate Area, and Kerr-McGee Disposal Area (Figure 2).

SOIL: The estimated volume of radionuclide contaminated soil in the Kerr-McGee Facility is 172,300 cubic meters, with the Factory Area having the largest amount (NRC, 1989a). While thorium is the most abundant radionuclide, large amounts of radium and uranium are also present (Tables 2 and 3). In general, the concentrations of radionuclides (Table 4) are highest near the surface and decrease with depth. Because parts of the waste have radium-226 levels up to 31,500 picoCuries per gram and radium-228 concentrations up to 6,400 picoCuries per gram, radionuclide levels in some areas are undoubtedly higher than those found in the soil cores (Table 4). Extreme variability is present in the waste, as apparent in the discrepancies between NRC (1989a) and USEPA (1986) data and differences between individual soil cores (Tables 4 and 5).

The concentrations of inorganic chemicals are available for only the Kerr-McGee Disposal Area (Table 3); their levels in the Factory and Intermediate Areas are unknown. Of particular interest is the high levels of lead found in the ore tailings and sludge pile. The

lead is believed to have come from fluorspar rather than from the thorium-containing monazite ore (USEPA, 1986). Fluorspar is the primary source of hydrogen fluoride (Hawley, 1981), which, when added to water, becomes hydrofluoric acid, one of the primary chemicals in the extraction of thorium from ores. Consequently, it is not surprising that sampling suggests high levels of lead and thorium may not be well-correlated (Table 5). Elements present in the tailings, but in unknown amounts, include cerium, dysprosium, europium, lanthanum, neodymium, praseodymium, samarium, titanium, ytterbium, and zirconium.

Minimal testing for organic priority pollutants has occurred (15 soil borings). They were above comparison values at depths of up to 17 feet (Table 6), but deeper samples were not taken, so the depth of this contamination is unknown.

Records indicate some of the liquid and solid wastes discarded in the Kerr-McGee Disposal Area between 1954 and 1973 (Table 7). These compounds included large amounts of rare earth oxides, ammonium salts, and a 20 percent solution of 2-ethylhexyl phosphate in kerosine. Kerosine contains benzene, ethyl benzene, toluene, xylenes, and other petroleum hydrocarbons. Benzene, ethyl benzene, toluene, and xylenes were not found by Kerr-McGee in 15 soil borings (Kerr-McGee, 1994); however, given the size of the Kerr-McGee Facility (about 40 acres), this sampling may have missed the disposal location.

In 1982, polychlorinated biphenyl (PCB) contaminated soil was found in part of the Kerr-McGee Facility where capacitors, circuit breakers, switches, and transformers had been stored. This contaminated soil was placed in drums. Twelve of these drums were sent to the Ensco, Inc. site in Eldorado, Arkansas and 177 of them were shipped to the US Ecology site in Beatty, Nevada (Denny, 1984). In January 1983, a large transformer was found, and it and the associated soil were contaminated with PCBs and thorium. The soil, which was placed in twenty-three 55 gallon drums and eight 85 gallon drums, contained 50 to 11,500 parts per million (ppm) of PCBs and 1.4 to 256 picoCuries per gram of thorium. No PCB disposal site would accept the drums because of the radioactive contamination (Denny, 1984; Shelly, 1983). In May 1989, the NRC reported that drums containing PCB-contaminated soil were shipped out, and their levels of radioactivity were below the release levels of 1,000 disintegrations per minute per 100 square centimeters for alpha smear and 0.1 microroentgens per hour of gamma at 1 centimeter (NRC Inspection Reports, 1989). However, the report did not state whether the drums were the ones containing radioactive material that no one would accept or where they were taken. According to Kerr-McGee (1994), the drums containing PCB-contaminated soil were ultimately sent to a disposal facility. In the U.S., PCBs were used from 1927 to 1977 (ATSDR, 1991g). Consequently, PCBs may have been used and disposed at the Kerr-McGee Facility from its beginning in 1932, and additional PCB-contaminated soil may still be present.

In 1984, Kerr-McGee obtained a composite sample of tailings from 24 places in the Kerr-McGee Facility and analyzed them for organic compounds. The tailings contained 0.6 percent total organic carbon, of which 0.05 percent by weight was an orange liquid. No

compounds in this liquid were positively identified, but it contained (1) 67 percent petroleum-based, semi-solid, highly aliphatic hydrocarbons, very similar to common lubricating oils; (2) 22 percent complex ester of phthalyl and alkyl structure similar to long-chain phthalic alkyls; (3) nine percent oxidized phthalyl/alkyl esters; and (4) two percent mixture of aliphatic hydrocarbons and esters. Kerr-McGee concluded that 98 percent of the extractable organic matter was lubricating oil and additives (Watson, 1984).

Vreeland (1975a) examined the leachability of the tailings. In general, even acidic water dissolved little of the radionuclides from the wastes. However, high radionuclide levels were leached from one sample of process intermediates which had been kept in a warehouse and had not been exposed to the weather. This suggests that some of the wastes may have more leachable material which could enter groundwater, and/or initially, all of the materials may have had more mobile compounds. USEPA (1986) found that little radioactivity was leached from the wastes.

GAMMA RADIATION: Inside the Kerr-McGee facility, gamma radiation levels are up to 100 milliroentgens per hour (100,000 microroentgens per hour) over areas several hundreds of square meters in extent (Argonne National Laboratory, 1978). On May 25, 1990, the IDNS measured gamma exposure rates at 50 foot intervals along the fenceline of the Kerr-McGee Facility using a Bicron (tissue equivalent) microroentgen meter. The exposure rate ranged from background (eight to 10 microroentgens per hour) to over 400 microroentgens per hour (Runyon, 1989).

AIR: Air monitoring has been performed by American Potash and Chemical Corporation, Kerr-McGee, the AEC, and the NRC from at least 1961 to the present at various locations inside factory buildings, in the Kerr-McGee Facility, and around the Kerr-McGee Facility (Inspection Reports: AEC, 1957-70 and NRC, 1976-89). In 1961, an AEC Inspection Report stated that the concentration of airborne radioactivity in plant buildings was non-detectable to 0.46 picoCuries per liter, but the isotope(s) was not reported.

In 1982, Argonne National Laboratory (Mausner, 1982) re-examined 1962-4 data from the analyses of particulate filters and found that because of mistaken assumptions, American Potash and Chemical Company personnel had greatly underestimated the levels of several radioisotopes. It had been assumed that radon-220 was in equilibrium with and equal in concentration to lead-212. However, such an equilibrium would occur only in a room with less than one air exchange per day, and not in a ventilated factory. Furthermore, because of its short half-life of 55 seconds, very sharp radon-220 gradients can occur near discrete sources, like piles of ore. A worker near such a source may be exposed to a level at least ten times that in the general room air. Using more realistic air exchange data, Mausner (1982) determined that the concentrations of thorium-232, bismuth-212, and radon-220 (Table 8) were about 75 percent, 15 percent, and 20 times higher, respectively, than those estimated by plant personnel, while the lead-212 levels were valid. Unfortunately, the American Potash and Chemical Corporation stopped measuring bismuth-212, lead-212, and radon-220 after 1964 (Mausner, 1982).

The AEC 1965 and 1966-67 inspection reports state that 0.0027 to 2.1 picoCuries per liter and 0.00009 to 0.0022 picoCuries per liter of thorium, respectively, were present in plant buildings. If the thorium levels were actually about 75 percent higher, as Mausner (1982) found for the 1962-4 data, then the highest thorium concentrations measured in 1965-7 would have been around 3.7 picoCuries per liter. In 1970, AEC Inspection Reports (1970) stated that up to 0.93 picoCuries per liter were present in plant buildings and up to 0.0125 picoCuries per liter were present along the fence boundary, but the radionuclide(s) was not identified.

A 1981 USEPA air monitoring program (Jensen et al., 1982) measured the concentrations of radon daughters, as well as lead-212, radium, thorium, and uranium (Figure 8). The results of using high volume and dichotomous samplers were reported. The high volume samplers collected all particulates, while the dichotomous samplers divided airborne dust into particles under 2.5 microns and over 2.5 microns in size. The amount of air displaced and the flow rates through the filters are unknown.

The high volume samplers were used to determine whether radon daughters were elevated downwind of the Kerr-McGee Facility (Table 9). While there was much variability in the data, radon daughters were generally elevated downwind of the area. While the highest level reported was for the background data, this was caused by one statistical outlier which occurred on a calm day. The radon concentrations in the air near the Kerr-McGee Facility were generally higher than those at Station 4 by Kress Creek.

Both the high volume and dichotomous samplers collected lead-212 data at each location (Table 10). While variability was high, the arithmetic and geometric mean radioactivity levels were generally higher for particles under 2.5 microns in diameter than for those over 2.5 microns in size. The mapping of the pollution roses for stations 1, 2, and 3 (Figure 8) showed that radioactive airborne particulates were higher when the wind was blowing from the Kerr-McGee Facility, identifying it as the probable source. The concentrations of specific radionuclides (Table 11), as determined using composite samples from high-volume particulate filters, were interpreted by Jensen et al. (1982) as being below regional background levels (data unavailable). Fenceline concentrations of radon-220 daughters, however, were up to 10 times over background levels.

Efforts to reduce airborne emissions, as measured by lead-212, through a water suppression system were unsuccessful, with up to 0.63 picoCuries per liter of lead-212 present outside of the fence (NRC Inspection Reports, 1983). In October 1983, in response to an NRC citation for excessive radon-220 daughter emissions (Jensen, 1993b), an asphalt cover was placed on the waste piles. In 1984, the NRC reported that lead-212 had been reduced to 0.20 to 0.50 picoCuries per liter outside of the fence. During this period, Building 9 in the Factory Area was demolished, and 0.049 picoCuries per liter of lead-212 and 7.7 picoCuries per liter of thorium were detected downwind and outside of the fence (NRC Inspection Reports, 1983-4). In May 1989, a NRC Inspection Report stated that the levels of radioactivity at the fence

were 0.77 to 0.84 times the maximum permitted concentration, but the isotope(s) was not defined.

With the exception of estimates of hydrogen fluoride levels, the presence of any nonradioactive air contaminants at the Kerr-McGee Facility has not yet been investigated. Resources Research, Incorporated (1967a,b) investigated vegetation damage around the Factory Area after the 1966 accidental release of about 116 pounds of hydrogen fluoride over a four hour period from two 240 foot stacks. This emission rate of 14.5 pounds per hour was about 300 times the emission rate that Resources Research, Incorporated measured under normal operating conditions. Using an unspecified air model, they estimated that under normal operating conditions, the theoretical maximum concentrations of hydrogen fluoride would be 5.5 parts per billion (ppb) for a wind speed of six miles per hour, 8.0 ppb for a four mile per hour wind, and 16.5 ppb for a two mile per hour wind. The maximum level would occur 95 to 220 yards from the stack, depending on the wind speed and lapse rate. For the accidental release, the maximum concentration would be about the same distance from the stacks, and they estimated the highest level would have been 1,650 ppb for a six mile per hour wind, 2,450 ppb for a four mile per hour wind, and 5,100 ppb for a two mile per hour wind. Unfortunately, the actual ambient hydrogen fluoride concentrations were never measured. It is extremely reactive and does not persist long in the environment.

SURFACE WATER: In 1964, when the plant was still operating, Butler (1965) sampled water from Pond 2 at the Kerr-McGee Disposal Area and the pond on the golf course of the Bowling Green Sports Center and analyzed them for dissolved and suspended alpha and beta radioactivity, as well as inorganic chemicals (Table 12). While Pond 2 had high dissolved alpha and beta levels, most of the radioactivity was present as suspended particles. Surface water from Pond 2 had high levels of some inorganic parameters (Table 12). Pond 1, abandoned and sediment-filled, and Ponds 3, 4, and 5, not yet constructed (Kerr-McGee, 1975), were not sampled by Butler (1965). Water from the pond on the golf course of the Bowling Green Sports Center and its outlet also had elevated inorganic parameters and alpha and beta concentrations, but the levels of radioactivity were much less than those of Disposal Pond 2.

Analyses for Pond 2 (1974-76) and for Ponds 3, 4, and 5 (1974-75), indicate all four ponds had elevated levels of several inorganic chemicals (Table 12). In Pond 2, from 1964 to 1974-6, fluoride, nitrate, sodium, and sulfate concentrations decreased, while ammonium and chloride levels did not change.

GROUNDWATER: Monitoring wells in three aquifers: shallow "B" wells (10 to 25 feet deep; upper sand and gravel) in the Kerr-McGee Disposal Area, shallow "F" wells (24 to 36 feet deep; upper sand and gravel) in the Factory Area, intermediate "B-14 to B-16" wells (intermediate sand and gravel) in the Kerr-McGee Disposal Area, and deeper "KM" wells (81 to 100 feet deep; lower sand and gravel and shallow dolomite aquifer) in the Kerr-McGee Disposal and Intermediate Areas (Figure 2) have been used to investigate inorganic and radioactive parameters in groundwater under the Kerr-McGee Facility. Data are

available for 1981-4 and 1990-2 for the Kerr-McGee Disposal Area, 1982-5 and 1990-2 for the Factory Area (NRC, 1989a; Kerr-McGee, 1994; Table 13 and Appendix A), and the USEPA sampled some of these wells in November 1985 (USEPA, 1986; Table 13). Upgradient "N" wells (shallow sand and gravel; Figure 2) have been used by the NRC for background level comparisons; however, they were impacted by past disposal activities at the Kerr-McGee Facility. Water of the shallow "B" wells of the Kerr-McGee Disposal Area and the intermediate "F" wells of the Factory Area had elevated levels of several inorganic chemicals and radionuclides (Tables 13 and Appendix A). In general, the limited data of USEPA were within the ranges found in the more extensive monitoring by Kerr-McGee. Water from the deeper "KM" wells in the shallow dolomite aquifer of the Kerr-McGee Disposal Area generally had lower concentrations of contaminants (Tables 13 and Appendix A). Water from many of these wells had higher chlorine, sulfate, and total dissolved solid levels than that of water from the upgradient "N" wells.

As will be discussed in subsection D (residential areas) under groundwater, from 1964 to 1976 around the Kerr-McGee Facility, the concentrations of several chemicals in the shallow dolomite aquifer declined. In general, however, levels of substances in the "B", "KM", and "F" wells did not decline from 1981-2 to 1984-5 (Appendix A). While Kerr-McGee performed statistical analyses which they claimed showed a decline (Kerr-McGee, 1985), they ignored the high variability and resulting poor correlation of the data. Consequently, near the Kerr-McGee Facility, the groundwater system may have reached steady state.

VEGETATION: In 1976, Argonne National Laboratory (1978) sampled vegetation outside of the Kerr-McGee Facility, 100 meters (330 feet) northeast, southeast, northwest, and southwest of the fence. One to 6.0 picoCuries per gram of thorium-232, 0.5 to 0.9 picoCuries per gram of thorium-230, and 0.4 to 1 picoCuries per gram of radium-226 were found in the plants. However, background samples were not taken and it is unknown whether the analyses were on a wet or dry weight basis. Consequently, the data cannot be compared to background values in the literature, and it is unknown whether radionuclide levels in vegetation are elevated.

In 1967, after a previously described (Air subsection) accidental release of hydrogen fluoride, Resources Research, Incorporated (1967a,b) found 51 to 3,750 ppm of fluoride in vegetation around the Factory Area, with an average of 490 ppm. Even if fertilizer were used, only 10 to 20 ppm of fluoride would be expected in plants from root uptake alone. Resources Research, Incorporated (1967a,b) concluded the high fluoride levels found in plants around the factory were probably from the absorption of airborne fluorides. The concentrations of other possible contaminants in vegetation around the Kerr-McGee Facility have not been examined. Because of the low water solubility and resulting low root uptake of thorium and lead, high levels of these elements in vegetation are not expected (Charp, 1994).

PHYSICAL HAZARDS: The Kerr-McGee Facility, especially the Factory Area, has piles of rusty metal, and Kerr-McGee Disposal Area has the disposal ponds, which are all physical hazards. Fire dangers at the Kerr-McGee Facility have not yet been evaluated; however,

thorium nitrate is a powerful oxidizing agent, and its contact with combustibles can cause ignition and violent combustion (Steadman, 1976). According to Kerr-McGee (1994), thorium nitrate is only a fire hazard in a solid state, and not when diluted by soil as in the wastes.

B. REED-KEPPLER PARK

SOIL: Reed-Keppler Park contains about 11,500 cubic meters of contaminated soil (NRC, 1989a). Most of the tailings are in a fenced spoil area about 1.5 acres in size. In 1976, much of the thorium residues beside the tennis courts were transferred to the spoil area, but tailings still remain under the courts.

In Reed-Keppler Park, the concentrations of radionuclides in the waste tailings (Tables 2, 5, and 14) are extremely variable. Cores in the fenced area show no anomalous activity below a depth of 16 feet, and most of the radioactive materials are less than 10 feet deep (Booth et al., 1982). Outside of the fenced area, almost exclusively between the fence and the adjacent roadway, there are small areas with five to 50 picoCuries per gram at two to six inches in depth (Figure 9; Booth et al., 1982). Although earlier sampling (Frigerio et al., 1978) found five to 50 picoCuries per gram of thorium-232 and two to 10 picoCuries per gram of radium-226 in the soil of a gully west of the fenced area, Booth et al. (1982) found surface contamination by radioactive materials only inside the fenced spoil area, where they covered a total area of about 25,000 square feet. Booth et al. (1982) concluded that radioactive materials outside of the fenced area are buried by at least six inches of uncontaminated material, and those next to the tennis courts are about two feet beneath the surface. Tailings beside, but not under the tennis courts have been removed (USEPA, 1986).

In 1986, soil samples were taken from the spoil area of Reed-Keppler Park, split, and analyzed for inorganic chemicals by USEPA and Kerr-McGee (Table 14). The results generally agree, with differences attributed to variability within the soil samples (USEPA, 1986). Many chemicals exceeded their comparison values. Like tailings at the Kerr-McGee Facility, high lead concentrations were found in the wastes at Reed-Keppler Park. Variability was also found between soil cores (Table 5). The levels of organic compounds in the soil are unknown.

In surface soil at the proposed new pool location, a USEPA contractor found the maximum and average thorium concentrations were 37 and 10 picoCuries per gram, respectively, and the highest level in subsurface soil (two feet deep) was 57 picoCuries per gram (Kerr-McGee, 1994).

GAMMA RADIATION: Booth et al. (1982) found that gamma radiation one meter above the ground ranged from a background of 13 microroentgens per hour to a high inside the fenced spoil area of 1,600 microroentgens per hour (Figure 10). Gamma radiation along the outside of the western edge of the fence measured over 20 microroentgens per hour, but less than 100 microroentgens per hour, for a distance up to 20 feet from the fence itself. No

radioactive materials underlie this area and the radiation is apparently caused by direct gamma shine from tailings in the fenced area. The rate near the tennis courts is 70 microroentgens per hour. The area outside the fence with gamma radiation exceeding background is about 5,000 square feet (Booth et al., 1982). USEPA (1986) estimated that if Reed-Keppler Park was not remediated and in the future, someone built a house on the spoil area, people inside it would be exposed to 1,300 microroentgens per hour of gamma radiation.

AIR: Frigerio et al. (1978) found long-lived radionuclide activity upwind and downwind of the fenced area was not above background levels. However, radon was consistently elevated downwind of the wastes. Radon-222 and radon-220 reached up to 30 picoCuries per liter and 4 picoCuries per liter, respectively. The concentrations decreased rapidly with distance downwind from the fenceline, and no elevated levels were detected at the nearest residences. Other measurement have found radon-220 concentrations are generally higher than those of radon-222, and alpha and beta activity are consistently at background levels (Table 15); consequently, airborne long-lived radionuclides were not elevated (Booth et al., 1982). USEPA (1986) estimated that if Reed-Keppler Park were not remediated and in the future, someone built a house on the spoil area, its inside air would have about 0.3 working levels of radon-220, which is very high (over 0.06 working levels). The presence of any nonradioactive airborne contaminants at Reed-Keppler Park is unknown.

SURFACE WATER: Surface water from the fenced area drains west into a gully, which flows into a slough and then into a lake northwest of Reed-Keppler Park. Shallow groundwater may also discharge into this lake. The levels of dissolved radionuclides in the gully water were variable, ranging from 0.5 to 15 picoCuries per liter of radium-226+228 and 0.2 to 1.5 picoCuries per liter of thorium 228+232 (Frigerio et al., 1978). The lake water did not have radioactivity above background concentrations (Booth et al., 1982; Frigerio et al., 1978). The levels of nonradioactive compounds in surface water are unknown.

GROUNDWATER: Groundwater from 10 bore holes was analyzed for gross alpha and beta activity (Table 16; Figure 11), and levels were slightly higher in bore holes of the spoil area than in those outside of it. The depths of the bore holes were not given, but those in cross sections of Booth et al. (1982) are less than 20 feet deep. The direction of groundwater flow at Reed-Keppler Park is unknown, so it is not known which wells outside of the fence are upgradient and downgradient of the waste. Bore hole three was also analyzed for radium-226 and thorium-232 (Table 16). The levels of nonradioactive chemicals in groundwater of the glacial aquifer and the water quality of the shallow dolomite aquifer under Reed-Keppler Park are unknown.

VEGETATION: Booth et al. (1982) collected four vegetation samples of "grass, weeds, and other common, non-edible vegetation" and analyzed them for gamma activity. In all samples, radioactivity was at background levels. However, elevated gamma radiation would

probably not be detected from vegetation, even at high radionuclide concentrations, unless this represented surface dusting (Jensen, 1992).

C. WEST CHICAGO REGIONAL WASTEWATER TREATMENT PLANT (WTP)

SOIL: The volume of contaminated soil at the WTP before the 1986-7 removal was estimated at 43,600 cubic meters, with the largest single area being a 125 by 260 foot plot identified as the East Area Thorium Residuals (Figure 4 and Tables 2 and 14). North of this, stretching eastward to the river, is a seven to 10 foot deep layer of thorium residues which appears to be the site of an old settling pond. Just to the south was the storage area, which had a synthetic liner and was used to temporarily receive materials excavated during WTP expansion.

The septic tank area is believed to have been a concrete septic tank and associated concrete sludge drying beds, which were filled with soil and thorium residues. The tank is about 40 feet long by 20 feet wide, but its depth is unknown. About 20 inches of soil and sod covered the tank, and the thorium concentration increased with depth. However, some residues were present on the soil surface. A small area of residues was between the East Area and the Septic Tank. About 1,000 cubic yards of contaminated material are along the river, and some of it has been eroded and carried downstream (USEPA, 1986).

The fill along the river bank is a mixture of trash and furnace cinders, topped by thorium residues mixed with sewage sludge. This area is about 400 feet long, and its width ranges from about seven feet at the southern end to around three feet at the northern boundary. About 30 percent of the river bank is contaminated above 30 microroentgens per hour (Table 14), and the external dose rate ranged from over 100 microroentgens per hour to 1,000 microroentgens per hour. At this location, the USEPA found 2,100 picoCuries per gram of thorium-232 in the upper six inches of the soil and over 4,000 picoCuries per gram of thorium-232 in the six to 12 inch layer. USEPA estimated that if the WTP were not remediated and, at some future date, someone built a house on the East Area, people inside it would be exposed to 400 microroentgens per hour of gamma radiation (USEPA, 1986).

Inorganic chemicals above comparison values in WTP soil are given in Table 14. Soil in the East Area had up to 6,400 ppm of lead; however, soil from the river bank had only 270 ppm of lead. Therefore, the concentrations of lead and radioactive materials are not always well-correlated (Table 5). Only low levels of organic chemicals were detected in soil from the East Area (Table 17). No PCBs were detected in soil from this location. It is unknown whether other areas of the WTP have or had PCBs.

In 1986-7, Kerr-McGee reportedly removed 57,000 cubic yards of thorium-contaminated soil from the WTP and took it to the Kerr-McGee Facility (Shafer, 1992). Consequently, much of the contamination described above is no longer present at WTP. According to Kerr-McGee, this includes most of the contaminants in the East Area (Kerr-McGee, 1994).

Contaminants still remain along the river bank, and the upcoming USEPA remedial investigation will assess the adequacy of past removal activities and identify any remaining contamination (Shafer, 1992). Kerr-McGee believes that its past removal activities were adequate (Kerr-McGee, 1994).

AIR: According to USEPA (1986), indoor radon-220 and radon-222 decay products at the WTP have generally reflected background levels. Also, because Reed-Keppler Park and the WTP have comparable amounts of radioactive materials, the airborne concentrations of radionuclides at both locations are probably similar (USEPA, 1986). However, the spoil area of Reed-Keppler Park is overgrown with brush and small trees, while, with the exception of the river bank, residues at the WTP are covered by grass. The brush and trees of Reed-Keppler Park may intercept radioactive particulates and would decrease wind velocity near the surface. Consequently, airborne levels of long-lived radionuclides on particulates may be lower at Reed-Keppler Park than at the WTP, while the reverse may be true for radon and its progeny. USEPA (1986) estimated that if the WTP were not remediated and in the future, someone built a house on the East Area, its inside air would have about 0.1 working level of radon, which is high (over 0.06 working levels). According to Kerr-McGee (1994), however, most of the contamination in the East Area has been removed. The presence of any nonradioactive airborne contaminants at the WTP is unknown. Because the area is well-vegetated, airborne dust production should be negligible.

GROUNDWATER: In glacial till groundwater at the WTP, inorganic chemicals and radionuclides above comparison values are given in Table 18. Downgradient wells were higher than upgradient wells for fluoride, manganese, nitrate, polonium-210, radium-226, radium-228, sulfate, thorium-228, uranium-234, uranium-235, and uranium-238. While arsenic and selenium were elevated in downgradient wells, they were also elevated in upgradient ones. At the WTP, the concentrations of organic chemicals in groundwater and the water quality of the shallow dolomite aquifer are unknown. The sampling described above was performed before removal activities by Kerr-McGee.

D. RESIDENTIAL AREAS

SOIL: Thorium concentrations are available for 29 of the approximately 150 properties which have or had tailings (USEPA files, 1990), and a depth profile was made of one (Table 19). Thorium levels ranged from non-detectable to 16,451 picoCuries per gram. Eight of the 29 properties equaled or exceeded 100 picoCuries per gram, and two exceeded 1,000 picoCuries per gram. Consequently, in most cases, tailings were diluted with uncontaminated soil. The sampling depths are unknown, although one property had contamination in the top six inches of soil. USEPA (1986) reported that one residence had 19,000 picoCuries per gram of thorium, which is slightly higher than any concentration found in the Kerr-McGee Facility, but within the Reed-Keppler Park ranges. Consequently, the tailings have not been diluted with clean soil in some Residential Areas.

Kerr-McGee has yet to remediate contamination beneath Factory Street, east of the Factory Area, and plans to remove this material during the remediation of the Kerr-McGee Facility (USEPA, 1986). Kerr-McGee removed tailings from under Weyrauch Street from Brown Street south to the Kerr-McGee Facility fenceline. Major portions of yards along Weyrauch Street were also excavated (Jensen, 1992). USEPA has not approved the remediation plans and cleanup criteria to date, and the upcoming USEPA remedial investigation will examine the adequacy of past removal and identify any remaining contamination (Shafer, 1992).

Inorganic mercury spilled on the second floor of Bolles Opera House when old pipes were removed, and these contaminated pipes were stored in the basement. The building owners attempted to clean up the spill, but some mercury seeped into cracks and crevices in the wooden floor. The floor has since been covered with linoleum and carpeting {National Institute for Occupational Safety and Health (NIOSH), 1988}.

The concentrations of other nonradioactive contaminants in residential areas are unknown. Chemicals are likely similar to those in the Kerr-McGee Facility, Reed-Keppler Park, and the WTP, although tailings may be diluted by clean soil in many properties. The Kerr-McGee Facility, Reed-Keppler Park, and the WTP have up to 18,000 ppm, 6,500 ppm, and 6,400 ppm, of lead respectively, with many samples showing high levels. It is likely that high levels of lead are/were present in residential properties with tailings. Sources such as house paint and automobiles must also be considered in attributing lead contamination to tailings. In the area downwind of the Kerr-McGee Facility apparently contaminated by aerial deposition (IDNS, 1991a; Argonne National Laboratory, 1983), lead and other contaminants may be close to the surface.

GAMMA RADIATION: The residential areas which contain(ed) waste residues were identified by measurements of gamma radioactivity in and around West Chicago. In the initial survey, Frigerio et al. (1978) found 77 radioactive residential areas in and around West Chicago (Figures 12a,b,c). The highest dose measured was 3,500 microroentgens per hour, but most were 500 microroentgens per hour or less. Kerr-McGee surveyed 2,733 properties inside the city and found 117 (4.3 percent) which measured over 30 microroentgens per hour. The company remediated 116 of these in 1985, but the owner of the remaining property refused clean-up. This residence contains residues in a small area of the back yard with an exposure rate of 35 to 40 microroentgens per hour. Seven properties were not surveyed because the City of West Chicago, Kerr-McGee, and USEPA could not reach the owners to secure permission. Kerr-McGee initiated remediation at properties with exposure rates which exceeded 30 microroentgens per hour, and reportedly continued removal until a dose rate of about 15 microroentgens per hour was achieved, when possible (Kerr-McGee, 1994; USEPA, 1986). These criteria were developed by Kerr-McGee and were never approved by the USEPA (Shafer, 1992). Reportedly, the company was able to mitigate exposure to 35 microroentgens per hour for all cases and 15 microroentgens per hour in all but four cases (USEPA, 1986). The USEPA did not oversee the cleanups and is concerned that remediation may have been inadequate (Shafer, 1991). The upcoming USEPA remedial investigation will examine the adequacy of the past remediation activities

and identify any remaining contamination (Shafer, 1992). Kerr-McGee (1994) believes their past cleanups have been adequate to eliminate any health risks from excessive radiation exposure at these properties.

Of the residential properties surveyed by Frigerio et al. (1978), 14 are outside of the area surveyed by Kerr-McGee. Four of the properties Frigerio et al. (1978) identified inside the City of West Chicago were not found by Kerr-McGee. Two of these areas have exposure rates under 30 microroentgens per hour, the Kerr-McGee cleanup criterion. Consequently, they may have been ignored by Kerr-McGee. The fate of the remaining two properties is unknown. USEPA (1986) suggested they may have been remediated by unknown parties.

In 1985, the IDNS surveyed properties in and around West Chicago and found 47 additional areas with exposure rates of 30 microroentgen per hour or more. Most of these properties lie outside of the city limits, and 11 of them were contaminated by Kress Creek or the West Branch of the DuPage River. In 1990, the IDNS found 31 microroentgens per hour at one property and ATSDR (1991a) recommended its remediation. The radioactivity was found in yards, gardens, and along the foundations of homes or garages. Some residential yards downwind of the Factory Area were apparently contaminated by aerial deposition during plant operations (IDNS, 1991a; Argonne National Laboratory, 1983). Maps from USEPA files (1991) show yards in this area contain about 20 micro-roentgens per hour of gamma radiation, which is above background (7 to 13 microroentgens per hour), but below the cleanup criterion of Kerr-McGee. The upcoming remedial investigation by USEPA will examine the levels of contamination from past airborne deposition. Most of the radioactive contamination in residential areas, however, was from the use of tailings as fill or contamination by Kress Creek or the West Branch of the DuPage River.

In USEPA and IDNS files (1991), maps of radiation surveys by Kerr-McGee or the IDNS were found for 97 residential properties (50 inside city and remediated; 47 outside city). Of these properties, 35 had tailings along house foundations (17 remediated by Kerr-McGee), and another three had slightly elevated gamma radiation levels along the house which were below the Kerr-McGee cleanup criterion. Three properties had tailings along attached garages. Four flower gardens (3 remediated by Kerr-McGee), 12 vegetable gardens (9 remediated by Kerr-McGee), and 1 apple tree (remediated by Kerr-McGee) were in contaminated areas, but the depth of the tailings at these locations is unknown. In one additional property, 16 to 18 milliroentgens per hour were found along a garden, which was below the Kerr-McGee cleanup criterion.

The IDNS has performed radiological surveys of all the West Chicago schools (IDNS, 1991b). Elevated readings were found at Gary Elementary, West Chicago Junior High, and West Chicago Senior High Schools, ranging from 10-18 microroentgens per hour. At Lincoln Elementary School, a small area by the building had 30 microroentgens per hour of gamma activity, and ATSDR (1991a) recommended removal of the contamination. The contaminated area is a grassy area several feet in diameter, which is not near the playground. The exposure of children to this material is probably negligible.

In April, 1990, the IDNS began monitoring gamma radiation around the Kerr-McGee Facility (Figure 8). Gamma levels measured by a calcium fluoride thermoluminescent dosimeter ranged from 0.08 to 1.53 milliroentgens per day (Table 20).

In addition to residential areas, contamination of commercial properties has occurred (included in Residential Areas category). Bolles Opera House was a Kerr-McGee laboratory. In 1980, the NRC found two plastic bags under the attic floor which produced gamma radiation of about 10 microroentgens per hour at contact. One bag had a bottle labelled "mesothorium" (radium-228; a Lindsay Light and Chemical Company product) which contained radium-226, radium-228 and other daughters. The other bag had several trays of unlabelled material. The NRC also found ten small bottles in the attic, six of which produced gamma doses of 0.05 to three milliroentgens per hour at contact, but no detectable radioactivity at one meter. These materials were removed from the building.

No radioactivity was found on the third floor, which had been renovated with new flooring, interior walls, and suspended ceilings. On the second floor, contamination was restricted to drain pipes (average eight microrads per hour), which was detectable at several breaks in the line. On the first floor, contamination (seven to 12 microrads per hour) was detected in a low spot of a ceiling air duct, a floor drain, several drainage pipes, and wood under the sink. In the basement, about 1/4 of the floor was contaminated by spillage from the removal of old pipes. Contamination was also found in the pipes and on one wall of the boiler room. Under the basement sewer pipe, a person could hypothetically receive an annual dose of 500 millirems.

In the storm sewer by George Street upgradient (i.e., north) of the Kerr-McGee Facility, the NRC (Hind, 1984) found that the gamma radiation level along the sewer west of the EJ&E tracks was 10 microroentgens per hour (background), but it was 2,000 microroentgens per hour along the sewer line east of the tracks. This contamination may have originated at Bolles Opera House or from fill used along the sewer line. The storm sewer network is not well known, and the actual source is uncertain. It is not related to the unloading of ore at the Kerr-McGee Facility, since it is north (i.e., upgradient) of it (Hind, 1984). Any radiation near storm sewer lines could be from tailings used for fill along them. Consequently, the radionuclides may not be inside the storm sewer upgradient of the Kerr-McGee Facility.

AIR: In April, 1990, the IDNS began an air monitoring program around the Kerr-McGee Facility (Figure 8). Two different sampling devices were used: particulate air samplers for gross alpha and beta activity, and radon-220 and radon-222 track etch monitors. The particulate samplers were placed at five schools, and gross alpha and beta readings were at background levels. The radon-220 and radon-222 track-etch monitors were placed at the five schools and outside of four residences (Figure 8). At Location 7, nearest the Kerr-McGee Facility, 3 picoCuries per liter of radon-220 plus radon-222 were detected. No radon was detected at the other locations. In the summer of 1993, however, screening tests at the Elliot Lake, Ontario, Canada radon chamber showed that Landauer alpha track monitors are very

inaccurate for measuring radon-220 levels (Jensen, 1993b). Consequently, the IDNS radon-220 measurements may be inaccurate.

In 1983, Argonne National Laboratory performed a screening survey in nine homes with tailings adjacent to their foundations and one control (Table 21). Several of these homes had slightly elevated radon-220 levels in the basements or first floor (below 0.06 working levels). The control home had elevated radon-222 (over 0.02 working levels). The radon-222 concentration was greater than that of radon-220 in the control house. However, in the homes with tailings along their foundations, radon-220 levels were sometimes higher than those of radon-222. Radon-220 is a decay product of thorium, so the tailings are the likely source of the elevated levels of radon-220 relative to radon-222. At one property where tailings were not removed from under part of the foundation, Kerr-McGee measured radon and lead-212 before remediation and radon after cleanup (Table 19). Before remediation, high levels of radon-220 were found in the crawlspace and living room (over 0.06 working levels). After remediation, they did not find elevated radon levels (concentrations not given; Nickels, 1985); consequently, the elevated levels before cleanup were evidently caused by the tailings. In 1989-90, the IDNS found 7.6 picoCuries per liter of radon in another home with tailings adjacent to its foundation, which is also high (over 4 picoCuries per liter).

In 1987, the NIOSH (1988) measured airborne mercury levels at 18 locations in Bolles Opera House. Only one sample, 85 micrograms/cubic meter, was above the NIOSH standard, 50 micrograms/cubic meter. The source was old mercury-contaminated pipes in the basement.

SURFACE WATER: With the exception of Kress Creek and the storm sewer outlet, surface water samples in residential areas have not been taken. Because the quantities of wastes in residential areas are small, their contribution to surface water contamination is probably negligible.

GROUNDWATER: The effect of residential contaminants on groundwater quality is unknown, but is probably negligible due to the small amounts of wastes involved (USEPA, 1986).

Prior to 1973, the discharge of wastes into the disposal ponds at the Kerr-McGee Facility caused extensive groundwater contamination. In 1958, the DuPage County Health Department found 260 ppm of chloride, 1,560 ppm of hardness, and 4,036 ppm of total dissolved solids in water from a well about 1000 feet south of Disposal Pond 2. For DuPage County at that time, the average levels of these substances in the shallow dolomite aquifer were 7 ppm of chlorides, 436 ppm of hardness, and 520 ppm of total dissolved solids (Butler, 1965). Butler (1965) sampled 23 private wells in the area and found similarly high values. Hardness was consistently higher near the Kerr-McGee Facility, and the concentrations of iron and hardness were higher in wells near the active disposal pond, Pond 2. Contamination was found in all directions up to about 4800 feet from Disposal Pond 2 (Butler, 1965).

In 1974, the DuPage County Health Department resampled seven wells of the Butler (1965) study and found no general decline in contaminant levels (IEPA Files, 1989). From 1964, when the disposal ponds were used for waste disposal, to 1976, after rare earth and thorium production had ceased, the concentrations of chloride, sulfate, hardness, and total dissolved solids in the shallow dolomite aquifer generally decreased. However, the spatial distribution of these chemicals changed, and the levels of some parameters increased in a few wells (Argonne National Laboratory, 1977). The chemicals examined in the 1958 to 1976 samples, however, were generally water quality parameters associated with the aesthetic characteristics of water (taste, smell) and not of general health concern.

In June 1981, the USEPA (Mortenson, 1981) sampled private wells around the Kerr-McGee Facility, including one on Pearl Street and one in the Joy Street Subdivision, for inorganic chemicals and other parameters. All of the measured radioactive concentrations were within two times those of the blanks; therefore, the data were considered invalid. The inorganic data was valid, but again this sampling was for general water quality parameters rather than for chemicals of health concern.

Frame (1984) sampled six private wells in the Joy Street Subdivision and analyzed them for alpha and beta activity. Radioactivity was not elevated in the samples, which ranged from not detected to 1.48 picoCuries per liter of gross alpha and not detected to 4.98 picoCuries per liter of gross beta activity. Any study of groundwater pollution near the Kerr-McGee Facility must take past impacts from plant operations into account.

Several West Chicago municipal wells draw water from the deep Ironton-Galesville Formation. This aquifer has naturally-occurring radium, which is not a result of migration from the Kerr-McGee wastes. Before 1960, the city used three wells which were cased to the top of the shallow dolomite aquifer. No radiological sampling of the water supply was done before 1960, as water was not taken from the Ironton-Galesville Formation at that time. A well was drilled into the Formation in 1960, and after 1966, two of the shallow wells were sealed. In 1975, the third was deepened to penetrate the Formation. Consequently, starting in 1975, all of the municipal water of West Chicago came from the Ironton-Galesville Formation. Between 1974 and 1979, sampling from the distribution system of the municipal water supply found 7.7 to 76.9 picoCuries per liter of gross alpha activity. In 1979, the IEPA notified the city that this level exceeded governmental standards for radioactivity. In 1982 and 1989, the city drilled two shallow wells to provide low-radium water for dilution. In the last quarter of 1992, sampling from the distribution system of the West Chicago public water supply for the USEPA Environmental Radiation Ambient Monitoring System found 29.4 picoCuries per liter of gross alpha and 5.2 picoCuries per liter of radium-226; collection in the last quarter of 1991 found 16.2 picoCuries per liter of gross alpha and 6.9 picoCuries per liter of radium-226; and sampling in the last quarter of 1990 found 16.7 picoCuries per liter of gross alpha and 7.7 picoCuries per liter of radium-226 (USEPA Environmental Radiation Data Reports, 1990-92). The MCL for alpha activity is 15 picoCuries per liter and that for radium is 5 picoCuries per liter, so while diluting deep

groundwater with water from shallow wells has helped the situation, it has not solved the problem.

E. KRESS CREEK

SOIL: The sediments and adjacent soils of Kress Creek have been contaminated with radioactive materials (Tables 2, 22, 23, 24). The estimated total volume of contaminated material along both Kress Creek and the West Branch of the DuPage River is about 62,100 cubic meters (NRC, 1989a). In 1976, 80 percent of the radioactive materials were found in the upper third of the creek below the Kerr-McGee storm sewer outfall (Frigerio et al., 1978). In 1980, however, sediment and soil samples showed that contamination was much more extensive (USEPA, 1986). The proportion of radium to thorium is generally less in the sediments and associated soils along Kress Creek than in wastes of the Kerr-McGee Facility, Reed-Keppler Park, or the WTP.

In July 1981, sampling of sediments (Figure 6) indicated that downstream from the Kerr-McGee storm outfall, contamination along Kress Creek did not decline with distance downstream (Frame, 1981). In the stream, accumulations of grayish-colored thorium-containing residues were visible in slower-moving sections, especially near the storm sewer outfall. Above the outfall, background sediment concentrations were 0.47 to 1.2 picoCuries per gram of radium-226, 0.54 to 1.6 picoCuries per gram of thorium-228, and 0.32 to 1.7 picoCuries per gram of thorium-232. One upstream sample had 5.7 picoCuries per gram of radium-226, 5.1 picoCuries per gram of thorium-228, and 3.8 picoCuries per gram of thorium-232, and these slightly elevated levels may have arisen from tailings used for fill along the stream. The highest sediment concentrations, 238 picoCuries per gram of thorium-232 and 187 picoCuries per gram of thorium-228, were about 100 meters below the outfall. Another location with high thorium levels, 141 picoCuries per gram of thorium-228 and 195 picoCuries per gram of thorium-232, was just north of Wilson Road (Frame, 1981).

In background soil, Frame (1981) found non-detectable to 1.2 picoCuries per gram of thorium-228 and non-detectable to 1.3 picoCuries per gram of thorium-232. Thorium was elevated in all soil samples collected between the storm outfall and the West Branch of the DuPage River. Concentrations did not decline with distance downstream from the storm outfall, and they were not correlated with those of the sediments. In the soil, the maximum level of thorium-232, 166 picoCuries per gram, and that of thorium-228, 105 picoCuries per gram, were about 600 meters downstream from the storm outfall. The soil concentrations of thorium-228 and thorium-232 at the storm outfall were 39.6 and 49.8 picoCuries per gram, respectively. The ranges of concentration of other radionuclides were 0.32 to 2.9 picoCuries per gram for radium-226, less than 0.01 to 1.7 picoCuries per gram for uranium-235, and less than 12 to 44 picoCuries per gram for uranium-238. These levels generally exceeded those for background (upstream) soil, 0.85 to 1.5 picoCuries per gram of radium-226, non-detectable to 0.16 picoCuries per gram of uranium-235, and non-detectable for

uranium-238. However, the concentrations were not elevated as much as those for thorium-232 or thorium-228.

Sediment and soil contamination was further defined in 1982-3 (Frame, 1984). The concentrations of thorium in the sediments of Kress Creek downstream of the storm outfall ranged from not detectable to 131 picoCuries per gram, with the highest level found 1950 meters downstream of the outfall, which is downstream of Route 59 (Table 22). The study confirmed the lack of apparent pattern in thorium levels with distance downstream from the storm outfall. In almost all cases, sediment thorium concentrations decreased to essentially background at 20 to 30 centimeters in depth, but at the sampling point closest to the outfall, the thorium levels were relatively constant to a depth of 40 centimeters. Background concentrations of various radionuclides were 0.68 to 1.38 picoCuries per gram of radium-226, 0.50 to 1.12 picoCuries per gram of thorium-228, 0.53 to 1.12 picoCuries per gram of thorium-232, 1.03 to 2.10 picoCuries per gram of total thorium, and 0.15 to 1.10 picoCuries per gram of uranium-238, and these concentrations were typical of normal soil (Frame, 1984).

In general, the maximum soil concentrations of thorium along the creek were 15 to 30 centimeters below the surface and decreased with increasing distance from the stream (Tables 23 and 24). However, 50 meters downstream from the outfall and 10 meters from the eastern edge of the stream, the maximum concentration, 226 picoCuries per gram, was 110 centimeters deep. This was an isolated case apparently not caused by flooding, but by the use of contaminated fill along the stream bank (Frame, 1984). Many of the highest levels were found near the Kerr-McGee outfall. In some cases, regrading of the stream banks, which is apparent in the Joy Street Subdivision, may have altered the depth and distance of contamination from the stream. The Joy Street Subdivision also has yards where tailings were used as fill.

The concentrations of nonradioactive compounds in the sediments and associated soils of Kress Creek are unknown. Because the Kerr-McGee Facility has high levels of lead, and possibly also PCB's and other contaminants, some of these compounds may be elevated in the sediments and soils along Kress Creek.

GAMMA RADIATION: Frame (1984) found the gamma radiation levels one meter above the ground along much of Kress Creek (Tables 24 and 25) exceeded background levels (six to 11 microroentgens per hour). The maximum exposure rate of 140 microroentgens per hour occurred about 100 meters downstream of Joy Street. Frigerio et al. (1978) found one location where the exposure was slightly higher, 150 microroentgens per hour. In general, gamma levels were well-correlated with soil radionuclide concentrations. Gamma levels one meter above the surface and one meter from the edge of the stream ranged from eight to 96 microroentgens per hour and averaged 28 microroentgens per hour. Five meters from the edge of Kress Creek, the levels ranged from seven to 72 microroentgens per hour and averaged 25 microroentgens per hour. Ten meters from the stream, they ranged from eight to 120 microroentgens per hour, with a 21 microroentgen per hour average. Twenty-five

meters from the stream, they ranged from eight to 32 microroentgens per hour, with a 14 microroentgen per hour average. While gamma levels generally decreased with increasing distance from the stream, they did not decrease progressively downstream from the outfall. Lower gamma levels were observed between 900 and 1,250 meters downstream from the storm outfall, and this was attributed to less flooding at this location (Frame, 1984).

AIR: Airborne radon-220 and radon-222 daughters (Tables 9 and 10), as well as long-lived radionuclides (Table 11) were sampled around the Kerr-McGee Facility (Jensen, 1982), including a sampling point 150 feet south of Joy Street, 90 feet from Kress Creek, and 75 feet from the nearest house. While around the Kerr-McGee Facility, the concentrations of radon daughters were elevated when the wind blew from the Kerr-McGee Facility, the pollution rose for Kress Creek showed little correlation with direction (Figure 8), and Kress Creek was not a significant source of radon-220 (Jensen, 1982). Long-lived radionuclides were not detected above background levels (Table 11). The presence of any nonradioactive airborne contaminants at Kress Creek has not yet been investigated.

SURFACE WATER: Analyses of water from the Kerr-McGee storm outfall and Kress Creek for dissolved and suspended alpha and beta activity, as well as inorganic compounds (Table 26) showed high levels of dissolved alpha activity, chloride, fluoride, nitrate, sodium, sulfate, and total dissolved solids in some samples, with levels for some contaminants higher below the storm outfall than above it. The concentration of fluoride was high both upstream and downstream of the outfall, but its level downstream was greater. The concentrations of nitrate and total dissolved solids downstream of the outfall were high, but the upstream nitrate level is unknown. The concentrations of radioactive and nonradioactive chemicals in Kress Creek have not been measured since 1964, so the effect of the Kerr-McGee plant closing on their levels is unknown.

From 1974-6, the IEPA sampled water from the storm discharge (Table 26). On at least one date, the water had high concentrations of ammonium, arsenic, chloride, fluoride, nitrate, sodium, sulfate, and total dissolved solids. From 1964 to 1974-6, the levels of ammonia, iron, nitrate, sodium, sulfate, and total dissolved solids in water from the storm discharge decreased. In this same time period, the peak concentration of chloride decreased slightly, while the level of fluoride remained about the same.

GROUNDWATER: Frame (1984) and Mortenson (1981) sampled six private wells in the Joy Street Subdivision and analyzed them for gross alpha and beta activity. The results of those analyses were previously described in the Residential subsection of the Environmental Contamination section. Any study of contamination along Kress Creek near the Kerr-McGee Facility must take into account past impacts from the plant.

F. WEST BRANCH OF THE DUPAGE RIVER

SOIL: In 1982-3, Frame (1984) examined radioactive compounds in sediment and soil, as well as gamma exposures along the West Branch of the DuPage River from 200 meters upstream to 200 meters downstream of its confluence with Kress Creek. Thorium concentrations in the sediments (Table 27) and soil (Table 28) were higher downstream of the confluence. Like Kress Creek, the maximum thorium concentrations along the West Branch of the DuPage River were generally 15 to 30 centimeters in depth (Frame, 1984). The maximum gamma exposure rate, 104 microroentgens per hour, was close to the maximum level found along Kress Creek by Frigerio et al. (1978), 150 microroentgens per hour.

In 1985, Radiation Management Corporation sampled sediments of the West Branch of the DuPage River and found not detectable to 33 picoCuries per gram of radium-224, 0.4 to 2.0 picoCuries per gram of radium-226, not detectable to 28 picoCuries per gram of thorium-232, not detectable to 2.4 picoCuries per gram of uranium-235, and not detectable to 5.2 picoCuries per gram of uranium-238.

In 1985, USEPA sampled the sediments of the West Branch of the DuPage River (Table 29) for radionuclides. Elevated levels were found by the northern edge of the contaminated bank by the WTP, as well as further downstream. At the 1600 foot sampling point, which is near the apartment complex previously described in the Site Visit section, there were 3.8 picoCuries per gram of total thorium in the sediment. Elevated concentrations were also found just before the confluence of the river with Kress Creek. With the exception of the contaminated bank by the WTP, the USEPA did not sample soils along the West Branch of the DuPage River.

Subsequent to the Frame (1984) study, Oak Ridge Associated Universities (Berger, 1984) measured gamma radiation levels (not given) along the West Branch of the DuPage River from 200 to 550 meters downstream from the confluence and used these levels to estimate thorium concentrations (Figure 13). According to their estimates, thorium was elevated downstream to the furthest measurement point. It is unknown how much farther downstream the sediments and associated soils of the West Branch of the DuPage River are contaminated with radioactive materials.

With the exception of soil of the contaminated bank by the WTP, the levels of nonradioactive chemicals in the sediments and associated soils of the West Branch of the DuPage River are unknown. Because the concentration of lead in the contaminated bank by the WTP is lower than that in much of the wastes, its levels along the river upstream of the confluence with Kress Creek may not be elevated. The part of the river downstream of the confluence; however, may have higher lead concentrations because of contamination from Kress Creek, which may have elevated lead levels. Other contaminants from the Kerr-McGee Facility may also have been deposited in soil along the river.

GAMMA RADIATION: Measurements of gamma radiation (Table 30) one meter above the soil surface along the West Branch of the DuPage River indicate higher levels downstream of the confluence.

AIR: The airborne concentrations of radioactive and nonradioactive chemicals at the West Branch of the DuPage River are unknown. However, airborne radionuclide levels are not elevated by Kress Creek and, with the exception of the contaminated river bank by the WTP, the West Branch of the DuPage River is no more contaminated with radioactive materials than Kress Creek. Consequently, with the exception of the part by the WTP, the levels of airborne radioactivity along the West Branch of the DuPage River are probably negligible. Airborne radioactivity at the WTP was discussed in its respective subsection. Like Kress Creek, however, the airborne concentrations of nonradioactive chemicals are unknown.

SURFACE WATER: Radionuclide levels in the water of the West Branch of the DuPage River are unknown. Between December 1984 and December 1988, the DuPage County Forest Preserve District (1988) sampled water from the river for organic and inorganic chemicals because of fears it may be affected by the DuPage County Landfill. All sample locations were downstream of the confluence, and no chemicals exceeded comparison values. Fecal coliform levels were extremely high, which indicated contamination by sewage, most likely from malfunctioning septic systems (DuPage County Forest Preserve District, 1988).

GROUNDWATER: The groundwater quality under the West Branch of the DuPage River is unknown.

G. QUALITY ASSURANCE AND QUALITY CONTROL

In preparing this Health Assessment, the Illinois Department of Public Health (IDPH) relied on information provided in the referenced documents. For USEPA (1986), quality assurance and quality control information was available for groundwater sampling at the Kerr-McGee Facility and the WTP, as well as soil cores from Kerr-McGee Facility. While these data are limited, they were taken and analyzed using USEPA quality assurance/quality control (QA/QC) procedures.

For the USEPA samples of "B" wells of the Kerr-McGee Facility; aluminum, iron, manganese, nickel, silver, and vanadium were found in the blanks at similar levels as in the samples. Consequently, their presence in the samples may have resulted from the collection or analytical procedures, and the USEPA data for these elements cannot be considered valid for the "B" wells. For the USEPA samples of "KM" wells; there was enough aluminum, iron, nickel, silver, thorium-230, uranium-238, and vanadium in the blanks to make the data for these chemicals invalid. It is unknown whether the Kerr-McGee analyses of the split samples had the same problem. For the USEPA samples of the "F" wells, there was enough manganese, nitrate, thorium-230, total dissolved solids, and uranium-238 in the blanks to

make the data for these chemicals invalid. It is unknown whether the Kerr-McGee analyses of the split samples had the same problem.

USEPA (1986) assumed water in monitoring wells on the edge of and upgradient of the Kerr-McGee Facility indicated background concentrations. However, considering the widespread contamination documented in all directions around the Kerr-McGee Facility, this is clearly not the case. In this health assessment, wells upgradient of the WTP (glacial till aquifer) and three wells of the Butler (1965) study (shallow dolomite aquifer) were considered representative of background levels.

For the WTP groundwater samples, the levels of aluminum, nickel, and zinc in the blanks were similar to those found in the groundwater; consequently, these analyses are invalid. In addition, for iron, potassium, and total suspended solids, the values for the upgradient wells were less than five times that for the blanks; therefore, for the upgradient wells, these analyses are invalid.

For the WTP, two of the soil samples of USEPA (1986) had broken chain-of-custody seals. Disregarding these samples had no effect on the ranges of concentrations or the conclusions of this report. USEPA (1986) also misnamed the West DuPage Woods Forest Preserve, which is north of the WTP.

Mausner (1982) found that 1962-4 estimates of airborne radionuclide levels inside the plant were considerably underestimated, and this questions the validity of early and subsequent ambient radionuclide monitoring by the American Potash and Chemical Corporation in and around the Kerr-McGee Facility.

AEC/NRC inspection reports stated that at one time, shower facilities were not available at the plant, but that it was assumed employees showered before going home. This inconsistency suggests that these reports are of questionable reliability. Furthermore, numerous AEC/NRC inspection reports stated airborne radiation levels, but did not specify what was being measured, making interpretation difficult.

Estimates of hydrogen fluoride concentrations around the plant are from an unspecified model. The validity of any modelling results depends on the assumptions used in it, which are unknown in this case. Consequently, the reliability of these estimates is unknown.

The NRC (1989a) used a model to estimate groundwater flow under the Kerr-McGee Facility and make predictions of the possible movement of contaminants. According to the USEPA (NRC, 1989b), this model was designed for confined aquifers, and not for unconfined ones like at the Kerr-McGee Facility. Consequently, until the model is tested for unconfined conditions, the results cannot be considered valid (NRC, 1989b). Furthermore, given the uncertainty of the geology under, and especially around, the Kerr-McGee Facility, no estimates of contaminant migration rates to private wells can be considered reliable. Consequently, the NRC (1989a) modelling results were not used in this document.

For air modelling around the Kerr-McGee Facility during remediation, the assumptions used by the NRC (1989a) are unknown. Because the validity of model results depends on the assumptions, the reliability of these estimates is unknown. In their estimates, Bernhardt et al. (1990) said that their air model may not be an accurate representation for an area source, so further validation is necessary.

For the other information included in this health assessment, IDPH relied on the information provided in the referenced documents and assumed that adequate QA/QC measures were followed with regard to chain-of-custody, laboratory procedures, and data reporting. The validity of the analyses and conclusions drawn for this health assessment is determined by the availability and reliability of the referenced information.

H. TOXIC CHEMICAL RELEASE INVENTORY

Since the reporting of toxic chemical releases began in 1987, the USEPA has collected information on estimated annual releases of toxic chemicals by industry to the environment (air, water, land, or underground injection). This data is compiled and retrievable through an on-line database, the Toxic Chemical Release Inventory (TRI). The reporting years of 1987, 1988, 1989, and 1990 are currently available for review.

The following information is taken from TRI records for industries near the six Kerr-McGee areas reporting releases of chemicals of concern at reportable quantities established by the USEPA. The total release of these chemicals to specific media for 1990 are summarized below:

CHEMICAL	MEDIA	TOTAL RELEASE (pounds)
Barium compounds	Air	32,750
	Water	250
Chlorine	Air	3,686
Dichloromethane	Air	145,022
Toluene	Air	458,379
1,1,1-Trichloroethane	Air	88,070
Xylenes	Air	18,184

There are no other industries in the vicinity that emit reportable quantities of radionuclides, lead, or hydrogen fluoride. In the past, Kerr-McGee dumped kerosine on the waste piles,

which contained toluene and xylenes. There are other sources of these chemicals in the vicinity, and they are also present in gasoline, diesel fuel, and vehicular exhaust. These air emissions of toluene and xylene may complicate an air quality study of any of the six Kerr-McGee areas.

PATHWAYS ANALYSES

A Public Health Assessment examines the past, present, and future exposure to hazardous chemicals. To evaluate the actual or potential exposure of a person to a hazardous substance, IDPH evaluates the surrounding environmental conditions and local human activities that may lead to exposure. Generally, this information is evaluated for five criteria which represent the parts of an exposure pathway. These five criteria include:

1. A contaminant source;
2. An environmental transport pathway (e.g., groundwater);
3. A point of potential exposure (e.g., private well);
4. A route of exposure (e.g., ingestion of contaminated groundwater); and
5. A receptor population or people who may be exposed.

A completed exposure pathway contains all of the above criteria and signifies that an exposure to contaminants has occurred, is occurring, or will occur in the future. A potential pathway is one where one of the five criteria is missing, but could exist. This indicates that exposure may have occurred, may be occurring, or may occur in the future. Incomplete pathways are those in which one of the criteria is absent and will never be present.

The principal environmental transport pathways at these six areas are air (gases and dust), biota, groundwater, sediments, soil, and surface water. Of particular concern are the dermal absorption, inhalation, and ingestion of radionuclides and non-radioactive chemicals. Dermal absorption can result from direct contact with contaminated air, dust, exposed wastes, groundwater, soil, or surface water. Exposure may also occur from the inhalation of gaseous substances and dust particles or the ingestion of contaminated dust, foodstuffs, groundwater, surface water, or soil. Gamma radiation is absorbed into the body with exposure being a function of the physical distance from the source, time of exposure, and shielding. People who live or work near hazardous waste are the most likely to experience long-term, or chronic exposure to the contaminants. Remediation workers may also be exposed, but the exposure duration is generally shorter. The exposure of remediation workers can be minimized by protective equipment.

Completed and potential exposure pathways of the respective Kerr-McGee areas are given in Tables 31 and 32. Since the route of exposure to each contaminated or potentially contaminated media ultimately determines the exposure dose to each contaminant of concern, the pathways have been discussed relative to common exposure routes.

A. COMPLETED EXPOSURE PATHWAYS

INHALATION

KERR-MCGEE FACILITY: Completed exposure pathways from air emissions exist at the Kerr-McGee Facility for remediation workers or trespassers. This warrants the use of protective equipment by remediation workers and actions to prevent trespassing. Air emissions from the Kerr-McGee Facility include gases and particulates. Dust production is greatest in areas with bare ground, while vegetation inhibits the liberation of dust. Radon-220 and radon-222 are gaseous radionuclides produced by the radioactive decay of thorium and uranium, respectively (Figure 7). The covering of the waste piles with asphalt in 1983 reduced the amount of radon emitted into the air.

The emission of radon-220 and 222 into the air is a function of the amount of parent material near the soil surface. Several inches of compacted soil will attenuate radon-220 emissions due to its short half-life, 55.61 seconds. However, several feet of soil are required to attenuate radon-222, due to its longer half-life, 3.82 days (USEPA, 1986). Radioactive lead-212 from radon-220 decay tends to be deposited on airborne particles and can be transported over long distances. Ambient air levels of radon are highest on windless days and early in the morning.

During plant operation (before July 1973), the extraction of rare earth and thorium compounds produced airborne dust and gases. The total amount dispersed beyond the plant boundaries is unknown. Butler (1965) found the plant effluent and Disposal Pond 2 had high temperatures, which would have increased emissions of volatile chemicals. The waste piles and intervening ground have been covered by asphalt, thereby reducing emissions. However, the Factory Area contained a large quantity of bare soil which could have produced airborne dust. The present vegetation in this area should inhibit dust production. The levels of nonradioactive compounds in dust is unknown.

In the past, hydrofluoric acid fumes, radionuclides, and lead were probably inhaled by plant workers. Exposure of workers to airborne contaminants was almost certainly higher than that of the surrounding residents, and their exposure to radionuclides above AEC/NRC limits has been documented (Polednak et al., 1983; AEC and NRC inspection reports, 1957 to 1983) at an estimated average worker exposure to thorium of 0.003 to 0.2 picoCuries per liter and radon-220 of 80 to 880 picoCuries per liter. However, these measurements have not been assessed for accuracy or methodology.

At this time, the airborne radionuclide exposure of residents and workers around the Kerr-McGee Facility is negligible.

Removal of the asphalt cover from the waste piles and excavating contaminated soil and sediments during remediation will increase the surface area of exposed materials, and consequently, the emission of radon-220 and radon-222. Inhalation exposure may

temporarily increase during remediation work, which will increase airborne dust and radon. People at increasing distances from the excavation site will be exposed to finer particles, as the larger particles will settle out near the source. However, wetting the soil during remediation would reduce dust production by about 50% and also decrease the amount of fine dust which can penetrate deeply into the lung (NRC, 1989a). Wetting the soil will also reduce radon emissions, especially of radon-220, because of its short radioactive half-life (Jensen, 1992).

REED-KEPPLER PARK: Gaseous and particulate contaminants could be inhaled at Reed-Keppler Park, which contains a smaller volume of wastes than that of the Kerr-McGee Facility. Trespassers and remediation workers could be exposed to airborne contaminants. This warrants the use of protective equipment for remediation workers and actions to prevent trespassing. At this time, exposure of the public to airborne radionuclides outside of the fenced spoil area is negligible.

WEST CHICAGO REGIONAL WASTEWATER TREATMENT PLANT: Airborne dispersal of radon has not been investigated, but is probably confined to the WTP. The likelihood of major emissions are small because the known gamma point sources are small. Trespassers and canoeists on the river could be exposed to radon near tailings. However, the wet soil should reduce the airborne concentrations of radon-220, and it is unlikely substantial exposure would occur (Jensen, 1992).

RESIDENTIAL AREAS: In northeastern Illinois, approximately 25 percent of all homes have naturally high radon concentrations (over 4 picoCuries per liter or 0.02 working levels), and in some areas, up to 40 percent of the homes have elevated radon levels (Gulezian, 1990). Most of this radon is radon-222 from uranium; however, most of the radon produced by the thorium wastes is radon-220. Some radon-222 is also evolved by uranium (via radium) in the tailings. In and around West Chicago, some homes have/had tailings adjacent to their foundations (35; 17 remediated by Kerr-McGee) or attached garages (3). In these homes, radon-220 and radon-222 from the wastes may penetrate or have penetrated into the interior, where occupants may be exposed. In two of the 10 such homes examined to date, high levels of radon (over 4 picoCuries per liter of total radon, 0.02 working levels of radon-222, or 0.06 working levels of radon-220) were detected. Much of the radon found in these 10 homes with tailings was radon-220, which suggests the thorium wastes were the source. By contrast, while the control house had elevated radon, most of it was radon-222. In one house, radon-220 levels were measured before and after remediation, and the concentration was lower after cleanup. This also implicates the tailings as the source of contamination. It is likely that radon-220 levels are not elevated in most homes with tailings, but only in ones with high concentrations of thorium in or along basements, crawlspaces, or foundations.

DERMAL CONTACT

Dermal (skin) exposure has probably occurred, at least in the past, for most of the six areas. Before 1957, the Kerr-McGee Facility was unfenced on the western side, making it readily accessible to the numerous nearby residents (children, teenagers). In 1976, some children routinely went through holes in the fence on their way to school. As late as June 4, 1990, some of the gates still had enough clearance that small children could squeeze under them. By July 1991, dirt fill had been used to correct this problem. At this time, trespassing by teenagers is more likely than small children (Shafer, 1992). Trespassing has also occurred within the fenced area of Reed-Keppler Park. Reportedly, many workers at the Kerr-McGee Facility were directly exposed to dust, ores, wastes, and other hazardous chemicals.

Trespassers, workers, or remediation workers could contact contaminated soil or dust at the Kerr-McGee Facility, Reed-Keppler Park, and WTP. Reed-Keppler Park and the WTP are generally vegetated, so little dust should be produced. Trespassers, workers, or remediation workers could also contact contaminated surface water of the disposal ponds of the Kerr-McGee Facility. Remediation workers could be exposed to the contaminated soil in any of the six areas. These exposure pathways warrant the use of protective equipment by remediation workers and actions to prevent trespassing. Canoeists on the West Branch of the DuPage River could conceivably be exposed to wastes at the contaminated river bank, which is eroding and contaminating the downstream banks and sediment. Remediation or other workers could be exposed to contaminants along Kress Creek or the West Branch of the DuPage River. These pathways warrant the use of protective equipment by remediation workers and actions to prohibit trespassing.

In residential yards which contain(ed) tailings, dermal exposure to contaminants could occur via direct contact with soil or dust, particularly if the contaminants are/were near the soil surface and the earth was bare. Contaminants are likely near the surface in properties near the Factory Area where areal deposition occurred, as well as in properties flooded by the West Branch of the DuPage River and Kress Creek. Because of its low solubility, most atmospherically deposited lead remains in the top one to two inches of soil and does not leach downward (ATSDR, 1991b). Thorium is also relatively insoluble and likely remains near the soil surface.

While radioactive surface contamination at Reed-Keppler Park is restricted to the fenced area, trespassing has occurred. Consequently, people may have been exposed to surface contamination. Dermal exposure could occur from contaminated dust or soil.

INGESTION

Remediation workers or trespassers at the Kerr-McGee Facility may incidentally ingest contaminated soil or dust. Pica (intentional dirt eating) children who trespass may ingest substantially larger amounts of contaminated soil or dust. However, trespassing by teenagers

is more likely than children (Shafer, 1992). These pathways warrant the use of protective equipment by remediation workers and actions to prevent trespassing.

Many residential properties have or had tailings used for fill. If this material is/was near the surface, it was potentially available for ingestion. It is also likely that soil in residential properties adjacent to the Kerr-McGee Facility (aerial deposition contamination), Kress Creek, and the West Branch of the DuPage River are contaminated with lead and/or radioactive constituents. Exposure of children to contaminants along Kress Creek or the West Branch of the DuPage River is likely because properties abut these areas and children tend to play near streams. Pica children dwelling within these areas are possibly at risk of lead contamination, particularly in barren yards where the lead may be near the surface.

GAMMA RADIATION

Gamma radiation spreads in all directions from a source, and it can pass through a large amount of low-density material without a great loss of energy (Charp, 1992). However, it can loose much of its energy in thin layers of high-density material (Jensen, 1992). It is attenuated by distance from the source and is a function of the radionuclides involved. If the distance from a radioactive point source doubles, the amount of gamma radiation decreases fourfold. However, the contaminated areas are not point sources, so the decline in gamma radiation will not drop exactly fourfold as the distance from the source is doubled (Jensen, 1992). Because the radioactive half-life of thorium-232 is about 14 billion years, the wastes will remain hazardous essentially forever.

According to the IDNS, because much of the radioactive materials is below grade, around the fence of the Kerr-McGee Facility, gamma exposure results from surface or subsurface contamination, and not direct shine from the waste piles (Runyon, 1990). However, according to the USEPA, direct shine from the waste piles extends beyond the fenceline. During surveys in the 1980's, it was difficult to determine whether elevated gamma levels in properties along the fenceline were from subsurface contamination or the waste piles (Jensen, 1993). According to Kerr-McGee, gamma levels decrease to background within a few hundred feet of the fenceline (Kerr-McGee, 1994). Residences and offices are within 75 to 100 feet of the fenceline, and a frame structure provides only about 10 percent shielding from gamma radiation. Consequently, people working and/or living in close proximity to the Kerr-McGee Facility are evidently exposed to elevated levels of gamma radiation.

Remediation workers and trespassers at the Kerr-McGee Facility have and will potentially be exposed to the highest levels of gamma radiation, because it contains greater gamma intensities than the other Kerr-McGee areas. This warrants exposure restrictions for remediation workers and actions to prevent trespassing.

At Reed-Keppler Park, human exposure to elevated gamma radiation is most likely at the tennis courts, but this exposure would probably be limited to a few hours per day. Consequently, this exposure should be negligible. Elevated gamma radiation was detected

along the fenced spoil and in the proposed pool area, but people are not likely to remain near these for an extended time. Consequently, at present, the exposure of park users and workers should be negligible. Remediation workers and trespassers could be exposed to the gamma radiation, and this warrants exposure restrictions for workers and actions to reduce trespassing.

Gamma radiation is emitted from the waste materials at the Wastewater Treatment Plant, and trespassers or remediation workers could be exposed to the radiation. This warrants exposure restrictions for remediation workers and actions to prevent trespassing.

The exposure of residential occupants to gamma radiation is a function of the amount and types of radioactive materials, distance, time, and shielding. In the remediated properties, exposure was reportedly reduced to 30 microroentgens per hour or less. The upcoming USEPA Remedial Investigation will evaluate the adequacy of past remediation activities and identify any remaining contamination (Shafer, 1992). People living in properly remediated properties would not be exposed to elevated gamma levels. In yards where tailings are still present, given the same amount of contamination, exposure will be higher if contamination is under or near the house (24 hour exposure possible) and lower if it is only in the yard (exposure likely for only a few hours each day). Because a frame structure provides only about 10 percent shielding from gamma radiation, occupants of homes and other buildings with tailings along foundations or in crawlspaces may receive excessive exposure to gamma radiation.

Recreational users, particularly children, may be exposed to elevated gamma radiation levels along Kress Creek and the West Branch of the DuPage River, especially where they run along residences (e.g., Joy Street Subdivision). However, this probably occurs for only a few hours per day, and should generally result in negligible exposure. However, this exposure may add to that from residences contaminated with tailings, particularly along foundations (e.g., some yards in the Joy Street Subdivision have yards contaminated with tailings). While a home constructed in contamination along Kress Creek or the West Branch of the DuPage River may have elevated inside gamma levels, this is unlikely given the risk of flooding, at least with present home construction techniques.

B. POTENTIAL EXPOSURE PATHWAYS

INHALATION

If any of the six areas are not remediated and houses or buildings are built on contaminated soil, their inhabitants would probably be exposed to radon and other compounds. This would likely also occur if houses are built on the proposed Kerr-McGee Facility disposal cell in the distant future (the radioactive half life of thorium-232 is about 14 billion years, so it will remain hazardous essentially forever). Immediately beyond the perimeter of the Kerr-McGee Facility and Reed-Keppler Park fences, radon and long-lived radionuclide concentrations are low, and the exposure potential negligible.

In residential areas, inhalation exposure could occur from airborne contaminants from (1) contaminated soil where tailings were used for fill, (2) contaminated soil along Kress Creek or the West Branch of the DuPage River, or (3) airborne emissions from the Kerr-McGee Facility. Some residential properties immediately downwind of the Factory Area were apparently contaminated by airborne deposition from the plant during its forty years of operation (IDNS, 1991a; Argonne National Laboratory, 1983). Most of the residential contamination, however, is from the use of tailings as fill, Kress Creek, and/or the West Branch of the DuPage River. Because airborne levels of nonradioactive airborne chemicals are unknown, exposure to them is a potential pathway. High lead concentrations may still exist in areas where remediation was incomplete or those which fell below the Kerr-McGee cleanup criterion of 30 microroentgens per hour. The potential for dust inhalation is highest where the ground is bare, while vegetational cover reduces dust production. Dirt tracked into a home can generate dust, which can be inhaled. The contribution of soil to indoor dust is likely variable and site-specific. Contaminated gardens may produce airborne chemicals upon soil disturbance, and alleys produce large amounts of dust. In an environmental chamber using soil from contaminated properties with up to 900 microroentgens per hour of gamma activity and 1726 picoCuries per gram of thorium-232, Argonne National Laboratory (1979) found that gardening activities (breaking up clumps of dirt with a trowel) and walking on bare soil under field moisture levels did not produce significant levels of airborne radionuclides. In addition, gloves on the hands of the gardener picked up negligible levels of radioactivity (Argonne National Laboratory, 1979). Nonradioactive compounds, however, were not examined. If chemicals enter the air, contaminants can be spread to a dwelling by dust or apparel. Historically, plant workers did not shower or change clothes at the facility and took clothes home for washing. This may have transferred chemicals on their clothing and bodies to their homes.

DERMAL CONTACT

Should the surface water of Kress Creek or the West Branch of the DuPage River or groundwater from private wells be found contaminated with chemicals of public health concern, dermal contact during general use of these waters is a potential exposure pathway. Children and anglers could be exposed to surface water, sediments, or soils along Kress Creek or the West Branch of the DuPage River. Although the surface water of the disposal ponds of the Kerr-McGee Facility is contaminated, exposure would be confined to remediation workers and trespassers. This warrants the use of protective equipment by remediation workers and actions to prevent trespassing.

In the future, people could be dermally exposed to contaminants in soil if homes are built on wastes in any of the six areas (no remediation).

INGESTION

While radionuclides were measured in vegetation near the Kerr-McGee Facility by Argonne National Laboratory (1978), background samples were not taken and it is unknown whether the analysis was on a wet or dry weight basis. Consequently, the data cannot be compared to other values given in the literature, and it is unknown whether radionuclide levels in vegetation are elevated. However, because of the low solubility and root uptake of thorium and lead, it is unlikely that this route would result in significant exposure (Charp, 1994). Contaminants, possibly including PCB's, may have accumulated in fish of Kress Creek and the West Branch of the DuPage River, which may be eaten.

Surface water of the Kerr-McGee Facility is contaminated. Trespassers could potentially ingest contaminated surface water, however, this is unlikely due to physical site restrictions, and the fact that few people would drink surface water. The water quality of Kress Creek and the West Branch of the DuPage River has not been adequately evaluated. Trespassers and remediation workers could ingest dust or soil. These potential exposure pathways warrant the use of protective equipment by remediation workers and actions to prevent trespassing.

At the Kerr-McGee Facility, many radioactive and nonradioactive chemicals exceeded comparison values in water of the glacial till and shallow dolomite aquifers. From the extensive reduction in general groundwater quality in private wells around the entire Kerr-McGee Facility (Butler, 1965), it is clear that (1) plant and waste storage activities have impacted the surrounding groundwater, and (2) hydraulic connections exist between the wastes and surrounding private wells. However, hydraulic connections between the glacial till and shallow dolomite aquifer and the wastes and private wells have not been well-investigated. To date, the chemicals found in private wells have been associated with the aesthetic qualities of water and are not of general health concern. The levels of possible chemicals of concern in private wells is largely unknown; consequently, the ingestion of contaminated groundwater is a potential pathway. Any such groundwater contamination is under IDNS jurisdiction.

People could ingest inhaled dust, particularly during remediation. Wetting of the soil during remediation, however, would reduce dust production.

PUBLIC HEALTH IMPLICATIONS

A. TOXICOLOGICAL EVALUATION

As described in the previous sections, contaminated media are present in and around the six areas of concern: the Kerr-McGee Facility, Reed-Keppler Park, the West Chicago Regional Wastewater Treatment Plant, Residential Areas, Kress Creek, and the West Branch of the DuPage River. Chemicals of concern include radioactive and nonradioactive compounds, and the many of the radioactive elements produce gamma radiation. The primary routes of human exposure are dermal absorption, inhalation, and ingestion of radionuclides and nonradioactive chemicals, as well as exposure to gamma radiation. Although many nonradioactive and radioactive compounds have been found in the six areas, only those discussed below were at high enough levels in air, groundwater, soil, or surface water to be of health concern. Around the Kerr-McGee Facility, chloride, hardness, and sulfate are elevated in groundwater of the shallow dolomite aquifer; however, they primarily affect the taste/aesthetic qualities of water, and are not of major health concern. Instead, these chemicals indicate hydraulic connections exist between the wastes and private wells, and contamination of private wells has occurred. Their presence also suggests chemicals of concern in groundwater at the Kerr-McGee Facility may have or possibly will affect private wells in the vicinity.

To evaluate potential health effects, estimated human exposure doses to site-related compounds have been compared with health effects information in cited references. ATSDR and USEPA have developed chemical-specific guidelines for evaluating the potential for adverse health effects from exposure to these chemicals in air, soil, and water.

ATSDR has developed Minimal Risk Levels (MRL's) to evaluate non-cancer health effects. A MRL is an estimate of the daily human exposure to a contaminant below which non-cancer, adverse health effects are unlikely. The exposure is expressed as milligrams of chemical per kilogram of body weight per day (mg/kg/day). MRL's are developed for oral and inhalation exposure routes for various exposure durations, such as acute (14 days or less), intermediate (15 to 365 days), and chronic (greater than 365 days).

An USEPA Reference Dose (RfD) for non-carcinogens is an estimate of lifetime daily exposure (mg/kg/day) to the general public that is unlikely to result in non-cancer deleterious health effects.

The USEPA has developed health advisories for exposure to non-carcinogens in drinking water for periods of one day, ten days, longer-term, and lifetime exposures.

The USEPA also evaluates the potential of a chemical or radiation to cause carcinogenic (cancer) effects by estimating the risk of developing cancer over a lifetime. The USEPA has estimated cancer slope factors (CSF's) for certain chemicals. These CSF's are estimates of the potency of a chemical to cause cancer and are used to estimate cancer risks from specific

exposure doses. These risk estimates, however, are extremely conservative and are meant to protect susceptible members of the public. There is a 95% probability the actual risk is no higher, it is probably lower, and it may be zero. Furthermore, cancer risk estimates are extrapolated to low doses from high dose animal or human (usually occupational exposure) studies. This approach is somewhat controversial. Some researchers believe body repair mechanisms can handle low doses, and that higher ones are needed to cause cancer. Some people also question the validity of high to low dose extrapolation. Until more information on carcinogenesis becomes available, the USEPA takes the conservative approach that there is no threshold and any exposure to a carcinogen carries a finite risk. If a chemical or radiation causes cancer, it generally occurs ten or more years after exposure.

Maximum Contaminant Levels (MCL's) are drinking water quality regulatory standards established by the USEPA for public water supplies to reduce the chances of adverse health effects from contaminated drinking water (considering the availability and economics of water treatment technology) over a lifetime (70 years).

It is difficult to determine what level of any soil, or hence, sediment, contaminant is of health concern because many factors affect the toxicity of chemicals in soil. These factors affect how tightly chemicals are absorbed to soil and include (1) clay content and type, (2) cation exchange capacity, (3) moisture level, (4) organic matter content, (5) pH, (6) soil particle size distribution, (7) temperature, and (8) the water and octanol solubilities of the compound of concern (Harris, 1972; Bailey and White, 1970; Harris, 1966). Chemicals which are tightly bound by soil are not easily absorbed by organisms, and this greatly reduces their toxicity. For example, for crickets, Harris (1966) found that soil organic matter had a large effect on insecticide activity. Heptachlor, diazinon, Memacide, DDT, and parathion were 209, 283, 546, 965, and 1132 times less toxic, respectively, in a muck soil with 64.4% organic matter than in quartz sand (Harris, 1966). This occurred because organic matter adsorbs compounds with low water solubility (e.g., many insecticides, PCBs), reducing their bioactivity. Soils with increased clay content and cation exchange capacity (increased primarily by clay and organic matter content) bind cations such as heavy metals and reduce their availability for uptake by organisms. In soils with high pH, most heavy metals are less soluble and less toxic. However, some metals are more soluble at high pH. In acidic soils (or the stomach), many heavy metals are more soluble and more toxic. Because of these effects, it is hard to evaluate possible health effects of contaminants in soils and sediments. While ATSDR has established comparison values and MRL's for soil, and CSF's can be applied to soil, they assume 100% absorption after ingestion. This is extremely unlikely, so these comparison values are very conservative. However, basing calculations on soil ingestion does not take dermal absorption into account, which may underestimate health risks.

The chemical-specific discussions which follow are limited to potential health effects that may occur at exposure levels similar to those found at the six Kerr-McGee areas. In this assessment, estimates of exposure doses via ingestion assume adults drink 2 liters of tap water per day and children drink 1 liter of tap water per day. For noncarcinogens, ingestion

assumptions for children were used because they ingest more liquid per body weight than adults, and thus receive a larger exposure dose. Inhalation of compounds which volatilize during showering and other water use activities is assumed equal to ingestion exposure. Estimates of exposure doses to chemicals in air and soil assume workers are exposed five days a week, eight hours per day, and residents are exposed seven days a week, 24 hours per day. The assumed soil ingestion rate for an adult is 0.1 milligrams per day, while that for a pica child is 5 grams per day.

1. RADIONUCLIDES AND GAMMA RADIATION

While the exact mechanisms of cell damage caused by alpha, beta, and gamma radiation is unknown, the damage can lead to cancers, as well as cell death (Hobbs and McClellan, 1986). Cell damage is the main health concern of low-level ionizing radiation, because cell death cannot cause cancer. Alpha, beta, and gamma radiation are called "ionizing radiation" because they interact with matter to produce ions, which can break chemical bonds. An alpha particle is a helium nucleus, consisting of two protons and two neutrons. It has great ionizing potential due to its double positive charge. However, the large size of alpha particles limits their tissue-penetrating ability. Most alpha particles cannot penetrate skin, and alpha emitters generally must be absorbed internally to damage tissue (Jensen, 1992; Hobbs and McClellan, 1986). Of the radionuclides in the thorium and uranium decay chains (Figure 7), all or most of the alpha particles from polonium-212 and polonium-214 have enough energy to penetrate skin. Beta particles are electrons which are emitted from the nuclei of some radioactive elements. Beta particles have a greater range and penetrating ability than alpha particles, but must less ionizing ability. Beta particles from some radionuclides have enough energy to penetrate skin, while others do not. Of the radionuclides in the Kerr-McGee wastes (Figure 7), all or most beta particles of actinium-228, bismuth-212, thallium-208, thorium-234, polonium-218 (but only 0.019% of the decay is beta), lead-214, bismuth-214, bismuth-210, thorium-231, lead-211, and thallium-207 have enough energy to penetrate skin. Gamma radiation is a high energy emission which has great skin/tissue penetrating ability, and it can pass through low-density materials without a great loss of energy (Hobbs and McClellan, 1986; Charp, 1992); however, it can be attenuated by thin layers of high-density material (Jensen, 1992). Nearly all of the radionuclides in the thorium and uranium decay series produce gamma radiation.

Chromosomal aberrations following radiation exposure have been observed in humans and animals. Depending upon the absorbed radiation dose and exposure duration, ionizing radiation can induce cancer. Cancers caused by radiation, however, cannot be distinguished from tumors which occur spontaneously. The different radionuclides tend to accumulate in different organs of the body, which influence the types of cancers that occur. Radiation-induced cancers in humans can occur in the blood-forming tissues, bone, liver, skin, thyroid, and other tissues. While animal data implicate ionizing radiation as carcinogenic and mutagenic at high doses, uncertainty exists regarding the carcinogenicity and mutagenicity potential at low doses. Like for chemical carcinogens, some researchers believe body repair

mechanisms can handle low doses of radiation, and that higher ones are needed to cause cancer. In general, the repair mechanisms for gene repair after radiation exposure work faster than those which function after damage from chemical carcinogens (Charp, 1994). Some people have even proposed that low doses of radiation may be stimulatory and beneficial (termed radiation hormesis), and only high doses are harmful (Hickey et al., 1983; Luckey, 1980); however, this view is extremely controversial. To be conservative, the USEPA assumes that any increased exposure to radiation elevates the cancer risk, and they have classified all radionuclides as known human carcinogens (Charp, 1993). While the USEPA has developed CSF's for estimating cancer risks from specific doses of radionuclides, these values were based on the BEIR III (1980) report. More recent evidence (BEIR V, 1990) indicates that for various cancers, BEIR III (1980) underestimated the cancer risks of continuous lifetime radiation exposure by 4.4 to 18.3 times. The USEPA is currently developing CSF's for individual radionuclides using BEIR V (1990) and any other new data.

RADIUM

All people are exposed to small quantities of radium which occur naturally in air, food, and water. Radium can be absorbed after inhalation or ingestion. There have been no studies of dermal absorption of radium, but it should not penetrate intact skin. Radium is chemically similar to calcium, and once ingested, absorbed, and systemically distributed; most of it is excreted; and that which remains is preferentially deposited in bone (Charp, 1991; ATSDR, 1989b). Radium-224 decays rapidly, but radium-226 remains longer in bone and is eliminated according to its biological half-life (Jensen, 1992; ATSDR, 1989b).

People exposed to radium have also been exposed to its decay products (radon and "daughters"). It is difficult to distinguish the health effects of the parent and daughter compounds. Radium is a known human carcinogen. After occupational exposure, human bone sarcomas have been induced by radium-226 and radium-228, and carcinomas of the mastoid and sinus cavities have been induced by radium-226. These cancers are thought to be produced by radon, a decay product of radium (ATSDR, 1989b).

The cumulative uptake of radium is a health concern relative to long-term, low-level exposure. Bone marrow effects have been observed in humans after radium ingestion. Eye effects have not been noted in humans or animals from inhalation, oral, or dermal exposures. However, eye effects in humans and animals have been noted after intravenous injection of radium. Information on other systemic effects is not available (ATSDR, 1989b).

RADON

All people are exposed to naturally-occurring radon, with exposure being highest indoors. Most of the available toxicological information on radon is for radon-222, and little is available regarding radon-220. Radon is a chemically inert, radioactive gas, and the primary exposure route is inhalation. However, it can also be absorbed after ingestion or through the

skin. The adverse health effects of radon-220 and radon-222 are caused by their short-lived decay products, which produce, among others, alpha particles. The half-lives of radon-222 daughters are short, and therefore, their alpha emissions decay in the lung before moving to other organs. Radon-220 affects lungs less adversely than radon-222. Radon-220, however, degrades into lead-212, which affects the lungs (ATSDR, 1989c). Lead-212 may also be transported from the lungs to other body organs, but the evidence is not definitive (Jensen, 1992). According to the International Commission on Radiological Protection, the impact of radon-220 on the lung is about one-third that of radon-222. The USEPA has advocated a value of forty percent (Jensen, 1993b).

Studies of uranium and other hard rock miners exposed to radon have shown elevated lung cancer incidence. However, the miners were also exposed to other known or suspected carcinogens, including other radionuclides, diesel exhaust, and silica. Consequently, it is uncertain whether radon alone was responsible for this increased cancer incidence (ATSDR, 1989c). In the examined homes with tailings around West Chicago, the measured concentrations of radon were much lower than those found in uranium mines. Cohen (1989) examined lung cancer rates in counties with high and low average radon levels (measured in 100 randomly selected homes) and found that lung cancer rates were unexpectedly lower in the "high radon" counties. However, radon levels were not measured in the homes of lung cancer cases. Radon levels are extremely variable between locations and can vary even between adjacent homes. Indoor concentrations are affected by the amount of radium in the soil, the ventilation rate of a building, and the duration of occupation. The study also did not examine moving, and looked at white females, which they regarded as more stationary and more likely to remain at home during the study years of 1950-9. Consequently, exposure levels are unknown, and it is uncertain whether the differences in lung cancer rates described in Cohen (1989) were from variations in radon exposure.

Greater frequencies of chronic, nonmalignant lung diseases have also been shown among miners. Human and animal studies implicate radon inhalation in non-neoplastic respiratory diseases such as emphysema, fibrosis, and pneumonia. These miners, however, were also exposed to other toxic agents, including diesel exhaust, ore dust, and silica. Consequently, it is unclear whether radon alone was responsible for the observed lung diseases. In animals, high level exposure is necessary for lung damage, and it is unclear to what extent low-level exposure causes non-neoplastic lung disease in humans. Animal studies suggest chronic high-level exposure may cause blood changes. No information exists regarding kidney or neurological effects on humans. Reproductive toxicity data are inconclusive. High level exposure damages genes in humans, but the animal exposure data are inconclusive and the implications for radon levels encountered in the environment are unclear (ATSDR, 1989c).

THORIUM

All people are exposed to small quantities of thorium which occur naturally in air, food, and water. Humans absorb only about 0.02 percent of ingested thorium, and inhalation accounts for 2/3 of the body burden of exposed workers. After absorption, thorium oxides and

hydroxides are retained by the body for years, while other thorium compounds remain in the body for weeks. The Kerr-McGee factory produced thorium nitrate (mostly for gas mantles and, later, the U.S. Government) and thorium oxide (for nuclear fuel and weapons material). Thorium is an alpha-emitting substance which tends to deposit in bone and also accumulates in the tracheobronchial lymph nodes. Different isotopes of thorium have different radioactive half-lives. Thorium-232 and thorium-230 are long-lived and emit alpha particles, while thorium-228 is a short-lived alpha emitter, and thorium-234 is a short-lived beta emitter. Very little data exist on the human health effects of thorium after inhalation, oral, or dermal exposure (ATSDR, 1989f). In New Jersey, Najem and Voyce (1990) found a slight increase in birth defects and liver disease in people near a thorium waste site. However, the small sample size and reliance on personal interviews rather than medical records decreases the confidence in these results. Other studies have found evidence of increased incidences of respiratory diseases, as well as blood forming tissue, lung, lymphatic, and pancreatic cancers in humans following inhalation exposure. Blood forming tissue and lymphatic cancers observed in two epidemiologic studies of uranium miners may have been caused by internally deposited thorium (ATSDR, 1989f). Increased pancreatic and lung cancer rates were shown in workers at the Kerr-McGee plant, but confounding factors may have been causative (see Health Outcome Evaluation section of this health assessment). Based on limited human data, thorium appears to be genotoxic (ATSDR, 1989f). The USEPA classifies all radionuclides as known human carcinogens. Hodgkin's disease is not associated with thorium exposure (Jensen, 1992).

Most of the human data on thorium derive from the effects of Thorotrast (colloidal thorium-232 dioxide) injections. Cirrhosis of the liver, liver tumors, and blood abnormalities have been observed in people injected with thorotrast. Liver cancer, however, has not been observed after inhalation or ingestion of thorium (ATSDR, 1989f).

Subchronic animal studies have found increased pneumocirrhosis and lung cancer following inhalation exposure (ATSDR, 1989f).

URANIUM

All people are exposed to small quantities of uranium which occur naturally in air, food, and water. Uranium can be absorbed after inhalation, ingestion, or skin contact. Uranium can pose chemical and radiological health hazards. It is hard to determine whether the inhalation of uranium can cause cancer in humans. While epidemiologic studies of uranium miners have found increased lung cancer rates, concurrent exposure to silica and other dusts, diesel exhaust, radon progeny, and tobacco smoke may have contributed to the cancer (ATSDR, 1989g). Furthermore, the miners were exposed to much higher levels of radionuclides than are present in the Kerr-McGee wastes. While two epidemiological studies found increased mortality from cancers of the lymphatic and blood forming tissues, this may have been from irradiation from thorium-230, a decay product of uranium-234. No human or animal studies have examined cancer following oral exposure to uranium. Intravenous injection of enriched

uranium can cause bone tumors in mice, and intratracheal administration in rats has been associated with bone, lung, or kidney tumors (ATSDR, 1989g).

The chemical hazard of uranium dominates over the radiological hazard, so the radiological limits for soluble uranium are based on its chemical toxicity (Jensen, 1992). Oral, inhalation, or dermal exposure of animals to uranium can cause kidney damage. In animals, oral, inhalation, and subcutaneous exposure to uranium are associated with minor liver effects. No human or animal studies have examined whether uranium has neurological or developmental effects (ATSDR, 1989g).

GAMMA RADIATION

All people are exposed to background levels of gamma radiation, which are produced by naturally-occurring radionuclides in the air, soil, and water. Cancers have occurred in humans who received radiotherapy, but these people were exposed to single or repeated short duration, high intensity x-ray or gamma radiation, which was also focused on certain parts of the body. X-rays have lower frequencies than gamma rays and usually also have less energy. Cancers observed in radiotherapy patients include leukemia and non-Hodgkin's lymphoma, as well as cancers of the brain and central nervous system, bladder, bone, breast, esophagus, kidney, lung, parathyroid, rectum, salivary glands, skin, and thyroid (BEIR V, 1990). Two studies using the same data base differed on whether radiotherapy can cause stomach cancer (BEIR V, 1990), so it is uncertain if external radiation exposure may cause it. Studies of colon cancer and multiple myeloma after radiotherapy have also given mixed results (BEIR V, 1990), so it is uncertain whether external radiation exposure may cause these cancers. Hodgkin's disease has not been associated with radiation exposure (BEIR V, 1990). Radiotherapy patients, however, are exposed to much higher doses than people exposed to the Kerr-McGee wastes. Consequently, it is uncertain whether any of the above cancers may occur at exposure rates found at any of the Kerr-McGee areas.

Some children treated with high doses of x-rays to the head have exhibited higher incidences of reduced IQ (ICRP, 1986). However, this occurred at much higher dose rates than found near the Kerr-McGee wastes. At much higher doses than those observed at Kerr-McGee, birth defects (primarily decreased mental development), cataracts, and sterility may occur in humans (BEIR V, 1990).

Some areas of the world, including much of the western United States, have higher levels of natural background radiation because the atmosphere is thinner, allowing more cosmic radiation (from space) to reach the ground. While some researchers have attributed lower cancer death rates in people living at higher elevations to a beneficial effect of radiation, the lower oxygen availability at greater altitudes stimulates many body function adaptations, which themselves may be protective and result in the lower cancer rates (BEIR V, 1990).

There are some areas of the world with elevated soil concentrations of some radionuclides, where the natural background radiation is two to six times higher than normal levels (normal

background about 120 millirems per year, not including radon; Charp, 1993; BEIR V, 1990). The three such areas described in BEIR (V) contain monazite sand, which was the main source of thorium and rare earth compounds at the Kerr-McGee Facility. Consequently, the naturally exposed people are exposed to the same radionuclides as any exposed to the Kerr-McGee tailings, although concentrations are different because of processing and dilution by clean soil. People in the three areas with elevated natural background radiation are also exposed to naturally elevated levels of radionuclides, so any observed health effects may be caused by external gamma radiation and/or radionuclides which enter the body. Because the total dose of radiation to people in these areas is low, and the lifetime accumulated dose of any one person is small, it is hard to determine whether (1) any disease rates are associated with elevated radiation exposure or (2) any observed variations in disease occurrence agree with health effects expected by extrapolation from observed effects of high dose and high dose rate exposures (e.g., radiotherapy). In three areas of elevated natural background radiation, an increased frequency of chromosome aberrations has been observed. The increases are consistent with those seen in people exposed to high dose levels, but the size of the increases was somewhat larger than expected. Increased cancer rates have not been observed in people living in areas with elevated natural background radiation (BEIR V, 1990).

2. INORGANIC COMPOUNDS

AMMONIA

Ammonia was found only in surface water (storm sewer discharge 1964 and 1974-6, Kress Creek downstream of the storm outfall, Disposal Pond 2 influent, and Disposal Ponds 2, 3, 4, and 5). Few people would ingest surface water, and direct contact is a more likely route of exposure. Little ammonia is absorbed through skin, so exposure to it has probably been negligible (past, present, and future).

ANTIMONY

Antimony exceeded its comparison value in ore tailings, the sludge pile, and sediments of Disposal Ponds 1 and 2 in the Kerr-McGee Disposal Area, as well as soil of Reed-Keppler Park and the East Area (may be mostly remediated) of the WTP. Antimony can be absorbed after ingestion or inhalation (ATSDR, 1990b). Ingestion of soil with the maximum level in ore tailings, the sludge pile, or sediments of Disposal Ponds 1 and 2 in the Kerr-McGee Disposal Area, as well as soil of Reed-Keppler Park or the East Area of the WTP would exceed the chronic R_fD for children, but not adults. Chronic antimony exposure may irritate the eyes, lungs, and skin, as well as cause diarrhea, heart problems, and vomiting (ATSDR, 1990b). However, these symptoms occurred at higher doses than possible from the soils and sediments with elevated antimony levels. While animals have contracted lung cancer after breathing antimony dust, there are no animal or human cancer studies after chronic ingestion of antimony (ATSDR, 1990b).

ARSENIC

Arsenic exceeded its comparison value in shallow and deep groundwater of the Kerr-McGee Disposal and Intermediate Areas, intermediate wells of the Kerr-McGee Disposal Area, shallow wells of the Kerr-McGee Factory Area, upgradient and downgradient monitoring wells at the WTP, and, for 1974-6, the storm discharge. In the Kerr-McGee Disposal Area, it also exceeded its comparison value in soil, ore tailings, the sludge pile, and sediments of Disposal Pond 2. Few people, however, would regularly drink surface water. Arsenic can be absorbed after inhalation or ingestion. Inhalation of arsenic increases the risk of lung cancer (ATSDR, 1991b). Most of the Kerr-McGee Facility is well-vegetated, but bare areas (e.g., dirt lanes and, in the past, parts of the Factory Area) may produce airborne dust. Oral exposure to arsenic has been linked to increased incidence of skin cancer in people (ATSDR, 1991b). The USEPA has developed a CSF for arsenic, which can be used to estimate the risk from consumption of specific doses. Lifetime consumption of water with the maximum arsenic concentration in shallow groundwater of the Kerr-McGee Disposal, Factory, and Intermediate Areas, intermediate groundwater of the Kerr-McGee Disposal Area, deep groundwater of the Kerr-McGee Disposal Area, and upgradient and downgradient shallow monitoring wells of the WTP would exceed the risk of drinking from a chlorinated public water supply and may pose an unacceptable health risk. These cancer risk estimates, however, are extremely conservative and may overestimate the actual risk. Ingestion of soil with the maximum arsenic concentration found in soil, ore tailings, the sludge pile, and Disposal Pond 2 sediments of the Kerr-McGee Disposal Area would not exceed the risk of drinking from a chlorinated public water supply. Consequently, it should not pose an unacceptable cancer risk.

The ingestion of water with the highest arsenic level in shallow or deep groundwater of the Intermediate Area would exceed the MRL for children, but not for adults. The ingestion of water with the highest concentration of arsenic in shallow groundwater at the Kerr-McGee Disposal and Factory Areas, upgradient and downgradient shallow monitoring wells at the WTP, and deep groundwater at the Kerr-McGee Disposal Area would exceed the chronic oral MRL for children or adults. Ingestion of sediments or soils with the highest arsenic concentration in soil, ore tailings, the sludge pile, and Disposal Pond 2 sediments of the Kerr-McGee Disposal Area, as well as Reed-Keppler Park soil would exceed the chronic oral MRL for a pica child, but not an adult. In the United States east of the 96th. Meridian, which includes Illinois, the average soil arsenic level is 4.8 parts per million (ppm), with a range of not-detectable to 73 ppm (Shacklette and Boerngen, 1984). In Illinois, soil arsenic levels are typically about 5 ppm (Kelty, 1983). Consequently, the concentrations of arsenic in all sampled soils and sediments (Table 3) were within regional background levels.

Ingestion of arsenic can cause areas of skin pigmentation (ATSDR, 1991b). In the body, arsenic is converted into methyl arsenic or dimethyl arsenic by enzymes, and these latter compounds are less toxic and more easily excreted. It is uncertain what intake of arsenic can be detoxified by this process, but limited data indicate the enzymes may begin to be saturated (i.e., cannot convert at a faster rate) at doses of 0.003 to 0.015 milligrams per kilogram per

day. Consequently, doses below 0.001 milligrams per kilogram per day are likely to pose little risk of noncancerous health effects (ATSDR, 1991b). Drinking water with the highest arsenic concentration in shallow groundwater of the Kerr-McGee Disposal and Factory Areas, and upgradient and downgradient WTP wells would exceed this level for both children and adults, while consumption of water with the highest level in intermediate wells of the Intermediate Area would exceed it only for children. For pica children, but not adults, ingestion of soil or sediments with the highest arsenic concentration in Kerr-McGee Disposal Area soil, Disposal Pond 2 sediments, or Reed-Keppler Park soil would exceed this level. It is unknown whether arsenic may reach private wells around the Kerr-McGee Facility at levels of concern.

BARIUM

Barium exceeded its comparison value in soil of the Kerr-McGee Disposal Area and Reed-Keppler Park, as well as that of the East Area (may be mostly remediated) and contaminated river bank at the WTP. It can be absorbed after inhalation or ingestion, and a small amount is absorbed after skin contact (ATSDR, 1990b). Ingestion of soil with the highest barium concentration in soil of the East Area (may be mostly remediated) contaminated river bank of the West Branch of the DuPage River at the WTP, the Kerr-McGee Disposal Area, and Reed-Keppler Park would exceed the chronic oral R_fD for a pica child, but not an adult. In the United States east of the 96th. Meridian, which includes Illinois, the average soil barium concentration is 290 ppm, with a range of 10 to 1500 ppm (Shacklette and Boerngen, 1984). In Illinois, soil barium levels are typically around 130 ppm (Kelty, 1983). Consequently, only the concentrations of barium in Kerr-McGee Disposal Area soil were above regional background levels.

Health effects seen in people exposed to barium include difficulty breathing, increased blood pressure, changes in heart rhythm, stomach irritation, minor changes in blood, muscle weakness, changes in nerve reflexes, swelling of the brain, and damage to the liver, kidney, heart, and spleen (ATSDR, 1990b).

BERYLLIUM

Beryllium exceeded its comparison value only in soil of the East Area of the WTP, and most of this soil may have been remediated, making only past exposure possible. Trespassing at the WTP and occupational exposure to soil in the East Area have probably been infrequent; consequently, past exposure to beryllium has probably been negligible. Furthermore, in soil of the United States east of the 96th. Meridian, which includes Illinois, the average beryllium concentration is 0.55 ppm, with a range of not detectable to 7 ppm (Shacklette and Boerngen, 1984). In Illinois, soil beryllium levels are typically about 1 ppm (Kelty, 1983). Consequently, the beryllium concentration in the East Area, 1 ppm, is within expected background levels.

BORON

Boron exceeded its comparison value in shallow groundwater of the Kerr-McGee Disposal and Factory Areas, the deep KM wells of the Kerr-McGee Disposal Area, and soil of the Kerr-McGee Disposal Area. Boron can be absorbed after inhalation or ingestion, as well as through abraded skin (ATSDR, 1990c).

Ingestion of water with the highest concentration of boron in shallow and deep wells of the Kerr-McGee Disposal Area and shallow wells of the Factory Area would exceed the intermediate MRL for children or adults. Ingestion of soil with the highest boron level in Kerr-McGee Disposal Area soil would exceed the intermediate MRL for a pica child, but not an adult. In the United States east of the 96th. Meridian, which includes Illinois, the average boron concentration is 31 ppm, with a range of not detectable to 150 ppm (Shacklette and Boerngen, 1984). In Illinois, soil boron levels are typically around 27 ppm (Kelty, 1983). Consequently, the boron levels in soil of the Kerr-McGee Disposal Area are greater than regional and state background concentrations.

The reproductive system is the most sensitive to boron. In dogs, mice, and rats, intermediate to chronic boron ingestion of higher levels than found in soil or groundwater at the Kerr-McGee Facility can damage the testes, but there is no information on possible reproductive effects in humans. Ingestion of higher levels can cause diarrhea, vomiting, liver changes, and neurological effects in animals and humans. It is unclear whether boron ingestion may cause kidney damage in infants. Exposure to boron dust in the workplace has been associated with eye and respiratory irritation (ATSDR, 1990c). It is unknown whether boron may reach private wells around the Kerr-McGee Facility at levels of concern.

CADMIUM

Cadmium was a chemical of concern in shallow groundwater of the Kerr-McGee Disposal and Factory Areas, deep groundwater of the Kerr-McGee Disposal and Intermediate Areas, downgradient monitoring wells at the WTP, and Reed-Keppler Park soil. Cadmium is readily absorbed after inhalation or ingestion, but little enters the body after skin contact. Once absorbed, it accumulates in the body, particularly in the kidney and liver. It can also bioaccumulate in fish, livestock, and plants (ATSDR, 1991c). Ingestion of water with the maximum detected concentration of cadmium in shallow wells of the Factory Area would exceed the chronic oral MRL for children and adults, while that in shallow groundwater of the Kerr-McGee Disposal Area, Intermediate Area, and downgradient wells of the WTP would exceed the MRL only for children. Ingestion of Reed-Keppler Park soil with the maximum cadmium concentration by a pica child or adult would not exceed the chronic oral MRL. In Illinois, soil cadmium levels are typically about 4 ppm (Kelty, 1983). Consequently, the cadmium concentrations found in Reed-Keppler Park soil were not above regional background levels.

Chronic exposure to low levels of cadmium can result in enough accumulation to cause toxic effects, including kidney damage, and possibly also anemia, endocrine alterations, high blood pressure, immunosuppression, and loss of smell. Cadmium exposure in pregnant women may result in lower birth weights, but birth defects have not been observed in humans (ATSDR, 1991c). It is not known whether cadmium may reach private wells around the Kerr-McGee Facility at levels of concern.

CHROMIUM

Chromium exceeded its comparison value in soil and the sludge pile of the Kerr-McGee Disposal Area, as well as sediments of Disposal Ponds 1 and 2, and soil of the East Area (may be mostly remediated) and river bank of the WTP. It was a chemical of concern in shallow groundwater of the Kerr-McGee Disposal and Factory Areas, deep groundwater at the Kerr-McGee Disposal Area, and the influent of Pond 2 during plant operations. The regular past ingestion of Pond 2 influent is not reasonable, so significant exposure to its chromium did not occur. Chromium can be absorbed after inhalation or ingestion. It occurs in several oxidative states, but only the hexavalent one has been associated with toxic effects. It is unknown whether any of the detected chromium was in this oxidation state; consequently, it is uncertain whether chromium in any of the areas poses a health risk to humans. After inhalation, hexavalent chromium can cause lung cancer, but there is no evidence it can cause cancer after ingestion or dermal exposure (ATSDR, 1991d). The Kerr-McGee Facility is mostly well-vegetated, but some bare areas (e.g., dirt lanes and, in the past, parts of the Factory Area) may produce airborne dust. Drinking water with the highest chromium concentration found in shallow groundwater of the Factory Area would exceed the R_fD for a child or adult, while ingestion of water with the highest level in shallow or deep groundwater of the Kerr-McGee Disposal Area would exceed the R_fD only for children. It is unknown whether chromium may reach downgradient private wells at levels of concern. Consumption of soil with the highest chromium level in the East Area (most may be remediated) and contaminated river bank of the West Branch of the DuPage River at the WTP, Kerr-McGee Disposal Area, as well as the sludge pile and sediments of Disposal Ponds 1 and 2 by a pica child, but not an adult, would exceed the chronic oral R_fD if the element is in the hexavalent state. In the United States east of the 96th. Meridian, which includes Illinois, the average chromium concentration is 33 ppm, with a range of 1 to 1000 ppm (Shacklette and Boerngen, 1984). In Illinois, soil chromium levels are typically about 19 ppm (Kelty, 1983). Consequently, the concentrations of chromium found the sampled sediments and soils (Tables 3 and 14) were not above regional background levels.

Chronic exposure to hexavalent chromium may cause skin dermatitis in sensitive people. While blood, cardiovascular, gastrointestinal, kidney, liver, and respiratory effects, as well as decreased weight gain (pregnant mice) have been seen in people or animals that ingested hexavalent chromium (ATSDR, 1991d), these effects occurred at higher doses than are possible from drinking water from monitoring wells of the Kerr-McGee Facility.

COPPER

This element exceeded its comparison value only in the influent of Disposal Pond #2 during plant operations. Past regular ingestion of this industrial wastewater is not reasonable, so significant exposure to copper did not occur.

FLUORIDE

While the plant was in operation, hydrogen fluoride was emitted. This stopped after thorium and rare earth production ceased. Workers and people around the plant were probably exposed to hydrogen fluoride, with workers having potentially higher exposures. Inhalation was probably the primary route of exposure, although workers may have had accidental eye and skin contact. Levels of hydrogen fluoride beyond the Kerr-McGee Facility boundary, as estimated by an unspecified model, were far below worker exposure limits and adjusted health-based levels of concern for the general public.

Fluoride was a chemical of concern in shallow groundwater of the Kerr-McGee Disposal, Factory, and Intermediate Areas, Intermediate groundwater of the Kerr-McGee Disposal Area, deep groundwater of the Kerr-McGee Disposal and Intermediate Areas, and downgradient shallow wells of the WTP. Ingestion of water with the highest fluoride level in shallow groundwater of the Kerr-McGee Disposal, Factory, and Intermediate Areas, intermediate wells of the Kerr-McGee Disposal Area, and deep wells of the Kerr-McGee Disposal and Intermediate Areas would exceed the MRL for children or adults, while consumption of water from downgradient wells of the WTP would exceed the MRL only for children. At low concentrations, fluoride is beneficial, however, higher levels may have harmful effects. Some children who drink water with more than 4 ppm of fluoride subsequently may have staining or mottling of new permanent teeth. These teeth tend to be more fragile and are at increased risk of cavities. Skeletal fluorosis can be caused by long-term ingestion of large amounts of fluoride, which makes bones brittle (Klaassen, 1986; Menzer and Nelson, 1986; Sittig, 1985). While the exact level of exposure which can cause this condition is not well-defined (Menzer and Nelson, 1986), the concentration of fluoride in the disposal ponds and some monitoring wells of the Kerr-McGee Facility are within the suspected range. Fluoride is not know to cause birth defects, affect reproduction in people or animals, or cause cancer in people. Regular ingestion of surface water is not likely, and it is unknown whether fluoride from the Kerr-McGee facility has reached or may affect private wells at levels of concern.

LEAD

Lead is elevated in soil, ore tailings, the sludge pile, and shallow and deep groundwater of the Kerr-McGee Disposal Area, as well as shallow groundwater of the Factory Area and soil at Reed-Keppler Park and the East Area of the WTP (much of the latter may be remediated). It is likely elevated in residential areas and possibly also along Kress Creek and the West Branch of the DuPage River. No minimum risk level has been established for lead.

Although lead is found naturally in soil, it is considered a no-threshold hazardous substance. Lead cannot be absorbed appreciably through intact skin, but it can be absorbed after inhalation or ingestion. After ingestion, lead absorption in children is about 50 percent, while only eight to 15 percent of it is absorbed by adults. Lead uptake is increased by fasting, fatty foods, or diets deficient in calcium, iron, selenium, or zinc. In the body, lead is mostly deposited in bone, where it is very persistent. After exposure is ended, it takes about 27 years for half of the bone lead to be eliminated from the body. Lead in the bones of mothers is liberated during pregnancy and lactation. It can readily pass the placenta, and because of its persistence in bone, fetal uptake can occur long after maternal exposure has ended. Infants and children up to two years of age retain about 34 percent of absorbed lead, while adults retain only one percent of it (ATSDR, 1991e).

Lead affects nearly every organ and system in the body, but is most detrimental to the blood forming, cardiovascular, and nervous systems. Evidence suggests that the kidney and immune systems are also affected. Children are more susceptible to the harmful effects of lead than adults. Symptoms observed in children after prenatal or postnatal exposure include cognitive deficit (decreased IQ), decreased growth, reduced birth weight, and reduced hearing. There seems to be no threshold below which lead does not affect IQ or hearing, and the neurological effects seem to be permanent (ATSDR, 1991e; Needleman et al., 1990). It is not known if lead may reach private wells around the Kerr-McGee Facility at levels of concern.

MANGANESE

Manganese exceeded its comparison value in (1) shallow groundwater of the Kerr-McGee Disposal, Factory and Intermediate Areas, (2) intermediate groundwater of the Kerr-McGee Disposal Area, (3) deep groundwater of the Kerr-McGee Disposal and Intermediate Areas, (4) upgradient and downgradient shallow groundwater at the WTP, (5) soil of the Kerr-McGee Disposal Area and Reed-Keppler Park, (6) soil of the East Area (may be mostly remediated) and river bank of the WTP, and (7) surface water of the storm discharge. Manganese can be absorbed after ingestion or inhalation. Only about 3 to 5% of ingested manganese is absorbed, but the amount absorbed after inhalation is unknown (ATSDR, 1990d). Consumption of water with the highest manganese level in shallow groundwater of the Kerr-McGee Disposal, Intermediate, and Factory Areas, intermediate groundwater of the Kerr-McGee Disposal Area, deep groundwater of the Kerr-McGee Disposal and Intermediate Areas, and shallow groundwater in upgradient and downgradient monitoring wells of the WTP would exceed the chronic oral R_fD for children or adults. Daily ingestion of surface water is unlikely. Ingestion of soil with the highest concentration of manganese in soil from the East Area (may mostly be remediated) and contaminated river bank of the WTP and the Kerr-McGee Disposal Area would exceed the chronic oral R_fD for a pica child, but not an adult. In the United States east of the 96th. Meridian, which includes Illinois, the average soil manganese level is 260 ppm, with a range of non-detectable to 7000 ppm (Shacklette and Boerngen, 1984). In Illinois, soil manganese levels are typically around 510 ppm (Kelty, 1983). Consequently, the manganese concentrations found in soil of the Kerr-McGee

Disposal Area, Reed-Keppler Park, and the WTP (Tables 3 and 14) were not above regional background levels.

There is controversial evidence that elevated manganese levels similar to those found in the sampled media listed above may be able to cause brain damage, with symptoms such as weakness, stiff muscles, and trembling of the hands. However, other chemicals may have been involved, and it is uncertain whether manganese was the cause (ATSDR, 1990d). It is not known whether manganese may reach private wells at levels of concern.

MERCURY

Mercury was a chemical of concern in shallow groundwater of the Kerr-McGee Facility, and it was also found in soil, ore tailings, the sludge pile, Disposal Ponds 1 and 2 sediments at the Kerr-McGee Disposal Area, and air of Bolles Opera House. It can enter the body after inhalation, but little is absorbed after ingestion or skin contact. Long-term exposure to inorganic or organic mercury can cause permanent damage to the brain, kidneys, or developing fetus. Low-level exposure to mercury vapors can cause damage to the kidneys and nervous system. Nervous system effects include tremors which initially affect the hands, as well as decreases in motor function, excessive shyness, and insomnia (ATSDR, 1992a). Consumption of water with the maximum mercury level in shallow groundwater of the Kerr-McGee Disposal Area would not exceed the R_fD for inorganic or organic mercury for children or adults. Ingestion of the sampled sediments or soils by a pica child or adult would not exceed the MRL for inorganic or organic mercury. Airborne mercury levels in Bolles Opera House were generally below the Occupational Health and Safety Administration (OSHA) standard, 50 micrograms per cubic meter, but they exceeded the Centers for Disease Control guideline for residential use by children, 0.3 micrograms per cubic meter. Residential use of the building is unlikely.

NICKEL

Nickel was a chemical of concern in shallow groundwater of the Kerr-McGee Disposal and Factory areas, deep groundwater of the Kerr-McGee Disposal Area, and surface water from the storm discharge. Regular ingestion of surface water is unlikely. Nickel can be absorbed after ingestion or inhalation, and a small amount can be absorbed after skin contact. Most ingested nickel is not absorbed, but is eliminated in the feces. After absorption, most nickel is transported to the kidneys and is eliminated in the urine (ATSDR, 1991f). Ingestion of water with the highest concentration in shallow groundwater of the Factory Area would exceed the R_fD for a child or adult, while shallow or deep groundwater of the Kerr-McGee Disposal Area would exceed the R_fD only for children. There is no CSF for this chemical. Lung and nasal cancer have been observed after occupational exposure (ATSDR, 1991f); however, these people were exposed to much higher levels than are likely from drinking water from the Kerr-McGee Facility. In two mouse studies, nickel did not cause cancer after oral exposure, and there is no information about cancer in people after oral exposure. Oral exposure to levels of nickel similar to those in Kerr-McGee Facility groundwater can cause

allergy. Sensitized individuals then exhibit skin dermatitis after being dermally exposed to nickel (ATSDR, 1991f). It is not known whether nickel may reach private wells around the Kerr-McGee Facility at levels of concern.

NITRATE

Nitrate exceeded the USEPA MCL in shallow monitoring wells, Disposal Pond 2 influent, and Disposal Pond 2 of the Kerr-McGee Facility, the Bowling Green Pond and its effluent, the storm outfall discharge, Kress Creek downstream of the storm outfall, and upgradient and downgradient shallow monitoring wells at the WTP. Nitrates did not exceed the MCL in residential wells. Only the ingestion of nitrates is of human health concern, and regular ingestion of surface water is unlikely. In the body, nitrates are converted into nitrites, which are responsible for the adverse health effects seen after nitrate consumption. Children less than four months of age fed formula diluted with nitrate containing water are particularly susceptible to nitrate, which can cause symptomatic methemoglobinemia ("blue baby syndrome") at levels above the MCL. In severe cases, cardiac arrhythmias, low blood pressure, and shock may occur, as well as instances of metabolic acidosis (Sittig, 1985). Infants would be at risk if levels in residential wells reach those of the Kerr-McGee Facility shallow monitoring wells.

SELENIUM

Selenium exceeded its comparison value in shallow monitoring wells of the Kerr-McGee Disposal Area, as well as shallow upgradient and downgradient groundwater of the WTP. It can be absorbed after inhalation or ingestion (ATSDR, 1989d). Ingestion of water with the maximum selenium concentration in upgradient and downgradient shallow wells of the WTP would exceed the intermediate MRL for children or adults, while consumption of water from shallow wells of the Kerr-McGee Disposal Area would exceed the intermediate MRL only for children. Because selenium was found in upgradient WTP wells and at higher concentrations than in wells of the Kerr-McGee Facility, elevated selenium levels were probably not related to the tailings or past thorium processing. The most sensitive effects of excess selenium in humans are excessive tooth decay and discoloration, hair loss, nail deformation and loss, and skin discoloration. Other health effects in animals or humans were observed at higher doses than possible from ingestion of groundwater from the Kerr-McGee Facility or WTP (ATSDR, 1989d). There is controversial evidence that low selenium intake may be associated with some types of cancer (Van't Veer et al., 1990; Hunter et al., 1990).

SILVER

Silver exceeded its comparison value only in soil of the Kerr-McGee Disposal Area. It can be absorbed after ingestion, inhalation, or skin contact (ATSDR, 1989e). Ingestion of soil with the highest silver concentration in the Kerr-McGee Disposal Area would equal the chronic oral R_fD for a pica child, but not an adult. Long-term exposure to silver may cause gray or blue-gray skin discoloration in people, but the required dose is uncertain. Other

health effects of silver (ATSDR, 1989e) occurred only at levels higher than possible from exposure at the Kerr-McGee Disposal Area.

THALLIUM

Thallium exceeded its comparison value in shallow groundwater of the Kerr-McGee Disposal and Factory Areas. It was also found in soil of the Kerr-McGee Disposal Area. It is readily absorbed after ingestion and can also be absorbed after inhalation or skin contact. Once absorbed, it is mainly transported to the liver and kidneys. About half of the absorbed thallium is eliminated from the body in 3 days. There are no data on health effects in humans or animals following long-term exposure to low levels of thallium (ATSDR, 1990e), and there is no MRL, R_fD, or CSF for this element. The most sensitive effect observed in animals was that offspring of rats given 0.08 milligrams per kilogram per day exhibited lower learning ability (ATSDR, 1990e). Exposure of pregnant women to groundwater or soil, however, would be at lower levels. There have been no studies of learning ability in children following maternal thallium consumption during pregnancy (ATSDR, 1990e).

VANADIUM

Vanadium exceeded its comparison value in shallow groundwater of the Factory Area, shallow upgradient and downgradient wells of the WTP, soil of the Kerr-McGee Disposal Area, and soil of the East Area (most may be remediated) and river bank of the WTP. In the United States east of the 96th. Meridian, which includes Illinois, the average soil vanadium concentration is 43 ppm, with a range of not detectable to 300 ppm (Shacklette and Boerngen, 1984). In Illinois, soil vanadium levels are typically about 130 ppm (Kelty, 1983). Consequently, the vanadium concentrations found in all sampled soils (Tables 3 and 14) were not above regional background levels.

Vanadium is poorly absorbed after ingestion, and some is absorbed after inhalation (ATSDR, 1990f). Consumption of water with the highest concentration of vanadium in shallow upgradient and downgradient WTP wells, and shallow wells of the Factory Area would exceed the intermediate oral MRL for children and adults. Ingestion of soil with the highest vanadium level in the East Area (most may be remediated) or contaminated river bank of the WTP, as well as the Kerr-McGee Disposal Area would exceed the intermediate oral MRL for a pica child, but not an adult. This MRL was derived using safety factors to extrapolate from a rat study to humans. In the rat study, mild kidney effects (increased plasma urea and mild cell changes) were observed after intermediate duration oral intakes of vanadium. Similar exposures also caused some vascular infiltration in the lung. In animals, slightly higher intakes have caused decreased weight gain (intermediate exposure), reduced pup weight and length, and lung changes (chronic exposure; ATSDR, 1990f). It is unknown whether vanadium may reach private wells at levels of concern.

ZINC

Zinc exceeded its comparison value in shallow wells of the Kerr-McGee Disposal and Factory Areas. It can be absorbed after inhalation or ingestion, but little is absorbed after skin contact (ATSDR, 1992b). Drinking water with the highest level found in shallow wells of the Kerr-McGee Disposal Area would exceed the chronic oral R_fD for children, but not adults.

In people, drinking water with the maximum zinc level found in shallow groundwater of the Kerr-McGee Disposal Area may cause anemia (possibly caused by gastrointestinal bleeding), gastrointestinal effects (abdominal cramps, diarrhea, intestinal bleeding, nausea, and vomiting), impaired immune and inflammatory responses, and reduced levels of high density lipoprotein cholesterol (ATSDR, 1992b). It is unknown whether zinc may reach private wells around the Kerr-McGee Facility at levels of concern.

3. ORGANIC COMPOUNDS

PHENOL

Phenol exceeded its comparison value only in shallow upgradient and downgradient groundwater at the WTP. Because it was found in upgradient wells, it is evidently not related to the tailings. Ingestion of water with the highest concentration found in these wells would exceed the MRL for children or adults. Phenol can be absorbed after inhalation, ingestion, or skin contact. Most absorbed phenol leaves the body within 24 hours. People who ingested phenol-contaminated water for six to eight weeks experienced diarrhea, mouth sores, and irritation, but the exposure doses were uncertain. Other noncancerous effects have been observed only at much higher doses than possible from drinking groundwater at the WTP. Phenol may be able to cause mutations, but cancer studies with animals have been inconsistent and do not provide sufficient evidence to classify phenol as a carcinogen (ATSDR, 1989a).

POLYCHLORINATED BIPHENYLS (PCBs)

In the past, PCBs were found in soil of the Kerr-McGee Facility, and this soil was removed. However, additional PCB-contaminated soil may exist at the Kerr-McGee Facility. PCBs were not found in the East Area of the WTP, but it is unknown whether PCBs are present in the other contaminated areas.

PCBs can enter the body after inhalation, ingestion, or skin contact, but the degree of absorption for each route is unknown. Once absorbed, PCBs tend to accumulate in fat. They can concentrate in human breast milk, and they can cross the placenta and enter the fetus. While dermal exposure to PCBs can cause chloracne, this has been observed only in

occupational studies at high concentrations (ATSDR, 1991g), and is not likely at soil levels found at the Kerr-McGee Facility.

In animal studies, PCBs can affect the liver through enlargement, fat deposition, and necrosis (cell death). At low concentrations, these effects are reversible upon removal from exposure. PCBs can depress the immunological system; decrease hormonal production by the pituitary gland; affect the gastrointestinal lining and function; cause kidney damage; and cause disturbances of reproduction, growth, and development. Induction of enzymes which metabolize foreign compounds can occur at levels lower than those that cause other health effects, with the liver enzymes being the most sensitive. This effect is also apparently reversible. There is insufficient evidence for any of these potential effects in humans (ATSDR, 1991g).

For animals, there is limited evidence PCBs can cause liver cancer. While epidemiological studies have not shown a consistent link with cancer in humans, the USEPA considers PCBs probable human carcinogens (ATSDR, 1991g). Worker exposure to PCB contaminated soils is estimated to cause a low to moderate increased risk of cancer. Incidental exposure by trespassers and others gaining access to contaminated areas is estimated to cause insignificant or no increased risk of cancer.

B. HEALTH OUTCOME DATA

WORKERS AT THE KERR-MCGEE FACILITY

Polednak et al. (1983) examined mortality in workers of the Kerr-McGee Facility. Because company records before 1940 were incomplete, only people employed in 1940 or later were used. The study was further limited to 3,039 men whose hiring date, social security number, and year of birth were known. Death certificates, follow-up, and Social Security Administration records were used to determine deaths from different causes, and their frequencies were compared to those of U.S. white males.

The present status (alive or dead) and cause of death was known for only 93 percent of the 3,039 workers. To be conservative, workers were presumed alive unless death could be established. When this was done, for all workers combined, the only significantly elevated cause of death was motor vehicle accidents. For seven percent of the workers, their status (alive or dead) could not be verified. If it is assumed that the proportion who died from each cause was the same for these as for the other workers, then the standardized mortality ratio {= (number observed)/(number expected)} for diseases of the circulatory and respiratory systems, lung cancer, and pancreatic cancer would be elevated (Polednak et al., 1983).

Polednak et al. (1983) also examined mortality in two subsets of the workers, those first employed in 1940-54 and 1955-69. Exposures were presumably lower after 1956, when the plant came under AEC regulation. The standardized mortality ratio for overall mortality and

some cancers were higher in the 1955-69 group than in the 1940-54 one, which was the opposite of what was expected. In the 1955-69 group, the standardized mortality ratio for all causes, all cancer, digestive cancer, and pancreatic cancer were significantly elevated. In the 1940-54 group, only motor vehicle accident deaths were significantly elevated. For lung cancer, the standardized mortality ratio for the 1940-54 group was lower than that of the 1955-69 one. This occurred in spite of the fact that radionuclide exposures were probably greater for the earlier group. Furthermore, three of the 10 lung cancer deaths in the 1955-69 group occurred within five years of first employment, and seven of the 10 occurred within 10 years after hiring. Polednak et al. (1983) cite other references which indicate thorium processing was not likely the cause for lung cancers which occurred such a short time after hiring. Furthermore, smoking was elevated in surviving workers, which may have caused part of the observed excess mortality.

Polednak et al. (1983) concluded that based on other studies the elevated pancreatic cancer levels may or may not have been occupationally related. Smoking, radiation exposure, and other occupational exposures such as alumina, fluorides, hydrocarbons, and sulfur dioxide may have contributed to the problem. Based on these studies, they concluded the possible role of hydrofluoric acid, sulfuric acid, and rare earth compounds in causing pancreatic cancer needs to be studied (Polednak et al., 1983). However, because of their reactivity and buffering systems within the body, the two acids would be neutralized long before they reached the pancreas. This leaves the hypothesis that rare earth exposure may be associated with pancreatic cancer. However, as previously discussed, smoking may have also been involved.

The Polednak et al. (1983) study used cancer data for U.S. white males for the control group because few workers were black. While West Chicago now has a large Hispanic population, their influx is a relatively recent phenomenon, probably beginning in the 1980's. Consequently, it is likely few plant workers were Hispanic (Jensen, 1992). However, one problem with using data for U.S. white males for controls is that the general population includes people who are too sick to work. The result is that workers are often healthier than the general population, and this phenomenon has been called the "healthy worker effect." The consequence is that actual health effects in exposed workers may not be discernible from the background rates of the general population. For the control group, it would have been better to use workers with no occupational chemical exposure.

CANCER INCIDENCE IN WEST CHICAGO

In 1990, in response to a request by a newspaper reporter, the Division of Epidemiologic Studies, IDPH, performed a cancer incidence study in West Chicago. For 1985-87, all cases of cancer in zip code 60185 recorded by the Illinois State Cancer Registry (ISCR) were grouped by age, sex, and tumor site. These data were then compared to expected numbers for an area with the same population age, race, sex, and size composition. Males had

significantly more overall cancer, as well as significantly elevated incidences of colon cancer, lung cancer, and melanomas. In females, no cancers were significantly elevated.

Smoking is strongly associated with lung cancer. The ISCR has recorded smoking history since 1986, and for the 18 cases of lung cancer in West Chicago in 1986-7, 13 of the people had smoking histories. Three of them had never smoked, and the smoking history of the other two is unknown (IDPH, 1990). Furthermore, for the three nonsmokers, possible exposure to secondary smoke at home or work is unknown. Secondary smoke is classified as a known human carcinogen by the USEPA and has been linked to lung cancer in nonsmokers. West Chicago is primarily a blue-collar community, and smoking is generally more common among people with lower incomes than in those with higher ones. This may help explain the observed elevated lung cancer incidence.

IDPH (1990) stated that colon cancer may be linked to a high fat and/or low fiber diet, and that it is also associated with workers in the construction, leather, metal, textile, and yarn industries. They also stated that the most important risk factor for melanoma is exposure to sunlight.

IDPH (1990) commented on some statistical aspects of this study. First, because there were at least 44 statistical tests, two or three results may appear statistically significant because of random fluctuations in the data. Second, they commented on the power of their testing. A test with more statistical power is more sensitive and has a higher probability of detecting a real difference. In this study, the probability of detecting a significant increase was high for overall cancer and cancer by sex, as well as male lung and colon cancer, and female breast cancer.

By grouping exposed and unexposed people in West Chicago together, the procedure used in this study may have masked any real differences.

In a follow-up study (IDPH, 1991), the Division of Epidemiologic Studies included cancer data for 1988 and also compared cancer occurrences to known tailing locations. The study included cancer cases reported to the ISCR, as well as cases diagnosed or treated in Iowa, Michigan, Missouri, or Wisconsin. These data were considered 94 percent complete. All cancer cases were grouped by age, sex, and tumor site. The cancer rates were then compared to the expected numbers for a population of similar size, as well as age and sex composition.

For all cancer cases combined, the observed cancer rates were significantly higher than expected for both sexes. In males, the rates for only colorectal cancer and melanoma were significantly elevated, while in females, only lung cancer was significantly higher than expected. Of these lung cancer cases, smoking histories are available for 14 of them, and 13 of these people were smokers. None of the 19 women worked in industries associated with increased cancer risk. Again, colorectal cancer may be associated with diet, and the risk of melanoma is markedly increased by exposure to the sun (IDPH, 1991).

Cancer cases were plotted on a map with contaminated areas if the number of observed cases was significantly higher than that expected or the type(s) of cancer(s) has a known or suspected association with thorium exposure. Melanomas, colorectal, and lung cancer cases were plotted because they were significantly elevated. Cancers of the bone, liver, and pancreas were also plotted because they have been associated with thorium exposure. For each of these types of cancer, there was no association with the waste tailings (IDPH, 1991).

Again, IDPH (1991) pointed out that because there were at least 44 tests for significance, two or three results might appear statistically significant even though the difference was due to random fluctuations in the data. In 1990, they found lung cancer was significantly elevated only in men (IDPH, 1990), while in 1991 they found it was significantly elevated only in women (IDPH, 1991). This suggests that the observed differences may have been due to random fluctuations in the data. In the IDPH (1991) study, the power to detect a significant increase in the cancer rate was high for the total cancer for each sex, as well as cancer of the breast, cervix, colorectum, lung, and prostate. Again, because of the long latent period for most cancers, current cases do not reflect recent exposure. This is a serious problem for cancer studies because the population of this country is so mobile. For this reason, any follow-up study should use cancer data for people who lived near tailings at least 10 years before their diagnosis. It should also take into account that West Chicago is primarily a blue-collar community. Although it currently has a considerable Hispanic population, this influx of Hispanics began in the 1980's. In addition, airborne exposure to nonradioactive contaminants around the Kerr-McGee Facility during the years of plant operation are unknown, and may have complicated the above studies, as well as any future ones.

C. COMMUNITY HEALTH CONCERNS EVALUATION

The community is concerned about their risk of cancer from exposure to radioactive wastes of the Kerr-McGee Facility and around their community, radioactive contamination in groundwater, and direct radiation from the Kerr-McGee Facility. They are particularly concerned should the waste remain in a storage cell at the Kerr-McGee Facility. This concern also included inquiries from prospective home buyers about the safety of living in a house in West Chicago because of this radioactive contamination. Although it is not possible to say with certainty what health effects will or will not occur from the past, present, or future exposure to contaminated media in West Chicago, the Toxicological Evaluation section discusses the known effects based on animal studies and some limited human health effects information. A number of the contaminants exceeded health guidelines and as a mixture are of public health concern for chronic exposure. The radioactive half-life of thorium-232 is about 14 billion years, and lead does not decompose, so they will remain hazardous essentially forever.

People within 300 to 400 feet of the Kerr-McGee Facility may be exposed to gamma shine from the area. For other people in and around West Chicago, only those near contamination

in the other areas would be exposed to contaminants. Exposure to gamma radiation, as well as radionuclides and potentially high lead levels in surficial contamination of residential areas (including along Kress Creek and the West Branch of the DuPage River) is of particular concern. In the past, however, greater exposure to airborne radionuclides and lead around the Kerr-McGee Facility likely occurred.

CONCLUSIONS

On the basis of the information reviewed, the IDPH has concluded that the Kerr-McGee Facility, Residential Areas, Reed-Keppler Park, the West Chicago Regional Wastewater Treatment Plant (WTP), Kress Creek, and the West Branch of the DuPage River are a public health hazard because of the risk to human health resulting from past, present, and/or potential future exposure to radioactive and nonradioactive substances at concentrations that may result in adverse health effects. As noted in the previous sections, exposure to contaminants in and around these areas may have occurred via any combination of: inhalation of contaminated dust and gases; the ingestion of polluted dust, food, groundwater, sediment, soil, and surface water; and dermal exposure to contaminated dust, gases, soil, and surface water. Any properly remediated properties, however, should not cause increased health risks from excessive radiation exposure. Contaminants of concern include radon, radium, thorium, uranium, antimony, arsenic, barium, boron, cadmium, fluoride, lead, manganese, nickel, nitrate, selenium, silver, vanadium, zinc, and possibly chromium and polychlorinated biphenyls (PCBs). Many of the radioactive elements in the wastes emit gamma radiation.

People in homes and businesses adjacent to the Kerr-McGee Facility, homes in contaminated residential areas, and visitors to Kress Creek and the West Branch of the DuPage River may be exposed to elevated levels of gamma radiation. Surface contamination is likely present in some areas, although this has not been well-investigated. Children may be exposed to radionuclides, gamma radiation, lead, and other contaminants in residential properties and along Kress Creek and the West Branch of the DuPage River. While gamma radiation exposure along Kress Creek and the West Branch of the DuPage River during recreational use would probably be negligible, it may add to that from residential areas. In residential areas, the highest gamma radiation exposure would occur if tailings are present along foundations or under houses (e.g., in crawlspaces). Lead contaminated media is of particular concern in areas frequented by children. The radioactive half-life of thorium-232 is about 14 billion years, and lead does not decompose, so the wastes will remain hazardous essentially forever. In the distant future, the greatest health hazard would occur if someone builds houses or other structures on the Kerr-McGee Facility or fenced spoil area of Reed-Keppler Park (no remediation). Any such buildings would probably have elevated indoor radon and gamma radiation levels, and their yards would likely have high soil concentrations of lead and radionuclides, as well as elevated gamma radiation. Home building on contamination at the Wastewater Treatment Plant or the banks of Kress Creek or the West Branch of the DuPage River are unlikely, but would raise similar concerns.

Exposures to airborne contaminants were certainly higher when the plant was still operating; however, the available data are too limited to fully assess the situation. Exposures were probably highest for plant workers, and the levels were probable high enough to increase the risk of adverse health effects as described in the Public Health Implications section of this report. Workers may have also increased the risk of their families if they took their clothes home to launder and did not shower before going home.

The greatest current risk of airborne and exposure is for people in houses with tailings along their foundations or basements. These buildings may be at increased risk of elevated radon-220 and radon-222 levels. However, excessive exposure probably occurs in only homes with the highest thorium concentrations. At this time, airborne exposure to radionuclides around the Kerr-McGee Facility is generally negligible. While radon-220 concentrations can become elevated around it, this is not a general occurrence and is of little health concern. However, remediation activities may greatly increase airborne emissions of radon and contaminated dust. This warrants measures to reduce these emissions. Elevated gamma radiation levels exist on and around the Kerr-McGee Facility. As previously noted, surficial radioactivity and elevated airborne radon levels in Reed-Keppler Park are restricted to the fenced area, while ambient long-lived radionuclides are at background levels. While some areas of elevated gamma radiation occur outside of the fence, it is unlikely that people are exposed to them for long periods. However, in the future, erosion or excavation could expose wastes buried outside of the fenced area, so this could change. Other areas have potentially negligible airborne exposure.

The community is concerned about increased cancer risks from exposure to the radioactive wastes of the Kerr-McGee Facility and around their community, radioactive contamination of groundwater, and direct radiation from the Kerr-McGee Facility. Contrary to the beliefs of some people in West Chicago, the radioactivity in the public water supply of the City comes from naturally occurring radium in the deep Ironton-Galesville Formation, and not from the Kerr-McGee wastes. While it is natural, it could add to other types of radioactive exposure and thus contribute to the problem.

Although the evaluated health outcome data indicated increases in certain cancers in the community and plant workers, these studies could not establish that the Kerr-McGee wastes were the cause. However, these studies had several previously discussed problems, which could be addressed in a follow-up study.

RECOMMENDATIONS

* Action should be taken to reduce public exposure in residential areas which still have tailings, including properties along Kress Creek and the West Branch of the DuPage River. Highest priority should be given to homes with tailings adjacent to their foundations or under them (e.g., in crawlspaces). If no permanent solution is available, interim measures should be taken.

* The hydrogeology of the Kerr-McGee Facility, Reed-Keppler Park, the West Chicago Regional Wastewater Treatment Plant (WTP), Kress Creek, and the West Branch of the DuPage River should be investigated to assess the actual or potential contamination of private wells.

* The leachability of the wastes at the Kerr-McGee Facility, Reed-Keppler Park, and the WTP should be further assessed.

* The presence, use, and water quality of private wells near the Kerr-McGee Facility, Reed-Keppler Park, and the WTP should be examined.

* The water quality of Kress Creek and the West Branch of the DuPage River should be assessed. Additional sampling of the West Branch of the DuPage River should be undertaken to define the extent and nature of radioactive and nonradioactive contamination of sediments and soils in and along the river.

* The concentrations of chemicals in filets of fish from Kress Creek and the West Branch of the DuPage River should be determined.

* The nature and concentrations of nonradioactive airborne contaminants, especially lead, in and around the Kerr-McGee Facility, Reed-Keppler Park, and the WTP should be examined.

* The presence and concentration of PCBs and other nonradioactive compounds in the sediment and soils of Kress Creek and the West Branch of the DuPage River should be assessed. Because contamination is variable in these areas, they should be surveyed prior to remediation. The possibility that radioactive and nonradioactive contaminants have affected downstream properties in Warrenville and Naperville should be investigated.

* The contribution of present runoff from the Kerr-McGee Facility to the contamination of the sediments, adjacent soils, and water of Kress Creek and the West Branch of the DuPage River should be investigated.

* The nature and extent of radioactive and nonradioactive contamination of the storm sewers in the Kerr-McGee Facility and residential areas should be determined.

* Surface and subsurface contamination by radionuclides, lead, and other non-radioactive contamination in residential yards in and around West Chicago, the Kerr-McGee Facility, the WTP, Kress Creek, and the West Branch of the DuPage River should be investigated. Because nonradioactive and radioactive contaminant levels are not necessarily correlated, cleanup objectives should include all contaminants of concern.

* Radon levels should be measured in all houses with tailings next to their foundations, and follow-up radon measurements should be performed after remediation, including the 11 houses originally tested.

* In the various environmental media, the presence and concentrations of other chemicals used by the Lindsay Light and Chemical Company, American Potash and Chemical Corporation, and/or Kerr-McGee should be assessed, including PCBs, lead, benzene, toluene, and xylene.

* During remediation, the dispersal of airborne radon and contaminated dust should be minimized. Computer modelling should be employed to estimate the dispersal of airborne contaminants which occurred during plant operation.

HEALTH ACTIVITIES RECOMMENDATION PANEL (HARP) STATEMENT

In accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended, the six Kerr-McGee areas have been evaluated for appropriate follow-up with respect to health activities. Kerr-McGee workers and members of the public have been exposed to contaminants from the areas. Action should be taken to reduce public exposure in residential areas which still have tailings, including properties along Kress Creek and the West Branch of the DuPage River. If no permanent solution is available, interim measures should be taken. The results of the epidemiologic studies of workers and people in yards with tailings showed no conclusive relationship between radiation exposure and types of cancer which may be caused by radioactive materials. If the completed Remedial Investigation suggests exposure to hazardous substances has occurred at levels which may cause adverse health effects, IDPH, in conjunction with ATSDR, will reevaluate these six areas for any indicated follow-up.

As part of the ATSDR Physician Education Cooperative Agreement, IDPH will inform area health professionals of the public health implications associated with these six areas and others in the vicinity.

Further environmental characterization and sampling of the six areas during the RI/FSs should be designed to address the environmental and human exposure pathways discussed above. When additional information and data become available, e.g., the completed RI/FSs, such material will form the basis for further assessment by IDPH or ATSDR.

PUBLIC HEALTH ACTIONS

Based on the recommendations made in the health assessment, the following public health actions have been or will be undertaken:

1. As part of the ATSDR Physician Education Cooperative Agreement, IDPH will inform area health professionals of the public health implications associated with the Kerr-McGee areas and other sites in the vicinity.

2. In the upcoming USEPA Remedial Investigation, the nature and extent of contamination in the four NPL areas (Reed-Keppler Park, WTP, Residential Areas, and Kress Creek + West Branch of the DuPage River) will be investigated. In addition, the adequacy of past removal activities will be evaluated.

3. IDPH and ATSDR will coordinate with the environmental agencies to carry out the recommendations made in this health assessment.

4. IDPH and ATSDR will reevaluate and expand the Public Health Action Plan when needed. New environmental, toxicological, or health outcome data, or the results of implementing the above proposed actions and recommendations may determine the need for additional actions at this site.

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CERTIFICATION

The Kerr McGee Radiation Areas Public Health Assessment was prepared by the Illinois Department of Public Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the public health assessment was begun.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health assessment, and concurs with its findings.

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FIGURES

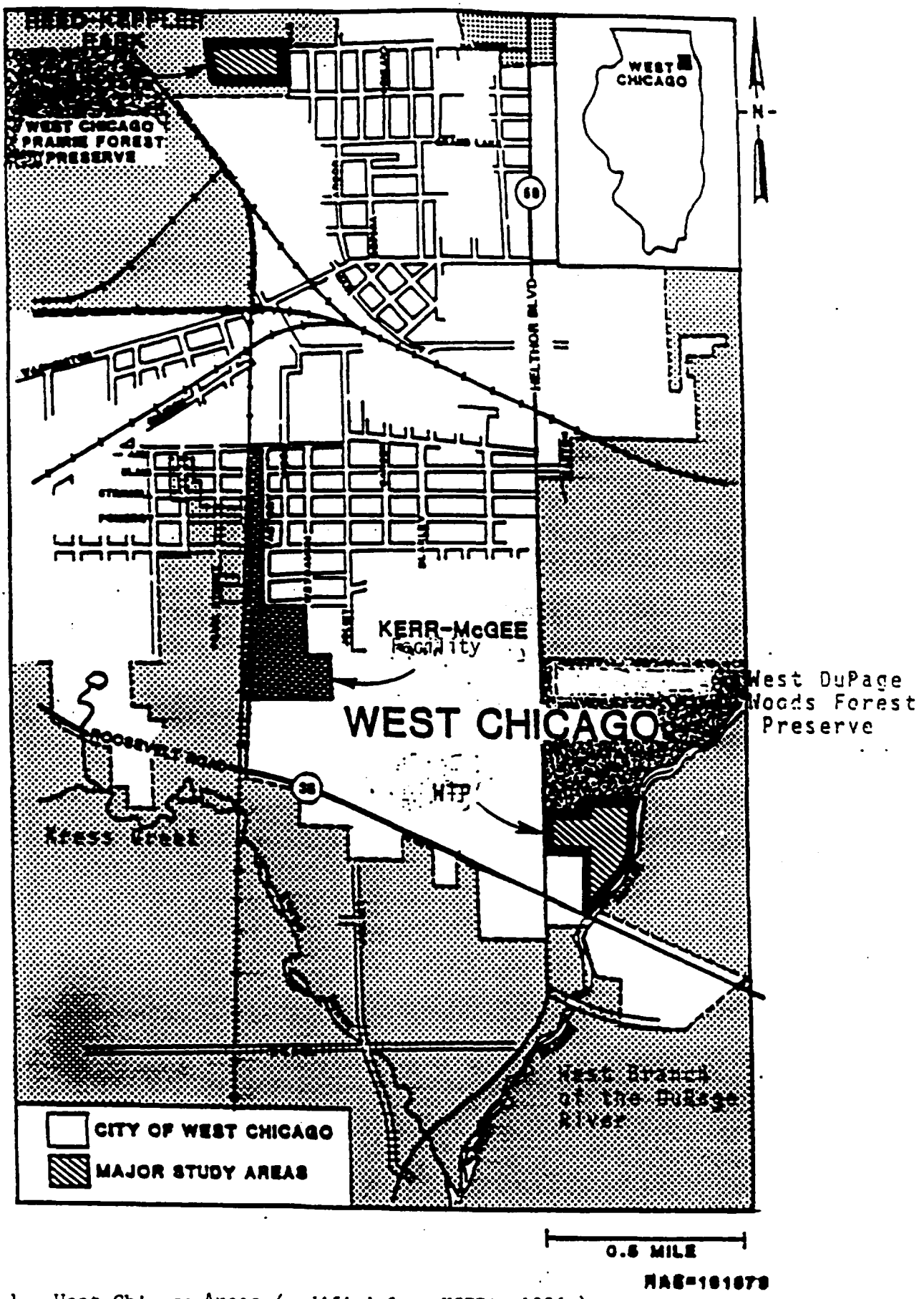


FIGURE 1. West Chicago Areas (modified from USEPA, 1986a).

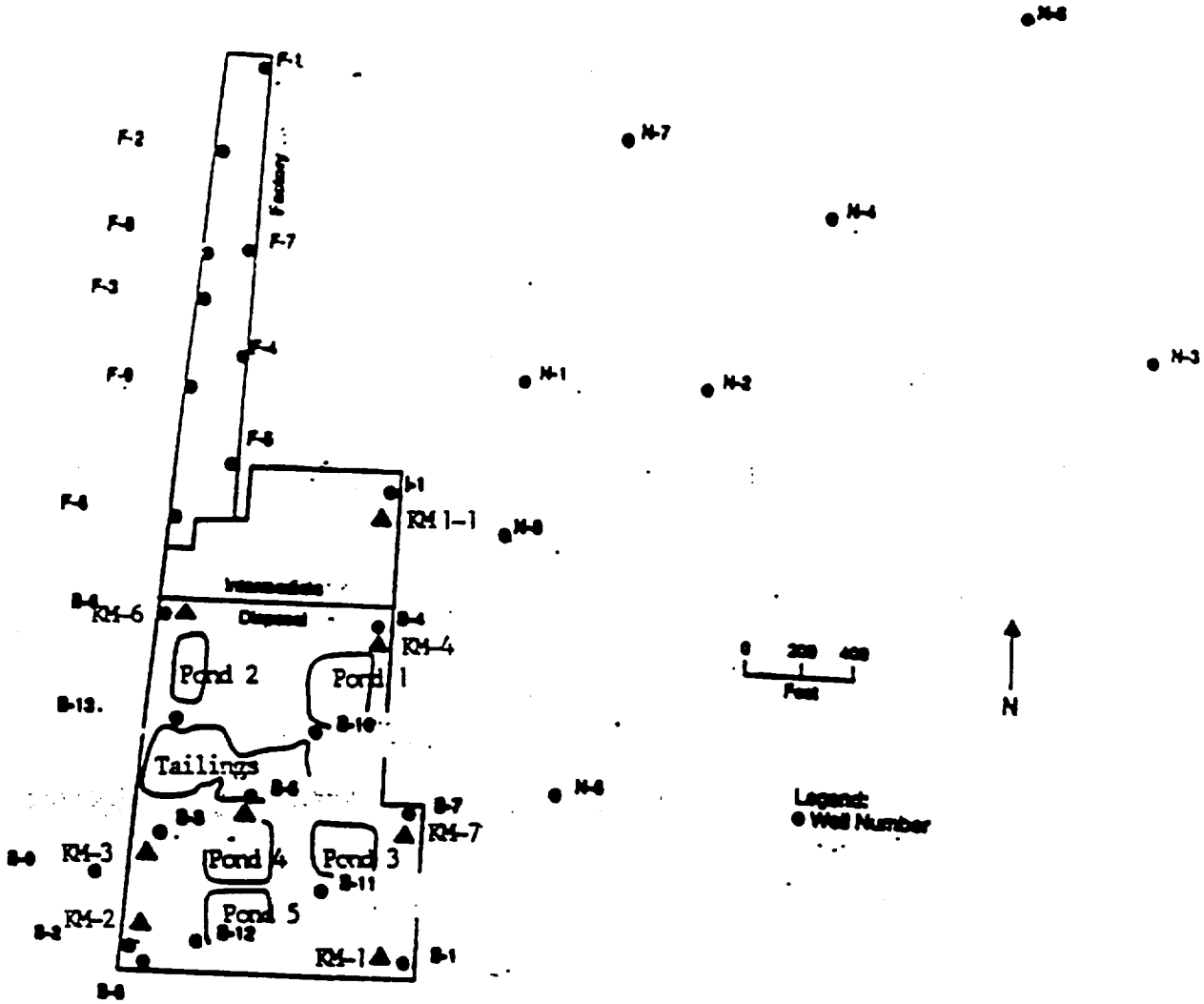


FIGURE 2. Locations of Wells on the Kerr-McGee Facility and N wells (NRC, 1989a).

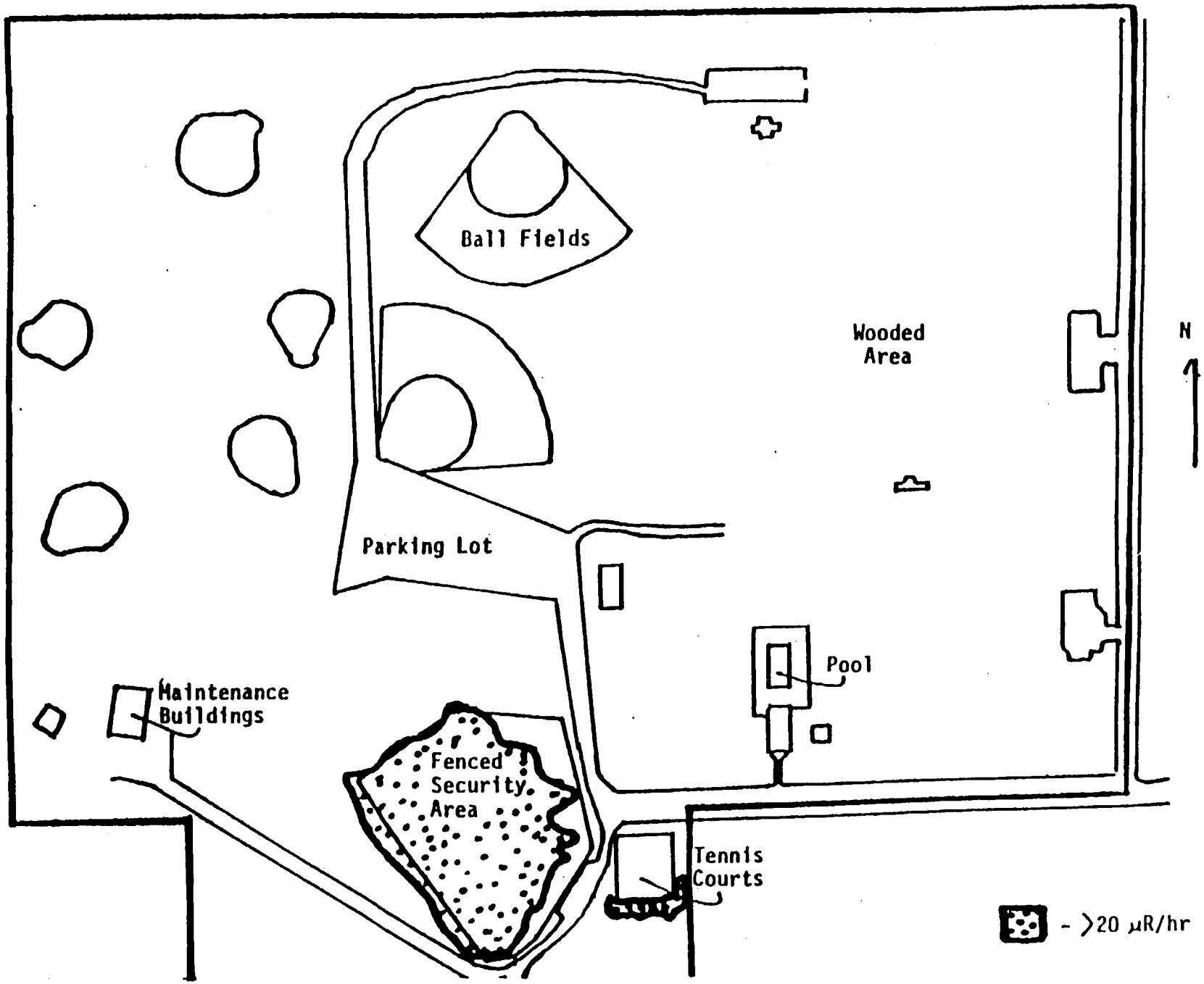


Fig. 3 Locations within Reed-Keppler Park which exceed 20 μR/hr. (Booth et al., 1982)

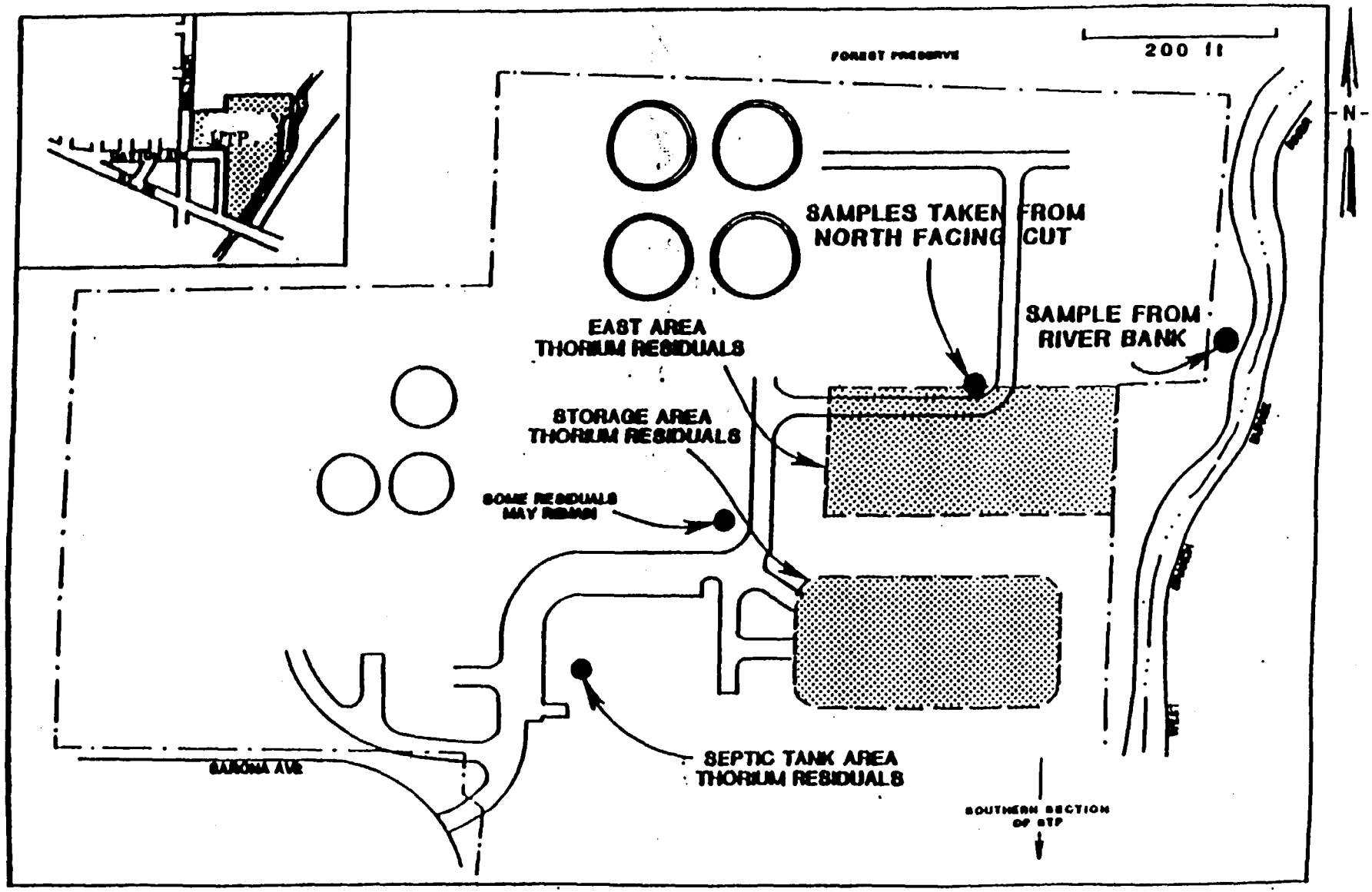


FIGURE 4. West Chicago Regional Wastewater Treatment Plant (USEPA, 1986a).

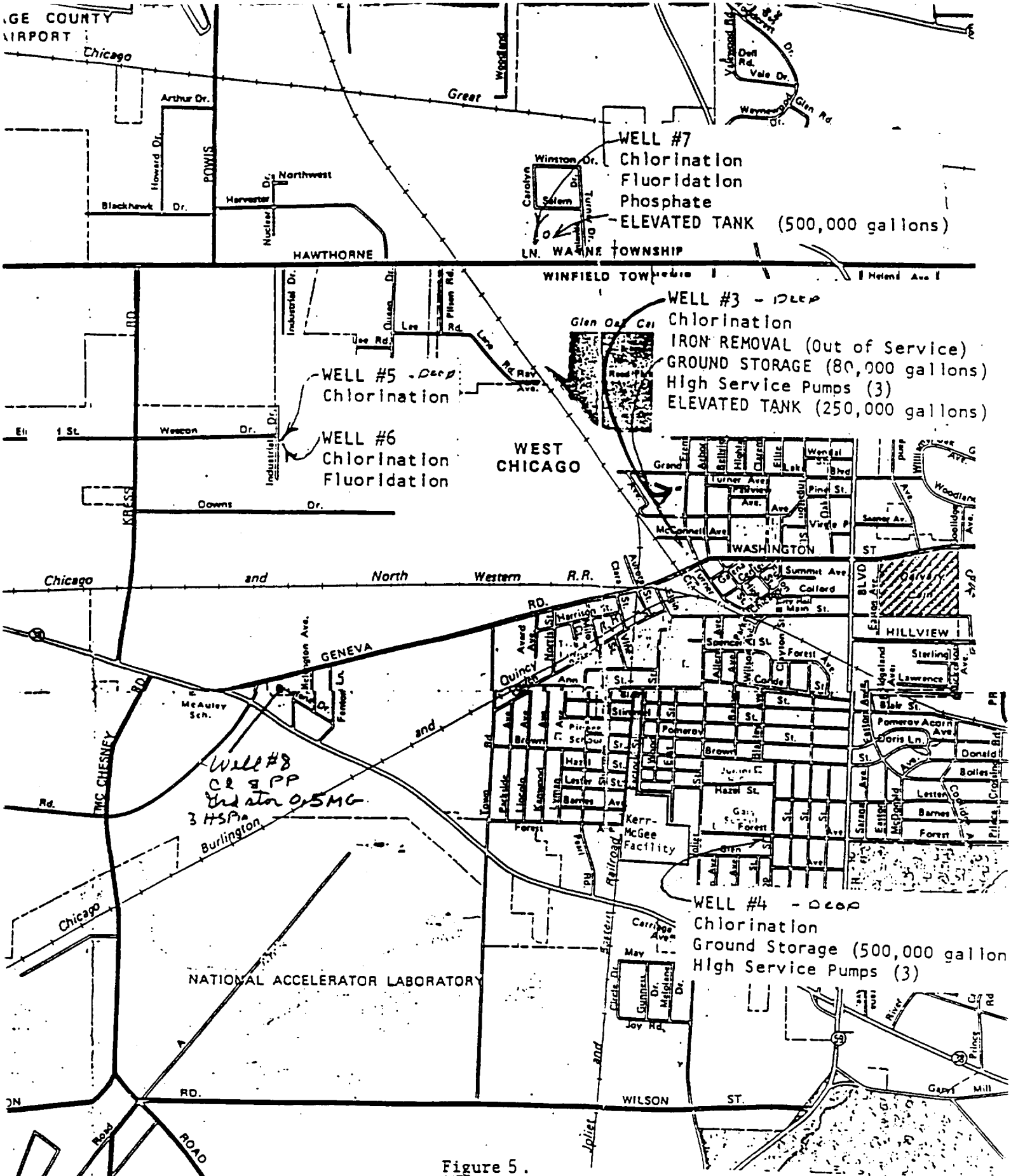


Figure 5.
WEST CHICAGO COMMUNITY WATER SUPPLY

DuPAGE COUNTY, ILLINOIS (IEPA Well and Public Water Supply Files, 1990).

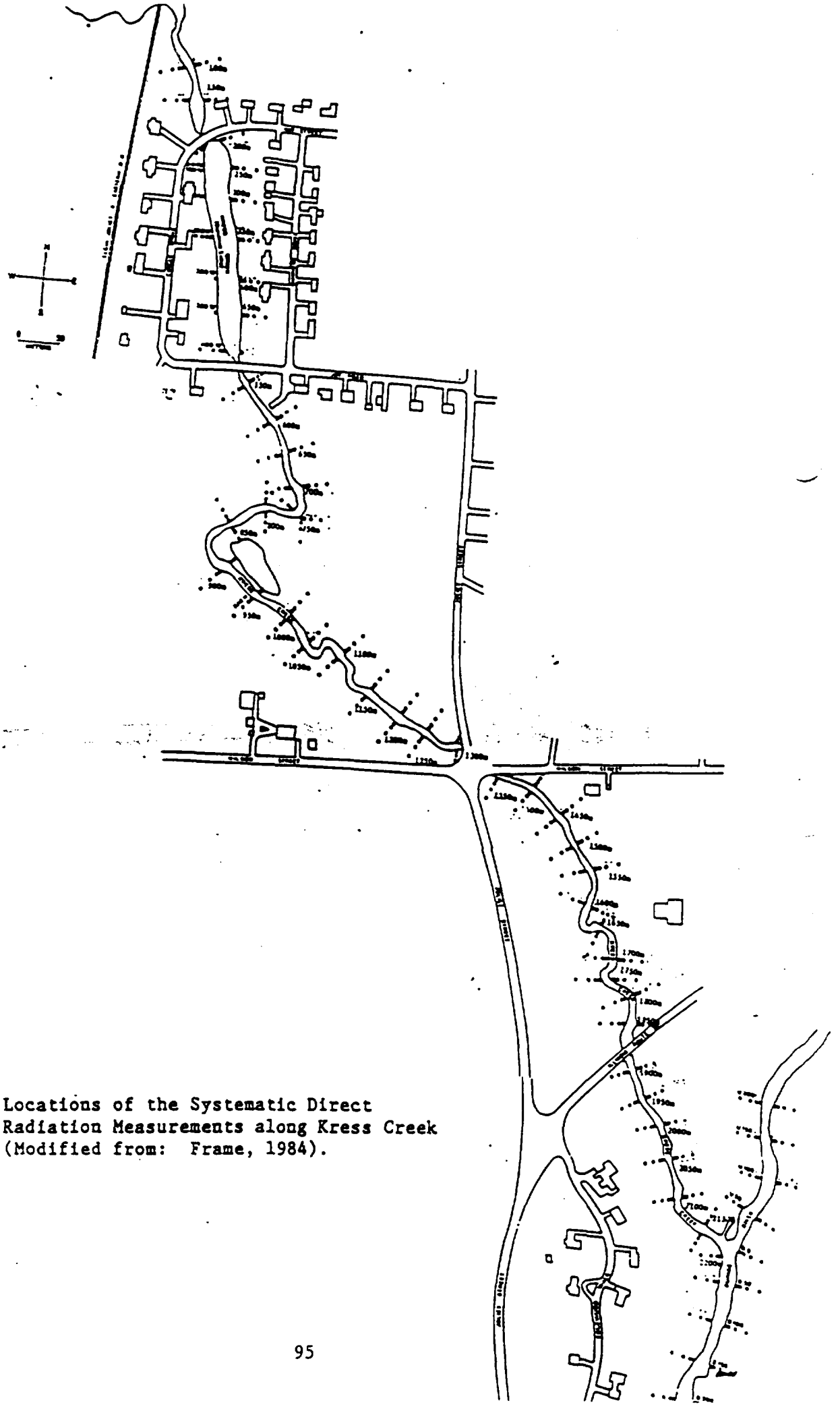


FIGURE 5. Locations of the Systematic Direct Radiation Measurements along Kress Creek (Modified from: Frame, 1984).

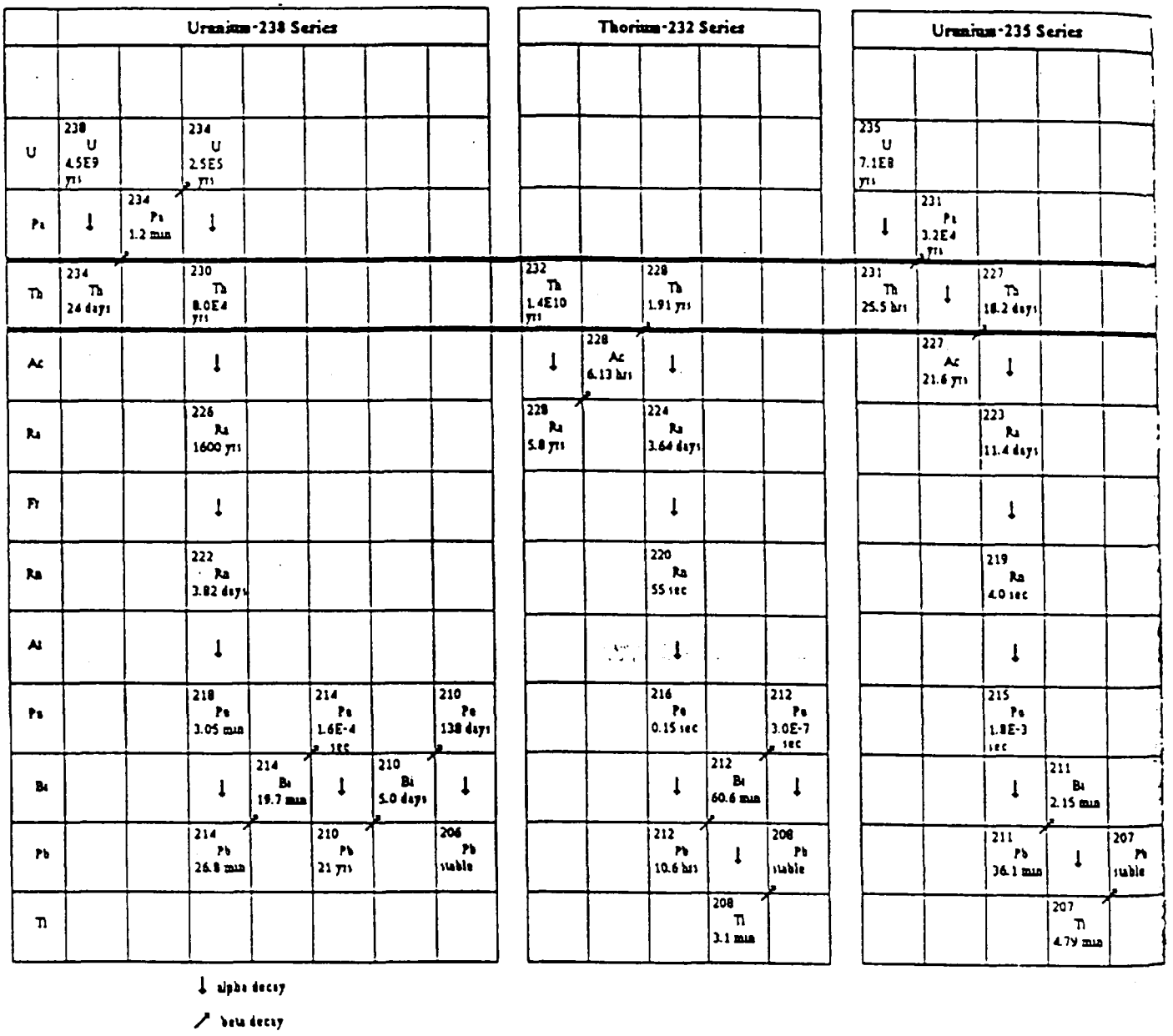
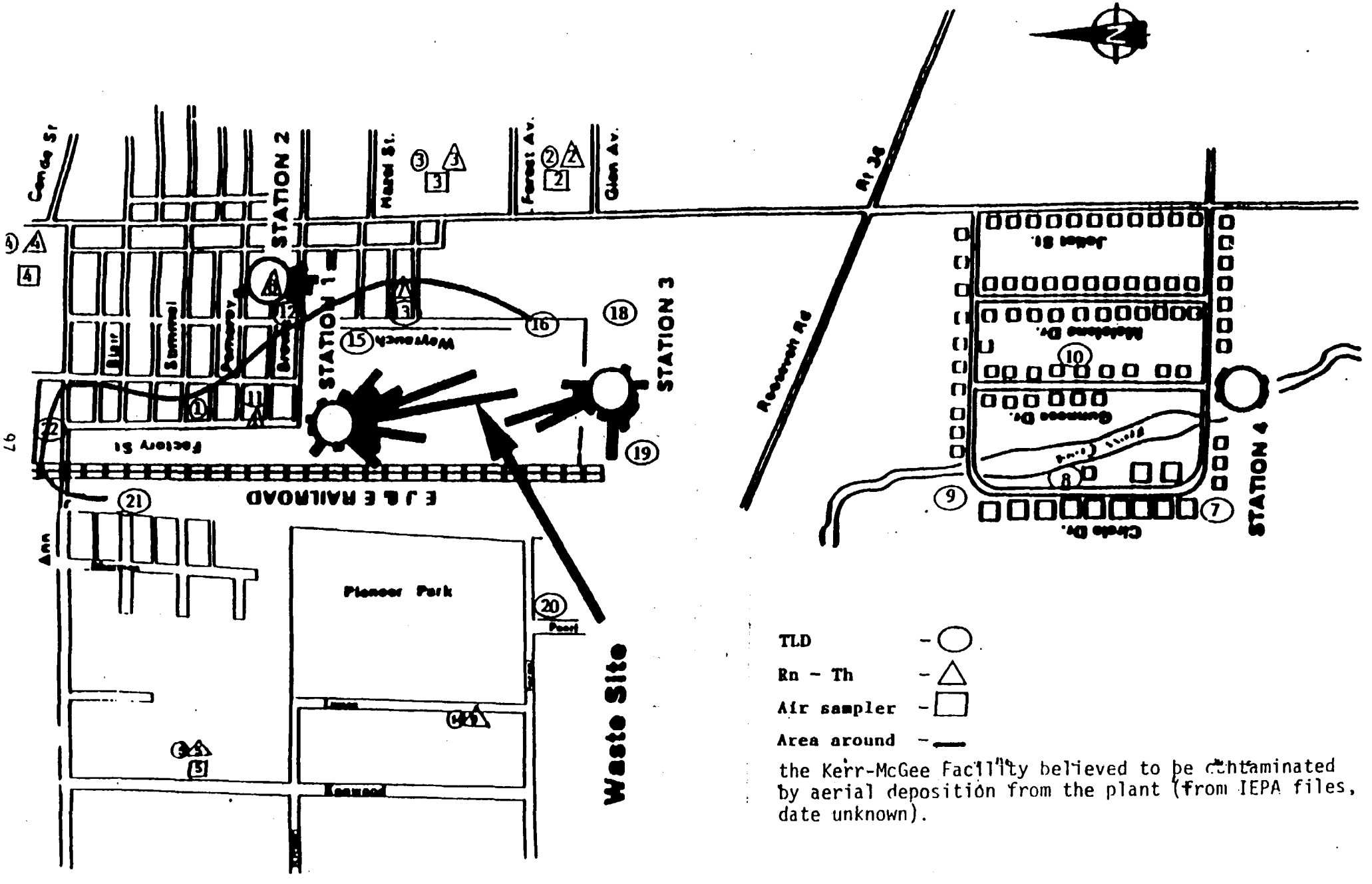


FIGURE 7. Uranium and Thorium Isotope Decay Series Showing the Sources and Decay Products of the Two Naturally-Occurring Isotopes of Thorium (ATSDR, 1989c).

Ac = Actinium
At = Astatine
Bi = Bismuth
Fr = Francium
Pa = Proactinium
Po = Polonium
Tl = Thallium

FIGURE 8. Air Monitoring Stations and Pollution Roses Around the Kerr-McGee Facility (Jensen et al., 1982; IDNS files, 1990).



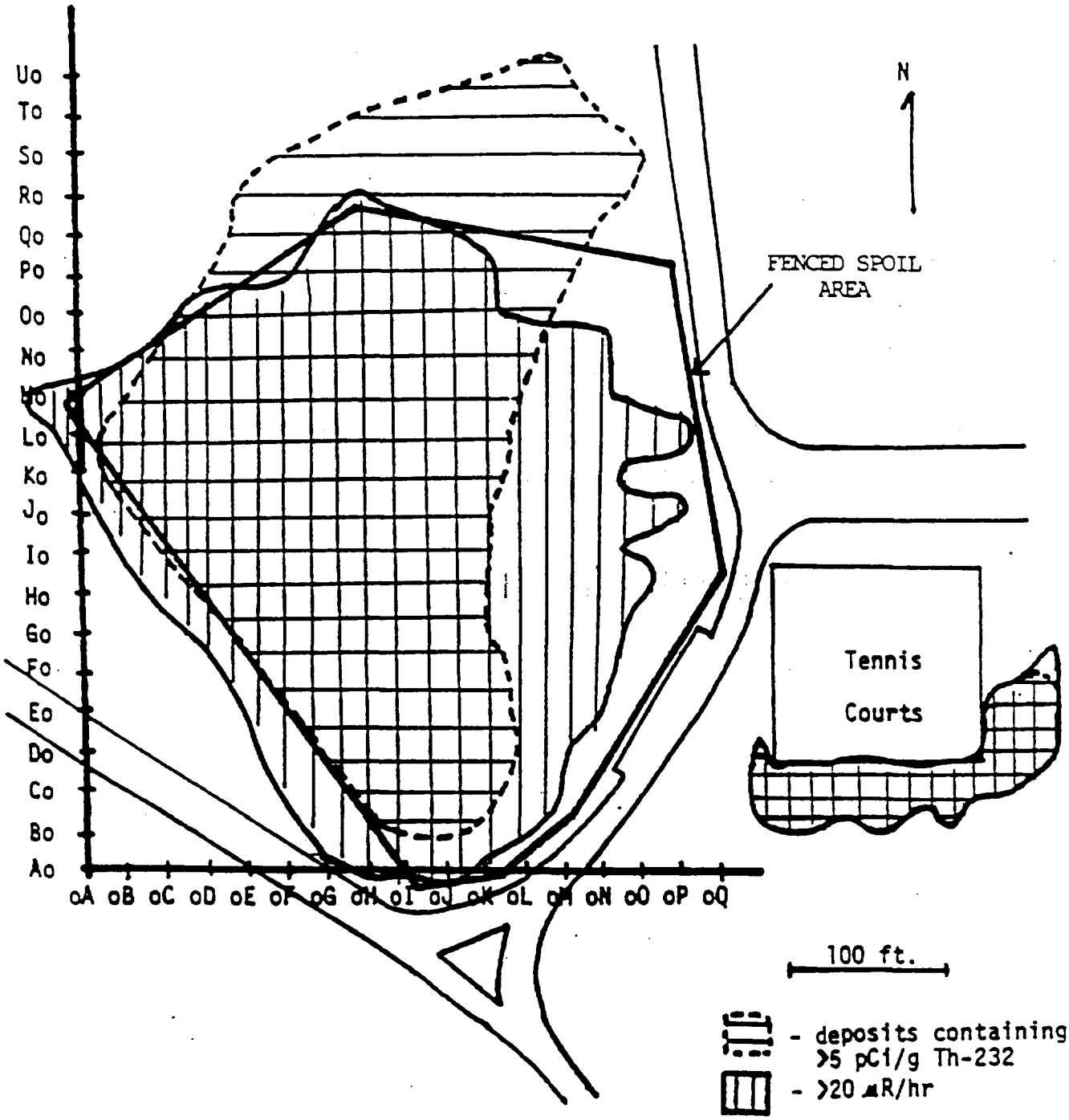


Figure 9.

Location of subsurface contamination and surface radiation levels which exceed target criteria.
(Booth et al., 1982).

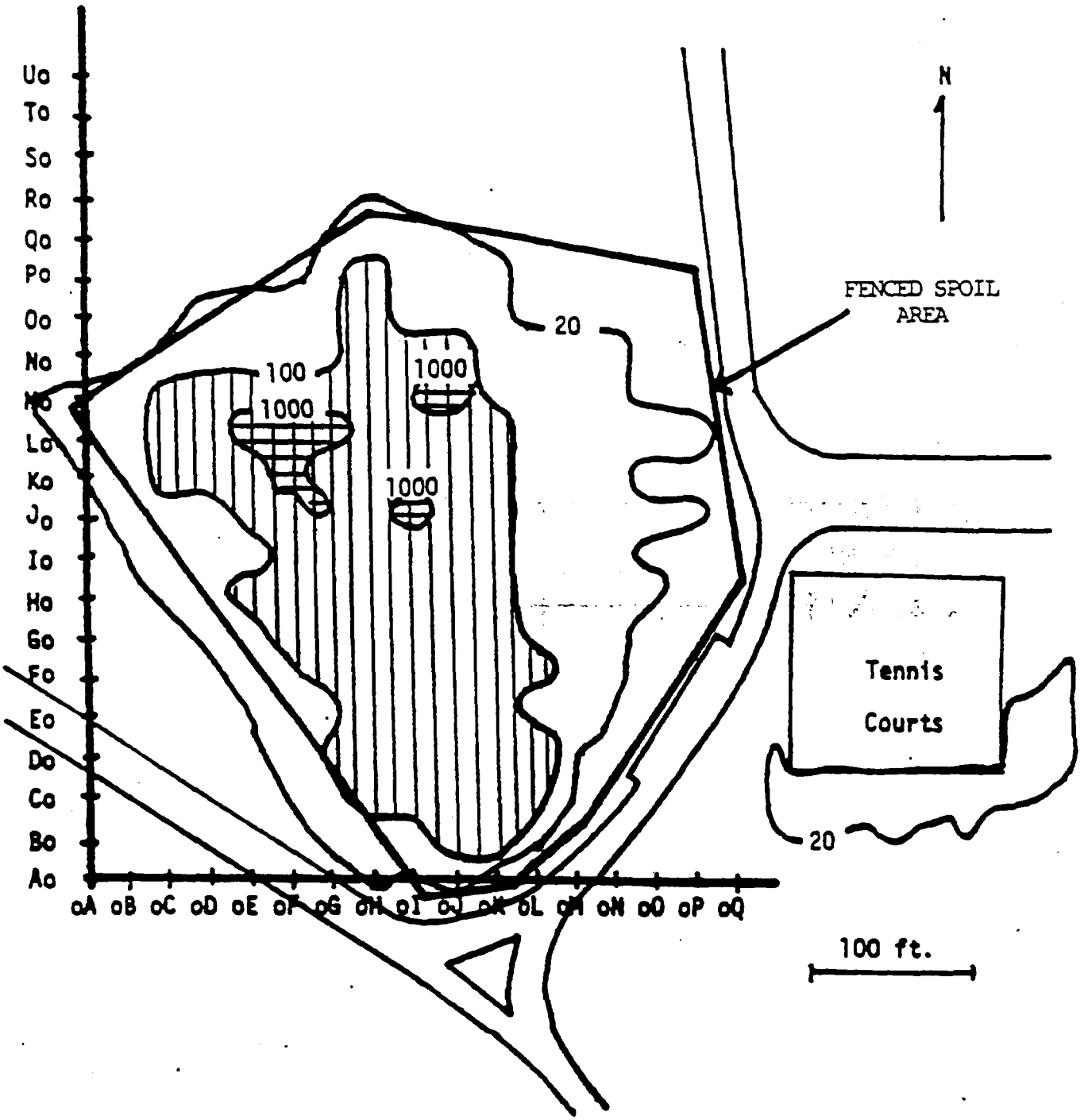


Figure 18.
Isodose lines in uR/hr, Reed-Keppler Park site, 1982. (Booth et al., 1982).

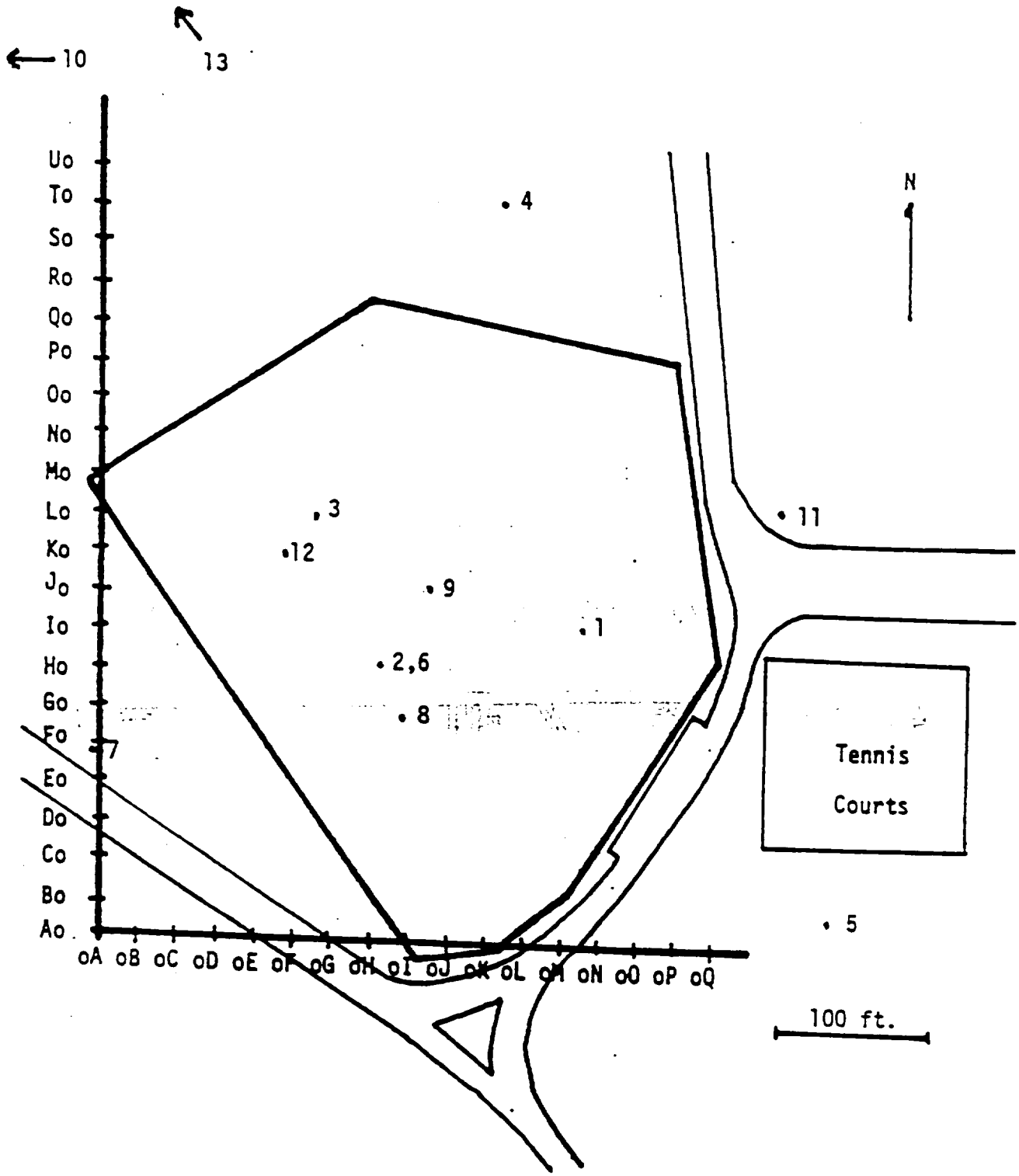


Figure 11.
Location of water samples. Sample 10 is from a pond 1000 ft. west of the site. Sample 13 is from a pond 0.5 miles northwest of the site.
(Booth et al., 1982).

FIGURE 12A. Residential areas with tailings (Frigerio et al., 1978).

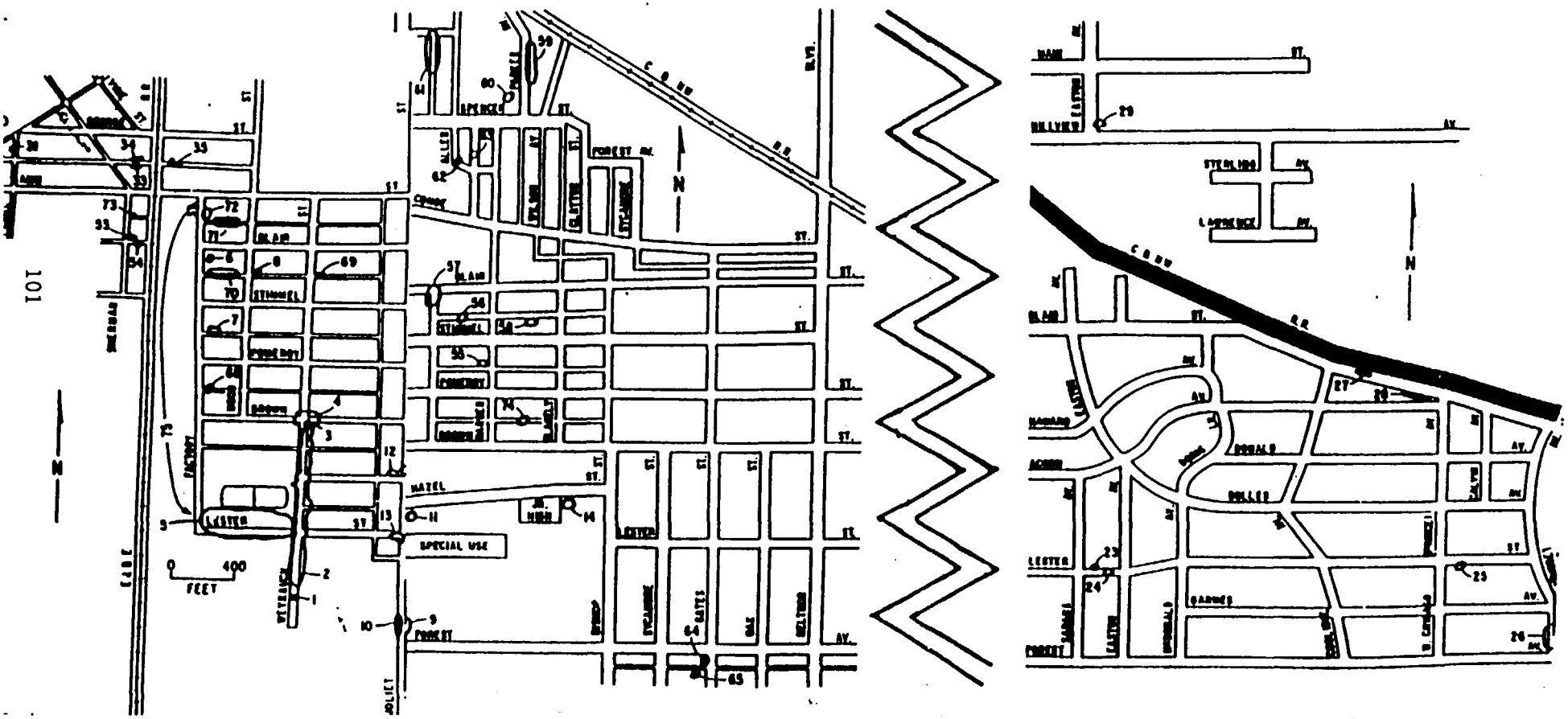


FIGURE 12B. Residential areas with tailings (Frigerio et al., 1978).

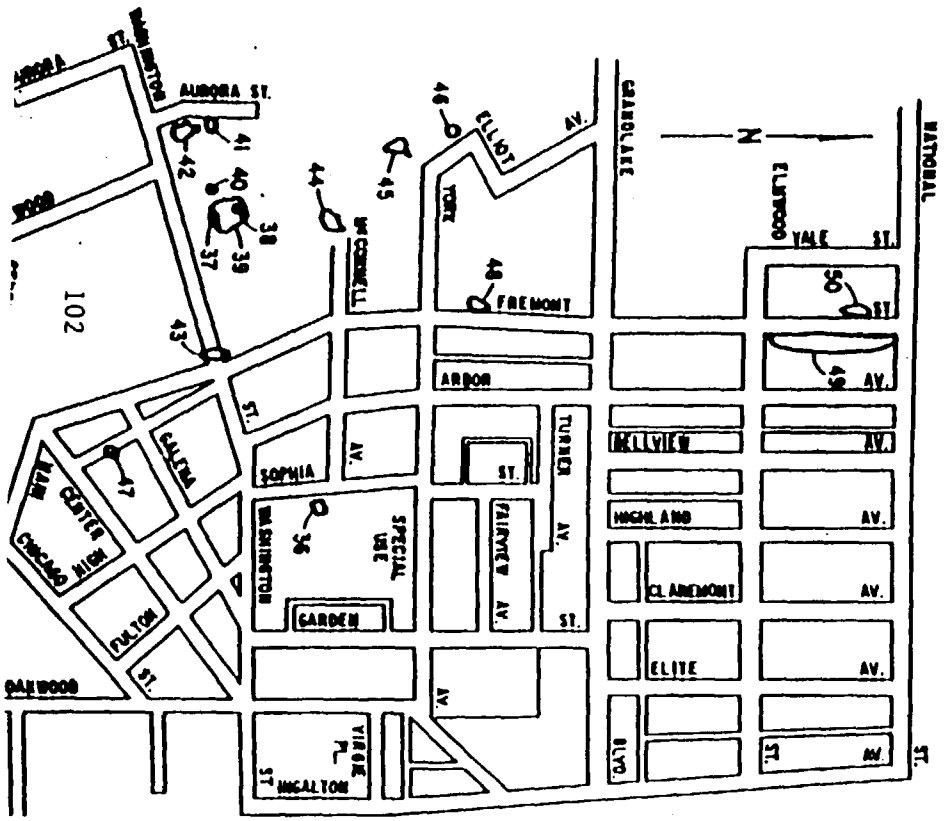
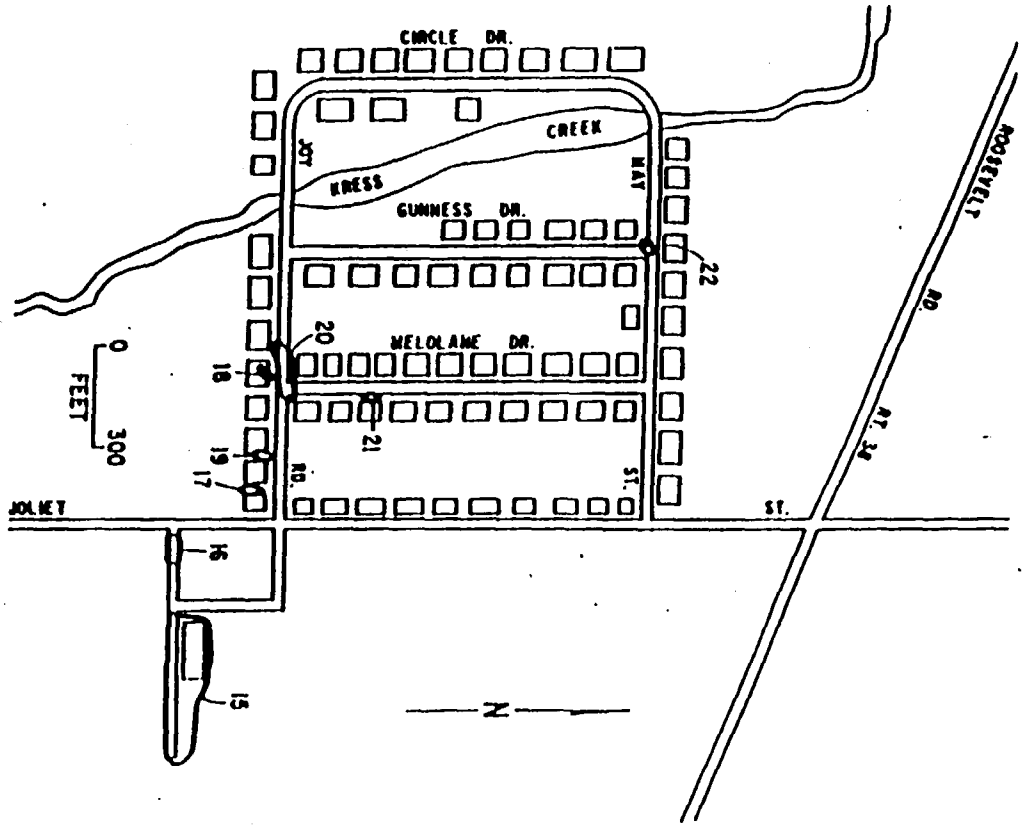


FIGURE 12C. Residential areas with tailings (Frigerio et al., 1978).



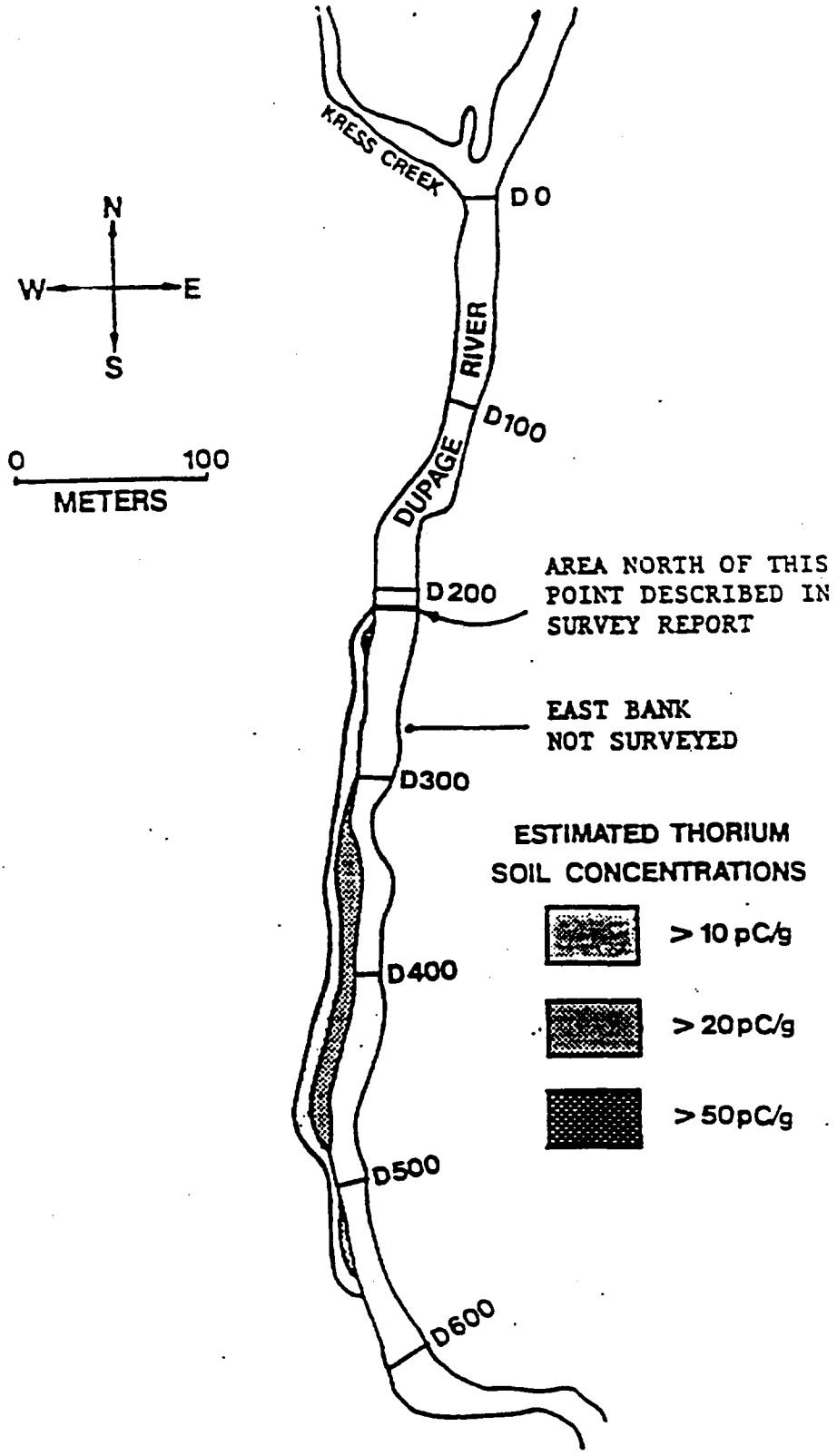


Figure 13.

Portion of Dupage River 200-500 m Downstream of the Juncture with Kress Creek

(Berger, 1984).

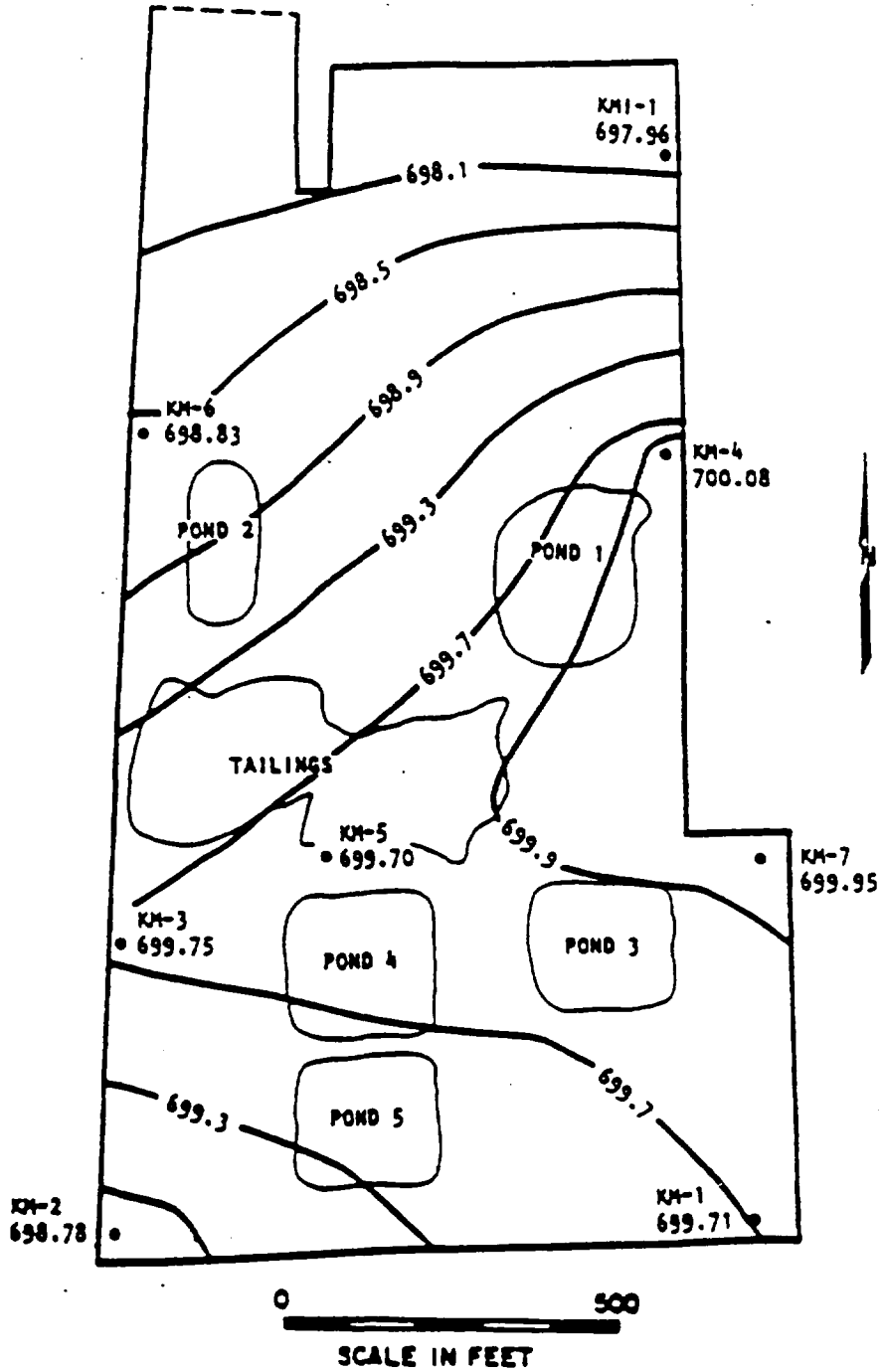


Figure 14. Potentiometric Surface of the Silurian Dolomite (measurements made November 1985).

(NRC, 1989a).

TABLES

TABLE 1. Products produced at the Kerr-McGee Facility 1932-73 (Vreeland, 1975b; Jensen, 1992b).

Product	End Usage
Thorium nitrate	Gas mantles
Thorium nitrate, refined	Chemical manufacturing
Thorium oxide	Nuclear fuel, miscellaneous
Mesothorium (radium-228)	Cancer treatment
Cerium hydrate	Catalyst, Glass decolorizer
Rare earth chloride	Catalyst (gasoline cracking)
Rare earth fluoride	Arc carbons
Didymium chloride	Catalyst
Didymium carbonate	Electronic capacitors
Didymium oxide	Arc carbons
Didymium fluoride	Arc carbons
Neodymium oxide	Glass, colored lenses
Samarium oxide	High strength magnets
Gadolinium oxide	TV phosphors, Nuclear use
Europium oxide	TV phosphors
Yttrium oxide	TV phosphors, Electronic materials
Miscellaneous high purity oxides	Chemical research
Cerium oxide polishes	Glass polishing, lenses, mirrors, etc.
Rare earth oxide polishes	Glass polishing, lenses, mirrors, etc.
Miscellaneous special products	Chemical research

TABLE 2. Radionuclide levels in soil, sediment, and waste components (NRC, 1989a).

CONTAMINATED MATERIAL	CONCENTRATION (pCi/g) Estimated or Measured Ranges (Averages if no range available)				
	Thorium-230*	Thorium-232*	Radium-226*	Radium-228*	Uranium 238*
Kerr-McGee Facility					
1) Factory Area					
Building Rubble	13	–	–	100	–
Steel	13	–	N.D.	100	–
Soil	22	0.1-4,120	N.D.-578	177	N.D.-1,040
2) Intermediate Area					
Soil	0.83	N.D.-26	0.6-5.1	6.6	14.6-128
3) Kerr-McGee Disposal Area					
Ore Tailings	172	40-8,445	6-9,398	5,500	N.D.-893
Sludge Pile	101	0.3-11,050	0.5-31,500	875	N.D.-3,426
Pond #1 Sediments	398	28-7,752	N.D.-1,105	3,140	N.D.-2,091
Ponds #2-5 Sediments	27	0.1-2,100	0.1-180	211	N.D.-1,860
Soil	23	N.D.-6,556	N.D.-4,557	187	N.D.-887
4) Miscellaneous					
Incinerator Ash	13	100	N.D.	100	–
Rare Earth Chemicals	13	100	N.D.	100	–
REED-KEPPLER PARK					
Soil	33	33	28	280	–
W. CHICAGO WTP					
Soil	37	298	53.1	298	6.8
KRESS Cr. & W. BRANCH DUPAGE River					
Soil & Sediments	–	16	0.8	16	1.6

– = Not Available.
N.D. = Not Detected.
pCi/g = picoCuries per gram.
* = Carcinogen with no cancer slope factor from which to derive CREG.

TABLE 3. Kerr-McGee Facility contaminants above co. . .rison values (USEPA, 1986[1] and NRC, 39a[2]).

CHEMICAL	SOIL[1]	ORE TAILINGS[2]	SLUDGE PILE[2]	POND 1 SEDIMENT[2]	POND 2 SEDIMENT[2]	COMPARISON VALUE (ppm)	COMPARISON SOURCE
Antimony (ppm)	N.D.	13	18	14	26	0.8	RMEG
Arsenic* (ppm)	N.D.-14	1.9	1.5	N.D.	4.2	0.4	CREG
Barium (ppm)	55-3,800	–	–	–	–	100	RMEG
Boron (ppm)	N.D.-420	–	–	–	–	20	Intermediate EMEG
Cadmium* (ppm)	0.07-0.5	0.78	0.80	0.65	0.85	1	EMEG
Chromium* (ppm)	N.D.-55	6.7	22	16	30	10	RMEG
Copper (ppm)	N.D.-1,200	42	34	20	11	–	–
Lead (ppm)	150-18,000	1,700	740	57	31	–	–
Manganese (ppm)	29-310	–	–	–	–	10	RMEG
Mercury (ppm)	0.3-1	0.48	0.10	0.81	0.045	–	–
Silver (ppm)	3-10	8.7	0.91	1.4	0.8	10	RMEG
Thallium (ppm)	N.D.-240	N.D.	N.D.	N.D.	N.D.	–	–
Vanadium (ppm)	18-72	–	–	–	–	6	Intermediate EMEG
Radium-226* (pCi/g)	N.D.-4,300	–	–	–	–	–	–
Radium-228* (pCi/g)	10-6,400	–	–	–	–	–	–
Thorium-232 (Pci/g)	11-4,900	–	–	–	–	–	–
Uranium-238 (pCi/g)	N.D.-230	–	–	–	–	–	–

N.D. = Not Detected.
– = Not Available.
ppm = parts per million (milligrams/kilogram = mg/kg).
pCi/g = picoCuries/gram.
* = Carcinogen with no cancer slope factor from which to derive CREG.

TABLE 4. Ranges of concentrations of radionuclides in the soil profile of the Kerr-McGee Disposal Area (Argonne National Laboratory, 1977).

	Concentration (pCi/g)		
Depth (feet)	*Radium-226 + Daughters	*Radium-228 + Actinium-228	*Thorium-228 + Daughters
0.0	0.07-9.53	0.18-22.7	0.37-41.2
1.5	0.06-9.53	0.15-15.8	0.30-29.2
3.0	0.06-3.73	0.15-9.16	0.28-18.7
4.5	0.05-2.37	0.13-5.75	0.24-11.2
6.0	0.05-1.38	0.12-3.30	0.23-2.15
7.5	0.04-0.37	0.11-1.11	0.20-2.15
9.0	0.04-0.39	0.11-1.06	0.20-1.86
10.5	0.04-0.38	0.11-0.90	0.21-1.66
12.0	0.05-0.34	0.11-0.84	0.22-1.70
13.5	0.05-0.35	0.12-0.87	0.23-1.73
15.0	0.06-0.22	0.15-0.98	0.26-1.79
16.5	0.07-0.42	0.16-1.01	0.30-1.83
18.0	0.08-0.40	0.18-0.98	0.34-1.86
19.5	N.D.-0.38	N.D.-0.93	N.D.-1.90
21.0	N.D.-0.42	N.D.-1.02	N.D.-1.95
22.4	N.D.-0.42	N.D.-1.02	N.D.-2.04
24.0	N.D.-0.41	N.D.-1.01	N.D.-2.07
25.5	N.D.-0.51	N.D.-1.22	N.D.-2.14
27.0	N.D.-0.51	N.D.-1.21	N.D.-2.15
28.5	N.D.-0.49	N.D.-1.17	N.D.-2.11
30.0	N.D.-0.49	N.D.-1.16	N.D.-2.09
31.5	N.D.-0.45	N.D.-1.08	N.D.-2.05
33.0	N.D.-0.44	N.D.-1.04	N.D.-1.88
34.5	N.D.-0.32	N.D.-0.79	N.D.-1.62
36.0	N.D.-0.23	N.D.-0.55	N.D.-1.09
37.5	N.D.-0.22	N.D.-0.53	N.D.-1.07
39.0	N.D.-0.19	N.D.-0.46	N.D.-0.84
40.5	N.D.-0.14	N.D.-0.33	N.D.-0.61
42.0	N.D.-0.08	N.D.-0.30	N.D.-0.61
43.5	N.D.-0.13	N.D.-0.32	N.D.-0.60
45.0	N.D.-0.13	N.D.-0.31	N.D.-0.60
46.5	N.D.-0.13	N.D.-0.32	N.D.-0.59
48.0	N.D.-0.12	N.D.-0.29	N.D.-0.59
49.5	N.D.-0.14	N.D.-0.34	N.D.-0.59
51.0	N.D.-0.12	N.D.-0.29	N.D.-0.58
52.5	N.D.-0.13	N.D.-0.32	N.D.-0.57
54.0	N.D.-0.13	N.D.-0.32	N.D.-0.57
55.5	N.D.-0.14	N.D.-0.32	N.D.-0.57
57.0	N.D.-0.11	N.D.-0.28	N.D.-0.56
58.5	N.D.-0.12	N.D.-0.29	N.D.-0.56
60.0	N.D.-0.13	N.D.-0.30	N.D.-0.55
61.5	N.D.-0.12	N.D.-0.29	N.D.-0.55
63.0	N.D.-0.12	N.D.-0.29	N.D.-0.54
64.5	N.D.-0.13	N.D.-0.30	N.D.-0.53
66.0	N.D.-0.11	N.D.-0.27	N.D.-0.52
67.5	N.D.-0.12	N.D.-0.29	N.D.-0.52
69.0	N.D.-0.11	N.D.-0.26	N.D.-0.51
70.5	N.D.-0.10	N.D.-0.25	N.D.-0.50
72.0	N.D.-0.11	N.D.-0.27	N.D.-0.50
73.5	N.D.-0.11	N.D.-0.26	N.D.-0.49
75.0	N.D.-0.11	N.D.-0.27	N.D.-0.48
76.5	N.D.-0.10	N.D.-0.23	N.D.-0.47
78.0	N.D.-0.09	N.D.-0.23	N.D.-0.46
79.5	N.D.-0.09	N.D.-0.22	N.D.-0.45
81.0	N.D.-0.11	N.D.-0.25	N.D.-0.44

N.D. = Not detected.
pCi/g = picoCuries per gram.
* = Carcinogen with no cancer slope factor from which CREG can be derived.

Table 5. Concentrations of radionuclides and lead at the Kerr-McGee Disposal Area, Reed-Keppler Park, and the WTP.

Kerr-McGee Disposal Area (pCi/g)				
Chemical	Core 613-8	Core 299-2	Core 607-11	Core 296-3
Ra-226	--	--	--	--
Ra-228	660	1,300	10	6,400
Th-232	640	1,300	14	4,200
U-238	180	110	50	230
Pb (ppm)	410	18,000	150	15,000

Reed-Keppler Park (pCi/g)			
	Kerr-McGee Analysis		USEPA Analysis
Chemical	S-3	S-4	84-3/S-3&4
Ra-226	39	N.D.	--
Ra-228	230	140	170
Th-232	230	160	140
U-238	6	1	2
Pb (ppm)	1,200	580	6,500

West Chicago Regional Wastewater Treatment Plant (pCi/g)						
				River		
Chemical	S 68	S 69	S 70	ATW-1	ATW-2	Bank
Ra-226	--	72	750	--	--	180
Ra-228	--	3,600	4,700	5,600	4,900	2,000
Th-232	--	3,700	4,500	3,300	2,900	2,100
U-238	--	560	400	270	340	350
Pb (ppm)	240	2,300	5,600	2,900	6,400	270

-- = Data not available.
N.D. = Not Detected.
pCi/g = PicoCuries per gram.
ppm = Parts per million.

TABLE 6. Organic priority pollutants in waste components of Kerr-McGee Disposal Area (NRC, 1989a).

	Concentration (ppm)									
	Sludge Pile		Ore Tailings		Pond 1 Sediment		Pond 2 Sediment		Comparison Value	Comparison Source
CHEMICAL	0-5 ft	5-11 ft	0-9 ft	9-17 ft	0-10 ft	10-14 ft	0-5 ft	5-9 ft		
Benz(a)-anthracene*	0.500	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	--	--
Benzo(a)-pyrene	0.340	N.D.	N.D.	2.0	N.D.	N.D.	N.D.	N.D.	0.12	CREG
Benzo(k)-fluoranthene*	1.23	N.D.	N.D.	1.9	N.D.	N.D.	N.D.	N.D.	--	--
Chrysene*	0.65	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	--	--

N.D. = Not Detected.
ppm = parts per million.
* = Carcinogen with no cancer slope factor from which to derive CREG.

Table 7. Selected chemicals discarded as wastes at the Kerr-McGee Disposal Area 1954 to 1973 (NRC, 1989a).

Chemical	Amount (MT)
Solid wastes	
Rare earth oxides	10,000
Barium sulfate	--
Liquid wastes	
Sodium sulfate	150,000
Sodium chloride	95,000
Sodium fluoride	23,000
Monosodium phosphate	7,800
Ammonium chloride	3,300
Ammonium sulfate	1,300
Calcium chloride	530
Ethylenediaminetetraacetic acid	35
20% Solution of 2-ethylhexylphosphate in kerosine	37,800 Liters

MT = Metric Tons.
-- = Not Available.

Table 8. Geometric mean concentrations of airborne radionuclides in three buildings in the Kerr-McGee Facility (Mausner, 1982).

		Concentration (pCi/1)			
Location	Year	Thorium-232*	Radon-220*	Lead-212	Bismuth-212
Bldg 9 Flr 2	1962	0.0071	143	6.6	2.6
Bldg 9 Flr 3	1962	0.042	764	106	41
Bldg 9 Flr 3	1963	0.027	436	61	45
Bldg 9 Flr 3	1964	0.072	4080	203	60
Bldg 9 Flr 4	1964	0.019	52	3.4	2.0
Bldg 2 Flr 1	1962	0.013	28	2.1	1.4
Bldg 3 Flr 1	1962	0.052	19	1.1	0.6

pCi/l = picoCuries per liter.
* = Carcinogen with no cancer slope factor from which CREG can be derived.

TABLE 9. Levels of radon daughters* in air around the Kerr-McGee Facility.

Location	Type	Range (pCi/m³)
Waste Site (Stations 1,2,3)	Background Downwind Withwind	0.72-2201 45-605 3-1423
Station 4	Background Downwind Withwind	1.2-13.0 6.3-115 5.8-43

TABLE 10. Levels of lead-212* in air around the Kerr-McGee Facility.

	Ranges of Concentration (pCi/m³)			
	High-volume		Dichotomous Sampler	
Station	Sampler	Under 2.5 microns	Over 2.5 microns	Total
1	1.9-1351	0.7-1094	0.2-109	1-1203
2	1.5-301	0.4-101	0.1-63	1-164
3	0.73-2201	0.5-2685	0.1-94	1-2835
4	1.2-143	–	–	–

TABLE 11. Concentrations of long-lived radionuclides in composite samples around the Kerr-McGee Facility.

(pCi//ml)							
	8/10-14/81				8/24/81	9/14/81	
Radionuclide	St 1	St 2	St 3	St 4	St 3	St 1	St 3
Radium-226*	9.70	8.06	5.09	1.60	–	–	–
Thorium-227*	28.2	9.71	9.91	9.09	5.79	12.6	8.44
Thorium-228*	4.93	–	–	–	9.21	20.3	17.2
Thorium-230*	4.98	3.21	2.53	2.04	6.23	11.7	8.44
Thorium-232*	15.1	6.59	0.45	N.D.	4.87	22.1	9.56
Uranium-234*	5.45	2.94	1.26	2.77	14.3	15.3	14.2
Uranium-235*	1.63	0.35	0.84	1.39	5.09	2.24	5.82
Uranium-238*	5.45	2.42	1.26	2.60	6.67	7.50	10.5

* = Carcinogen with no cancer slope factor from which CREG can be derived.
pCi/m³ = picoCuries per cubic meter.
pCi/ml = picoCuries per milliliter.
St = Station.
– = Not available.

(Source: Jensen et al., 1982)

TABLE 12. Concentrations of inorganic chemicals and alpha and beta particles in surface water of the Kerr-McGee facility (Butler, 1965[1] and IEPA files, 1989[2]).

CHEMICAL	CONCENTRATION (mg/l)									
	Pond 2[1] Influent	Pond 2[1]	Pond 2[2]	Pond 3[2]	Pond 4[2]	Pond 5[2]	*Bowling Green Pond[1]	*Bowling Green Pond Effluent[1]	Comparison Value	Comparison Source
Aluminum	6.4	--	--	--	--	--	--	--	--	--
Ammonia	174-360	62-208	0.2-208	8.3-62.5	13.1-132	9.8-73.4	N.D.-0.5	0.1-1.9	3	Intermediate EMEG
Chloride	475-3,100	550-1,550	850-1,350	550-1,300	1,325-4,000	575-2,300	625-1,250	600-1,280	--	--
Copper	2.1	--	--	--	--	--	--	--	1.3	MCL
Fluoride	60-850	52-300	14.4-40.5	13.1-43.5	94-206	32-61	0.8-36	0.5-1	0.5	EMEG
Nitrate	211-1,980	257-925	25.5-237	1.1-11.4	5.6-7.5	1.9-9.7	10.5-230	6-17.4	10	MCL
Sodium	1,830-6,190	1,840-3,550	664-1061	426-1,273	1,898-4,810	896-2,100	1,760-3,950	1,880-4,010	20	USEPA guidance
Sulfate	4,190-8,920	1,890-5,680	225.4-507	723-1,504	1,954-4,581	949-1,856	3,940-7,920	3,810-8,240	--	--
Titanium	0.97	--	--	--	--	--	--	--	--	--
Dissolved alpha (pCi/l)**	32-4,640	72-550	--	--	--	--	22-34	4-34	--	--
Dissolved beta (pCi/l)**	41-2,530	65-234	--	--	--	--	32-126	27-1,560	--	--
Suspended alpha (pCi/l)**	14,500 949,000	61-1,260	--	--	--	--	4-37	2-43	--	--
Suspended beta (pCi/l)**	8,400-256,000	105-951	--	--	--	--	22-171	2-221	--	--

mg/l = milligrams per liter.
* = Bowling Green Pond was filled in during late 1960's.
pCi/l = picoCuries per liter.
-- = Not Available.
** = Carcinogen with no cancer slope factor from which to derive CREG.

TABLE 13. Ranges of concentration of inorganic chemicals and radionuclides (pCi/l) for the B, F, I, and KM wells of the Kerr-McGee Facility (NRC, 1989a[1]; USEPA, 1986[2]) - (continued).

	Concentration (ppm)										
	Kerr-McGee Disposal Area				Factory Area		Intermediate Area				
Chemical or Parameter	B Wells[1] (shallow)	B Wells[2] (shallow)	KM Wells[1] (deep)	KM Wells[2] (deep)	F Wells[1] (inter-mediate)	F Wells[2] (inter-mediate)	I-1[2] (shallow)	KMI-1[2] (deep)	Blank	Comparison Value	Comparison Source
Aluminum	ND-0.88	ND-0.887	ND-0.66	0.344	ND-60	6.190	ND	ND	0.177-0.596	–	–
Arsenic	ND-0.24	ND-0.066	ND-0.30	ND	ND-0.30	ND	0.0081	ND	ND	0.00002	CREG
Boron	ND-1.5	–	ND-0.52	–	0.1-2.8	–	–	–	–	0.1	Intermediate RMEG
Beryllium	–	ND	–	ND	–	ND	ND	ND	ND-0.036	0.000008	CREG
Cadmium*	ND-0.024	ND	ND-0.023	ND	ND-0.096	ND	ND	0.0051	ND	0.005	RMEG
Chloride	36-480	10-200	73-290	205	29-810	680	130	190	ND	–	–
Chromium*	ND-0.090	ND-0.010	ND-0.080	ND	ND-0.20	ND	ND	ND	ND	0.05	RMEG
Cobalt	ND-0.088	ND	ND-0.057	ND	ND-0.14	ND	ND	ND	ND	–	–
Fluoride	ND-26	0.3-11	ND-6.9	0.9	ND-36	5.9	0.42	0.85	ND	0.5	EMEG
Lead	ND-0.35	ND	ND-0.33	ND	ND-0.72	ND	ND	ND	ND	0.015	Action Level
Manganese	0.067-3.2	0.071-1.430	ND-0.30	0.083	0.048-6	7.060	0.392	0.278	ND-1.430	0.05	RMEG
Mercury	ND-0.0034	ND	ND-0.00044	ND	ND-0.0014	ND	ND	ND	ND	0.002	LTHA
Molybdenum	ND-0.18	–	ND-0.063	–	ND-0.11	–	–	–	–	0.035	LTHA
Nickel	ND-0.27	ND-0.217	ND-0.27	0.156	ND-1.089	1.030	ND	0.088	ND-0.064	0.1	LTHA
Nitrate and Nitrite	ND-25	0.32-35	ND-8.7	0.1	ND-520	0.07	0.04	ND	ND-0.48	10	MCL
Silver	–	ND	–	0.076	–	ND	ND	ND	ND-0.016	0.05	RMEG
Sodium	–	27-343	–	391	–	1289	97.6	154	ND-7.070	20	USEPA guidance

TABLE 13. Ranges of concentration of inorganic chemicals and radionuclides (pCi/l) for the B, F, I, and KM wells of the Kerr-McGee Facility (NRC, 1989a[1]; USEPA, 1986[2]) - (continued).

	Concentration (ppm)

* = Carcinogen with no cancer slope factor from which to derive CREG

ppm = parts per million pCi/l = picoCuries/liter

ND = None Detected – = Not Available

	Kerr-McGee Disposal Area				Factory Area		Intermediate Area				
Chemical or Parameter	B Wells[1] (shallow)	B Wells[2] (shallow)	KM Wells[1] (deep)	KM Wells[2] (deep)	F Wells[1] (inter-mediate)	F Wells[2] (inter-mediate)	I-1[2] (shallow)	KMI-1[2] (deep)	Blank	Comparison Value	Comparison Source
Sulfate	–	450-2175	–	1000	–	275	212	47.5	ND-5	–	–
Tin	–	ND	–	ND	–	0.340	0.019	ND	ND	–	–
Vanadium (total)	–	ND-0.066	–	0.041	–	0.705	ND	0.044	ND-0.042	0.03	LTHA
Zinc	–	0.019-3.33	–	0.050	–	0.775	0.015	0.048	0.028-0.052	2.1	LTHA
Polonium-210*	–	ND-0.18	–	0.087	–	0.20	0.12	ND	–	–	–
Radium-224*	ND-0.19	–	ND-7.50	–	ND-11.5	–	–	–	–	–	–
Radium-226*	ND-0.27	–	ND-2.06	0.095	ND-1.39	ND	0.37	–	–	5 pCi/l	MCL
Radium-228*	ND-0.27	ND	0.04-2.57	ND	ND-16.1	ND	–	–	–	5 pCi/l	MCL
Radium*(total)	ND-0.32	–	ND-9.38	–	ND-28.6	–	–	–	–	5 pCi/l	MCL
Thorium-228*	–	ND-1.4	–	ND	–	ND	–	–	–	–	–
Thorium-230*	ND-1.87	ND-0.74	0.006-1.09	0.12	0.003-0.66	0.13	ND	0.071	–	–	–
Thorium-232*	0.0004-0.034	0.094-1.4	0.001-0.063	0.29	0.003-0.025	0.26	ND	0.05	–	–	–
Uranium-234*	–	2.4-340	–	0.21	–	0.96	2.8	0.44	–	–	–
Uranium-235*	–	0.061-12	–	ND	–	ND	0.10	ND	–	–	–
Uranium-238*	0.001-0.16	2.3-340	ND-0.078	0.12	0.002-6.7	0.84	2.6	0.25	–	–	–

* = Carcinogen with no cancer slope factor from which to derive CREG
ppm = parts per million pCi/l = picoCuries/liter
ND = None Detected – = Not Available

TABLE 13. Ranges of concentration of inorganic chemicals and radionuclides (pCi/l) for the B, F, I, and KM wells of the Kerr-McGee Facility (1990-1992; Kerr-McGee, 1994) - (continued).

Chemical	Disposal Area B wells (shallow) (ppm)	Disposal Area KM wells (deep) (ppm)	Disposal Area B-14 to B-16 (intermediate) (ppm)	Factory Area F wells (shallow) (ppm)	Intermediate Area I-1 (shallow) (ppm)	Intermediate Area KMI-1 (deep) (ppm)	Comparison Value (ppm)	Source of Comparison Value
Arsenic	N.D.-0.025	N.D.-0.007	N.D.-0.022	N.D.-0.038	N.D.-0.006	N.D.-0.004	0.00002	CREG
Barium	N.D.-0.074	0.026-0.160	N.D.-0.13	N.D.-0.075	N.D.-0.018	0.021-0.055	0.7	RMEG
Cadmium*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.005	RMEG
Chromium*	N.D.	N.D.	N.D.	N.D.-0.030	N.D.	N.D.	0.05	RMEG
Copper	N.D.-0.083	N.D.	–	N.D.-0.10	N.D.	N.D.	1.3	MCL
Fluoride	0.2-21.0	N.D.-2.5	0.2-4.9	N.D.-25.0	N.D.-1.9	N.D.-2.1	0.5	EMEG
Lead	N.D.	N.D.	N.D.	N.D.	N.D.-0.007	N.D.	0.015	Action Level
Manganese	N.D.-2.71	0.023-0.230	0.12-0.68	0.005-1.23	0.180-0.620	0.14-0.23	0.05	RMEG
Mercury	N.D.-0.0002	N.D.	N.D.	N.D.-0.0002	N.D.-0.0002	N.D.	0.002	LTHA
Nickel	N.D.-0.30	N.D.-0.051	0.035-0.080	0.021-0.210	N.D.-0.043	N.D.-0.095	0.1	LTHA
Nitrate + Nitrite	N.D.-5.5	N.D.	–	N.D.-8.4	3.6	N.D.	10	MCL
Selenium	N.D.-0.054	N.D.-0.012	N.D.	N.D.-0.011	N.D.	N.D.	0.02	Intermediate EMEG
Silver	N.D.-0.031	N.D.-0.043	N.D.	N.D.-0.003	N.D.	N.D.-0.001	0.05	RMEG
Thallium	N.D.	N.D.-0.010	–	N.D.-0.010	N.D.	N.D.	0.0004	LTHA
Vanadium	N.D.-0.026	N.D.	–	N.D.-0.059	N.D.	N.D.	0.03	LTHA
Zinc	N.D.-1.06	N.D.-0.140	N.D.-0.060	0.037-2.08	N.D.-1.60	N.D.-0.066	2	LTHA

* = Carcinogen with no cancer slope factor from which to derive CREG
ppm = parts per million pCi/l = picoCuries/liter
ND = None Detected – = Not Available

TABLE 14. Concentrations of inorganic chemicals and radionuclides in soil of the West Chicago Wastewater Treatment Plant (WTP) and Reed-Keppler Park (Reed-Keppler Park samples 4 to 6 feet in depth; USEPA, 1986).

	Concentration (ppm)					
	WTP		Reed-Keppler Park			
Compound	East Area	River Bank	KM Analysis	USEPA Analysis	Comparison Value (ppm)	Comparison Source
Antimony	1-150	ND	ND	7	0.8	RMEG
Arsenic	ND	ND	ND	3	0.4	CREG
Barium	300-1500	168	–	200	100	RMEG
Beryllium	ND-1	ND	ND	ND	0.2	CREG
Cadmium*	ND-0.3	ND	ND	2	0.4	EMEG
Chromium*	ND-20	104	ND	ND	10	RfD
Copper	40-430	3	ND-160	60	–	–
Lead	240-6400	270	580-1200	6500	–	–
Manganese	8-470	318	–	36	10	RMEG
Mercury	0.2-0.4	1.1	ND-0.4	0.5	–	–
Thallium	ND	ND	15	ND	–	–
Tin	ND-10	ND	ND	4	–	–
Vanadium	3-47	25	ND	26	6	Intermediate EMEG
Zinc	30-200	200	49-310	310	600	Intermediate EMEG
Radium-226* (pCi/g)	72-750	180	ND-39	–	–	–
Radium-228* (pCi/g)	3600-5600	2000	140-230	170	–	–
Thorium-232* (pCi/g)	2900-4500	2100	160-230	140	–	–
Uranium-238* (pCi/g)	270-560	350	1-6	2	–	–

TABLE 15. Concentrations of ambient radon, as well as gross alpha and gross beta activities, at Reed-Keppler Park (Booth et al., 1982).

Location	Radon-220* (pCi/l)	Radon-222* (pCi/l)
Inside Fence	ND-57	ND-1.1
Fence upwind	17-70	0.015-0.13
Fence downwind	ND-56	–
North fenceline	9.7	0.025
Ingalton Ave. (residential)	0.70	0.039
RMC Northbrook office	0.01	0.0034
	Gross Alpha* (pCi/l)	Gross Beta* (pCi/l)
Inside fence	$3.2E^{-6}$-$1.2E^{-5}$	$1.4E^{-5}$-$9.1E^{-5}$
Downwind at fenceline	$7.7E^{-6}$-$1.2E^{-5}$	$4.5E^{-6}$-$1.0E^{-4}$

KM = Kerr-McGee.
ND = Not Detected.
pCi/g = picoCuries/gram.
pCi/l = picoCuries per liter.
ppm = parts per million.
– = Not Available.
* = Carcinogen with no cancer slope factor from which to derive CREG.

TABLE 16. Levels of radioactivity and concentrations of radionuclides in groundwater at Reed-Keppler Park (Booth et al., 1982).

LOCATION	Gross Alpha* (pCi/l)	Gross Beta* (pCi/l)
Inside fence	1.6-17	11-210
Outside fence	1.2-8.9	5.6-30
	Radium-226* (pCi/L)	Thorium-232* (pCi/l)
Borehole 3	7.6	23

TABLE 17. Concentrations of organic priority pollutants in soil from the East Area of the WTP (USEPA, 1986).

COMPOUND	Concentration (ppm)	Comparison Value
Benzo(a)anthracene*	ND - 3.7	–
Benzo(b)anthracene*	ND - 7.5	–
Chrysene*	ND - 4.7	–

ppm = parts per million.
pCi/l = picoCuries per liter.
* = Carcinogen with no cancer slope factor from which to derive CREG.

TABLE 18. Ranges of concentration of chemicals and other parameters in groundwater at the WTP, 1984-5 (USEPA, 1986).

	Concentration (ppm)				
	Monitoring Wells				
Chemical or Parameter	Upgradient	Downgradient	Blank	Comparison Value	Comparison Source
Arsenic	ND-0.18	ND-0.32	ND	0.00002	CREG
Cadmium	ND	ND-0.062	ND	0.005	RMEG
Chromium	ND	ND-0.013	ND	0.05	RMEG
Fluoride	ND-0.16	ND-0.77	ND	0.5	EMEG
Lead	ND	ND-0.06	ND	0.015	Action Level
Magnesium	52.4-65	46-77	0.313	–	–
Manganese	0.006-0.28	0.17-1.9	ND	0.05	RMEG
Mercury	ND	ND-0.0007	ND	0.002	LTHA
Nitrate	ND-12	ND-35	0.04	10	MCL
Phenol	ND-57	0.007-59	–	4	LTHA
Selenium	ND-0.16	ND-0.17	ND	0.02	Intermediate EMEG
Sulfate	ND-67.5	44-425	ND	–	–
Vanadium	0.033	0.030-0.049	ND	0.03	LTHA
	Concentration (pCi/l)				
	Monitoring Wells				
Chemical or Parameter	Upgradient	Downgradient	Blank	Comparison Value	Comparison Source
Polonium-210*	ND	ND-0.12	–	–	–
Radium-226*	0.13-0.19	ND-1.8	–	–	–
Radium-228*	0.03-0.24	0.20-2.3	–	–	–
Thorium-228*	ND	ND-1.1	–	–	–
Thorium-230*	0.038-4.79	0.028-1.26	–	–	–
Thorium-232*	0.009-0.045	ND-0.092	–	–	–
Uranium-234-*	0.17	0.13-0.14	–	–	–
Uranium-235*	ND	ND-0.044	–	–	–
Uranium-238*	0.18	0.13-1.4	–	–	–

ND = Not Detected.
* = Carcinogen with no cancer slope factor from which to derive CREG.
– = Not Available.
ppm = parts per million.
pCi/l = picoCuries per liter.

TABLE 19. Depth profile of thorium concentrations in the soil, indoor air, and crawlspace soil concentrations of radionuclides at a remediated residential property (USEPA files, 1990).

Depth (inches)	Thorium (pCi/g)	Depth (inches)	Thorium (pCi/g)
0-6	52	60-66	5.0
6-12	419	66-72	5.4
12-18	85	72-78	362[1]
18-24	140	78-84	3.8
24-30	597	84-90	4.7
30-36	787	90-96	21[1]
36-42	471	96-102	2.2
42-48	1084	102-108	2.3
48-54	503	108-126	99[1]
54-60	8.0		

[1] Hole cave-in possible.

Crawlspace Soil Concentration (pCi/g)		
Thorium	Uranium	Radium
26-930	ND-4.9	ND-130

Airborne Concentrations (WL)			
Location	Radon-222	Radon-220	Lead-212
Crawl space	0.006-0.009	0.008-0.564	$6.2E^{-11}$-$4.5E^{-9}$
Living room	0.005-0.011	0.002-0.228	$2.3E^{-12}$-$1.9E^{-9}$

pCi/g = picoCuries per gram.
WL = Working levels.

TABLE 20. Gamma radiation levels around the Kerr-McGee Facility in 1990 as measured with calcium fluoride thermoluminescent dosimeters. Measurement locations are given in Figure 13 (IDNS files, 1990).

Sampling Location	Dose Rate (mR/day)
1	–
2	0.11
3	0.21
4	0.08
5	0.09
6	0.09
7	0.13
8	0.16
9	0.72
10	0.33
11	0.31
12	0.25
13	0.32
14	0.10
15	0.29
16	1.53
17	0.19
18	0.14
19	0.23
20	0.13
21	–
22	–

– = Not Available.
mR/day = milliroentgens per day.

Table 21. Concentrations of radon in homes with tailings along their foundations (Argonne National Laboratory, 1983).

House	Location	Radon-220 (WL)	Radon-222 (WL)	Total Radon (WL)	Percent Radon-220
Background	1st floor	0.00072	0.01788	0.0186	4
	Basement	0.0022	0.02284	0.0248	9
Tailings A	1st Floor	0.00251	0.00353	0.006	42
	Basement	0.00577	0.00766	0.013	44
Tailings B	1st Floor	0.01221	0.00507	0.017	71
	Basement	0.03901	0.01000	0.049	80
Tailings C	1st Floor	0.00772	0.00340	0.011	70
	Basement	0.00824	0.00241	0.011	75
Tailings D	1st Floor	0.00196	0.00731	0.00927	21
	Basement	0.00241	0.00227	0.0093	26
Tailings E	1st Floor	0.00306	0.00939	0.012	26
	Basement	0.00604	0.00868	0.015	40
Tailings F	1st Floor	0.00380	0.00136	0.00516	74
	Basement	0.00907	0.00329	0.0124	73
Tailings G	1st Floor	0.00168	0.01222	0.0139	12
	Basement	0.00281	0.02400	0.0268	10
Tailings H	1st Floor	0.01178	0.01598	0.0278	10
	Basement	0.00789	0.01060	0.0185	43
Tailings I	1st Floor	0.00450	0.00085	0.0054	83
	Basement	0.00538	0.00238	0.0078	69

WL = Working levels.

TABLE 22. Concentrations of selected radionuclides in the sediments of Kress Creek at various depths (Frame, 1984) - (Continued).

Distance downstream from storm outfall (meters)	DEPTH (cm)	Concentration (pCi/g)		
		RADIUM-226*	THORIUM-228*	THORIUM-232*
100	0-10	2.31	30.0	27.9
	10-20	1.69	24.2	26.2
	20-30	1.16	6.12	6.51
	30-40	1.99	25.8	24.0
200	0-10	7.46	4.08	4.09
	10-20	0.71	1.49	0.99
	20-30	1.45	0.51	0.96
300	0-10	2.98	29.0	29.4
	10-20	1.84	22.7	23.3
	20-30	1.58	6.54	7.69
	30-40	1.80	2.35	2.95
	40-50	1.20	1.08	0.76
	50-60	1.39	0.65	1.64
400	0-10	1.64	3.21	4.38
	10-20	0.64	0.83	1.01
	20-30	1.31	0.65	0.58
500	0-10	0.80	1.40	1.29
	10-20	1.12	0.75	N.D.
	20-30	0.59	0.15	N.D.
600	0-10	0.89	2.55	2.33
	10-20	1.83	19.0	24.2
	20-30	0.76	0.57	N.D.
700	0-10	1.45	39.6	44.4
	10-20	0.70	8.13	9.96
800	0-10	0.66	1.47	1.56
	10-20	0.46	0.51	0.53
	20-30	0.61	1.59	N.D.
900	0-10	1.43	13.8	12.2
	10-20	1.16	9.99	11.1
	20-30	0.87	2.83	1.80

* Carcinogen with no cancer slope factor from which to derive CREG
pCi/g = picoCuries per gram
cm = centimeters

TABLE 22. Concentrations of selected radionuclides in the sediments of Kress Creek at various depths (Frame, 1984) - (continued).

Distance downstream from storm outfall (meters)	DEPTH (cm)	Concentration (pCi/g)		
		RADIUM-226*	THORIUM-228*	THORIUM-232*
1000	0-10	1.09	1.49	1.60
	10-20	0.67	0.84	0.21
	20-30	0.59	0.44	0.57
1100	0-10	2.08	1.78	1.18
	10-20	1.68	4.38	5.29
	20-30	0.65	1.29	1.16
1200	0-10	1.06	6.18	6.38
	10-20	0.90	1.15	1.33
	20-30	0.64	0.52	0.87
1350	0-10	1.34	18.1	21.5
	10-20	1.41	10.1	11.9
	20-30	0.68	2.19	2.29
1450	0-10	0.56	5.04	5.96
	10-20	1.28	4.29	5.32
	20-30	0.75	4.71	5.09
1550	0-10	0.84	0.95	N.D.
	10-20	1.73	1.01	0.85
	20-30	1.13	0.54	0.46
1750	0-10	1.05	3.27	3.77
	10-20	0.62	0.27	0.60
	20-30	0.64	1.48	0.65
1850	0-10	0.89	1.91	2.39
	10-20	1.17	0.66	1.28
	20-30	0.94	0.98	1.00
1950	0-10	2.60	49.8	66.0
	10-20	2.66	59.1	71.7
	20-30	0.77	3.06	4.13
2050	0-10	0.39	0.67	0.64
	10-20	0.70	N.D.	0.43
	20-30	0.37	0.33	0.44
2150	0-10	0.92	3.69	4.40
	10-20	0.75	1.17	1.13
	20-30	0.53	0.50	0.69

* Carcinogen with no cancer slope factor from which to derive CREG
pCi/g = picoCuries per gram
cm = centimeters

Table 23. Total thorium* concentrations (pCi/g) in soil from boreholes along Kress Creek (Frame, 1984) - (continued).

Distance downstream from outfall (meters)	DEPTH (cm)	Distance from Bank (meters)			
		one	five	ten	twenty-five
150	0	28.4-46.6	13.4	19.9	29.1
	15	38.9-121	12.2	24.0	9.14
	30	23.3-101	9.98	27.7	3.34
	45	–	11.1	–	–
	60	7.33-20.0	–	76.6	–
	70	7.89-23.6	–	–	–
	90	–	–	169	–
	110	–	–	226	–
	130	–	–	176	–
	150	–	–	–	46.8
	170	–	–	23.5	–
200	0	20.0	7.07-41.8	11.6-45.2	3.17
	15	14.8	9.16-38.8	18.5-32.9	5.38
	30	8.90	7.39-17.5	18.2-30.0	4.83
	60	5.65	6.38-8.99	7.22	5.49
	70	6.10	–	–	–
	75	–	–	8.10	–
	80	–	6.99	–	–
250	0	3.32-8.66	9.47-23.1	8.01-16.8	–
	15	2.50-14.6	15.6-42.4	12.9-24.6	–
	30	3.56-25.2	41.8-46.7	9.50-25.6	–
	50	5.25	–	–	–
	60	66.5	33.5-41.1	20.3–27.7	–
	80	–	–	35.8	–
	90	68.5	41.6	63.7	–
	100	51.4	–	–	–
300	0	37.9-39.9	25.5-51.5	166	22.7
	15	44.2-51.1	40.4-44.6	261	37.4
	30	23.5-35.4	32.3-54.5	296	23.0
	60	13.0-17.3	15.0-24.1	193	9.68
	70	–	7.42	–	–
	80	11.1	–	–	–
	90	–	11.3	51.7	–
	100	–	–	25.4	–

* = Carcinogen with no cancer slope factor from which to derive CREG
CM = centimeters
– = Not Available
pCi/g = picoCuries per gram

Table 23. Total thorium* concentrations (pCi/g) in soil from boreholes along Kress Creek (Frame, 1984) - (continued).

Distance downstream from outfall (meters)	DEPTH (cm)	Distance from Bank (meters)			
		one	five	ten	twenty-five
350	0	8.01-49.5	5.63	21.1	9.20
	15	5.99-32.8	10.3	33.3	16.9
	30	2.34-14.7	15.1	44.3	24.8
	40	9.17	–	–	–
	45	2.34	–	–	–
	60	–	–	12.2	14.2
	70	–	3.22	–	–
	75	–	–	–	9.14
400	0	5.16-25.7	22.4	19.6	5.02
	15	10.9-49.5	28.3	21.4	5.10
	30	12.0-66.1	20.2	21.0	6.13
	60	5.32-71.3	7.54	7.1	6.99
	75	–	3.89	–	6.38
	80	55.0	–	–	–
	90	2.59	–	–	–
450	0	9.17-76.2	–	–	–
	15	8.63-116	–	–	–
	30	4.10-93.5	–	–	–
	50	2.68-34.4	–	–	–
500	0	11.8-74.2	32.8	55.1	4.65
	15	8.72-74.8	27.6	125	5.65
	30	5.13-29.8	24.2	163	7.10
	60	1.86-10.1	14.2	21.9	7.36
	80	–	8.04	–	9.95
	90	–	–	12.1	–
	100	–	–	10.0	–
550	0	18.4-64.7	3.05-5.05	3.51	4.20
	15	31.2-102	4.36-6.44	6.16	6.07
	30	28.4-79.7	3.74-5.30	7.89	6.33
	40	–	–	–	6.84
	45	30.2	3.32	–	–
	60	2.68	15.8	5.96	4.81
	70	–	18.6	–	–
	80	–	–	4.59	–
600	0	156	69.8	3.97	3.37-3.76
	15	251	111	4.97	4.75-4.86
	30	150	106	2.79	4.25-4.97
	60	14.5	14.5	1.41	3.74-6.16
	80	5.57	3.64	–	6.84
	90	–	–	–	4.28

* = Carcinogen with no cancer slope factor from which to derive Creg
cm = centimeters
– = Not Available
pCi/g = picoCuries per gram

Table 23. Total thorium* concentrations (pCi/g) in soil from boreholes along Kress Creek (Frame, 1984) - (continued).

Distance downstream from outfall (meters)	DEPTH (cm)	Distance from Bank (meters)			
		one	five	ten	twenty-five
650	0	5.30-118	46.2	11.1	3.84
	15	4.20-222	3.65	11.1	3.84
	30	3.94-354	43.5	4.94-5.02	4.78-4.83
	50	–	–	1.27	–
	60	1.90-35.5	8.21	2.15	4.35-4.75
	70	2.04	–	–	4.49
	80	–	2.61	–	–
700	0	4.89-5.65	3.05-5.38	3.17-4.05	2.61
	15	8.57	5.54	4.41	–
	30	4.30-6.3	1.43-3.34	3.51-4.44	–
	60	2.45-4.28	1.77-2.70	1.45-4.86	–
	75	1.36	1.45	–	–
750	0	26.3-102	7.51025.8	5.43-9.77	2.41-4.05
	15	25.7=173	34.5	11.6	4.20
	30	8.33-220	11.7-12.5	5.71-6.16	4.62-5.24
	60	3.61-45.9	2.08-3.51	2.00-4.73	4.02-5.24
	70	2.45-29.7	–	2.33-2.54	3.34
	75	–	1.41	1.70	–
	90	–	–	–	4.30
800	0	38.4-133	2.91-47.1	2.68-8.15	1.36-3.05
	15	75.3-186	2.86-79.4	3.71	2.41
	30	79.6-133	47.4-47.5	2.98-5.05	1.60-7.28
	45	–	0.57	–	–
	60	31.3	–	–	0.49-5.46
	70	–	–	–	0.60
	80	–	–	–	3.82
850	0	13.2-20.8	3.12-2.45	2.15-3.42	2.54
	15	12.5-18.1	4.15	4.54-5.90	4.46
	30	6.16-52.4	2.15-5.65	5.99-7.48	4.73
	40	5.32	–	–	–
	60	22.8	2.41	4.73-7.39	1.73
	70	5.88	–	3.10-5.99	0.73
900	0	4.38-25.5	3.42-6.61	3.03	3.29
	15	35.0	8.39	4.57	3.94
	30	9.62-35.3	4.62-5.65	5.65	6.61
	45	–	–	–	4.89
	60	3.42-10.4	1.06-2.98	4.97	–
	70	–	1.00-2.15	–	–
	75	2.23	–	5.54	–

* = Carcinogen with no cancer slope factor from which to derive CREG
cm = centimeters
– = Not Available
pCi/g = picoCuries per gram

Table 23. Total thorium* concentrations (pCi/g) in soil from boreholes along Kress Creek (Frame, 1984) - (continued).

Distance downstream from outfall (meters)	DEPTH (cm)	Distance from Bank (meters)			
		one	five	ten	twenty-five
950	0	3.51-7.57	2.30-3.64	4.53	3.07
	15	4.70-12.0	4.44	5.00	6.73
	30	4.97-22.0	5.60-6.16	6.49	6.58
	60	5.71-59.0	5.02-6.73	7.85	7.44
	70	–	2.79	–	–
	90	3.71-6.13	6.54	6.25	
	110	26.6	–	–	–
	120	7.95	–	–	–
	130	6.67	–	–	–
1000	0	18.6-48.3	3.51-5.35	1.72-2.96	2.98-3.64
	15	10.9-83.4	4.81	–	–
	30	10.9-32.2	4.83-7.36	2.45-2.70	4.86-5.82
	60	5.13-26.2	1.34-4.92	2.59-3.82	5.08-6.44
	70	–	3.87	6.70	5.05
	90	–	–	–	6.50
1050	0	4.23-44.3	3.97-30.2	4.41-19.3	4.10-5.27
	15	77.9	59.1	27.9	–
	30	6.27-41.6	6.67-24.6	7.51-12.7	2.93-9.86
	60	6.47-8.99	5.49-7.30	2.43-9.65	1.08-6.07
	70	5.63	3.76	–	–
	75	–	5.96	–	–
	90	–	–	9.44	–
1100	0	19.6-59.1	6.70-14.0	3.54-4.20	2.54-4.23
	15	78.2	17.7	–	–
	30	14.7-53.0	4.94-7.98	3.56-4.12	5.21-5.46
	50	–	–	1.54	–
	60	3.03-6.24	1.27-1.94	1.24	3.64
	65	–	1.68	–	–
	70	–	–	1.16	–
	75	–	–	–	3.15
	90	–	–	–	5.46
1150	0	4.62-14.1	4.10-6.70	2.47-2.56	2.15-2.82
	30	4.62-18.8	7.22-11.8	5.74-7.57	3.69-6.33
	60	3.39-8.10	3.00-8.2		4.15-7.74
	70	6.81	7.95	–	–
	75	3.89	–	–	7.85
	80	–	–	7.01	–

* = Carcinogen with no cancer slope factor from which to derive CREG
cm = centimeters
– = Not Available
pCi/g = picoCuries per gram

Table 23. Total thorium* concentrations (pCi/g) in soil from boreholes along Kress Creek (Frame, 1984) - (continued).

Distance downstream from outfall (meters)	DEPTH (cm)	Distance from Bank (meters)			
		one	five	ten	twenty-five
1200	0	5.00-7.39	2.25-3.47	2.41-3.44	1.68-3.59
	30	5.02-5.41	1.94-4.36	4.78-8.96	3.32-7.36
	40	–	4.10	–	–
	60	1.54-4.38	0.98	3.37-9.05	1.32-8.69
	75	–	–	0.91	–
	90	–	–	–	1.04-7.63
1250	0	12.1-61.1	3.89-20.4	1.41-4.46	1.84-3.59
	30	6.38-78.9	3.07-13.3	3.99-4.70	3.59-7.10
	60	1.72-13.1	3.29-6.19	1.79-2.61	1.58-8.75
	70	1.06	5.49	–	10.2
	75	–	3.71	0.98	1.37
	80	9.29	–	–	–
1300	0	4.94-7.60	2.10	2.39	–
	30	6.56-11.1	2.93	5.32	–
	60	8.10-14.7	3.24	2.32	–
	75	7.80	4.59	–	–
	90	16.0	–	–	–
1350	0	2.23-11.2	2.71	2.98	4.75
	15	2.79-16.6	3.68	3.75	6.01
	30	2.36-30.3	4.36	3.91	4.84
	60	2.07-21.5	4.10	2.35	3.18
1400	0	7.08-46.2	2.22-3.69	1.85-12.2	2.95
	15	9.35-77.4	3.09-3.77	3.04-7.42	5.03
	30	7.34-69.7	2.93-3.25	3.65-17.8	3.27
	60	2.08-9.07	1.58-2.13	3.49-80.3	1.46
	70	2.24	–	–	–
	90	–	1.38	3.39-9.88	1.45
1450	0	2.16-30.1	2.17-20.5	2.36-9.31	2.07-3.17
	15	2.37-38.0	2.58-27.3	2.92-12.9	2.78-3.71
	30	2.7-93.3	4.00-24.3	4.45-10.6	3.86-3.46
	60	2.75-52.3	4.50-4.86	3.51-5.76	1.64-4.47
	65	30.0	–	–	–
	80	–	3.37	–	–
	90	2.83	4.07	–	–

* = Carcinogen with no cancer slope factor from which to derive CREG
cm = centimeters
– = Not Available
pCi/g = picoCuries per gram

Table 23. Total thorium* concentrations (pCi/g) in soil from boreholes along Kress Creek (Frame, 1984) - (continued).

Distance downstream from outfall (meters)	DEPTH (cm)	Distance from Bank (meters)			
		one	five	ten	twenty-five
1500	0	1.88-8.88	2.24-5.24	2.16-5.30	2.13
	15	1.72-11.8	2.41-5.11	3.63-5.89	2.39
	30	1.42-11.0	3.81-4.20	4.47-5.65	1.34
	60	3.01-14.3	1.84-3.15	1.36-5.00	1.31
	70	–	–	1.38	–
	80	1.61	1.74	–	–
	90	2.46	2.37	2.57	–
1550	0	2.87-6.44	1.31-3.54	1.67-3.90	2.12-2.86
	15	2.63-7.93	1.60-3.89	1.77-4.55	2.87-2.95
	30	3.30-6.54	1.72-3.99	2.82-5.57	3.31-4.06
	60	1.69	1.09-1.39	2.30-3.20	4.96
	75	2.62	–	–	–
	80	1.15	–	–	–
	90	–	1.48	1.31-2.93	1.29-4.57
1600	0	14.6-34.3	14.9-30.9	15.8-22.8	2.58
	15	21.3-50.9	17.7-42.2	19.4-33.1	2.84
	30	15.4-104	15.3-46.9	13.5-32.5	2.70
	60	4.70-39.6	4.57-5.16	2.65-5.83	1.31
	70	13.6	–	–	–
	75	–	3.45	2.69	–
	80	1.50	2.45	–	1.33
1650	0	8.31-10.9	6.91-10.5	7.36-7.52	1.72-6.98
	15	10.4-16.4	11.0-15.8	8.38-10.3	4.92-11.6
	30	7.96-14.9	12.6-16.9	7.63-13.4	3.30-9.63
	60	1.84-3.07	2.44-6.18	2.18-2.33	2.53-4.20
	75	–	–	1.48	–
	80	–	3.03	–	–
	90	–	–	1.89	2.14-4.43
1700	0	1.74-5.29	1.79-11.8	1.64-38.3	4.17-6.98
	15	2.16-7.75	2.19-16.2	4.91-56.3	1.77-11.6
	30	2.93-5.92	2.87-27.0	4.13-79.3	2.34-9.63
	60	3.04-3.35	3.20-48.9	4.17-7.92	2.53-3.25
	90	2.84	3.01-7.09	3.42	2.14-3.67
1750	0	5.26-8.29	5.89-18.0	5.35-29.1	3.38-3.47
	15	6.96-11.7	6.57-25.0	6.98-45.5	3.6404.95
	30	8.31-10.1	5.2-4.29	5.82-86.1	3.64-4.17
	60	3.10-3.54	2.59-53.9	3.73-23.8	2.70
	80	–	50.5	–	–
	90	1.91-3.00	2.42	2.57-4.11	2.61-2.88

* = Carcinogen with no cancer slope factor from which to derive CREG
cm = centimeters
– = Not Available
pCi/g = picoCuries per gram

Table 23. Total thorium* concentrations (pCi/g) in soil from boreholes along Kress Creek (Frame, 1984) - (continued).

Distance downstream from outfall (meters)	DEPTH (cm)	Distance from Bank (meters)			
		one	five	ten	twenty-five
1800	0	6.17-46.4	2.12-40.6	1.43-15.8	1.22-6.23
	15	8.52-21.4	3.13-64.1	2.33-22.8	1.97-7.62
	30	6.85-12.7	2.74-90.2	2.68-19.8	2.33-6.64
	60	3.7-5.21	2.78-19.9	2.82-4.04	1.80-2.86
	90	4.50-20.5	2.6-4.36	2.47-2.59	1.92-3.12
1850	0	3.71-43.7	5.15-20.2	1.27-5.75	3.11
	15	4.88	9.58-30.1	1.53-7.04	3.85
	30	3.72-140	21.0-21.7	1.93-5.36	3.51
	60	4.11-555	3.79-59.4	1.41-3.14	3.24
	90	3.15-357	2.50-9.26	2.06-2.92	3.03
1870	0	5.91	3.17	8.31	2.70
	15	8.79	3.67	9.75	3.76
	30	9.64	4.27	12.7	3.87
	60	9.62	5.71	20.6	3.44
	90	–	–	4.10	2.85
1900	0	4.55-14.6	3.09-8.40	2.14-2.75	2.18-2.47
	15	6.26-19.0	3.84-12.5	2.71-3.04	2.27-2.53
	30	5.98-31.1	5.52-17.2	2.78-3.42	2.78-3.22
	60	3.09-10.7	5.48-19.1	2.48-2.97	1.91-3.30
	75	2.94-7.59	5.92	–	3.59
	80	–	9.59	–	–
	90	–	–	–	1.88
1950	0	9.21-41.9	8.82-34.5	2.33-21.7	2.45-3.34
	15	14.0-60.4	11.2-36.1	3.35-26.3	3.14-3.69
	30	15.6-107	9.21-40.2	2.96-18.1	3.19-3.78
	60	4.33-32.7	3.26-6.23	2.66-4.99	2.85-3.25
	80	10.0	–	–	–
	85	–	2.92	–	–
	90	2.69	3.18	1.82	2.47
2000	0	4.63-40.3	2.09-19.5	2.22-13.8	2.54-2.62
	15	4.96-58.4	2.76-30.4	2.42-19.7	3.19-3.46
	30	4.25-107	3.27-32.3	2.60-18.2	3.47-5.75
	60	4.62-62.7	3.49-5.80	3.34-5.49	2.98-3.84
	70	3.55	–	–	–
	85	–	3.16	3.60	2.58
	90	17.71	3.16	3.60	–

* = Carcinogen with no cancer slope factor from which to derive CREG
cm = centimeters
– = Not Available
pCi/g = picoCuries per gram

Table 23. Total thorium* concentrations (pCi/g) in soil from boreholes along Kress Creek (Frame, 1984) - (continued).

Distance downstream from outfall (meters)	DEPTH (cm)	Distance from Bank (meters)			
		one	five	ten	twenty-five
2050	0	14.0-60.5	17.1-20.6	5.44-20.2	2.25-2.35
	15	24.6-93.1	24.7-29.2	6.1-29.6	2.78-2.91
	30	23.8-154	22.9-24.5	5.02-31.2	3.81-3.99
	60	5.81-20.2	4.40-4.69	4.49-5.93	3.12-4.10
	75	11.0	–	–	–
	80	3.12	–	–	–
	90	–	2.39-2.75	2.85-3.12	2.33-3.73
2100	0	10.1-28.7	2.79-21.1	2.51-18.5	13.3
	15	15.2-42.5	3.00-29.4	2.17-26.6	3.17-17.5
	30	23.6-89.4	4.28-31.5	3.70-38.0	4.45-15.1
	60	9.16-33.2	4.15-6.58	4.20-11.0	4.06-4.53
	65	–	3.65	–	–
	70	5.26	–	–	–
2150	0	33.1-44.6	6.08-21.2	3.05-14.1	2.67-4.14
	15	41.3-58.6	7.29-29.8	3.01-20.2	3.31-5.78
	30	59.0-94.8	5.89-28.1	3.87-16.3	4.37-7.13
	40	–	3.35	–	–
	60	8.44-139	4.68	3.39-4.50	2.07
	75	4.62	–	–	–
	80	–	3.40	–	–
	85	30.2	–	–	–
	90	–	–	2.13-3.71	2.51
2200	0	5.4-28.5	26.0	19.0	2.32
	15	7.46-43.2	41.5	29.3	3.21
	30	11.5-71.4	101	30.0	4.30
	60	7.40-27.3	17.3	5.91	3.92
	85	3.14	8.72	–	–
	90	9.15	–	2.70	2.09

* = Carcinogen with no cancer slope factor from which to derive CREG
cm = centimeters
– = Not Available
pCi/g = picoCuries per gram

TABLE 24. Locations of elevated gamma radiation levels and soil thorium concentrations along Kress Creek (Frame, 1985) - (continued).

Distance downstream from outfall (meters)	Distance from Bank (meters)	Gamma Exposure Rate (uR/hr)	Depth (cm)	Total Thorium (pCi/G)
125	1	170	0	428
			15	432
			30	364
			60	158
			70	126
297	15	210	0	489
			15	428
			30	155
			60	26.3
			90	27.3

* = Carcinogen with no cancer slope factor from which to derive CREG
cm = centimeters
– = Not Available
pCi/g = picoCuries per gram

TABLE 24. Locations of elevated gamma radiation levels and soil thorium concentrations along Kress Creek (Frame, 1985) - (continued).

Distance downstream from outfall (meters)	Distance from Bank (meters)	Gamma Exposure Rate (uR/hr)	Depth (cm)	Total Thorium (pCi/G)
305	12	130	0	303
			15	417
			30	372
			60	77.7
			90	18.3
415	8	35	0	31.5
			30	32.5
			60	23.9
			80	12.4
425	5	49	0	171
			15	232
			60	19.2
			90	16.9
501	7	84	0	136
			15	140
			30	56.9
			45	20.2
510	1	76	0	131
			15	179
			30	196
			60	72.7
			70	61.6
565	1	43	0	92.8
			15	91.8
			30	47.8
			60	7.1
685	2	155	0	138
			15	247
			25	351
			30	322
			60	103
720	0.5	80	0	123
			15	201
			30	121
			60	25.0
			70	12.2
755	2	–	0	165
			15	259
			30	216
			60	44.9
765	2	–	0	135
			15	224
			30	205
			60	26.8
860	1	18	0	5.24
			15	8.30
			30	16.7
			60	3.87
			70	1.54

cm - Centimeters
– = Not Available
uR/hr = microroentgens per hours
pCi/g = picoCuries per gram

TABLE 24. Locations of elevated gamma radiation levels and soil thorium concentrations along Kress Creek (Frame, 1985) - (continued).

Distance downstream from outfall (meters)	Distance from Bank (meters)	Gamma Exposure Rate (uR/hr)	Depth (cm)	Total Thorium (pCi/G)
865	1	31	0	64.9
			15	120
			30	135
			50	106
865	3	105	0	150
			15	232
			30	395
			60	200
			90	49.0
875	1	61	0	68.1
			15	106
			30	101
			60	20.0
890	2	63	0	119
			15	140
			30	53.6
			60	20.0
			70	13.8
989	2	31	0	53.9
			15	101
			30	204
			60	75.5
1035	4	–	0	95.9
			15	141
			30	76.5
			60	11.0
			70	7.42
1089	1	–	0	94.9
			15	191
			30	218
			60	67.3
1130	3	59	0	106
			30	285
			60	66.5
			70	39.8
1380	1	74	0	41.1
			15	42.9
			30	18.5
			60	4.22
1382	1	–	0	30.3
			15	37.6
			30	45.3
			60	3.13
			90	2.30
1425	4	76	0	15.5
			15	19.7
			30	13.1
			60	3.64

cm - Centimeters
– = Not Available
uR/hr = microroentgens per hours
pCi/g = picoCuries per gram

TABLE 24. Locations of elevated gamma radiation levels and soil thorium concentrations along Kress Creek Frame, 1985) - (continued)

Distance downstream from outfall (meters)	Distance from Bank (meters)	Gamma Exposure Rate (uR/hr)	Depth (cm)	Total Thorium (pCi/G)
1440	1	110	0	38.0
			15	64.2
			30	128
			60	47.0
1698	6	74	0	80.4
			15	122
			30	299
			60	117
			90	7.00
1765	5	120	0	83.3
			15	145
			30	109
			60	76.8
			90	12.3
1787	1	135	0	75.8
			15	107
			30	181
			60	64.3
			90	17.5
1815	1	140	0	107
			15	151
			30	301
			60	37.2
			90	6.67
1910	1	84	0	53.3
			15	49.4
			30	30.6
			60	4.49
1970	1	85	0	53.9
			15	87.3
			30	80.9
			60	10.1
			70	6.35
1980	1	--	0	27.0
			15	34.0
			30	9.40
			60	9.11
			75	6.89
2015	1.5	--	0	44.1
			15	58.3
			30	54.5
			60	13.0
2070	1	53	0	46.3
			15	63.2
			30	54.7
			60	12.7
			65	10.6

cm - Centimeters
-- = Not Available
uR/hr = microroentgens per hours
pCi/g = picoCuries per gram

TABLE 24. Locations of elevated gamma radiation levels and soil thorium concentrations along Kress Creek (Frame, 1985) - (continued).

Distance downstream from outfall (meters)	Distance from Bank (meters)	Gamma Exposure Rate (uR/hr)	Depth (cm)	Total Thorium (pCi/G)
2075	4	88	0	51.4
			15	81.5
			30	148
			60	25.2
			80	6.35
2080	20	72	0	89.8
			15	137
			30	253
			60	117
			80	45.0
2106	1	95	0	109
			15	108
			30	205
			60	103
			75	54.3
2130	1	63	0	46.7
			15	63.7
			30	33.7
			60	3.86
			65	3.57

cm - Centimeters
– = Not Available
uR/hr = microroentgens per hours
pCi/g = picoCuries per gram

Table 25. Gamma exposure ranges one meter above the soil surface along Kress Creek, systematic survey (background rate 6 to 11 microroentgens per hour; Frame, 1984) - (continued).

Distance downstream from outfall (meters)	Gamma* Exposure Rate (uR/hr) Distance from Bank (meters)			
	1	5	10	25
100	19-24	19-22	16-17	11-12
150	26-30	26	13-22	13-22
200	22-28	16-28	11-18	10
250	13-14	13-22	15-19	8
300	28-34	30-48	120	24
350	16-50	18-36	22-24	13-16
400	16-24	19-26	24	12
450	17-50	16	22	10
500	22-30	26-36	22-32	11-19
550	20-34	11-13	9-11	8-10
600	16-88	13-52	10-16	9-10
650	11-58	10-40	10-19	9-10
700	12-16	10-16	8-13	8
750	18-68	14-36	11-19	9-12
800	24-68	13-52	11-24	10-11
850	8-14	9-10	10-10	10
900	8-19	9-12	10	9
950	8-9	7-8	8	8
1000	19-26	9-19	8-11	8-10
1050	10-26	10-32	10-24	9-13
1100	24-32	16-24	10-11	8-10
1150	11-13	10-13	10	8-9
1200	10-11	9-10	9	8-10
1250	14-24	11-22	8-16	8-9
1300	8-22	8-9	8	--
1350	19-40	19-26	13-22	12-17
1400	92-96	24-68	19-64	16-22
1450	40-48	42-44	24-32	16-22
1500	11-19	12-19	12-19	12-13
1550	18-28	13-17	13-16	12-13
1600	28-38	34-58	30-44	16
1650	22-24	24-28	24-26	17-24
1700	14-19	14-36	16-64	14-24
1750	19-24	24-38	22-54	16-22
1800	19-38	18-72	16-40	13-24
1850	16-40	19-44	13-24	16
1870	16	16	19	16

cm - Centimeters
-- = Not Available
uR/hr = microroentgens per hours
pCi/g = picoCuries per gram

Table 25. Gamma exposure ranges one meter above the soil surface along Kress Creek, systematic survey (background rate 6 to 11 microroentgens per hour; Frame, 1984) - (continued).

Distance downstream from outfall (meters)	Gamma* Exposure Rate (uR/hr) Distance from Bank (meters)			
	1	5	10	25
1900	14-26	14-22	13-14	10-13
1950	26-44	26-48	16-46	14-17
2000	17-38	14-44	14-36	13-16
2050	30-50	40-44	19-38	14-16
2100	24-44	16-46	15-44	13-32
2150	32-40	28-46	16-30	14-19
2200	48	42	34	15

cm - Centimeters
-- = Not Available
uR/hr = microroentgens per hours
pCi/g = picoCuries per gram

TABLE 26. Ranges of concentrations of chemicals and other parameters in water from the Kerr-McGee storm discharge and Kress Creek, 1964 (Butler, 1965) and 1974-6 (IEPA Maywood files, 1990).

	Concentration (ppm)					
	Storm Discharge		Kress Creek (1964)			
Chemical or Parameter	1964	1974-6	Upstream	Downstream	Comparison Value	Comparison Source
Ammonia	37-128	0.3-79.5	–	13.5	3 ppm	Intermediate EMEG
Arsenic	–	0.03	–	–	0.00002	CREG
Chloride	535-1400	280-1100	22-38	40-210	–	–
Fluoride	18-25	18.8-25.8	0.5	9	0.5 ppm	EMEG
Manganese	–	1.11	–	–	0.05	RMEG
Nickel	–	10.2	–	–	0.1 ppm	LTHA
Nitrate	379-542	9.2-54.3	–	70	10 ppm	MCL
Sodium	1440-3280	380-1224	22-83	67-519	20 ppm	USEPA guidance
Sulfate	2890-6060	900-1543	134-170	206-924	–	–
Dissolved alpha* (pCi/l)	ND-15	–	–	–	15 pCi/l	MCL
Dissolved beta* (pCi/l)	45-198	–	–	–	4mrem	MCL
Suspended alpha* (pCi/l)	6-30	–	–	–	15 pCi/l	MCL
Suspended beta* (pCi/l)	27-135	–	–	–	4mrem	MCL

– = Not Available.
ND = Not Detected.
pCi/l = picoCuries per liter.
ppm = parts per million.
pMCL = proposed MCL = proposed Maximum Contaminant Level.
* = Carcinogen with no cancer slope factor from which to derive CREG.

TABLE 27. Concentrations of radionuclides in the sediments of the West Branch of the DuPage River near its confluence with Kress Creek (Frame, 1984).

Distance from Confluence (meters)	Depth	Concentration (pCi/g)		
	(cm)	Radium-225*	Thorium-228*	Thorium-232*
Upstream				
200	0-10	0.57	0.70	0.51
	10-20	0.40	1.18	1.06
	20-30	0.54	N.D.	N.D.
100	0-10	N.D.	0.70	N.D.
	10-20	0.63	0.40	0.58
	20-30	0.72	1.16	N.D.
0	0-10	0.50	0.71	1.23
	10-20	0.83	0.53	0.71
	20-30	0.36	0.81	0.58
Downstream				
100	0-10	1.39	12.0	15.2
	10-20	0.67	0.65	0.38
	20-30	0.29	N.D.	0.41
200	0-10	0.48	2.84	1.83
	10-20	0.57	1.07	1.22
	20-30	0.38	0.26	0.33

cm = centimeters.
pCi/g = picoCuries per gram.
* = Carcinogen with no cancer slope factor from which to derive CREG.

Table 28. Total thorium concentrations in soil from boreholes along the West Branch of the DuPage River near its confluence with Kress Creek (Frame, 1984) - (continued).

Distance from Confluence (meters)	Depth	Total Thorium * (pCi/g) Distance from Bank (meters)			
	(cm)	1	5	10	25
Upstream					
200	0	2.87-3.60	3.07-6.23	2.92-3.31	1.74-2.31
	15	3.87-4.71	0.71-3.79	3.50-4.55	2.87-2.92
	30	4.67-7.16	4.28-11.9	5.59-7.49	3.00-3.36
	60	3.52-9.61	2.86-7.11	2.65-2.88	2.71-2.78
	90	2.84-5.51	1.96-2.39	1.5-1.88	2.04-2.09
150	0	1.51-6.80	2.00-7.11	1.64-3.73	1.58-2.21
	15	2.5-11.2	2.61-12.6	2.33-6.33	1.98-2.33
	30	2.55-24.8	3.15-25.4	2.51-2.55	2.00-2.91
	60	2.79-13.4	3.37-5.84	2.48-3.21	1.72-3.84
	90	3.29-4.80	2.09-3.74	3.42	1.37-2.92
100	0	2.20-3.59	1.35-3.12	2.15-2.63	1.92-2.06
	15	2.34-4.42	1.45-4.00	2.87-3.23	2.34-3.13
	30	2.28-5.39	1.74-4.67	3.68-3.73	2.86-3.83
	60	1.50-3.84	1.87-3.15	1.84-3.18	3.06-3.91
	70	1.50	1.87	1.84	3.91
	80	–	2.19	–	–
	90	2.55	2.95	2.27	3.19
50	0	3.46-5.00	1.84-2.50	1.55-2.25	1.83-1.97
	15	4.62-7.55	2.18-2.96	1.92-2.85	1.84-2.53
	30	7.61-11.9	2.80-3.70	1.97-3.28	2.05-3.32
	60	3.91-4.80	1.60-3.04	1.65-3.34	2.84
	80	–	–	–	1.69
	85	1.95	–	–	–
	90	2.08	1.55-3.84	1.42-2.72	–
0	0	2.03	2.56	2.33	2.68
	15	2.42	2.99	2.86	3.80
	30	5.19	2.99	4.87	3.00
	60	2.41	3.69	3.05	2.42
	80	–	–	–	1.78
	90	–	3.53	1.74	–
Downstream					
50	0	2.71-2.85	1.66-7.51	1.64-33.0	2.01-33.8
	15	3.34-3.71	2.23-9.35	1.53-48.9	3.13-47.1
	30	3.67-6.47	2.85-7.89		
	60	3.42-3.83	1.71-4.16	1.83-133	2.89-249
	70	–	–	–	2.41
	85	–	–	–	85.3
	90	1.71-4.02	1.50-3.31	15.0	–

Table 28. Total thorium concentrations in soil from boreholes along the West Branch of the DuPage River near its confluence with Kress Creek (Frame, 1984) - (continued).

Distance from Confluence (meters)	Depth	Total Thorium * (pCi/g) Distance from Bank (meters)			
	(cm)	1	5	10	25
Downstream					
100	0	2.66-14.5	1.86-17.3	1.87-60.8	2.19-2.32
	15	3.51-18.7	1.84-22.4	2.20-14.4	2.55-2.96
	30	2.71-31.4	2.27-33.9	2.89-49.7	3.21-3.69
	60	1.54-55.1	1.44-111	2.31-18.3	3.30-4.23
	80	–	–	1.45	2.12
	85	–	29.7	2.32	–
	90	52.6	1.65	–	2.82
150	0	4.61-28.1	7.73-17.0	3.81-6.15	2.49-2.68
	15	3.47-63.3	2.61-23.1	2.98-7.56	2.55-2.75
	30	3.32-96.7	3.43-17.3	3.90-7.89	3.39-3.59
	60	1.79-12.6	3.65-7.82	2.52-4.29	3.86-3.96
	85	3.27	–	3.06	3.83
	90	–	3.34-4.01	–	3.09
200	0	4.61-28.1	7.73-14.7	3.81-4.57	2.39-2.49
	15	7.13-41.8	12.5-24.1	5.49-6.08	2.75-2.91
	30	11.0-90.7	20.3-37.3	5.42-8.36	3.55-3.68
	60	13.8-34.4	6.87-11.4	4.41-4.42	4.10-4.47
	70	–	–	–	3.03
	80	–	3.37	–	–
	85	2.51	–	2.20	4.17
	90	3.91	2.73	3.98	–

* = Carcinogen with no cancer slope factor from which to derive CREG
– = Not Available
pCi/g = picoCuries per gram
cm = centimeters

TABLE 29. Concentrations of radionuclides in sediments of the West Branch of the DuPage River at various distances from the northern end of the contaminated bank by the WTP (USEPA, 1986; USEPA files, 1990).

Distance (feet)	Concentration (pCi/g)			
	Radium-226*	Radium-228*	Thorium-227*	Thorium-228*
Background	1.7	1.4	0.042	0.69
0	0.47-1.3	0.30-0.70	0.025-0.0041	0.33-0.83
100	1.3	--	0.027-0.047	0.50-0.57
250	0.012-0.12	--	0.012-2.2	0.28-0.38
400	1.0	--	0.032	0.28
450	0.77-1.3	--	0.045-0.14	0.34-3.5
640	0.68-1.8	--	0.0078-1.1	0.30-15
700	0.71-1.0	--	0.016-0.056	0.34-1.0
800	0.66-1.3	--	0.012-0.043	0.26-1.4
1050	0.88-1.0	--	0.066	1.2
1300	0.64-1.1	--	0.021	0.24
1500	0.82	--	0.045	0.75
2100	2.8	--	0.039	1.3
2500	1.6-2.6	--	N.D.-0.054	2.2-2.9
6700	1.0	--	0.068	3.2

Distance (feet)	Concentration (pCi/g)			
	Thorium-232*	Uranium-234*	Uranium-235*	Uranium-238*
Background	0.56	0.69	0.019	0.70
0	0.10-0.61	0.20-0.61	0.019-0.021	0.30-0.64
100	0.50-0.55	0.52-1.1	0.013-0.049	0.61-1.1
250	0.31-2.5	0.25-0.33	0.014-0.060	0.28-0.34
400	0.29	0.61	0.034	0.59
450	0.22-5.9	0.39-0.52	0.022-0.070	0.35-0.43
640	0.21-23	0.53-4.0	0.029-0.082	0.51-3.5
700	0.33-2.3	0.48-0.49	0.055-0.078	0.44-0.58
800	0.51-1.6	0.22-2.0	0.0004-0.054	0.36-2.0
1050	1.1	0.40-1.4	0.021-0.062	0.33-1.4
1300	0.29	0.71	0.011	0.64
1500	1.3	1.3	0.057	1.4
2100	1.5	--	--	--
2500	2.3-3.2	0.84-0.98	0.022-0.024	0.68-0.97
6700	3.3	1.2	0.097	1.3

-- = Not Available pCi/g = picoCuries per gram
* = Carcinogen with no cancer slope factor from which to derive CREG

TABLE 30. Gamma* radiation (uR/hr) exposures one meter above the soil surface along the West Branch of the DuPage River near its confluence with Kress Creek (Frame, 1984).

Distance from confluence (meters)	Distance from Bank (meters)			
	one	five	ten	twenty-five
Upstream				
200	13-14	14-17	13-16	11-13
150	10-19	11-22	10-17	13-14
100	10-14	9-16	12-14	11-13
50	14-18	12-16	10-14	10-14
0	13	13	13	8
Downstream				
50	16-42	11-52	11-30	12-16
100	14-32	14-36	12-17	13-64
150	14-104	12-64	11-24	12-16
200	19-44	22-40	19-22	11-16

uR/hr = microroentgens per hour
* = Carcinogen with no cancer slope factor from which to derive CREG

TABLE 31. Completed Exposure Pathways.

Pathway Name	Source	Environmental Transport Media	Point of Exposure	Route of Exposure	Receptor Population	Time
Air	Kerr-McGee Facility, Reed-Keppler Park, WTP	Air	Kerr-McGee Facility, Reed-Keppler Park, WTP	Inhalation, Dermal Contact, Ingestion (dust)	On-Site Workers, Remediation Workers, Trespassers	Past, Present, Future
Air	All Six Areas	Air	Residential Areas, Kress Creek, West Branch DuPage River	Inhalation, Dermal Contact, Ingestion (dust)	Residents	Past, Present, Future
Soil, Dust, Sediments	Kerr-McGee Facility, Reed-Keppler Park, WTP	Soil	Kerr-McGee Facility, Reed-Keppler Park, WTP	Ingestion, Dermal Contact, Inhalation	On-Site Workers, Remediation Workers, Trespassers	Past, Present, Future
Soil, Dust, Sediments	All Six Areas	Soil	All Six Areas	Ingestion, Dermal Contact, Inhalation	Residents	Past, Present, Future

TABLE 32. Potential Exposure Pathways.

Pathway Name	Source	Environmental Transport Medium	Point of Exposure	Route of Exposure	Receptor Population	Time
Air	Kerr-McGee Facility, Reed-Keppler Park, WTP	Air	Kerr-McGee Facility, Reed-Keppler Park, WTP	Inhalation, Dermal Contact, Ingestion (dust)	Residents	Future
Biota	All Six Areas	Soil	All Six Areas	Ingestion	Persons Eating Biota	Past, Present, Future
Private Wells	Main Water Area, Reed-Keppler Park, WTP, Residential Areas	Groundwater	Kerr-McGee Facility, Reed-Keppler Park, WTP, Residential Areas	Ingestion, Inhalation, Dermal Contact	Residents with Private Wells	Past, Present, Future
Surface water	Kerr-McGee Facility, Kress Creek, West Branch DuPage River	Surface Water	Kerr-McGee Facility, Kress Creek, West Branch DuPage River	Ingestion, Dermal Contact	Persons Recreating in Surface Water	Past, Present, Future

Six Areas = Kerr-McGee Facility, Kress Creek, West Chicago Regional Waste Treatment Plant, Reed-Keppler Park, West Branch of the DuPage River, and Residential Areas

APPENDIX A

Appendix A-1
(NRC, 1989a)

Table A.1. Concentrations of Chemical and Radiological Parameters in the B Wells on the West Chicago Site, Well B-1

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	<0.002	<0.002	<0.002
Al	mg/L	0.20	<0.005	0.15	0.21	0.29
As	mg/L	0.046	0.10	0.003	0.021	0.028
B	mg/L	0.24	0.36	0.009	0.34	0.33
Ba	mg/L	0.013	0.19	0.10	0.11	0.17
Ca	mg/L	210	320	250	220	280
Cd	mg/L	<0.001	<0.002	0.003	<0.002	<0.002
Co	mg/L	0.011	0.014	0.012	<0.006	0.014
Cr	mg/L	<0.001	0.010	<0.001	0.002	<0.001
Cu	mg/L	0.023	0.11	0.069	<0.001	0.08
Fe	mg/L	0.047	0.13	0.11	3.6	0.13
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	1.4	38	3.0	2.4	3
Mg	mg/L	85	110	95	80	97
Mn	mg/L	0.64	0.94	0.96	0.15	0.9
Mo	mg/L	0.016	0.18	0.007	0.009	0.002
Na	mg/L	250	450	650	540	670
Ni	mg/L	0.067	0.12	0.011	0.073	0.11
Pb	mg/L	0.003	0.05	0.003	0.02	<0.004
Se	mg/L	0.001	0.14	<0.001	0.066	0.21
V	mg/L	0.011	<0.003	0.015	<0.003	<0.003
Zn	mg/L	0.57	1.2	1.3	0.006	1.2
F	mg/L	17	17	18	17	18
Cl	mg/L	210	330	315	250	290
HCO_3	mg/L	367	334	496	470	473
CO_3	mg/L	-	30	<6	<3	<10
$NH_3(N)$	mg/L	2	<0.1	5	4.3	6.4
$NO_2(N)$	mg/L	<0.1	0.23	<0.1	7.5	<0.1
$NO_3(N)$	mg/L	6	3	4	4	3.2
SO_4	mg/L	770	1580	1630	1350	1610
TDS	mg/L	1762	3030	3290	2660	3330
TSS	mg/L	3	6	<2	<2	<2
pH	units	6.8	7.1	7	7.2	6.9
Sp.Cond.	µmhos	2398	3860	4180	3190	4150
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.013	0.06	0.03	0.02	0.06
Ra-226t	pCi/L	0.12	0.15	0.10	0.19	0.06
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<1.04	<2.8	<1.2	<2.4	<2.2
Th-230	pCi/L	0.037	0.196	0.042	0.046	0.022
Th-232	pCi/L	0.004	0.018	0.014	0.015	0.003
U-238	mg/L	0.001	0.016	0.02	0.006	0.008

Table A1. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	0.035	0.085	0.059	<0.020
Al	mg/L	<0.05	0.25	0.45	0.47	0.16
As	mg/L	0.003	<0.1	0.20	0.11	<0.11
B	mg/L	0.27	0.28	0.36	0.59	0.32
Ba	mg/L	<0.001	<0.02	<0.02	<0.013	<0.013
Ca	mg/L	220	220	210	210	200
Cd	mg/L	<0.002	<0.01	0.016	0.009	<0.007
Co	mg/L	0.011	<0.04	0.066	0.040	<0.011
Cr	mg/L	<0.001	<0.03	0.056	0.052	<0.026
Cu	mg/L	0.077	0.092	0.12	0.14	0.081
Fe	mg/L	0.11	0.093	0.11	0.059	0.10
Hg	mg/L	0.00013	<0.0001	0.00023	0.00092	0.00034
K	mg/L	3	2.7	2.5	4	2.8
Mg	mg/L	80	70	71	78	71
Mn	mg/L	0.68	0.61	0.63	0.62	0.56
Mo	mg/L	0.017	0.032	0.056	0.033	0.027
Na	mg/L	570	440	400	420	430
Ni	mg/L	0.095	0.13	0.16	0.15	0.069
Pb	mg/L	<0.001	0.11	0.29	0.18	<0.068
Se	mg/L	0.002	0.099	0.22	0.10	<0.10
V	mg/L	<0.003	<0.04	0.081	0.050	0.031
Zn	mg/L	0.91	0.76	0.82	3.4	0.77
F	mg/L	17	13.1	17	16	17
Cl	mg/L	260	150	170	190	190
TOC	mg/L	-	-	-	-	22
HCO_3	mg/L	480	750	460	420	420
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	7	<0.1	4.8	5.4	<0.1
$NO_2(N)$	mg/L	7	0.1	0.14	<0.04	<0.01
$NO_3(N)$	mg/L	<1	11	2	2	<1
SO_4	mg/L	1310	760	950	1020	1160
TDS	mg/L	2710	2160	2130	2240	2360
TSS	mg/L	<2	3	<2	<1	1
pH	units	7.3	7.7	6.8	6.7	6.8
Sp.Cond.	µmhos	*3890	2810	2730	3540	3050
Ra-224s	pCi/L	0	-	0.05	0.04	0.013
Ra-224t	pCi/L	-	-	0.14	0.11	0.024
Ra-226s	pCi/L	0.03	0.08	0.0002	0.07	0.004
Ra-226t	pCi/L	0.06	0.21	0.5	0.14	0.008
Ra-228s	pCi/L	-	-	-	-	0.09
Ra-228t	pCi/L	<1.3	<2.5	<2.0	<1.3	≥0.09
Th-230	pCi/L	0.047	0.004	0.009	-	0.021
Th-232	pCi/L	0.008	0.004	0.006	-	0.006
U-238	mg/L	0.004	0.0009	0.003	0.002	0.014

Table A.1. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	0.048	<0.002
Al	mg/L	0.18	0.15	0.23	0.70
As	mg/L	0.14	<0.11	0.12	<0.06
B	mg/L	0.37	0.31	0.38	0.52
Ba	mg/L	<0.013	<0.013	0.007	0.11
Ca	mg/L	260	210	290	200
Cd	mg/L	0.010	<0.007	0.024	<0.002
Co	mg/L	0.026	0.017	0.054	<0.006
Cr	mg/L	<0.026	<0.026	0.043	<0.001
Cu	mg/L	0.062	0.066	0.083	<0.001
Fe	mg/L	0.046	0.054	0.097	0.070
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.0005
K	mg/L	2.1	1.9	2.37	9.8
Mg	mg/L	72	70	68	60
Mn	mg/L	0.79	0.54	0.63	0.48
Mo	mg/L	0.023	0.018	0.046	0.010
Na	mg/L	380	350	300	340
Ni	mg/L	0.096	0.080	0.11	0.002
Pb	mg/L	<0.068	<0.068	0.21	<0.008
Se	mg/L	<0.10	<0.10	0.11	<0.08
V	mg/L	0.021	0.014	0.059	<0.003
Zn	mg/L	1.1	1.3	0.88	0.49
F	mg/L	20	21	21	20
Cl	mg/L	190	160	180	150
TOC	mg/L	8.5	20	24	9.4
HCO_3	mg/L	450	390	390	430
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	7.2	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	<0.05	0.06	-	-
$NO_3(N)$	mg/L	<1	<1	7	<1
SO_4	mg/L	1030	890	800	680
TDS	mg/L	2210	1990	1960	1800
TSS	mg/L	3	<2	<2	9
pH	units	6.9	6.8	6.8	6.9
Sp.Cond.	µmhos	3330	2920	2940	2710
Ra-224s	pCi/L	0.001	0	0.06	0
Ra-224t	pCi/L	0.08	0	0.07	0
Ra-226s	pCi/L	0.06	0.04	0	0
Ra-226t	pCi/L	0.08	0.04	0	0
Ra-228s	pCi/L	0.05	0.14	0.06	0.06
Ra-228t	pCi/L	-	0.14	0.07	0.12
Th-230	pCi/L	0.022	0.014	0.022	0.086
Th-232	pCi/L	0.013	0.005	0.006	0.010
U-238	mg/L	0.003	0.019	0.012	0.014

Table A.2. Concentrations of Chemical and Radiological Parameters in the B Wells on the West Chicago Site, Well B-2

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	<0.002	<0.002	<0.002
Al	mg/L	0.025	<0.05	<0.050	0.21	0.11
As	mg/L	0.025	<0.009	0.004	0.018	0.006
B	mg/L	0.14	0.16	<0.009	0.21	0.10
Ba	mg/L	0.018	0.21	0.13	0.11	0.097
Ca	mg/L	110	120	100	110	97
Cd	mg/L	<0.001	<0.002	<0.002	<0.002	<0.002
Co	mg/L	<0.001	<0.006	<0.006	<0.006	<0.006
Cr	mg/L	<0.001	0.021	0.003	0.002	<0.001
Cu	mg/L	<0.001	0.014	<0.001	<0.001	<0.001
Fe	mg/L	3.0	3.8	2.2	3.6	3.5
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	6.3	31	5.5	5.4	5.2
Mg	mg/L	70	63	63	58	61
Mn	mg/L	0.17	0.12	0.15	0.15	0.14
Mo	mg/L	0.012	0.018	0.003	0.009	0.003
Na	mg/L	220	210	250	170	200
Ni	mg/L	0.071	0.088	0.082	0.073	0.065
Pb	mg/L	0.001	<0.001	<0.001	0.017	<0.004
Se	mg/L	0.002	0.028	<0.001	0.011	0.019
V	mg/L	0.004	0.023	0.011	<0.003	<0.003
Zn	mg/L	0.004	<0.003	<0.003	0.006	<0.003
F	mg/L	2.5	7	1.4	2	1.8
Cl	mg/L	94	130	110	88	100
HCO_3	mg/L	436	326	454	400	438
CO_3	mg/L	-	30	<6	<3	<10
NH_3(N)	mg/L	4	<0.1	2	<0.1	1.7
NO_2(N)	mg/L	<0.1	0.34	0.1	<0.1	<0.1
NO_3(N)	mg/L	<1	1	2	2	<1
SO_4	mg/L	540	590	540	490	460
TDS	mg/L	1264	1350	1350	1120	1190
TSS	mg/L	16	97	6	56	19
pH	units	7.1	7.4	7.3	7.4	7.3
Sp.Cond.	µmhos	1831	2500	2000	1490	1700
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.02	0.09	0.10	0.08	0.07
Ra-226t	pCi/L	0.26	0.39	0.17	0.33	0.21
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<1.9	<4.5	<1.6	<1.5	<1.6
Th-230	pCi/L	0.015	0.032	0.048	0.024	0.031
Th-232	pCi/L	0.002	0.003	0.007	0.006	0.010
U-238	mg/L	0.005	0.005	0.006	0.001	0.003

Appendix A-5
(NRC, 1989a)

Table A.2. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	0.035	0.079	0.029	<0.020
Al	mg/L	<0.05	<0.2	0.33	0.072	0.14
As	mg/L	0.002	<0.1	0.18	<0.1	<0.11
B	mg/L	0.18	0.38	0.12	0.26	0.13
Ba	mg/L	<0.001	<0.02	<0.02	0.013	0.017
Ca	mg/L	100	110	100	98	90
Cd	mg/L	<0.002	0.011	0.015	<0.007	<0.007
Co	mg/L	<0.006	<0.04	<0.04	0.015	<0.011
Cr	mg/L	<0.001	<0.03	0.067	<0.03	<0.026
Cu	mg/L	<0.001	<0.03	0.056	0.033	0.027
Fe	mg/L	1.5	3.5	3.0	1.7	0.21
Hg	mg/L	<0.00008	<0.0001	<0.0001	<0.00030	0.00028
K	mg/L	5	5.1	4.9	5.4	4.0
Mg	mg/L	53	54	53	50	50
Mn	mg/L	0.15	0.16	0.15	0.12	0.13
Mo	mg/L	0.011	0.029	0.047	<0.02	0.024
Na	mg/L	180	140	130	120	140
Ni	mg/L	0.062	0.099	0.15	0.086	0.042
Pb	mg/L	<0.001	0.12	0.26	0.10	<0.068
Se	mg/L	<0.001	0.10	0.20	<0.1	<0.10
V	mg/L	<0.003	<0.04	0.073	0.020	0.021
Zn	mg/L	0.015	0.070	0.045	0.036	0.023
F	mg/L	2	1.3	3	5.8	<1
Cl	mg/L	96	65	64	87	66
TOC	mg/L	-	-	-	-	12
HCO_3	mg/L	450	355	460	410	410
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	<1	<0.1	2.6	2.9	<0.1
$NO_2(N)$	mg/L	0.1	0.1	0.14	1.2	0.28
$NO_3(N)$	mg/L	<1	6	2	<1	<1
SO_4	mg/L	430	320	280	270	310
TDS	mg/L	1030	910	910	840	910
TSS	mg/L	7	18	15	<1	19
pH	units	7.7	7.5	7.2	7.1	7.1
Sp.Cond.	µmhos	1600	1300	1340	1530	1370
Ra-224s	pCi/L	0.02	-	0.04	0.02	0.01
Ra-224t	pCi/L	-	-	0.11	0.09	0.06
Ra-226s	pCi/L	0.07	0.056	0.01	0.06	0.04
Ra-226t	pCi/L	0.16	0.34	0.16	0.33	0.12
Ra-228s	pCi/L	-	-	-	-	0.19
Ra-228t	pCi/L	-	<2.5	<1.9	<1.9	≥0.19
Th-230	pCi/L	0.039	0.016	0.026	0.027	0.024
Th-232	pCi/L	0.007	0.004	0.006	0.005	0.009
U-238	mg/L	0.002	0.002	0.002	0.04	0.004

Table A.2. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	<0.020	<0.002
Al	mg/L	<0.0008	<0.008	<0.11	0.49
As	mg/L	<0.11	<0.11	<0.11	<0.06
B	mg/L	0.065	0.093	0.11	0.25
Ba	mg/L	<0.013	<0.013	0.011	0.17
Ca	mg/L	86	92	94	91
Cd	mg/L	<0.007	<0.007	<0.015	<0.002
Co	mg/L	<0.011	<0.011	<0.011	<0.006
Cr	mg/L	<0.026	<0.026	<0.026	<0.001
Cu	mg/L	<0.017	0.017	<0.015	<0.001
Fe	mg/L	1.3	0.32	<0.033	0.47
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.005
K	mg/L	3.0	4.2	4.0	9.4
Mg	mg/L	35	49	49	48
Mn	mg/L	0.14	0.12	0.11	0.091
Mo	mg/L	<0.018	<0.018	<0.018	0.006
Na	mg/L	130	110	115	110
Ni	mg/L	0.087	0.043	<0.069	0.027
Pb	mg/L	<0.068	<0.068	<0.050	<0.08
Se	mg/L	<0.10	<0.10	<0.10	<0.08
V	mg/L	<0.005	0.005	<0.025	<0.003
Zn	mg/L	0.41	0.18	0.024	0.042
F	mg/L	<1	<1	2	3
Cl	mg/L	58	60	80	36
TOC	mg/L	7.5	19	15	11
HCO_3	mg/L	420	400	400	400
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	<0.1	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	<0.05	1.7	-	-
$NO_3(N)$	mg/L	<1	<1	<1	<1
SO_4	mg/L	180	210	250	180
TDS	mg/L	750	740	750	660
TSS	mg/L	25	630	7	35
pH	units	7.2	7.5	7.3	7.3
Sp.Cond.	µmhos	1280	1330	1210	1180
Ra-224s	pCi/L	0.04	0	0	0.03
Ra-224t	pCi/L	1.85	0	0	0.03
Ra-226s	pCi/L	0.007	0	0	0.06
Ra-226t	pCi/L	0.36	0.14	0	0.14
Ra-228s	pCi/L	0.04	0.03	0.11	0.16
Ra-228t	pCi/L	≥0.04	0.18	0.15	0.30
Th-230	pCi/L	0.029	0.024	0.028	0.183
Th-232	pCi/L	0.005	0.012	0.003	0.015
U-238	mg/L	0.002	0.007	0.005	0.002

Appendix A-7
(NRC, 1989a)

Table A.3. Concentrations of Chemical and Radiological Parameters in the B Wells on the West Chicago Site, Well B-3

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	<0.002	0.009	<0.002
Al	mg/L	0.26	0.72	0.36	0.88	0.3
As	mg/L	0.037	0.026	0.004	0.075	0.008
B	mg/L	1.4	1.29	0.73	0.83	0.83
Ba	mg/L	0.016	0.20	0.13	0.11	0.091
Ca	mg/L	240	280	240	230	220
Cd	mg/L	0.001	0.010	0.004	0.006	<0.002
Co	mg/L	0.018	0.032	0.018	0.009	0.011
Cr	mg/L	<0.001	0.038	<0.001	0.025	<0.001
Cu	mg/L	0.098	0.52	0.22	0.13	0.1
Fe	mg/L	0.050	0.056	0.029	0.076	0.044
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	2.7	47	2.6	2.5	3.0
Mg	mg/L	150	130	130	120	110
Mn	mg/L	1.5	1.3	1.4	1.3	1.5
Mo	mg/L	0.013	0.034	0.003	0.024	<0.002
Na	mg/L	180	250	270	190	210
Ni	mg/L	0.17	0.27	0.27	0.18	0.18
Pb	mg/L	0.001	0.001	0.002	0.031	<0.004
Se	mg/L	0.007	0.052	0.001	0.032	0.036
V	mg/L	0.036	0.085	0.028	0.016	<0.003
Zn	mg/L	0.88	1.2	1.3	0.90	0.81
F	mg/L	18	16	6	15	17
Cl	mg/L	160	370	300	140	250
HCO_3	mg/L	369	280	402	370	374
CO_3	mg/L	-	30	<6	<3	<10
$NH_3(N)$	mg/L	4.	<0.1	3	0.8	2.5
$NO_2(N)$	mg/L	<0.1	3.20	<0.1	4.4	<0.1
$NO_3(N)$	mg/L	2	<1	3	2	2.9
SO_4	mg/L	990	970	850	790	800
TDS	mg/L	2044	2300	2120	1850	1950
TSS	mg/L	2	144	7	2	<2
pH	units	6.6	6.8	6.8	0?	6.7
Sp.Cond.	µmhos	2616	3110	2840	2140	2580
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	-0.01	0.09	0.09	0.06	0.07
Ra-226t	pCi/L	0.16	0.33	0.10	0.07	1.14
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<3	<4.4	<1.1	<2.1	<2
Th-230	pCi/L	0.011	0.149	0.072	0.029	0.021
Th-232	pCi/L	0.004	0.007	0.010	0.003	0.006
U-238	mg/L	0.019	0.017	0.02	0.01	0.009

Table A.3. Continued

Chemical Species	Unit	1982	1983			
		4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.002	0.036	0.098	0.066	<0.020
Al	mg/L	0.14	0.36	0.63	0.45	0.31
As	mg/L	0.003	<0.1	0.22	0.13	<0.11
B	mg/L	0.98	1.2	0.96	1.5	1.1
Ba	mg/L	<0.001	<0.02	<0.02	<0.013	0.019
Ca	mg/L	240	240	250	330	280
Cd	mg/L	<0.002	0.012	0.020	0.012	<0.007
Co	mg/L	0.025	0.048	0.071	0.053	0.034
Cr	mg/L	0.005	0.033	0.088	0.045	<0.026
Cu	mg/L	0.21	0.15	0.13	0.15	0.19
Fe	mg/L	0.053	0.083	0.094	0.071	0.085
Hg	mg/L	<0.00008	<0.0001	0.00038	<0.00030	0.0034
K	mg/L	3.0	2.8	3.0	5.5	3.5
Mg	mg/L	121	120	120	170	190
Mn	mg/L	1.5	1.5	1.8	2.6	3.2
Mo	mg/L	0.016	0.032	0.061	0.027	0.022
Na	mg/L	260	190	140	200	300
Ni	mg/L	0.23	0.21	0.24	0.24	0.23
Pb	mg/L	<0.001	0.16	0.32	0.18	<0.068
Se	mg/L	0.003	<0.1	0.31	0.15	<0.10
V	mg/L	<0.003	0.049	0.10	0.067	0.041
Zn	mg/L	1.1	0.96	0.93	1.1	1.5
F	mg/L	16	14	14	15	15
Cl	mg/L	300	200	110	270	200
TOC	mg/L	-	-	-	-	18
HCO_3	mg/L	380	325	400	350	360
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	2	<0.1	3.7	3.6	<0.1
$NO_2(N)$	mg/L	25	0.2	0.08	<0.04	0.28
$NO_3(N)$	mg/L	<1	7	1	<1	<1
SO_4	mg/L	830	780	770	1410	1450
TDS	mg/L	2030	1790	1760	2520	2830
TSS	mg/L	<2	3	<2	<1	<2
pH	units	7.2	6.7	6.6	6.5	6.4
Sp.Cond.	µmhos	2890	2480	2310	3780	3570
Ra-224s	pCi/L	0.006	-	0.02	0.02	0
Ra-224t	pCi/L	-	-	0.02	0.06	0.08
Ra-226s	pCi/L	0.007	0.04	0.06	0.02	0.08
Ra-226t	pCi/L	0.03	0.06	0.09	0.11	0.13
Ra-228s	pCi/L	-	-	-	-	0.16
Ra-228t	pCi/L	-	<1.8	<2.0	<2.4	≥0.16
Th-230	pCi/L	0.034	0.014	0.046	0.024	0.014
Th-232	pCi/L	0.008	0.004	0.007	0.0084	0.003
U-238	mg/L	0.01	0.003	0.02	0.016	0.014

Table A.3. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	0.046	<0.002
Al	mg/L	0.19	0.35	0.53	1.7
As	mg/L	<0.11	<0.11	<0.11	<0.06
B	mg/L	0.35	0.98	0.90	1.2
Ba	mg/L	<0.013	<0.013	0.009	0.17
Ca	mg/L	150	210	300	250
Cd	mg/L	<0.007	<0.007	0.029	<0.002
Co	mg/L	0.037	0.022	0.088	<0.006
Cr	mg/L	<0.026	<0.026	0.040	<0.001
Cu	mg/L	0.054	0.068	0.14	<0.001
Fe	mg/L	0.051	0.024	0.086	0.047
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.005
K	mg/L	1.6	3.6	3.9	25
Mg	mg/L	60	110	140	160
Mn	mg/L	1.6	2.2	3.0	2.8
Mo	mg/L	<0.018	<0.018	0.038	0.010
Na	mg/L	73	170	180	190
Ni	mg/L	0.12	0.16	0.27	0.17
Pb	mg/L	<0.068	<0.068	0.20	<0.08
Se	mg/L	<0.10	<0.10	0.13	<0.08
V	mg/L	0.009	0.026	0.080	<0.003
Zn	mg/L	0.81	0.92	1.3	0.88
F	mg/L	12	18	22	20
Cl	mg/L	78	170	230	95
TOC	mg/L	20	11	13	11
HCO_3	mg/L	200	340	350	410
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	1.0	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	1.7	4.0	-	-
$NO_3(N)$	mg/L	<1	1	2	<1
SO_4	mg/L	520	710	910	970
TDS	mg/L	1050	1680	1890	2020
TSS	mg/L	3	140	15	9
pH	units	6.6	6.6	6.5	6.6
Sp.Cond.	µmhos	1660	2460	2730	2660
Ra-224s	pCi/L	0.009	0.04	0	0.01
Ra-224t	pCi/L	0.04	0.13	0	0.02
Ra-226s	pCi/L	0.011	0	0	0.02
Ra-226t	pCi/L	0.031	0	0	0.03
Ra-228s	pCi/L	0.12	0.08	0.05	0.15
Ra-228t	pCi/L	≥0.12	0.08	0.06	0.20
Th-230	pCi/L	0.029	0.039	0.033	0.031
Th-232	pCi/L	0.010	0.004	0.016	0.011
U-238	mg/L	0.006	0.011	0.010	0.010

Table A.4. Concentrations of Chemical and Radiological Parameters in the B Wells on the West Chicago Site, Well B-4

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	0.010	<0.002	<0.002
Al	mg/L	0.21	0.48	0.22	0.28	0.46
As	mg/L	0.024	<0.010	0.006	0.013	0.008
B	mg/L	0.18	0.22	<0.009	0.19	0.20
Ba	mg/L	0.002	0.22	0.15	0.18	0.12
Ca	mg/L	120	150	210	130	170
Cd	mg/L	<0.001	<0.002	<0.002	<0.002	<0.002
Co	mg/L	<0.001	<0.006	<0.006	<0.006	<0.006
Cr	mg/L	0.001	0.012	0.002	<0.001	0.001
Cu	mg/L	0.015	0.035	0.003	<0.001	<0.001
Fe	mg/L	0.019	0.021	0.021	0.014	0.023
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	0.88	19	0.8	0.7	1
Mg	mg/L	50	55	52	54	63
Mn	mg/L	0.11	0.13	0.14	0.13	0.15
Mo	mg/L	0.019	0.022	0.007	0.012	<0.002
Na	mg/L	72	63	63	60	99
Ni	mg/L	0.004	0.024	0.013	0.014	0.014
Pb	mg/L	0.002	<0.001	<0.001	0.015	<0.004
Se	mg/L	0.008	0.035	0.002	0.017	0.019
V	mg/L	0.046	0.044	0.047	0.094	0.027
Zn	mg/L	0.20	0.23	0.21	0.22	0.29
F	mg/L	22	21	21	19	18
Cl	mg/L	95	150	100	180	300
HCO_3	mg/L	295	293	353	300	310
CO_3	mg/L	-	<10	<6	<3	<10
$NH_3(N)$	mg/L	4	<0.1	3	2.4	3.8
$NO_2(N)$	mg/L	<0.1	0.05	<0.1	0.1	<0.1
$NO_3(N)$	mg/L	3	1	4	4	3
SO_4	mg/L	180	210	230	140	220
TDS	mg/L	765	796	806	800	1130
TSS	mg/L	2.4	13	18	6	3
pH	units	6.8	7.1	6.9	7.3	6.9
Sp.Cond.	µmhos	1199	1360	1260	1060	1600
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.05	0.15	0.25	0.05	0.02
Ra-226t	pCi/L	0.17	0.35	0.39	0.05	0.02
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<2.5	<3.4	<1	<1.8	<2.6
Th-230	pCi/L	<0.019	0.046	0.037	0.019	0.027
Th-232	pCi/L	0.003	0.007	0.007	0.003	0.006
U-238	mg/L	0.079	0.12	0.14	0.10	0.10

Table A.4. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	<0.03	0.088	<0.020	<0.020
Al	mg/L	0.24	0.28	0.54	0.24	0.20
As	mg/L	0.002	<0.1	0.20	<0.11	<0.11
B	mg/L	0.15	0.22	0.18	0.28	0.17
Ba	mg/L	0.15	<0.02	<0.02	<0.013	<0.013
Ca	mg/L	140	120	150	140	100
Cd	mg/L	<0.002	<0.01	0.015	<0.007	<0.007
Co	mg/L	<0.006	<0.04	0.044	<0.011	<0.011
Cr	mg/L	<0.001	<0.03	0.066	<0.026	<0.026
Cu	mg/L	<0.001	0.032	0.073	0.040	0.024
Fe	mg/L	0.009	<0.05	<0.05	<0.024	<0.024
Hg	mg/L	<0.00009	0.00017	<0.0001	0.00035	0.00053
K	mg/L	0.8	1.1	0.92	1.9	0.92
Mg	mg/L	58	49	57	61	41
Mn	mg/L	0.15	0.13	0.15	0.14	0.095
Mo	mg/L	0.014	0.026	0.052	0.019	0.020
Na	mg/L	120	91	68	110	90
Ni	mg/L	0.010	<0.08	0.08	<0.038	<0.038
Pb	mg/L	<0.001	<0.1	0.28	<0.068	<0.068
Se	mg/L	0.004	<0.1	0.20	<0.10	<0.10
V	mg/L	0.004	0.050	0.11	0.051	0.054
Zn	mg/L	0.25	0.25	0.30	0.31	0.17
F	mg/L	17	17	17	16	19
Cl	mg/L	320	180	140	230	90
TOC	mg/L	-	-	-	-	6
HCO_3	mg/L	370	290	370	330	340
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	3	2	2.3	2.4	<0.1
$NO_2(N)$	mg/L	<0.1	<0.1	1.2	<0.04	<0.01
$NO_3(N)$	mg/L	2	6	4	3	4.2
SO_4	mg/L	130	110	140	160	160
TDS	mg/L	1000	760	840	840	720
TSS	mg/L	<2	5	<2	<1	<2
pH	units	7.6	7.2	6.9	6.8	6.8
Sp.Cond.	µmhos	1750	1300	1470	1770	1210
Ra-224s	pCi/L	0.04	-	0.19	0	0.02
Ra-224t	pCi/L	-	-	0.24	0.084	0.02
Ra-226s	pCi/L	0.003	0.001	0.04	0.064	0.13
Ra-226t	pCi/L	0.01	0.10	0.04	0.15	0.16
Ra-228s	pCi/L	-	-	-	-	0.15
Ra-228t	pCi/L	-	<1.7	<1.5	<1.6	≥0.15
Th-230	pCi/L	0.025	0.065	0.018	0.030	0.046
Th-232	pCi/L	0.008	0.009	0.004	0.007	0.007
U-238	mg/L	0.14	0.10	0.15	0.11	0.11

Table A.4. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.02	<0.020	<0.020	<0.002
Al	mg/L	0.25	0.15	0.18	0.62
As	mg/L	<0.11	<0.11	<0.11	<0.060
B	mg/L	0.19	0.13	0.15	0.29
Ba	mg/L	<0.013	<0.013	<0.002	0.16
Ca	mg/L	140	130	130	100
Cd	mg/L	<0.007	<0.007	<0.015	<0.002
Co	mg/L	0.012	<0.011	0.015	<0.006
Cr	mg/L	<0.026	<0.026	<0.026	<0.001
Cu	mg/L	<0.017	<0.017	0.019	<0.001
Fe	mg/L	<0.024	<0.024	<0.033	<0.008
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.0005
K	mg/L	0.62	1.2	1.1	<0.03
Mg	mg/L	40	4.8	52	42
Mn	mg/L	0.14	0.13	0.12	0.087
Mo	mg/L	0.029	0.018	0.026	<0.002
Na	mg/L	75	210	170	130
Ni	mg/L	<0.038	<0.038	<0.069	<0.003
Pb	mg/L	<0.068	<0.068	0.075	<0.08
Se	mg/L	<0.10	<0.10	<0.10	<0.08
V	mg/L	0.038	0.035	0.050	<0.003
Zn	mg/L	0.38	0.46	0.21	0.17
F	mg/L	21	18	18	18
Cl	mg/L	88	480	350	110
TOC	mg/L	2.5	21	16	7.9
HCO_3	mg/L	330	280	370	360
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	2.8	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	<0.05	0.10	-	-
$NO_3(N)$	mg/L	2.0	4	5	3
SO_4	mg/L	240	71	100	98
TDS	mg/L	830	1050	990	720
TSS	mg/L	2	11	<2	1
pH	units	6.8	6.8	6.9	7.0
Sp.Cond.	µmhos	1540	2110	1780	1300
Ra-224s	pCi/L	0.07	0.07	0.01	0
Ra-224t	pCi/L	0.09	0.98	0.01	0.04
Ra-226s	pCi/L	0.03	0	0	0
Ra-226t	pCi/L	0.05	0	0	0
Ra-228s	pCi/L	0.21	0.23	0.09	0.02
Ra-228t	pCi/L	≥0.21	0.65	0.13	0.15
Th-230	pCi/L	0.007	0.357	0.076	0.067
Th-232	pCi/L	0.014	0.003	0.006	0.026
U-238	mg/L	0.14	0.066	0.15	0.16

Appendix A-13
(NRC, 1989a)

Table A.5. Concentrations of Chemical and Radiological Parameters in the B Wells on the West Chicago Site, Well B-5

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	0.025	<0.002	<0.002
Al	mg/L	0.19	0.31	0.19	0.12	0.32
As	mg/L	0.056	0.027	0.002	0.02	0.010
B	mg/L	0.43	0.48	<0.009	0.36	0.32
Ba	mg/L	0.014	0.19	0.13	0.13	0.11
Ca	mg/L	260	250	230	340	230
Cd	mg/L	<0.001	<0.002	0.005	<0.002	<0.002
Co	mg/L	0.009	0.009	<0.006	<0.006	<0.0006
Cr	mg/L	<0.001	0.018	0.009	0.004	0.01
Cu	mg/L	0.076	0.20	0.074	0.044	0.07
Fe	mg/L	0.024	0.043	0.023	0.011	0.028
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	3	27	2.4	2.3	2
Mg	mg/L	92	75	80	110	80
Mn	mg/L	0.83	0.49	0.56	0.73	0.6
Mo	mg/L	0.013	0.026	0.017	<0.002	0.007
Na	mg/L	320	210	300	380	240
Ni	mg/L	0.11	0.11	0.10	0.13	0.085
Pb	mg/L	<0.001	<0.001	0.004	0.03	<0.004
Se	mg/L	0.010	0.026	<0.001	0.11	0.045
V	mg/L	0.012	0.020	0.032	0.081	0.013
Zn	mg/L	0.52	0.49	0.40	0.45	0.44
F	mg/L	18	16	17	13	16
Cl	mg/L	91	93	89	67	90
HCO_3	mg/L	329	246	372	350	346
CO_3	mg/L	-	20	<6	<3	<10
$NH_3(N)$	mg/L	7	<0.1	3	3.8	3.4
$NO_2(N)$	mg/L	<0.1	1.47	<0.1	1.8	<0.1
$NO_3(N)$	mg/L	4	2	7	5	3.1
SO_4	mg/L	1310	960	1030	1690	850
TDS	mg/L	2375	1840	2030	3040	1850
TSS	mg/L	<2	50	30	24	12
pH	units	6.9	7	7	7.2	6.8
Sp.Cond.	µmhos	2943	2400	2580	3140	2380
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.028	0.03	0.10	0.04	0.06
Ra-226t	pCi/L	0.27	0.09	0.13	0.14	0.06
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	2.31	<3.3	<2	<2.5	<1.8
Th-230	pCi/L	0.031	0.036	0.042	0.010	0.021
Th-232	pCi/L	0.003	0.006	0.024	0.003	0.003
U-238	mg/L	0.022	0.020	0.02	0.01	0.01

Table A.5. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	0.060	0.11	0.077	<0.020
Al	mg/L	0.12	0.29	0.56	0.40	0.17
As	mg/L	0.001	<0.1	0.24	0.11	<0.11
B	mg/L	0.43	0.11	0.55	0.56	0.43
Ba	mg/L	<0.001	<0.02	<0.02	<0.013	0.016
Ca	mg/L	210	290	300	260	240
Cd	mg/L	<0.002	0.014	0.018	0.012	<0.007
Co	mg/L	<0.006	0.041	0.068	0.044	<0.011
Cr	mg/L	0.002	0.040	0.090	0.040	<0.026
Cu	mg/L	0.072	0.11	0.14	0.13	0.076
Fe	mg/L	0.011	0.051	0.080	0.061	0.025
Hg	mg/L	<0.0009	<0.0001	<0.0001	<0.00030	0.00025
K	mg/L	1.8	2.5	2.5	4.1	2.1
Mg	mg/L	70	88	87	92	82
Mn	mg/L	0.49	0.68	0.70	0.61	0.47
Mo	mg/L	0.022	0.048	0.071	0.040	0.033
Na	mg/L	180	230	260	260	170
Ni	mg/L	0.077	0.15	0.18	0.14	0.042
Pb	mg/L	<0.001	0.18	0.38	0.21	<0.068
Se	mg/L	0.007	0.013	0.28	0.20	<0.10
V	mg/L	<0.003	0.042	0.098	0.060	0.029
Zn	mg/L	0.43	0.49	0.54	0.50	0.35
F	mg/L	15	15	17	17	17
Cl	mg/L	90	88	77	92	85
TOC	mg/L	-	-	-	-	11
HCO_3	mg/L	350	315	370	310	330
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	<1	<0.1	3.3	3	<0.1
$NO_2(N)$	mg/L	0.5	<0.1	0.04	0.04	<0.01
$NO_3(N)$	mg/L	<1	9	3	<1	<1
SO_4	mg/L	660	960	1060	1330	880
TDS	mg/L	1520	1840	2180	2105	1650
TSS	mg/L	2	6	3	4	<2
pH	units	7.3	6.8	6.9	6.7	6.7
Sp.Cond.	µmhos	2080	2590	2520	3070	2100
Ra-224s	pCi/L	0.02	-	0.02	0.006	0.01
Ra-224t	pCi/L	-	-	0.03	0.32	0.17
Ra-226s	pCi/L	0.03	0.04	0.11	0.03	0.04
Ra-226t	pCi/L	0.05	0.09	0.12	0.16	0.23
Ra-228s	pCi/L	-	-	-	-	0.27
Ra-228t	pCi/L	-	<2	<1.7	<1.6	≥0.27
Th-230	pCi/L	0.043	0.021	0.027	0.033	0.027
Th-232	pCi/L	0.005	0.003	0.007	0.0004	0.006
U-238	mg/L	0.02	0.009	0.02	0.016	0.018

Table A.5. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	0.024	<0.002
Al	mg/L	0.10	0.12	0.15	0.83
As	mg/L	<0.11	<0.11	0.13	<0.06
B	mg/L	0.54	0.44	0.44	0.85
Ba	mg/L	<0.013	0.013	0.010	0.18
Ca	mg/L	240	330	270	260
Cd	mg/L	0.008	<0.007	0.016	<0.002
Co	mg/L	0.025	0.022	0.029	<0.006
Cr	mg/L	<0.026	0.035	0.049	<0.001
Cu	mg/L	0.044	0.041	0.052	<0.001
Fe	mg/L	0.033	0.024	0.037	0.022
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.0005
K	mg/L	1.5	2.4	1.8	12
Mg	mg/L	58	110	78	78
Mn	mg/L	0.59	0.66	0.54	0.48
Mo	mg/L	0.061	0.035	0.054	0.033
Na	mg/L	200	290	120	190
Ni	mg/L	0.064	0.076	0.085	0.045
Pb	mg/L	<0.068	<0.068	0.10	<0.08
Se	mg/L	<0.10	<0.10	0.12	<0.08
V	mg/L	0.008	0.024	0.034	<0.003
Zn	mg/L	0.46	0.47	0.30	0.25
F	mg/L	18	26	19	17
Cl	mg/L	72	110	100	45
TOC	mg/L	16	14	15	11
HCO_3	mg/L	320	310	290	330
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	2.3	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	0.50	1.0	-	-
$NO_3(N)$	mg/L	2.0	3	2	2
SO_4	mg/L	950	1290	670	770
TDS	mg/L	1710	2420	1410	1680
TSS	mg/L	<2	1040	79	100
pH	units	6.9	6.8	6.8	6.9
Sp.Cond.	µmhos	2690	3280	1890	2180
Ra-224s	pCi/L	0.007	0.04	0	0
Ra-224t	pCi/L	0.12	0.70	0	0
Ra-226s	pCi/L	0.06	0.05	0	0
Ra-226t	pCi/L	0.14	0.86	0	0.02
Ra-228s	pCi/L	0.05	0.19	0.15	0.001
Ra-228t	pCi/L	≥0.05	0.78	0.31	0.20
Th-230	pCi/L	0.039	0.006	0.064	0.120
Th-232	pCi/L	0.034	0.006	0.015	0.003
U-238	mg/L	0.011	0.019	0.015	0.014

Appendix A-16
(NRC, 1989a)

Table A.6. Concentrations of Chemical and Radiological Parameters in the B Wells on the West Chicago Site, Well B-6

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	0.009	<0.002	<0.002
Al	mg/L	0.018	<0.05	<0.050	0.31	0.24
As	mg/L	0.052	0.015	0.022	0.044	0.020
B	mg/L	0.32	0.32	0.065	0.31	0.22
Ba	mg/L	0.014	0.26	0.16	0.21	0.12
Ca	mg/L	110	110	97	110	110
Cd	mg/L	<0.001	<0.002	<0.002	0.002	<0.002
Co	mg/L	0.001	<0.006	0.007	0.014	<0.006
Cr	mg/L	<0.001	0.014	0.002	0.023	0.008
Cu	mg/L	0.001	0.002	<0.001	0.027	<0.001
Fe	mg/L	1.6	1.4	0.75	1.8	1.9
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	8.3	34	6.8	6	5.6
Mg	mg/L	82	69	70	70	72
Mn	mg/L	0.35	0.33	0.41	0.43	0.37
Mo	mg/L	0.020	0.022	0.005	0.012	0.005
Na	mg/L	100	76	85	90	79
Ni	mg/L	0.069	0.058	0.046	0.055	0.042
Pb	mg/L	0.002	<0.001	0.003	0.024	<0.004
Se	mg/L	0.003	0.019	0.004	0.013	0.015
V	mg/L	0.004	0.011	0.010	0.054	0.01
Zn	mg/L	0.084	0.040	0.049	0.049	0.074
F	mg/L	5.7	5.2	5	5	4.9
Cl	mg/L	120	120	120	130	130
HCO_3	mg/L	431	244	436	420	431
CO_3	mg/L	-	22	<6	<3	<10
$NH_3(N)$	mg/L	16	<0.1	12	7.6	12.4
$NO_2(N)$	mg/L	<0.1	0.37	<0.1	0.6	<0.1
$NO_3(N)$	mg/L	<1	7	<1	2	<1
SO_4	mg/L	290	260	260	250	240
TDS	mg/L	955	903	871	890	910
TSS	mg/L	80	410	21	375	320
pH	units	7	7.1	7.2	7.4	7.3
Sp.Cond.	µmhos	1548	1320	1480	1300	1440
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.010	0.13	0.09	0.003	0.04
Ra-226t	pCi/L	0.46	0.43	0.23	0.83	0.05
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	1.3	<2.7	<1	<1.2	<1.9
Th-230	pCi/L	0.025	0.07	0.036	0.031	0.055
Th-232	pCi/L	0.003	0.009	-	0.003	0.006
U-238	mg/L	0.094	0.004	0.012	0.004	0.003

Table A.6. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	0.035	0.061	0.033	<0.020
Al	mg/L	<0.05	<0.2	0.22	0.10	0.12
As	mg/L	0.023	<0.1	0.14	<0.11	<0.11
B	mg/L	0.31	0.40	0.30	0.40	0.28
Ba	mg/L	<0.001	0.027	0.026	0.015	0.016
Ca	mg/L	110	120	120	120	110
Cd	mg/L	<0.002	<0.01	0.011	<0.007	<0.007
Co	mg/L	<0.006	<0.04	<0.04	0.022	<0.011
Cr	mg/L	0.002	<0.03	0.044	<0.026	0.029
Cu	mg/L	<0.001	<0.03	0.042	0.034	0.019
Fe	mg/L	3.3	3.5	2.9	1.4	0.30
Hg	mg/L	<0.00009	<0.0001	<0.0001	<0.00030	0.00031
K	mg/L	5	5.1	4.9	5.9	4.7
Mg	mg/L	71	75	73	78	78
Mn	mg/L	0.38	0.46	0.46	0.43	0.39
Mo	mg/L	0.020	0.029	0.036	<0.018	0.029
Na	mg/L	80	79	76	81	83
Ni	mg/L	0.045	0.084	0.10	0.082	0.051
Pb	mg/L	<0.001	0.10	0.21	0.085	<0.068
Se	mg/L	0.005	<0.1	0.14	<0.10	0.11
V	mg/L	<0.003	<0.04	0.049	0.025	0.024
Zn	mg/L	0.093	0.17	0.11	0.087	0.099
F	mg/L	4	3.7	6	3.2	<1
Cl	mg/L	130	120	120	120	150
TOC	mg/L	-	-	-	-	23
HCO_3	mg/L	430	400	470	420	410
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	13	<0.1	12	13	<0.1
$NO_2(N)$	mg/L	25	<0.1	0.14	1	<0.01
$NO_3(N)$	mg/L	<1	14	2	<1	<1
SO_4	mg/L	220	220	250	240	230
TDS	mg/L	840	880	950	870	920
TSS	mg/L	25	23	14	17	21
pH	units	7.5	7.2	7.1	7	7.0
Sp.Cond.	µmhos	1430	1510	1420	1770	1470
Ra-224s	pCi/L	0.014	-	0	0	0.01
Ra-224t	pCi/L	-	-	0.15	0.04	0.01
Ra-226s	pCi/L	0.06	0.05	0.03	0.07	0.05
Ra-226t	pCi/L	0.42	0.37	0.53	0.36	0.07
Ra-228s	pCi/L	-	-	-	-	0.20
Ra-228t	pCi/L	-	<2	<0.9	<2.2	≥0.20
Th-230	pCi/L	0.021	0.045	0.019	0.024	0.057
Th-232	pCi/L	0.004	0.007	0.006	0.016	0.003
U-238	mg/L	0.006	0.003	0.002	0.002	0.010

Table A.6. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	0.025	<0.002
Al	mg/L	<0.008	0.013	<0.11	0.78
As	mg/L	<0.11	<0.11	<0.11	<0.06
B	mg/L	0.28	0.30	0.31	0.68
Ba	mg/L	<0.013	0.016	0.015	0.19
Ca	mg/L	120	110	130	130
Cd	mg/L	<0.007	<0.007	0.017	<0.002
Co	mg/L	<0.011	<0.011	0.026	0.018
Cr	mg/L	<0.026	<0.026	0.027	<0.001
Cu	mg/L	<0.017	<0.017	0.016	<0.001
Fe	mg/L	0.84	0.79	0.88	3.0
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.005
K	mg/L	3.9	4.2	3.8	14
Mg	mg/L	70	74	77	77
Mn	mg/L	0.50	0.42	0.45	0.44
Mo	mg/L	0.019	0.024	0.035	0.045
Na	mg/L	82	83	69	97
Ni	mg/L	0.087	0.059	<0.069	0.050
Pb	mg/L	<0.068	<0.068	0.12	<0.08
Se	mg/L	<0.10	<0.10	<0.10	<0.08
V	mg/L	<0.005	<0.005	0.030	<0.003
Zn	mg/L	0.24	0.23	0.050	0.106
F	mg/L	3.0	7.2	4	5
Cl	mg/L	120	180	170	140
TOC	mg/L	7.6	22	18	8.1
HCO_3	mg/L	410	340	340	420
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	11	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	<0.05	0.04	-	-
$NO_3(N)$	mg/L	<1	<1	<1	<1
SO_4	mg/L	250	220	220	180
TDS	mg/L	920	910	890	870
TSS	mg/L	16	9	8	10
pH	units	7.1	7.0	6.9	7.2
Sp.Cond.	µmhos	1540	1640	1420	1420
Ra-224s	pCi/L	0.01	0	0.03	0
Ra-224t	pCi/L	0.09	0.05	0.03	0
Ra-226s	pCi/L	0.057	0	0.01	0
Ra-226t	pCi/L	0.28	0.07	0.14	0.17
Ra-228s	pCi/L	0.01	0.08	0.01	0.02
Ra-228t	pCi/L	≥0.01	0.47	0.05	0.23
Th-230	pCi/L	0.019	0.027	0.034	0.039
Th-232	pCi/L	0.0041	0.006	0.007	0.011
U-238	mg/L	0.001	0.002	0.003	0.004

Table A.7. Concentrations of Chemical and Radiological Parameters in the B Wells on the West Chicago Site, Well B-7

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	0.043	<0.002	<0.002
Al	mg/L	0.042	0.42	0.19	0.26	0.19
As	mg/L	0.016	0.009	0.005	0.021	0.004
B	mg/L	0.25	0.26	0.071	0.31	0.26
Ba	mg/L	0.019	0.27	0.16	0.21	0.11
Ca	mg/L	140	150	120	130	140
Cd	mg/L	<0.001	0.005	0.005	<0.002	<0.002
Co	mg/L	0.007	<0.006	0.010	<0.006	<0.006
Cr	mg/L	<0.001	0.024	0.015	0.014	<0.001
Cu	mg/L	0.020	0.091	0.027	0.024	<0.001
Fe	mg/L	0.013	0.034	0.020	0.012	0.023
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	1	20	1	0.8	1
Mg	mg/L	56	52	47	49	55
Mn	mg/L	0.21	0.22	0.23	0.20	0.17
Mo	mg/L	0.012	0.023	0.011	0.002	<0.002
Na	mg/L	120	120	120	90	96
Ni	mg/L	0.022	0.047	0.033	0.030	0.020
Pb	mg/L	0.001	<0.001	0.001	0.018	<0.004
Se	mg/L	0.007	0.020	0.003	0.022	0.017
V	mg/L	0.012	0.043	0.054	0.030	<0.003
Zn	mg/L	0.15	0.14	0.11	0.041	0.22
F	mg/L	15	12	14	11	11
Cl	mg/L	180	220	160	120	190
HCO_3	mg/L	378	299	401	400	391
CO_3	mg/L	-	26	<6	<3	<10
$NH_3(N)$	mg/L	1	<0.1	1	0.2	1
$NO_2(N)$	mg/L	<0.1	0.40	<0.1	0.4	<0.1
$NO_3(N)$	mg/L	7	3	5	10	6
SO_4	mg/L	180	190	150	120	150
TDS	mg/L	934	1010	885	820	920
TSS	mg/L	2	<2	<2	5	<2
pH	units	6.9	7.2	7.2	7.5	7.1
Sp.Cond.	µmhos	1461	1650	1450	1230	1460
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.056	0.04	0.03	0.03	0.16
Ra-226t	pCi/L	0.216	0.14	0.04	0.06	0.16
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<1.9	<3.1	<2	<1.9	<1.4
Th-230	pCi/L	0.039	1.87	0.050	0.026	0.021
Th-232	pCi/L	0.010	0.005	0.012	0.004	0.003
U-238	mg/L	0.099	0.001	0.003	0.003	0.001

Table A.7. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	<0.03	0.073	<0.020	<0.02
Al	mg/L	<0.05	<0.2	0.33	0.087	0.057
As	mg/L	0.003	<0.1	0.14	<0.11	<0.11
B	mg/L	0.15	0.32	0.26	0.31	0.19
Ba	mg/L	<0.001	<0.02	<0.02	<0.013	0.013
Ca	mg/L	120	140	120	130	120
Cd	mg/L	<0.002	<0.01	0.013	<0.007	<0.007
Co	mg/L	<0.006	<0.04	0.04	<0.011	<0.011
Cr	mg/L	<0.001	<0.03	0.055	<0.026	<0.026
Cu	mg/L	<0.001	<0.03	0.056	0.034	<0.017
Fe	mg/L	<0.008	<0.05	<0.05	<0.024	<0.024
Hg	mg/L	<0.00008	0.00011	<0.0001	<0.00030	0.00047
K	mg/L	0.8	1.8	0.88	1.9	1.3
Mg	mg/L	46	49	51	53	49
Mn	mg/L	0.16	0.13	0.11	0.12	0.11
Mo	mg/L	0.009	0.019	0.037	<0.018	<0.018
Na	mg/L	96	70	55	74	78
Ni	mg/L	0.017	<0.08	<0.08	0.041	<0.038
Pb	mg/L	<0.001	<0.1	0.20	<0.068	<0.068
Se	mg/L	0.007	0.10	0.19	0.10	<0.10
V	mg/L	<0.003	<0.038	0.069	0.025	0.029
Zn	mg/L	0.093	0.12	0.096	0.095	0.11
F	mg/L	13	10	10	10	13
Cl	mg/L	150	110	75	130	150
TOC	mg/L	-	-	-	-	4
HCO_3	mg/L	390	380	430	370	390
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	<1	<0.1	0.1	0.3	<0.1
$NO_2(N)$	mg/L	3.5	<0.1	0.6	0.04	<0.01
$NO_3(N)$	mg/L	4	9	8	7	<1
SO_4	mg/L	110	110	87	140	150
TDS	mg/L	770	710	680	790	770
TSS	mg/L	<2	4	2	18	3
pH	units	7.5	7.1	7	6.8	6.9
Sp.Cond.	µmhos	124	1150	1060	1480	2100
Ra-224s	pCi/L	0.020	-	0	0	0.02
Ra-224t	pCi/L	-	-	0.03	0.004	0.03
Ra-226s	pCi/L	0.011	0.03	0.04	0.10	0.03
Ra-226t	pCi/L	0.012	0.13	0.06	0.19	0.04
Ra-228s	pCi/L	-	-	-	-	0.27
Ra-228t	pCi/L	-	<2	<1.9	<1.4	≥0.27
Th-230	pCi/L	0.022	0.025	0.025	0.020	0.021
Th-232	pCi/L	0.008	0.006	0.008	0.007	0.015
U-238	mg/L	0.006	0.002	0.01	0.002	0.010

Table A.7. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	<0.020	<0.002
Al	mg/L	<0.008	0.049	<0.11	0.61
As	mg/L	<0.11	<0.11	<0.11	<0.057
B	mg/L	0.18	0.17	0.19	0.64
Ba	mg/L	<0.013	<0.013	0.011	0.18
Ca	mg/L	110	100	120	120
Cd	mg/L	0.008	<0.007	<0.015	<0.002
Co	mg/L	0.017	<0.011	<0.011	<0.006
Cr	mg/L	<0.026	<0.026	0.039	<0.001
Cu	mg/L	<0.017	<0.017	0.016	<0.001
Fe	mg/L	0.029	<0.024	<0.033	0.020
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.005
K	mg/L	0.78	0.93	1.1	8
Mg	mg/L	44	44	50	48
Mn	mg/L	0.11	0.071	0.067	0.079
Mo	mg/L	<0.018	<0.018	<0.018	<0.020
Na	mg/L	69	47	79	89
Ni	mg/L	<0.038	<0.038	<0.069	0.024
Pb	mg/L	<0.068	<0.068	0.076	<0.06
Se	mg/L	<0.10	<0.10	<0.10	<0.08
V	mg/L	0.008	0.009	0.027	0.060
Zn	mg/L	0.24	0.22	0.083	0.091
F	mg/L	14	11	9	11
Cl	mg/L	91	63	95	95
TOC	mg/L	18	7.2	17	6.2
HCO_3	mg/L	390	380	380	380
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	0.2	<0.1	<0.1	0.2
$NO_2(N)$	mg/L	0.05	0.04	-	-
$NO_3(N)$	mg/L	5	6	5	5
SO_4	mg/L	130	80	200	94
TDS	mg/L	700	580	700	700
TSS	mg/L	<2	3	<2	<2
pH	units	7.0	7.0	7.0	7.1
Sp.Cond.	µmhos	1540	1120	1260	1050
Ra-224s	pCi/L	0	0	0.09	0.04
Ra-224t	pCi/L	0.08	0.01	0.09	0.04
Ra-226s	pCi/L	0.08	0	0	0.02
Ra-226t	pCi/L	0.15	0	0	0.02
Ra-228s	pCi/L	0.02	0.05	0.03	0.17
Ra-228t	pCi/L	≥0.02	0.17	0.07	0.23
Th-230	pCi/L	0.046	0.025	0.069	0.007
Th-232	pCi/L	0.019	0.007	0.005	0.007
U-238	mg/L	0.002	0.001	0.002	0.005

Table A.8. Concentrations of Chemical and Radiological Parameters in the KM Wells on the West Chicago Site, Well KM-1

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	0.001	<0.002	<0.002	<0.002	<0.002
Al	mg/L	0.067	0.06	0.010	0.021	<0.050
As	mg/L	0.071	0.077	<0.001	0.27	0.020
B	mg/L	0.24	0.25	<0.009	0.22	0.22
Ba	mg/L	0.044	0.21	0.12	0.16	0.093
Ca	mg/L	190	200	210	200	200
Cd	mg/L	<0.001	0.008	<0.002	<0.002	<0.002
Co	mg/L	0.008	<0.006	<0.006	<0.006	<0.006
Cr	mg/L	<0.001	0.029	<0.001	0.014	<0.001
Cu	mg/L	<0.001	0.008	<0.001	0.035	<0.001
Fe	mg/L	1.7	0.76	0.50	0.58	0.49
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	6.8	48	6.4	7.3	6.8
Mg	mg/L	130	120	120	110	120
Mn	mg/L	0.068	0.083	0.080	0.087	0.065
Mo	mg/L	0.020	0.021	<0.002	0.004	<0.002
Na	mg/L	540	450	550	530	510
Ni	mg/L	0.16	0.17	0.16	0.17	0.16
Pb	mg/L	0.003	<0.001	<0.001	0.042	<0.004
Se	mg/L	0.002	0.22	<0.001	0.15	0.091
V	mg/L	0.009	0.19	0.010	0.021	<0.003
Zn	mg/L	0.037	0.11	0.068	0.089	0.12
F	mg/L	0.50	<0.5	0.44	<1	0.57
Cl	mg/L	270	280	270	290	250
HCO_3	mg/L	554	485	568	570	572
CO_3	mg/L	-	13	<6	<3	<10
$NH_3(N)$	mg/L	2	<0.1	<0.1	0.3	1
$NO_2(N)$	mg/L	<0.1	0.71	<0.1	0.1	0.12
$NO_3(N)$	mg/L	<1	1	<1	1	<1
SO_4	mg/L	1290	1320	1320	1280	1240
TDS	mg/L	2813	2640	2705	2720	2730
TSS	mg/L	99.4	3660	370	200	64
pH	units	7.3	7.5	7.5	7.5	7.6
Sp.Cond.	µmhos	4142	3560	3380	3190	3650
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.08	0.21	0.32	0.26	0.19
Ra-226t	pCi/L	0.122	4.42	0.48	0.62	0.47
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<1.1	<3.1	<2	<0.9	<2.1
Th-230	pCi/L	0.048	0.065	0.025	0.017	0.025
Th-232	pCi/L	0.005	0.006	0.012	0.004	0.006
U-238	mg/L	0.003	0.01	0.01	0.004	0.003

Table A.8. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	<0.03	0.10	0.031	0.024
Al	mg/L	<0.05	<0.2	0.42	0.22	0.11
As	mg/L	0.001	<0.1	0.20	<0.11	<0.11
B	mg/L	0.19	0.35	0.24	0.35	0.20
Ba	mg/L	<0.001	0.021	0.027	0.021	0.022
Ca	mg/L	200	210	200	190	170
Cd	mg/L	<0.002	0.010	0.020	<0.007	<0.007
Co	mg/L	<0.006	<0.04	0.056	0.019	<0.011
Cr	mg/L	0.008	0.030	0.080	0.045	0.035
Cu	mg/L	<0.001	<0.03	0.074	0.043	0.019
Fe	mg/L	0.60	0.72	0.77	0.96	0.36
Hg	mg/L	0.00012	0.00023	<0.0001	<0.00030	0.00031
K	mg/L	6.2	6.2	6.3	7.4	5.8
Mg	mg/L	120	120	120	120	110
Mn	mg/L	0.074	0.081	0.087	0.074	0.066
Mo	mg/L	0.019	0.029	0.063	0.026	<0.018
Na	mg/L	500	500	480	460	460
Ni	mg/L	0.16	0.19	0.27	0.19	0.13
Pb	mg/L	0.001	<0.1	0.33	0.13	<0.068
Se	mg/L	0.001	<0.1	0.28	0.1	0.10
V	mg/L	<0.003	<0.04	0.085	0.032	0.014
Zn	mg/L	0.090	0.14	0.12	0.71	0.087
F	mg/L	<1	3.1	1	1	<1
Cl	mg/L	240	280	240	230	190
TOC	mg/L	-	-	-	-	14
HCO_3	mg/L	570	505	620	550	560
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	<1	<0.1	1.2	1	<0.1
$NO_2(N)$	mg/L	1	0.6	2	1	0.50
$NO_3(N)$	mg/L	<1	6	3	1	<1
SO_4	mg/L	1100	1180	1090	1170	1030
TDS	mg/L	2490	2670	2550	2440	2370
TSS	mg/L	31	38	40	1016	54
pH	units	7.9	7.6	7.3	7.2	7.4
Sp.Cond.	µmhos	3550	3510	3460	3890	3150
Ra-224s	pCi/L	0.14	-	0.03	0.27	0.80
Ra-224t	pCi/L	0.03	-	3.65	1.32	2.42
Ra-226s	pCi/L	0.03	0.14	0.34	0.71	0.29
Ra-226t	pCi/L	0.13	0.41	2.81	1.25	0.63
Ra-228s	pCi/L	-	-	-	-	1.08
Ra-228t	pCi/L	<3	<3	<1.5	<2.2	≥1.08
Th-230	pCi/L	0.077	0.028	0.017	0.008	0.006
Th-232	pCi/L	0.010	0.007	0.003	0.009	0.003
U-238	mg/L	0.003	0.0065	0.002	0.002	0.015

Table A.8. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.02	0.026	<0.002
Al	mg/L	<0.008	0.03	<0.11	0.66
As	mg/L	<0.11	<0.11	<0.11	<0.06
B	mg/L	0.23	0.22	0.24	0.30
Ba	mg/L	0.017	0.014	0.016	0.17
Ca	mg/L	180	170	200	180
Cd	mg/L	0.010	<0.007	0.018	<0.002
Co	mg/L	<0.011	0.011	0.030	<0.006
Cr	mg/L	<0.026	<0.026	0.030	<0.001
Cu	mg/L	<0.017	<0.017	0.018	<0.001
Fe	mg/L	0.20	3.2	3.7	4.8
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.0005
K	mg/L	5.2	6.2	5.6	20
Mg	mg/L	94	100	110	106
Mn	mg/L	0.077	0.066	0.076	0.086
Mo	mg/L	0.020	<0.018	0.034	0.008
Na	mg/L	390	430	390	460
Ni	mg/L	0.19	0.14	0.18	0.11
Pb	mg/L	<0.068	<0.068	0.14	<0.08
Se	mg/L	<0.10	<0.1	<0.10	<0.08
V	mg/L	<0.005	0.013	0.036	<0.003
Zn	mg/L	0.22	0.24	0.029	0.055
F	mg/L	<1	<1.0	<1	<1
Cl	mg/L	250	260	230	190
TOC	mg/L	17	0.93	12	38
HCO_3	mg/L	520	550	470	560
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	1.3	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	0.50	0.02	-	-
$NO_3(N)$	mg/L	<1	2	2	<1
SO_4	mg/L	1040	900	880	800
TDS	mg/L	2220	2230	2220	2200
TSS	mg/L	28	22	12	10
pH	units	7.7	7.1	7.1	7.2
Sp.Cond.	µmhos	3580	3510	3150	3190
Ra-224s	pCi/L	2.55	-	0	0
Ra-224t	pCi/L	3.02	-	0	0
Ra-226s	pCi/L	0.37	-	0.04	0.06
Ra-226t	pCi/L	0.55	-	0.05	0.06
Ra-228s	pCi/L	0.68	-	0.38	0.31
Ra-228t	pCi/L	0.68	-	0.59	0.51
Th-230	pCi/L	0.029	-	0.047	0.402
Th-232	pCi/L	0.010	-	0.005	0.006
U-238	mg/L	0.003	-	0.003	0.003

Appendix A-25
(NRC, 1989a)

Table A.9. Concentrations of Chemical and Radiological Parameters in the KM Wells on the West Chicago Site, Well KM-2

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	0.010	0.007	<0.002
Al	mg/L	0.051	0.05	0.071	0.3	0.16
As	mg/L	0.005	0.007	0.001	0.02	0.004
B	mg/L	0.23	0.26	0.075	0.21	0.20
Ba	mg/L	0.14	0.35	0.28	0.32	0.13
Ca	mg/L	100	97	93	90	96
Cd	mg/L	<0.001	<0.008	<0.002	0.003	<0.002
Co	mg/L	0.002	<0.006	<0.006	0.007	<0.006
Cr	mg/L	<0.001	0.007	0.002	0.023	0.003
Cu	mg/L	<0.001	<0.001	<0.001	0.033	<0.001
Fe	mg/L	0.53	0.16	0.11	0.13	0.13
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	3.2	27	2.7	3.5	3.2
Mg	mg/L	81	76	72	74	75
Mn	mg/L	0.034	0.015	0.025	0.031	0.02
Mo	mg/L	0.004	0.007	0.003	0.009	0.002
Na	mg/L	120	104	120	120	120
Ni	mg/L	0.042	0.038	0.040	0.053	0.041
Pb	mg/L	0.002	<0.001	<0.001	0.017	<0.004
Se	mg/L	0.001	0.004	0.001	0.019	0.016
V	mg/L	0.002	<0.003	0.006	0.05	<0.003
Zn	mg/L	0.017	<0.003	0.009	0.032	0.073
F	mg/L	0.81	1.8	0.74	<1	0.84
Cl	mg/L	73	89	85	85	79
HCO_3	mg/L	444	316	415	420	420
CO_3	mg/L	-	22	<6	<3	<10
$NH_3(N)$	mg/L	2	<0.1	<0.1	1.2	0.9
$NO_2(N)$	mg/L	<0.1	0.06	<0.1	0.2	0.28
$NO_3(N)$	mg/L	<1	<1	<1	1	<1
SO_4	mg/L	360	380	370	330	340
TDS	mg/L	971	830	926	910	960
TSS	mg/L	979	207	140	95	32
pH	units	7.4	7.8	7.9	7.8	7.8
Sp.Cond.	µmhos	1482	1450	1320	1280	1440
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.30	0.28	0.28	0.54	0.52
Ra-226t	pCi/L	1.24	0.62	0.37	0.87	0.53
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<2.5	<2.3	<1.5	<1.5	<2.8
Th-230	pCi/L	0.047	0.351	0.109	0.031	0.030
Th-232	pCi/L	0.005	0.003	0.014	0.003	0.001
U-238	mg/L	0.010	0.002	0.003	0.003	0.002

Table A.9. Continued

Chemical Species	Unit	1982	1983			
		4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.002	<0.03	0.094	<0.020	0.022
Al	mg/L	<0.05	<0.2	0.39	0.097	0.082
As	mg/L	<0.001	<0.1	0.19	<0.11	<0.11
B	mg/L	0.24	0.33	0.25	0.37	0.23
Ba	mg/L	0.12	0.13	0.13	0.093	0.13
Ca	mg/L	97	100	98	99	89
Cd	mg/L	<0.002	<0.1	0.016	<0.007	<0.007
Co	mg/L	<0.006	<0.04	0.044	<0.011	<0.011
Cr	mg/L	0.003	<0.03	0.077	<0.026	<0.026
Cu	mg/L	<0.001	<0.03	0.067	0.029	0.022
Fe	mg/L	11	0.14	0.17	0.067	0.16
Hg	mg/L	<0.00008	<0.001	<0.0001	<0.00030	0.00031
K	mg/L	2.6	2.9	2.9	4.4	2.8
Mg	mg/L	71	73	74	75	73
Mn	mg/L	0.022	0.029	0.036	0.030	0.036
Mo	mg/L	0.014	0.023	0.054	0.030	0.023
Na	mg/L	110	110	120	120	110
Ni	mg/L	0.039	<0.08	0.12	0.076	0.060
Pb	mg/L	<0.001	0.11	0.30	<0.068	<0.068
Se	mg/L	0.005	<0.1	0.25	<0.10	<0.10
V	mg/L	<0.003	<0.04	0.077	0.021	0.009
Zn	mg/L	0.026	0.14	0.10	0.14	0.087
F	mg/L	<1	<1	<1	<1	<1
Cl	mg/L	73	92	85	90	73
TOC	mg/L	-	-	-	-	15
HCO_3	mg/L	410	365	460	410	420
CO_3	mg/L	<5	<5	<5	<19	<10
NH_3(N)	mg/L	<1	<0.1	1.1	0.8	<0.1
NO_2(N)	mg/L	<0.1	0.7	4	8	0.40
NO_3(N)	mg/L	<1	8	2	<1	<1
SO_4	mg/L	260	300	320	300	350
TDS	mg/L	900	900	940	880	960
TSS	mg/L	25	229	25	412	64
pH	units	7.9	7.8	7.7	7.4	7.6
Sp.Cond.	µmhos	1340	1460	1360	1530	1360
Ra-224s	pCi/L	0.07	-	0.16	0.014	0.22
Ra-224t	pCi/L	-	-	1.29	3.11	1.33
Ra-226s	pCi/L	0.33	0.35	0.27	0.86	0.04
Ra-226t	pCi/L	0.39	0.91	0.80	5.03	0.05
Ra-228s	pCi/L	-	-	-	-	0.59
Ra-228t	pCi/L	<2.6	<2.0	<1.8	<1.7	≥0.59
Th-230	pCi/L	0.017	0.027	0.032	0.0084	0.006
Th-232	pCi/L	0.013	0.006	0.005	0.003	0.003
U-238	mg/L	<0.002	0.01	0.002	0.002	0.015

Table A.9. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	<0.020	<0.002
Al	mg/L	<0.008	<0.008	<0.11	0.6
As	mg/L	<0.11	<0.11	<0.11	<0.06
B	mg/L	0.23	0.24	0.24	0.29
Ba	mg/L	0.15	0.14	0.14	0.11
Ca	mg/L	94	90	110	99
Cd	mg/L	<0.007	<0.007	<0.015	<0.002
Co	mg/L	<0.011	<0.011	0.016	<0.006
Cr	mg/L	<0.026	<0.026	<0.026	<0.006
Cu	mg/L	<0.017	<0.017	<0.015	<0.001
Fe	mg/L	0.047	0.18	0.042	2.1
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.0005
K	mg/L	2.4	3.2	2.9	12
Mg	mg/L	68	71	79	77
Mn	mg/L	0.030	0.022	0.025	0.018
Mo	mg/L	<0.018	<0.018	0.026	0.010
Na	mg/L	110	120	120	140
Ni	mg/L	<0.038	<0.038	<0.069	0.030
Pb	mg/L	<0.068	<0.068	0.077	<0.08
Se	mg/L	<0.10	<0.10	<0.10	<0.08
V	mg/L	<0.005	0.006	<0.025	<0.003
Zn	mg/L	0.18	0.25	0.018	0.047
F	mg/L	<1	<1	<1	<1
Cl	mg/L	82	88	130	79
TOC	mg/L	8.0	12	11	12
HCO_3	mg/L	420	410	390	430
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	0.5	<0.1	0.6	<0.1
$NO_2(N)$	mg/L	1.4	0.90	-	-
$NO_3(N)$	mg/L	<1	<1	<1	1
SO_4	mg/L	270	280	340	260
TDS	mg/L	980	900	890	960
TSS	mg/L	19	21	19	5
pH	units	7.9	7.7	7.6	7.7
Sp.Cond.	µmhos	1540	1640	1470	1480
Ra-224s	pCi/L	0.19	0	0	0
Ra-224t	pCi/L	3.49	0	0	0
Ra-226s	pCi/L	0.40	0.21	0	0.30
Ra-226t	pCi/L	0.84	0.21	0	0.30
Ra-228s	pCi/L	-	0.34	0.52	0.11
Ra-228t	pCi/L	-	0.40	0.55	0.14
Th-230	pCi/L	0.022	0.364	0.045	0.086
Th-232	pCi/L	0.007	0.008	0.004	0.009
U-238	mg/L	0.001	0.006	0.002	<0.002

Table A.10. Concentrations of Chemical and Radiological Parameters in the KM Wells on the West Chicago Site, Well KM-4

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	0.006	0.006	0.007
Al	mg/L	0.018	0.19	<0.050	0.29	0.31
As	mg/L	0.005	<0.006	0.001	0.018	0.006
B	mg/L	0.20	0.25	<0.009	0.20	0.22
Ba	mg/L	0.039	0.26	0.15	0.22	0.10
Ca	mg/L	120	120	110	120	130
Cd	mg/L	<0.001	<0.002	0.002	<0.002	<0.002
Co	mg/L	0.002	<0.006	<0.006	0.013	0.006
Cr	mg/L	<0.001	0.014	0.002	0.025	0.019
Cu	mg/L	0.003	<0.001	0.002	0.04	0.026
Fe	mg/L	0.063	0.024	0.040	0.034	0.26
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	0.001
K	mg/L	3.8	26	3.6	4	5.2
Mg	mg/L	74	70	60	62	68
Mn	mg/L	0.26	0.23	0.28	0.25	0.23
Mo	mg/L	0.001	0.040	<0.002	<0.002	<0.002
Na	mg/L	110	93	120	100	140
Ni	mg/L	0.015	0.025	0.019	0.03	0.036
Pb	mg/L	0.002	<0.001	<0.001	0.011	<0.004
Se	mg/L	0.005	0.003	<0.001	0.012	0.010
V	mg/L	0.002	0.005	0.010	0.057	0.026
Zn	mg/L	0.022	0.050	0.072	0.021	0.12
F	mg/L	0.80	0.8	0.75	<1	0.7
Cl	mg/L	180	170	180	160	180
HCO_3	mg/L	457	364	469	460	471
CO_3	mg/L	-	41	<6	<3	<10
$NH_3(N)$	mg/L	<1	<0.1	<0.1	0.1	0.7
$NO_2(N)$	mg/L	<0.1	0.04	<0.1	<0.1	0.34
$NO_3(N)$	mg/L	1	2	<1	2	<1
SO_4	mg/L	200	230	220	140	280
TDS	mg/L	954	867	960	860	1090
TSS	mg/L	35.1	87	400	-	10
pH	units	7.4	7.6	7.5	8	7.5
Sp.Cond.	µmhos	1504	1480	1470	1340	1660
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.13	0.25	0.13	0.16	0.16
Ra-226t	pCi/L	0.54	0.43	0.27	-	0.25
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<1.9	<2.5	<2	<1.6	<1.6
Th-230	pCi/L	0.085	0.108	0.121	0.045	0.046
Th-232	pCi/L	0.010	0.006	0.010	0.011	0.007
U-238	mg/L	0.078	0.007	0.004	0.003	0.003

Table A.10. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	<0.03	0.095	0.024	0.026
Al	mg/L	<0.05	<0.2	0.40	0.072	0.14
As	mg/L	0.001	<0.1	0.20	<0.11	<0.11
B	mg/L	0.16	0.33	0.22	0.31	0.18
Ba	mg/L	0.006	0.035	0.044	0.035	0.031
Ca	mg/L	140	150	140	140	130
Cd	mg/L	<0.002	<0.01	0.018	<0.007	<0.007
Co	mg/L	<0.006	<0.04	0.057	0.018	<0.011
Cr	mg/L	0.004	<0.03	0.078	<0.026	<0.026
Cu	mg/L	<0.001	<0.03	0.078	0.033	0.040
Fe	mg/L	0.035	0.059	0.092	<0.024	0.026
Hg	mg/L	<0.00009	<0.001	0.00014	<0.00030	0.00041
K	mg/L	4	4.4	4.2	3	4.0
Mg	mg/L	66	70	67	70	67
Mn	mg/L	0.24	0.28	0.30	0.28	0.27
Mo	mg/L	0.005	<0.02	0.050	<0.018	<0.018
Na	mg/L	130	150	150	150	130
Ni	mg/L	0.027	<0.08	0.12	0.064	0.054
Pb	mg/L	<0.001	0.12	0.32	0.085	<0.068
Se	mg/L	0.009	<0.1	0.24	<0.10	<0.10
V	mg/L	<0.003	<0.04	0.083	0.019	0.027
Zn	mg/L	0.13	0.12	0.091	0.077	0.096
F	mg/L	<1	<1	<1	<1	<1
Cl	mg/L	170	230	150	190	160
TOC	mg/L	-	-	-	-	8
HCO_3	mg/L	460	425	510	460	460
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	<1	<0.1	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	0.1	0.4	1.2	0.5	0.40
$NO_3(N)$	mg/L	<1	7	3	<1	<1
SO_4	mg/L	200	302	230	250	240
TDS	mg/L	860	1100	1080	1050	1010
TSS	mg/L	33	26	17	29	32
pH	units	7.8	7.6	7.7	7.2	7.3
Sp.Cond.	µmhos	1580	1620	1580	1770	1680
Ra-224s	pCi/L	0.11	-	0.53	0.50	0.17
Ra-224t	pCi/L	-	-	1.83	0.93	1.50
Ra-226s	pCi/L	0.08	0.14	0.40	0.65	0.33
Ra-226t	pCi/L	0.24	0.15	0.91	1.29	0.82
Ra-228s	pCi/L	-	-	-	-	0.57
Ra-228t	pCi/L	<2	<2	<2.2	<2.7	≥0.57
Th-230	pCi/L	0.007	0.037	0.012	0.042	0.009
Th-232	pCi/L	0.004	0.005	0.003	0.005	0.003
U-238	mg/L	0.002	0.0005	0.003	0.002	0.009

Table A.10. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	0.033	<0.002
Al	mg/L	<0.008	0.010	<0.11	0.54
As	mg/L	<0.11	<0.11	<0.11	<0.06
B	mg/L	0.20	0.20	0.21	0.25
Ba	mg/L	0.028	0.033	0.032	0.18
Ca	mg/L	120	120	160	130
Cd	mg/L	0.015	<0.007	0.020	<0.004
Co	mg/L	<0.011	<0.011	0.037	<0.006
Cr	mg/L	<0.026	<0.026	0.032	<0.001
Cu	mg/L	<0.017	<0.017	0.024	<0.001
Fe	mg/L	<0.024	<0.024	<0.033	0.035
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.0005
K	mg/L	3.7	4.0	3.7	12
Mg	mg/L	61	65	67	66
Mn	mg/L	0.30	0.25	0.27	0.26
Mo	mg/L	<0.018	<0.018	0.026	<0.001
Na	mg/L	130	120	103	140
Ni	mg/L	0.055	<0.038	<0.069	0.018
Pb	mg/L	<0.068	<0.068	0.16	<0.08
Se	mg/L	<0.10	<0.10	<0.10	<0.08
V	mg/L	<0.005	0.009	0.038	<0.003
Zn	mg/L	0.26	0.20	0.039	<0.003
F	mg/L	6.9	<1	<1	<1
Cl	mg/L	160	180	160	140
TOC	mg/L	3.7	12	74	8.6
HCO_3	mg/L	470	460	420	460
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	<0.1	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	0.1	0.04	-	-
$NO_3(N)$	mg/L	<1	<1	<1	<1
SO_4	mg/L	250	190	210	180
TDS	mg/L	960	930	930	950
TSS	mg/L	78	4	<2	2
pH	units	7.8	7.2	7.2	7.2
Sp.Cond.	µmhos	1790	1660	1580	1530
Ra-224s	pCi/L	0.63	0	0	0.04
Ra-224t	pCi/L	3.89	0	0	0.07
Ra-226s	pCi/L	0.35	0.08	0.06	0.03
Ra-226t	pCi/L	1.21	0.08	0.02	0.04
Ra-228s	pCi/L	0.64	0.23	0.38	0.16
Ra-228t	pCi/L	≥0.64	0.23	0.42	0.34
Th-230	pCi/L	0.023	0.062	0.060	0.058
Th-232	pCi/L	0.023	0.004	0.003	0.003
U-238	mg/L	0.004	0.009	0.005	0.003

Appendix A-31
(NRC, 1989a)

Table A11. Concentrations of Chemical and Radiological Parameters in the KM Wells on the West Chicago Site, Well KM-5

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	0.005	<0.002	<0.002
Al	mg/L	0.13	<0.05	<0.050	0.29	0.15
As	mg/L	0.011	<0.006	0.002	0.021	0.004
B	mg/L	0.25	0.26	<0.009	0.24	0.18
Ba	mg/L	0.056	0.27	0.14	0.21	0.12
Ca	mg/L	140	120	100	120	130
Cd	mg/L	<0.001	<0.002	<0.002	0.003	<0.002
Co	mg/L	0.009	<0.006	<0.006	0.011	<0.006
Cr	mg/L	<0.001	0.024	0.002	0.023	0.004
Cu	mg/L	0.008	0.017	<0.001	0.042	<0.001
Fe	mg/L	2.3	0.46	0.048	0.24	0.23
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	4.2	3.6	3.6	4.6	4.4
Mg	mg/L	81	67	69	69	70
Mn	mg/L	0.17	0.11	0.13	0.13	0.12
Mo	mg/L	0.004	0.013	<0.002	0.003	<0.002
Na	mg/L	120	110	120	120	110
Ni	mg/L	0.025	0.028	0.025	0.04	0.029
Pb	mg/L	0.002	<0.001	0.001	0.021	<0.004
Se	mg/L	0.003	<0.001	0.001	0.02	0.012
V	mg/L	0.001	0.024	0.06	0.053	<0.003
Zn	mg/L	0.033	0.021	0.04	0.032	0.075
F	mg/L	0.48	0.7	0.41	<1	0.47
Cl	mg/L	140	140	150	150	140
HCO_3	mg/L	454	323	458	470	472
CO_3	mg/L	-	16	<6	<3	<10
NH_3(N)	mg/L	<1	<0.1	<0.1	<0.1	0.5
NO_2(N)	mg/L	<0.1	0.03	<0.1	<0.1	0.19
NO_3(N)	mg/L	1	<1	<1	1	<1
SO_4	mg/L	270	270	260	260	280
TDS	mg/L	1017	780	990	970	1040
TSS	mg/L	73	201	46	28	15
pH	units	7.6	7.6	7.6	7.8	7.6
Sp.Cond.	µmhos	1526	1530	1570	1390	1520
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.16	0.13	0.05	0.16	0.13
Ra-226t	pCi/L	0.26	0.70	0.20	0.16	0.15
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<2.5	<5.2	<1.5	<2	<3
Th-230	pCi/L	0.044	0.051	0.028	0.032	0.014
Th-232	pCi/L	0.010	0.006	0.005	0.010	0.005
U-238	mg/L	0.005	0.005	0.004	0.002	0.003

Table A.11. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	<0.03	0.096	<0.020	<0.020
Al	mg/L	<0.05	<0.2	0.39	0.087	0.073
As	mg/L	0.001	<0.1	0.18	<0.11	<0.11
B	mg/L	0.19	0.37	0.22	0.30	0.19
Ba	mg/L	0.003	0.033	0.042	0.037	0.039
Ca	mg/L	140	140	130	130	130
Cd	mg/L	<0.002	<0.01	0.018	<0.007	<0.007
Co	mg/L	<0.006	<0.04	0.052	0.014	<0.011
Cr	mg/L	<0.001	<0.03	0.076	<0.026	<0.026
Cu	mg/L	<0.001	<0.03	0.067	0.030	0.019
Fe	mg/L	0.46	0.41	0.21	0.024	0.039
Hg	mg/L	<0.00008	0.00014	0.00024	0.00032	0.00041
K	mg/L	3.8	4.2	3.9	4.9	4.0
Mg	mg/L	67	70	74	71	70
Mn	mg/L	0.13	0.14	0.15	0.13	0.14
Mo	mg/L	0.005	<0.02	0.045	<0.018	<0.018
Na	mg/L	110	110	120	100	100
Ni	mg/L	0.023	<0.08	0.11	0.047	0.038
Pb	mg/L	0.001	<0.1	0.32	0.079	<0.068
Se	mg/L	0.001	<0.1	0.26	<0.10	<0.10
V	mg/L	<0.003	<0.04	0.079	0.016	0.011
Zn	mg/L	0.11	0.10	0.11	0.59	0.10
F	mg/L	<1	<1	<1	<1	<1
Cl	mg/L	150	150	130	170	110
TOC	mg/L	-	-	-	-	10
HCO_3	mg/L	470	415	510	460	460
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	<1	<0.1	0.2	0.2	<0.1
$NO_2(N)$	mg/L	0.5	0.8	1.4	0.28	0.50
$NO_3(N)$	mg/L	<1	4	2	1	<1
SO_4	mg/L	270	260	220	260	260
TDS	mg/L	1000	950	960	940	980
TSS	mg/L	17	27	50	21	15
pH	units	7.7	7.5	7.5	7.4	7.3
Sp.Cond.	µmhos	1490	1510	1520	1770	1470
Ra-224s	pCi/L	0.05	-	0.67	1.75	0.27
Ra-224t	pCi/L	-	-	2.69	2.61	1.24
Ra-226s	pCi/L	0.19	0.41	0.39	0.84	0.47
Ra-226t	pCi/L	0.33	1.05	1.06	1.26	0.71
Ra-228s	pCi/L	-	-	-	-	0.24
Ra-228t	pCi/L	<1.6	<1.5	<1.5	-	0.65
Th-230	pCi/L	0.039	0.022	0.015	0.027	0.015
Th-232	pCi/L	0.005	0.004	0.003	0.009	0.003
U-238	mg/L	<0.002	0.009	0.004	0.002	0.005

Table A.11. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	0.038	<0.002
Al	mg/L	<0.008	<0.008	<0.11	<0.05
As	mg/L	<0.11	<0.11	<0.11	<0.06
B	mg/L	0.19	0.19	0.21	0.21
Ba	mg/L	0.040	0.039	0.033	0.19
Ca	mg/L	130	90	160	140
Cd	mg/L	<0.007	<0.007	0.023	<0.002
Co	mg/L	<0.011	<0.011	0.038	<0.006
Cr	mg/L	<0.026	<0.026	0.039	<0.001
Cu	mg/L	<0.017	<0.017	0.021	<0.001
Fe	mg/L	0.037	<0.024	1.8	1.6
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.0005
K	mg/L	3.5	3.8	3.4	12
Mg	mg/L	62	68	69	69
Mn	mg/L	0.15	<0.003	0.14	0.14
Mo	mg/L	<0.018	<0.018	0.033	<0.002
Na	mg/L	98	110	85	120
Ni	mg/L	<0.038	0.040	0.074	<0.003
Pb	mg/L	<0.068	<0.068	0.19	<0.08
Se	mg/L	<0.10	<0.10	<0.10	<0.08
V	mg/L	<0.005	<0.005	0.042	<0.003
Zn	mg/L	0.21	0.074	0.030	0.045
F	mg/L	<1	<1	<1	<1
Cl	mg/L	130	150	160	120
TOC	mg/L	0.4	42	20	5
HCO_3	mg/L	460	470	350	470
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	<0.1	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	0.50	<0.01	-	-
$NO_3(N)$	mg/L	<1	<1	6	<1
SO_4	mg/L	250	160	240	180
TDS	mg/L	910	830	880	920
TSS	mg/L	7	2	<2	1
pH	units	7.8	7.2	7.1	7.3
Sp.Cond.	µmhos	1660	1640	1470	1530
Ra-224s	pCi/L	0.22	0	0	0.14
Ra-224t	pCi/L	1.51	0.01	0	0.14
Ra-226s	pCi/L	0.20	0.11	0.13	0.15
Ra-226t	pCi/L	0.38	0.13	0.13	0.15
Ra-228s	pCi/L	0.79	0.27	0.19	0.48
Ra-228t	pCi/L	≥0.79	0.41	0.23	0.49
Th-230	pCi/L	0.009	0.078	0.072	0.105
Th-232	pCi/L	0.003	0.045	0.006	0.029
U-238	mg/L	0.005	0.007	0.004	0.003

Table A.12. Concentrations of Chemical and Radiological Parameters in the KM Wells on the West Chicago Site, Well KM-6

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	<0.002	<0.002	<0.002
Al	mg/L	0.067	<0.05	0.29	0.24	0.093
As	mg/L	0.15	<0.006	0.001	0.012	<0.004
B	mg/L	0.18	0.25	<0.009	0.24	0.24
Ba	mg/L	0.045	0.25	0.13	0.2	0.11
Ca	mg/L	140	140	110	120	130
Cd	mg/L	<0.001	<0.002	<0.002	<0.002	<0.002
Co	mg/L	0.001	<0.006	<0.006	0.012	<0.006
Cr	mg/L	<0.001	0.017	<0.001	0.023	<0.001
Cu	mg/L	<0.001	<0.001	<0.001	0.045	<0.001
Fe	mg/L	0.25	0.076	0.070	0.09	0.026
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	3.9	29	3.7	4.5	4
Mg	mg/L	78	68	65	67	66
Mn	mg/L	0.25	0.21	0.26	0.23	0.24
Mo	mg/L	0.004	0.13	0.004	0.004	<0.002
Na	mg/L	140	120	140	140	120
Ni	mg/L	0.040	0.035	0.028	0.044	0.017
Pb	mg/L	0.001	0.002	0.002	0.013	<0.004
Se	mg/L	0.002	0.006	<0.001	0.016	0.006
V	mg/L	0.003	0.011	<0.003	0.05	<0.003
Zn	mg/L	0.043	0.046	0.026	0.013	0.07
F	mg/L	1.01	0.9	0.97	<1	0.77
Cl	mg/L	190	190	210	200	180
HCO_3	mg/L	457	300	455	460	465
CO_3	mg/L	-	16	<6	<3	<10
$NH_3(N)$	mg/L	1	<0.1	<0.1	0.2	0.6
$NO_2(N)$	mg/L	<0.1	0.04	<0.1	0.2	0.39
$NO_3(N)$	mg/L	<1	<1	<1	1	<1
SO_4	mg/L	290	300	270	250	220
TDS	mg/L	1107	905	1053	1000	1050
TSS	mg/L	620	2291	91	40	8
pH	units	7.4	7.5	7.7	7.8	7.6
Sp.Cond.	µmhos	1700	1650	1570	1450	1600
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.074	0.27	0.30	0.02	0.13
Ra-226t	pCi/L	0.81	1.89	0.67	0.04	0.18
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<1.2	4.6	<1.3	<2.2	<1.4
Th-230	pCi/L	0.017	0.042	0.048	0.041	0.019
Th-232	pCi/L	0.007	0.009	0.007	0.006	0.006
U-238	mg/L	0.004	0.008	0.004	0.002	0.004

Table A.12. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	<0.03	0.070	<0.02	<0.020
Al	mg/L	<0.05	<0.2	0.26	<0.042	0.068
As	mg/L	0.002	<0.1	0.19	<0.11	<0.11
B	mg/L	0.18	0.30	0.23	0.29	0.20
Ba	mg/L	<0.001	0.028	0.034	0.033	0.030
Ca	mg/L	130	140	140	140	130
Cd	mg/L	<0.002	<0.01	0.015	<0.007	<0.007
Co	mg/L	<0.006	<0.04	<0.04	0.014	<0.011
Cr	mg/L	0.002	<0.03	0.049	<0.026	<0.026
Cu	mg/L	<0.001	<0.03	0.050	0.024	0.030
Fe	mg/L	0.19	0.16	0.12	0.054	0.048
Hg	mg/L	<0.00009	<0.0001	0.00017	0.00032	0.00031
K	mg/L	4.2	4	4.2	5.3	4.2
Mg	mg/L	66	68	68	70	68
Mn	mg/L	0.21	0.24	0.26	0.25	0.24
Mo	mg/L	0.005	<0.02	0.035	<0.018	<0.018
Na	mg/L	140	130	130	140	130
Ni	mg/L	0.027	<0.08	0.087	0.052	0.046
Pb	mg/L	<0.001	<0.1	0.21	<0.068	<0.068
Se	mg/L	0.007	<0.1	0.20	<0.10	<0.10
V	mg/L	<0.003	<0.04	0.057	0.012	0.019
Zn	mg/L	0.26	0.076	0.094	0.19	0.12
F	mg/L	<1	<1	<1	<1	<1
Cl	mg/L	210	180	170	190	140
TOC	mg/L	<5	<5	<5	<10	8
HCO_3	mg/L	470	385	510	470	460
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	<1	<0.1	0.4	0.2	<0.1
$NO_2(N)$	mg/L	0.5	0.3	0.6	0.40	0.40
$NO_3(N)$	mg/L	<1	4	3	<1	<1
SO_4	mg/L	300	265	240	260	230
TDS	mg/L	1030	1020	1060	1010	1010
TSS	mg/L	270	23	37	300	216
pH	units	7.8	7.8	7.6	7.4	7.5
Sp.Cond.	µmhos	1600	1620	1580	1770	1630
Ra-224s	pCi/L	0.24	-	1.17	7.50	0.40
Ra-224t	pCi/L	-	-	5.37	8.08	3.67
Ra-226s	pCi/L	0.17	0.24	0.73	0.94	0.31
Ra-226t	pCi/L	0.28	0.36	4.68	1.01	4.25
Ra-228s	pCi/L	-	-	-	0.94	1.22
Ra-228t	pCi/L	<0.5	<1.5	<2.0	<2.4	≥1.22
Th-230	pCi/L	0.033	0.024	0.014	0.009	0.009
Th-232	pCi/L	0.006	0.003	0.011	0.008	0.003
U-238	mg/L	0.002	0.003	0.07	0.002	0.014

Table A.12. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	0.034	<0.002
Al	mg/L	<0.008	0.043	<0.11	0.46
As	mg/L	<0.11	<0.11	<0.11	<0.06
B	mg/L	0.21	0.20	0.22	0.25
Ba	mg/L	0.034	0.027	0.030	0.18
Ca	mg/L	140	120	160	140
Cd	mg/L	<0.007	<0.007	0.020	<0.002
Co	mg/L	<0.011	<0.011	0.031	<0.006
Cr	mg/L	<0.026	<0.026	0.037	<0.001
Cu	mg/L	<0.017	<0.017	0.020	<0.001
Fe	mg/L	0.044	1.5	22	2.1
Hg	mg/L	<0.0005	0.0014	<0.0005	<0.0005
K	mg/L	3.8	3.9	3.5	8.4
Mg	mg/L	59	64	67	68
Mn	mg/L	0.27	0.22	0.25	0.25
Mo	mg/L	<0.018	<0.018	0.029	0.005
Na	mg/L	120	130	97	140
Ni	mg/L	<0.038	<0.038	<0.069	<0.003
Pb	mg/L	<0.068	<0.068	0.17	<0.08
Se	mg/L	<0.10	<0.10	<0.10	<0.08
V	mg/L	<0.005	0.008	0.037	<0.003
Zn	mg/L	0.18	0.56	0.031	<0.003
F	mg/L	5.9	<1	<1	<1
Cl	mg/L	170	200	180	150
TOC	mg/L	6.0	7.9	17	3.3
HCO_3	mg/L	460	460	360	470
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	0.3	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	1.4	<0.01	-	-
$NO_3(N)$	mg/L	<1	<1	<1	<1
SO_4	mg/L	170	210	230	170
TDS	mg/L	980	980	920	930
TSS	mg/L	140	5	3	10
pH	units	7.6	7.2	7.1	7.3
Sp.Cond.	µmhos	2050	1760	1580	1590
Ra-224s	pCi/L	2.21	0	0.02	0
Ra-224t	pCi/L	31.4	0	0.02	0.01
Ra-226s	pCi/L	0.36	0.02	0.07	0.05
Ra-226t	pCi/L	2.74	0.02	0.07	0.06
Ra-228s	pCi/L	2.57	0.32	0.19	0.19
Ra-228t	pCi/L	≥2.57	0.32	0.21	0.32
Th-230	pCi/L	0.099	0.037	0.024	0.051
Th-232	pCi/L	0.063	0.005	0.003	0.030
U-238	mg/L	0.005	0.008	0.005	0.006

Table A.13. Concentrations of Chemical and Radiological Parameters in the KM Wells on the West Chicago Site, Well KM-7

Chemical Species	Unit	1981		1982		
		2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.
Ag	mg/L	<0.001	<0.002	<0.002	<0.002	<0.002
Al	mg/L	0.010	0.16	0.21	0.24	<0.05
As	mg/L	0.016	<0.007	0.002	0.23	<0.004
B	mg/L	0.18	0.26	<0.009	0.22	0.20
Ba	mg/L	0.038	0.22	0.14	0.22	0.14
Ca	mg/L	120	110	110	120	130
Cd	mg/L	<0.001	<0.002	<0.002	0.003	<0.002
Co	mg/L	0.001	<0.006	<0.006	0.008	<0.006
Cr	mg/L	<0.001	0.019	<0.001	0.025	<0.001
Cu	mg/L	<0.001	<0.001	<0.001	0.028	<0.001
Fe	mg/L	0.085	0.045	0.092	0.041	0.02
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
K	mg/L	4.3	3.9	3.9	3.9	4.6
Mg	mg/L	75	62	52	64	64
Mn	mg/L	0.20	0.18	0.21	0.21	0.19
Mo	mg/L	<0.001	0.005	<0.002	<0.002	<0.002
Na	mg/L	80	74	74	70	73
Ni	mg/L	0.010	0.021	0.010	0.025	0.006
Pb	mg/L	0.001	0.002	0.004	0.01	<0.004
Se	mg/L	0.004	0.003	<0.001	0.02	0.008
V	mg/L	0.001	0.008	<0.003	0.046	<0.003
Zn	mg/L	0.033	0.069	0.028	0.21	0.31
F	mg/L	0.51	1	0.48	<1	0.48
Cl	mg/L	120	120	120	160	130
HCO_3	mg/L	464	283	436	470	461
CO_3	mg/L	-	16	<6	<3	<10
$NH_3(N)$	mg/L	<1	<0.1	<0.1	0.1	0.3
$NO_2(N)$	mg/L	<0.1	0.02	<0.1	<0.1	0.3
$NO_3(N)$	mg/L	2	<1	<1	1	<1
SO_4	mg/L	210	200	170	190	180
TDS	mg/L	890	635	832	790	871
TSS	mg/L	180	7551	4500	225	150
pH	units	7.4	7.5	7.6	7.9	7.6
Sp.Cond.	µmhos	1406	1222	1220	1380	1340
Ra-224s	pCi/L	-	-	-	-	-
Ra-224t	pCi/L	-	-	-	-	-
Ra-226s	pCi/L	0.16	0.26	0.12	0.27	0.14
Ra-226t	pCi/L	0.33	2.28	0.16	1.56	0.15
Ra-228s	pCi/L	-	-	-	-	-
Ra-228t	pCi/L	<1.9	<2.5	<2	<1.5	<1.9
Th-230	pCi/L	0.024	0.081	0.036	0.012	0.019
Th-232	pCi/L	0.003	0.012	0.011	0.006	0.009
U-238	mg/L	0.007	0.007	0.003	0.003	0.003

Table A.13. Continued

Chemical Species	Unit	1982 4th Qtr.	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.
Ag	mg/L	<0.002	<0.03	0.060	<0.020	<0.020
Al	mg/L	<0.05	<0.2	0.20	<0.042	0.061
As	mg/L	<0.001	<0.1	0.11	<0.11	<0.11
B	mg/L	0.13	0.35	0.20	0.27	0.18
Ba	mg/L	0.006	0.035	0.041	0.044	0.043
Ca	mg/L	130	130	130	130	120
Cd	mg/L	<0.002	<0.01	0.011	<0.007	<0.007
Co	mg/L	<0.006	<0.04	<0.04	<0.011	<0.011
Cr	mg/L	<0.001	<0.03	0.041	<0.026	<0.026
Cu	mg/L	<0.001	<0.03	0.046	<0.017	0.024
Fe	mg/L	0.025	<0.05	0.13	<0.024	0.067
Hg	mg/L	<0.00009	<0.0001	0.00044	0.00038	0.00038
K	mg/L	3.8	4	3.8	4.4	3.7
Mg	mg/L	62	66	63	65	65
Mn	mg/L	0.19	0.20	0.23	0.19	0.21
Mo	mg/L	<0.002	<0.02	0.019	<0.018	<0.018
Na	mg/L	72	67	68	70	64
Ni	mg/L	0.011	<0.08	<0.08	<0.038	<0.038
Pb	mg/L	<0.001	<0.1	0.18	<0.068	<0.068
Se	mg/L	0.003	<0.1	0.13	<0.10	<0.10
V	mg/L	<0.003	<0.04	0.045	<0.005	0.011
Zn	mg/L	0.034	0.058	0.10	0.072	0.094
F	mg/L	<1	1.3	3	<1	<1
Cl	mg/L	140	140	110	140	120
TOC	mg/L	<5	<5	<5	<10	7
HCO_3	mg/L	460	410	500	460	460
CO_3	mg/L	<5	<5	<5	<19	<10
$NH_3(N)$	mg/L	<1	<0.1	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	0.5	0.3	2	0.70	1.4
$NO_3(N)$	mg/L	<1	4	2	<1	<1
SO_4	mg/L	210	180	180	190	180
TDS	mg/L	800	800	820	830	820
TSS	mg/L	41	81	118	1426	23
pH	units	7.8	7.6	7.5	7.3	7.4
Sp.Cond.	µmhos	1340	1400	1260	1530	1360
Ra-224s	pCi/L	0.10	-	0.52	0.76	0.57
Ra-224t	pCi/L	-	-	1.34	8.36	0.58
Ra-226s	pCi/L	0.11	0.27	0.59	2.06	0.54
Ra-226t	pCi/L	0.23	0.38	1.07	6.07	1.31
Ra-228s	pCi/L		-	-	-	0.93
Ra-228t	pCi/L	1.2	<3.3	<1.6	<2.5	≥0.93
Th-230	pCi/L	0.056	0.055	0.017	0.004	0.009
Th-232	pCi/L	0.008	0.009	0.006	0.0076	0.006
U-238	mg/L	0.003	0.007	0.004	0.002	0.005

Table A.13. Continued

Chemical Species	Unit	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	<0.020	0.026	<0.002
Al	mg/L	<0.008	<0.008	<0.11	0.60
As	mg/L	<0.11	<0.11	<0.11	<0.057
B	mg/L	0.17	0.19	0.20	0.52
Ba	mg/L	0.041	0.037	0.037	0.21
Ca	mg/L	120	120	160	130
Cd	mg/L	<0.007	<0.007	0.016	<0.002
Co	mg/L	<0.011	<0.011	0.026	<0.006
Cr	mg/L	<0.026	<0.026	0.032	<0.001
Cu	mg/L	<0.017	<0.017	0.017	<0.001
Fe	mg/L	<0.024	0.14	0.41	0.74
Hg	mg/L	<0.0005	<0.0003	<0.0005	<0.0005
K	mg/L	3.0	4.0	3.5	12
Mg	mg/L	59	64	66	63
Mn	mg/L	0.22	0.19	0.20	0.19
Mo	mg/L	<0.018	<0.018	0.021	0.015
Na	mg/L	69	70	59	81
Ni	mg/L	<0.038	<0.038	<0.069	<0.003
Pb	mg/L	<0.068	<0.068	0.14	<0.08
Se	mg/L	<0.10	<0.10	<0.10	<0.08
V	mg/L	<0.005	<0.005	<0.030	<0.003
Zn	mg/L	0.23	0.22	0.023	0.051
F	mg/L	<1	<1	<1	<1
Cl	mg/L	120	130	130	110
TOC	mg/L	13	14	22	7.5
HCO_3	mg/L	460	450	400	460
CO_3	mg/L	<10	<10	<10	<10
$NH_3(N)$	mg/L	<0.1	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	1.0	0.34	-	-
$NO_3(N)$	mg/L	<1	<1	1	1
SO_4	mg/L	110	220	170	130
TDS	mg/L	780	800	740	760
TSS	mg/L	72	4	<2	9
pH	units	7.7	7.2	7.2	7.2
Sp.Cond.	µmhos	1540	1380	1310	1300
Ra-224s	pCi/L	0.33	0	0	0
Ra-224t	pCi/L	1.61	0	0	0
Ra-226s	pCi/L	0.06	0.18	1.03	0.09
Ra-226t	pCi/L	0.35	0.18	1.03	0.09
Ra-228s	pCi/L	0.74	0.31	1.92	0.32
Ra-228t	pCi/L	≥0.74	0.31	1.94	0.33
Th-230	pCi/L	0.032	0.039	0.053	1.09
Th-232	pCi/L	0.024	0.003	0.006	0.021
U-238	mg/L	0.005	0.004	0.003	0.005

Table A.14. Concentrations of Chemical and Radiological Parameters in the F Wells on the West Chicago Site, Well F-1

Chemical Species	Unit	1982 2nd Qtr.	1982 3rd Qtr.	1982 4th Qtr.	1983 1st Qtr.
Ag	mg/L	<0.002	<0.002	<0.002	0.058
Al	mg/L	0.083	<0.05	<0.05	0.25
As	mg/L	0.049	0.004	0.002	0.11
B	mg/L	0.20	0.78	0.26	0.35
Ba	mg/L	0.17	0.11	<0.001	<0.02
Ca	mg/L	540	260	360	560
Cd	mg/L	0.003	<0.002	0.012	0.021
Co	mg/L	0.019	0.022	0.12	0.084
Cr	mg/L	0.042	0.007	0.018	0.077
Cu	mg/L	0.14	0.094	0.42	0.20
Fe	mg/L	0.47	0.52	2.8	0.84
Hg	mg/L	<0.001	<0.001	<0.00008	<0.0001
K	mg/L	7.3	4.8	4.6	6.1
Mg	mg/L	220	140	210	280
Mn	mg/L	0.82	0.47	0.95	0.93
Mo	mg/L	0.007	<0.002	0.014	0.032
Na	mg/L	110	100	100	90
Ni	mg/L	0.078	0.059	0.22	0.23
Pb	mg/L	0.02	0.004	<0.001	0.20
Se	mg/L	0.016	0.016	0.011	0.14
V	mg/L	0.066	<0.003	<0.003	0.052
Zn	mg/L	0.86	0.96	3.1	1.4
F	mg/L	4	5.6	5	4.1
Cl	mg/L	150	100	320	210
HCO_3	mg/L	270	287	280	240
CO_3	mg/L	<3	<10	<5	<5
$NH_3(N)$	mg/L	14	4.5	5	<0.1
$NO_2(N)$	mg/L	0.44	0.10	4.0	0.3
$NO_3(N)$	mg/L	520	110	240	400
SO_4	mg/L	450	720	530	620
TDS	mg/L	3740	1970	2490	3480
TSS	mg/L	145	18	66	10
pH	units	6.8	7.0	7.4	6.9
Sp.Cond.	µmhos	4410	2580	3640	4430
Ra-224s	pCi/L	-	-	0.03	-
Ra-224t	pCi/L	-	-	-	-
Ra-226s	pCi/L	0.04	-0.004	0.04	-0.02
Ra-226t	pCi/L	1.21	-0.004	0.10	0.03
Ra-228s	pCi/L	-	-	-	-
Ra-228t	pCi/L	<1.4	11.9	<2.5	<3.4
Th-230	pCi/L	0.02	0.011	0.008	0.041
Th-232	pCi/L	0.01	0.004	0.004	0.005
U-238	mg/L	0.002	0.005	0.004	0.007

Table A.14. Continued

Chemical Species	Unit	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.	1984 1st Qtr.
Ag	mg/L	0.11	0.058	0.044	<0.020
Al	mg/L	0.45	0.25	<0.042	<0.008
As	mg/L	0.23	<0.11	<0.11	<0.11
B	mg/L	0.40	0.58	0.35	0.38
Ba	mg/L	<0.02	<0.013	<0.013	<0.013
Ca	mg/L	440	280	230	170
Cd	mg/L	0.026	0.019	0.007	0.015
Co	mg/L	0.10	0.068	0.061	0.082
Cr	mg/L	0.10	0.033	<0.026	<0.026
Cu	mg/L	0.20	0.20	0.26	0.32
Fe	mg/L	0.69	1.2	1.5	1.1
Hg	mg/L	<0.0001	0.00030	0.00038	<0.0005
K	mg/L	5.9	6.5	5.7	4.0
Mg	mg/L	230	160	120	88
Mn	mg/L	0.75	0.62	0.59	0.68
Mo	mg/L	0.050	0.021	<0.018	<0.018
Na	mg/L	71	56	66	53
Ni	mg/L	0.22	0.14	0.083	0.12
Pb	mg/L	0.39	0.17	0.074	<0.068
Se	mg/L	0.26	<0.10	<0.10	<0.10
V	mg/L	0.099	0.042	0.007	0.005
Zn	mg/L	1.3	1.9	1.8	2.2
F	mg/L	4	<1	4.0	6.7
Cl	mg/L	190	170	150	77
TOC	mg/L	-	-	17	12
HCO_3	mg/L	280	280	270	270
CO_3	mg/L	<5	<19	<10	<10
$NH_3(N)$	mg/L	3.7	0.2	<0.1	0.1
$NO_2(N)$	mg/L	4.0	1.0	0.14	5.0
$NO_3(N)$	mg/L	250	130	78	45
SO_4	mg/L	650	460	500	320
TDS	mg/L	2570	1680	1590	1120
TSS	mg/L	<2	34	6.0	9
pH	units	6.8	6.8	6.9	7.0
Sp.Cond.	µmhos	3370	2830	2100	2050
Ra-224s	pCi/L	0.03	-	0.01	0.023
Ra-224t	pCi/L	0.05	0.07	0.02	0.16
Ra-226s	pCi/L	0.03	-	0.02	0.025
Ra-226t	pCi/L	0.07	0.07	0.03	0.11
Ra-228s	pCi/L	-	-	0.13	0
Ra-228t	pCi/L	<1.5	<2.0	≥0.13	≥0
Th-230	pCi/L	0.016	0.009	0.004	0.018
Th-232	pCi/L	0.007	0.007	0.004	0.003
U-238	mg/L	0.004	0.002	0.010	0.003

Table A.14. Continued

Chemical Species	Unit	1984 2nd Qtr.	1984 3rd Qtr.	1984 4th Qtr.	1985 1st Qtr.
Ag	mg/L	<0.020	0.045	-	<0.004
Al	mg/L	0.052	0.19	60	0.91
As	mg/L	<0.11	<0.11	<0.06	<0.12
B	mg/L	0.42	0.51	0.90	0.62
Ba	mg/L	<0.013	0.005	0.17	0.021
Ca	mg/L	350	210	190	160
Cd	mg/L	0.008	0.033	<0.002	<0.004
Co	mg/L	0.030	0.099	<0.006	<0.012
Cr	mg/L	0.034	0.049	<0.001	<0.010
Cu	mg/L	0.12	0.18	<0.001	<0.002
Fe	mg/L	0.15	2.0	0.12	0.054
Hg	mg/L	<0.0003	<0.0005	<0.005	<0.0005
K	mg/L	5.0	4.1	19	4.5
Mg	mg/L	180	95	95	78
Mn	mg/L	0.060	0.57	0.23	0.088
Mo	mg/L	<0.018	0.034	0.019	<0.004
Na	mg/L	65	39	110	290
Ni	mg/L	0.14	0.12	0.024	<0.006
Pb	mg/L	<0.068	0.21	<0.08	<0.16
Se	mg/L	<0.10	<0.10	<0.08	<0.16
V	mg/L	0.013	0.050	0.046	<0.006
Zn	mg/L	1.4	1.5	0.14	0.037
F	mg/L	<1	<1	8	8
Cl	mg/L	260	66	160	400
TOC	mg/L	20	18	12	14
HCO_3	mg/L	260	320	400	410
CO_3	mg/L	<10	<10	<10	-
$NH_3(N)$	mg/L	<0.1	<0.1	<0.1	1.8
$NO_2(N)$	mg/L	6.6	-	-	-
$NO_3(N)$	mg/L	210	36	23	32
SO_4	mg/L	530	430	290	300
TDS	mg/L	2146	1040	1230	1540
TSS	mg/L	13	46	60	7
pH	units	6.8	7.0	7.1	7.1
Sp.Cond.	µmhos	3390	1520	1830	2670
Ra-224s	pCi/L	0	0	0	0
Ra-224t	pCi/L*	0	0	0	0
Ra-226s	pCi/L	0	0.01	0	0
Ra-226t	pCi/L	0	0.01	0	0.01
Ra-228s	pCi/L	0.58	0.02	0.44	0.10
Ra-228t	pCi/L	0.70	0.02	0.44	0.12
Th-230	pCi/L	0.064	0.033	0.153	0.069
Th-232	pCi/L	0.024	0.003	0.012	0.005
U-238	mg/L	0.004	0.003	0.007	0.007

Table A.15. Concentrations of Chemical and Radiological Parameters in the F Wells on the West Chicago Site, Well F-2

Chemical Species	Unit	1982 2nd Qtr.	1982 3rd Qtr.	1982 4th Qtr.	1983 1st Qtr.
Ag	mg/L	<0.002	<0.002	<0.002	0.095
Al	mg/L	0.28	0.75	<0.05	1.1
As	mg/L	0.022	0.016	0.005	0.15
B	mg/L	0.36	0.48	-	2.8
Ba	mg/L	0.13	0.099	0.011	<0.02
Ca	mg/L	500	550	550	670
Cd	mg/L	<0.002	0.007	<0.002	0.021
Co	mg/L	0.01	0.022	<0.006	0.066
Cr	mg/L	0.017	0.047	0.007	0.078
Cu	mg/L	0.017	0.098	0.002	0.099
Fe	mg/L	0.71	0.048	0.074	1.1
Hg	mg/L	<0.001	0.001	<0.00008	<0.0001
K	mg/L	8.5	14	8.0	8.6
Mg	mg/L	100	68	120	110
Mn	mg/L	0.79	0.36	0.68	0.76
Mo	mg/L	0.007	0.024	0.019	0.062
Na	mg/L	540	570	520	500
Ni	mg/L	0.078	0.073	0.11	0.19
Pb	mg/L	0.014	<0.004	<0.001	0.34
Se	mg/L	0.045	0.091	0.012	0.28
V	mg/L	0.027	0.13	<0.003	0.099
Zn	mg/L	1.4	1.2	2.1	3.0
F	mg/L	18	17	16	18
Cl	mg/L	190	110	240	180
HCO_3	mg/L	420	521	310	280
CO_3	mg/L	<3	<10	<5	<5
$NH_3(N)$	mg/L	5.4	3.3	4	<0.1
$NO_2(N)$	mg/L	4.9	0.19	50	0.5
$NO_3(N)$	mg/L	16	26	40	120
SO_4	mg/L	2160	2160	2370	2090
TDS	mg/L	3920	3920	3990	3950
TSS	mg/L	2	93	-	17
pH	units	6.9	7.0	7.4	6.9
Sp.Cond.	µmhos	3940	4460	4960	4320
Ra-224s	pCi/L	-	-	-	-
Ra-224t	pCi/L	-	-	-	-
Ra-226s	pCi/L	0.03	0.11	0.22	0.12
Ra-226t	pCi/L	0.57	3.10	-	0.52
Ra-228s	pCi/L	-	-	-	-
Ra-228t	pCi/L	2.7	<1.8	<1.9	<1.7
Th-230	pCi/L	0.66	0.018	0.079	0.066
Th-232	pCi/L	0.007	0.003	0.016	0.010
U-238	mg/L	2.0	2.7	0.14	0.93

Table A.15. Continued

Chemical Species	Unit	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.	1984 1st Qtr.
Ag	mg/L	0.17	0.12	0.024	0.060
Al	mg/L	0.93	0.73	0.45	0.56
As	mg/L	0.34	0.22	<0.11	0.14
B	mg/L	0.47	0.40	0.23	0.54
Ba	mg/L	0.026	0.018	0.019	<0.013
Ca	mg/L	620	520	570	610
Cd	mg/L	0.032	0.022	<0.007	0.013
Co	mg/L	0.088	0.057	0.016	0.033
Cr	mg/L	0.14	0.079	0.034	0.070
Cu	mg/L	0.87	0.56	0.089	0.27
Fe	mg/L	0.82	0.16	0.65	0.059
Hg	mg/L	<0.0001	<0.00030	0.00025	<0.0005
K	mg/L	12	10	8.0	8.6
Mg	mg/L	59	110	98	51
Mn	mg/L	0.31	0.45	0.62	0.34
Mo	mg/L	0.080	0.056	0.022	0.045
Na	mg/L	430	640	400	320
Ni	mg/L	0.19	0.23	0.17	0.18
Pb	mg/L	0.54	0.37	<0.068	0.15
Se	mg/L	0.41	0.28	<0.10	0.11
V	mg/L	0.18	0.11	0.021	0.12
Zn	mg/L	3.2	4.2	5.0	2.4
F	mg/L	14	15	18	17
Cl	mg/L	100	170	190	41
TOC	mg/L	-	-	15	5.1
HCO_3	mg/L	580	340	180	470
CO_3	mg/L	<5	<19	<10	<10
$NH_3(N)$	mg/L	1.3	0.1	<0.1	0.7
$NO_2(N)$	mg/L	4.0	1.2	0.70	3.0
$NO_3(N)$	mg/L	14	23	13	9.7
SO_4	mg/L	1870	2450	2180	1830
TDS	mg/L	3320	3790	3700	3130
TSS	mg/L	6	150	35	3
pH	units	7.0	6.6	6.5	6.9
Sp.Cond.	µmhos	3570	5070	4200	4100
Ra-224s	pCi/L	8.99	4.84	1.56	3.24
Ra-224t	pCi/L	13.8	28.9	4.53	3.81
Ra-226s	pCi/L	0.54	0.65	0.56	0.23
Ra-226t	pCi/L	1.31	4.22	0.56	0.36
Ra-228s	pCi/L	-	-	1.44	8.15
Ra-228t	pCi/L	17.0	<1.3	≥1.44	≥8.15
Th-230	pCi/L	0.024	0.018	0.009	0.036
Th-232	pCi/L	0.003	0.007	0.003	0.014
U-238	mg/L	6.7	2.2	0.199	4.66

Appendix A-45
(NRC, 1989a)

Table A.15. Continued

Chemical Species	Unit	1984 2nd Qtr.	1984 3rd Qtr.	1984 4th Qtr.
Ag	mg/L	<0.020	0.14	<0.002
Al	mg/L	0.31	0.96	1.8
As	mg/L	0.11	0.31	<0.06
B	mg/L	0.28	0.36	0.77
Ba	mg/L	<0.013	0.016	0.17
Ca	mg/L	510	590	600
Cd	mg/L	0.010	0.066	<0.002
Co	mg/L	0.030	0.13	0.021
Cr	mg/L	0.056	0.16	<0.001
Cu	mg/L	0.17	0.16	0.074
Fe	mg/L	0.44	115	0.076
Hg	mg/L	<0.0003	<0.0005	<0.005
K	mg/L	7.0	5.7	18
Mg	mg/L	130	79	84
Mn	mg/L	0.49	1.0	0.72
Mo	mg/L	0.038	0.10	0.020
Na	mg/L	600	200	350
Ni	mg/L	0.15	0.36	0.20
Pb	mg/L	0.093	0.60	<0.08
Se	mg/L	<0.10	0.32	<0.08
V	mg/L	0.041	0.16	0.057
Zn	mg/L	2.6	6.5	3.8
F	mg/L	<1	21	25
Cl	mg/L	510	340	130
TOC	mg/L	17	13	35
HCO_3	mg/L	470	140	190
CO_3	mg/L	<10	<10	<10
$NH_3(N)$	mg/L	<0.1	<0.1	<0.1
$NO_2(N)$	mg/L	4.0	-	-
$NO_3(N)$	mg/L	30	21	27
SO_4	mg/L	3290	1820	1660
TDS	mg/L	6020	3150	3230
TSS	mg/L	-	7	8
pH	units	8.0	7.1	7.0
Sp.Cond.	µmhos	7020	3680	3890
Ra-224s	pCi/L	0	0	0
Ra-224t	pCi/L	15.2	0	0.40
Ra-226s	pCi/L	0.23	0	0
Ra-226t	pCi/L	3.25	0	0.09
Ra-228s	pCi/L	1.18	0.95	0.007
Ra-228t	pCi/L	11.3	2.21	0.65
Th-230	pCi/L	0.048	0.134	0.20
Th-232	pCi/L	0.006	0.008	0.006
U-238	mg/L	0.89	0.72	0.48

Table A.16. Concentrations of Chemical and Radiological Parameters in the F Wells on the West Chicago Site, Well F-3

Chemical Species	Unit	1982 2nd Qtr.	1982 3rd Qtr.	1982 4th Qtr.	1983 1st Qtr.
Ag	mg/L	<0.002	0.006	<0.002	0.071
Al	mg/L	1.6	0.10	1.6	1.5
As	mg/L	0.046	0.006	0.001	0.17
B	mg/L	0.36	0.40	0.21	0.30
Ba	mg/L	0.15	0.12	<0.001	<0.02
Ca	mg/L	400	470	450	550
Cd	mg/L	<0.002	0.003	0.002	0.021
Co	mg/L	0.012	0.012	0.014	0.067
Cr	mg/L	0.012	0.02	0.002	0.061
Cu	mg/L	0.17	0.1	0.17	0.32
Fe	mg/L	6.9	1.8	4.7	5.9
Hg	mg/L	<0.001	<0.001	<0.00008	0.00011
K	mg/L	3.4	4.2	3.4	4.5
Mg	mg/L	90	71	97	95
Mn	mg/L	0.68	0.27	0.68	0.82
Mo	mg/L	<0.002	<0.002	0.014	0.038
Na	mg/L	170	95	160	150
Ni	mg/L	0.12	1.089	0.14	0.27
Pb	mg/L	0.021	<0.004	<0.001	0.29
Se	mg/L	0.009	0.043	0.013	0.20
V	mg/L	0.022	0.046	0.023	0.066
Zn	mg/L	0.26	0.15	0.40	0.71
F	mg/L	16	16	16	14
Cl	mg/L	280	120	250	280
HCO_3	mg/L	260	232	260	180
CO_3	mg/L	<3	<10	<5	<5
$NH_3(N)$	mg/L	17	2.5	11	0.1
$NO_2(N)$	mg/L	<0.1	0.1	5	0.1
$NO_3(N)$	mg/L	6	3.2	<1	23
SO_4	mg/L	1140	1300	1180	1270
TDS	mg/L	2400	2290	2380	2600
TSS	mg/L	680	3800	1660	1060
pH	units	6.5	6.6	7.2	6.6
Sp.Cond.	µmhos	2720	2630	3220	3080
Ra-224s	pCi/L	-	-	0.76	-
Ra-224t	pCi/L	-	-	-	-
Ra-226s	pCi/L	0.10	-0.0003	0.23	0.19
Ra-226t	pCi/L	0.17	0.52	0.35	0.27
Ra-228s	pCi/L	-	-	-	-
Ra-228t	pCi/L	<1.6	<2.0	<1.9	<2.7
Th-230	pCi/L	0.036	0.012	0.030	0.032
Th-232	pCi/L	0.006	0.003	0.009	0.003
U-238	mg/L	0.01	0.08	0.09	0.06

Table A.16. Continued

Chemical Species	Unit	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.	1984 1st Qtr.
Ag	mg/L	0.16	0.10	0.057	0.021
Al	mg/L	1.4	1.5	0.80	0.80
As	mg/L	0.31	0.14	<0.11	<0.11
B	mg/L	0.36	0.44	0.31	0.32
Ba	mg/L	0.029	0.017	<0.013	<0.013
Ca	mg/L	420	450	420	420
Cd	mg/L	0.035	0.023	<0.007	0.013
Co	mg/L	0.080	0.071	0.054	0.027
Cr	mg/L	0.12	0.059	<0.026	0.033
Cu	mg/L	0.26	0.56	0.58	0.089
Fe	mg/L	3.1	6.1	9.2	0.34
Hg	mg/L	<0.0001	<0.00030	0.00028	<0.0005
K	mg/L	3.1	6.6	5.4	2.1
Mg	mg/L	48	86	82	34
Mn	mg/L	0.21	0.48	0.72	0.13
Mo	mg/L	0.074	0.039	<0.018	0.023
Na	mg/L	73	140	210	27
Ni	mg/L	0.19	0.24	0.22	0.096
Pb	mg/L	0.54	0.32	0.12	<0.068
Se	mg/L	0.43	0.21	<0.10	<0.10
V	mg/L	0.13	0.079	0.007	0.033
Zn	mg/L	0.86	1.5	1.4	0.37
F	mg/L	16	15	17	17
Cl	mg/L	70	170	250	29
TOC	mg/L	-	-	30	6.8
HCO_3	mg/L	180	110	160	120
CO_3	mg/L	<5	<19	<10	<10
$NH_3(N)$	mg/L	1.6	7.4	<0.1	<0.1
$NO_2(N)$	mg/L	4.0	1.2	0.70	5.0
$NO_3(N)$	mg/L	<10	13	11	1.5
SO_4	mg/L	950	1200	1280	960
TDS	mg/L	1790	2250	2430	1530
TSS	mg/L	2140	1270	580	3560
pH	units	6.7	6.4	6.6	6.6
Sp.Cond.	µmhos	2000	3190	3150	2110
Ra-224s	pCi/L	0.89	0.86	1.55	0.30
Ra-224t	pCi/L	4.2	10.2	1.57	12.5
Ra-226s	pCi/L	0.04	0.43	1.04	0.10
Ra-226t	pCi/L	1.64	1.93	1.80	7.45
Ra-228s	pCi/L	-	-	1.05	1.58
Ra-228t	pCi/L	<1.8	<2.5	≥1.55	≥1.58
Th-230	pCi/L	0.017	0.013	0.009	0.009
Th-232	pCi/L	0.007	0.004	0.003	0.006
U-238	mg/L	0.080	0.071	0.068	0.065

Table A.16. Continued

Chemical Species	Unit	1984 2nd Qtr.	3rd Qtr.	4th Qtr.
Ag	mg/L	<0.020	0.086	<0.002
Al	mg/L	0.87	1.2	1.9
As	mg/L	<0.11	0.17	<0.06
B	mg/L	0.28	0.31	0.69
Ba	mg/L	<0.013	0.015	0.17
Ca	mg/L	380	380	310
Cd	mg/L	0.015	0.042	<0.002
Co	mg/L	0.038	0.084	0.033
Cr	mg/L	0.034	0.072	<0.001
Cu	mg/L	0.40	0.28	0.33
Fe	mg/L	6.6	3.6	8.1
Hg	mg/L	<0.0003	<0.0005	<0.0005
K	mg/L	4.4	3.9	13
Mg	mg/L	72	52	67
Mn	mg/L	0.53	0.45	0.45
Mo	mg/L	<0.018	0.063	0.015
Na	mg/L	140	82	130
Ni	mg/L	0.19	0.18	0.17
Pb	mg/L	<0.068	0.36	<0.08
Se	mg/L	<0.10	0.18	<0.08
V	mg/L	0.024	0.090	0.048
Zn	mg/L	1.2	0.78	0.83
F	mg/L	29	21	21
Cl	mg/L	250	140	140
TOC	mg/L	24	25	31
HCO_3	mg/L	140	90	170
CO_3	mg/L	<10	<10	<10
$NH_3(N)$	mg/L	<0.1	<0.1	<0.01
$NO_2(N)$	mg/L	6.7	-	-
$NO_3(N)$	mg/L	18	<1	3
SO_4	mg/L	760	730	680
TDS	mg/L	1980	1350	1590
TSS	mg/L	2180	157	125
pH	units	6.5	6.8	6.7
Sp.Cond.	µmhos	2920	1940	2120
Ra-224s	pCi/L	2.42	0.03	0
Ra-224t	pCi/L	4.03	0.06	0
Ra-226s	pCi/L	1.39	0.03	0.07
Ra-226t	pCi/L	2.06	0.03	0.07
Ra-228s	pCi/L	4.36	0.28	0.60
Ra-228t	pCi/L	6.14	0.32	2.20
Th-230	pCi/L	0.047	0.027	0.094
Th-232	pCi/L	0.005	0.004	0.014
U-238	mg/L	0.080	0.039	0.034

Appendix A-49
(NRC, 1989a)

Table A.17. Concentrations of Chemical and Radiological Parameters in the F Wells on the West Chicago Site, Well F-4

Chemical Species	Unit	1982 2nd Qtr.	1982 3rd Qtr.	1982 4th Qtr.	1983 1st Qtr.
Ag	mg/L	0.004	<0.002	<0.002	0.036
Al	mg/L	0.21	<0.1	0.05	<0.2
As	mg/L	0.025	<0.004	0.001	<0.1
B	mg/L	0.36	0.46	0.10	0.37
Ba	mg/L	0.18	0.088	0.009	0.047
Ca	mg/L	150	170	180	210
Cd	mg/L	<0.002	<0.002	0.002	0.016
Co	mg/L	0.007	0.003	0.009	<0.04
Cr	mg/L	0.014	0.003	<0.001	0.035
Cu	mg/L	0.007	<0.001	0.003	0.076
Fe	mg/L	2.6	0.074	0.95	0.49
Hg	mg/L	0.001	0.001	<0.00009	<0.0001
K	mg/L	4.2	3.2	3.8	3.2
Mg	mg/L	80	64	80	85
Mn	mg/L	0.19	0.33	0.34	0.17
Mo	mg/L	<0.002	<0.002	0.010	0.022
Na	mg/L	120	86	110	120
Ni	mg/L	0.11	0.073	0.11	0.15
Pb	mg/L	0.028	<0.004	<0.001	0.20
Se	mg/L	0.008	0.006	0.004	<0.1
V	mg/L	0.026	<0.003	0.018	<0.04
Zn	mg/L	0.022	0.14	0.049	0.22
F	mg/L	<1	0.68	<1	<1
Cl	mg/L	230	190	200	240
HCO_3	mg/L	430	406	440	375
CO_3	mg/L	<3	<10	<5	<5
$NH_3(N)$	mg/L	0.4	0.6	<1	<0.1
$NO_2(N)$	mg/L	<0.1	<0.1	<0.1	<0.1
$NO_3(N)$	mg/L	1	<1	<1	14
SO_4	mg/L	370	280	350	350
TDS	mg/L	1120	1020	1060	1270
TSS	mg/L	280	<2	5	83
pH	units	7.2	7.0	7.7	7.2
Sp.Cond.	µmhos	1600	1540	1730	1840
Ra-224s	pCi/L	-	-	0.03	-
Ra-224t	pCi/L	-	-	-	-
Ra-226s	pCi/L	0.11	0.14	0.19	0.15
Ra-226t	pCi/L	1.37	0.15	0.21	0.27
Ra-228s	pCi/L	-	-	-	-
Ra-228t	pCi/L	<1.6	<1.6	<1.3	4.9
Th-230	pCi/L	0.032	0.012	0.087	0.018
Th-232	pCi/L	0.003	0.004	0.012	0.004
U-238	mg/L	0.003	0.005	0.006	0.003

Table A.17. Continued

Chemical Species	Unit	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.	1984 1st Qtr.
Ag	mg/L	[illegible].11	<0.020	<0.020	<0.020
Al	mg/L	0.45	0.10	0.042	<0.008
As	mg/L	0.22	<0.11	<0.11	<0.11
B	mg/L	0.44	0.62	0.56	0.33
Ba	mg/L	0.041	0.042	0.045	0.042
Ca	mg/L	160	150	160	190
Cd	mg/L	0.020	<0.007	<0.007	0.008
Co	mg/L	0.059	<0.011	<0.011	0.021
Cr	mg/L	0.087	<0.026	<0.026	<0.026
Cu	mg/L	0.083	0.033	<0.017	<0.017
Fe	mg/L	0.38	0.065	0.062	0.054
Hg	mg/L	<0.0001	<0.00030	0.00022	<0.0005
K	mg/L	2.2	2.9	2.9	2.2
Mg	mg/L	52	49	57	56
Mn	mg/L	0.13	0.048	0.052	0.15
Mo	mg/L	0.047	<0.018	<0.018	<0.018
Na	mg/L	66	63	74	72
Ni	mg/L	0.16	0.051	0.050	0.12
Pb	mg/L	0.36	<0.068	<0.068	<0.068
Se	mg/L	0.28	<0.10	<0.10	<0.10
V	mg/L	0.089	<0.019	0.011	<0.005
Zn	mg/L	0.090	0.30	0.035	0.17
F	mg/L	<1	<1	<1	<1
Cl	mg/L	110	110	160	300
TOC	mg/L	-	-	9	11
HCO_3	mg/L	400	330	380	310
CO_3	mg/L	<5	<19	<10	<10
$NH_3(N)$	mg/L	<0.1	0.2	<0.1	<0.1
$NO_2(N)$	mg/L	0.14	0.28	0.04	0.15
$NO_3(N)$	mg/L	5	<1	<1	<1
SO_4	mg/L	190	240	260	260
TDS	mg/L	840	790	910	1090
TSS	mg/L	<2	17	32.0	8
pH	units	7.1	6.9	7.0	7.1
Sp.Cond.	µmhos	1210	1180	1420	2180
Ra-224s	pCi/L	0.10	0.024	0.05	0.05
Ra-224t	pCi/L	0.13	1.36	0.05	0.15
Ra-226s	pCi/L	0.07	0.164	0.13	0.12
Ra-226t	pCi/L	0.08	0.64	0.21	0.18
Ra-228s	pCi/L	-	-	0.24	0.19
Ra-228t	pCi/L	<1.9	<1.9	≥0.24	≥0.19
Th-230	pCi/L	0.012	0.022	0.009	0.009
Th-232	pCi/L	0.004	0.009	0.003	0.009
U-238	mg/L	0.010	0.008	0.010	0.006

Table A.17. Continued

Chemical Species	Unit	1984 2nd Qtr.	1984 3rd Qtr.	1984 4th Qtr.	1985 1st Qtr.
Ag	mg/L	<0.020	0.035	<0.002	<0.004
Al	mg/L	0.010	<0.11	0.70	0.85
As	mg/L	<0.11	<0.11	<0.06	<0.12
B	mg/L	0.40	0.49	0.84	0.32
Ba	mg/L	0.046	0.052	0.21	0.065
Ca	mg/L	170	210	170	210
Cd	mg/L	<0.007	0.019	<0.002	<0.004
Co	mg/L	<0.011	0.037	<0.006	<0.012
Cr	mg/L	<0.026	0.039	<0.001	<0.010
Cu	mg/L	<0.017	0.034	0.010	<0.002
Fe	mg/L	0.17	0.43	0.25	0.25
Hg	mg/L	<0.0003	<0.0005	<0.0005	<0.0005
K	mg/L	2.9	3.4	11	<0.10
Mg	mg/L	59	75	64	78
Mn	mg/L	0.065	0.18	0.074	0.11
Mo	mg/L	<0.018	0.030	0.011	<0.004
Na	mg/L	70	82	99	92
Ni	mg/L	0.071	0.13	0.069	0.045
Pb	mg/L	<0.068	0.17	<0.08	<0.16
Se	mg/L	<0.10	<0.10	<0.08	<0.16
V	mg/L	0.007	0.038	<0.003	<0.006
Zn	mg/L	0.21	0.081	0.073	0.032
F	mg/L	<1	<1	<1	<0.2
Cl	mg/L	230	220	140	340
TOC	mg/L	8	11	7.4	10
HCO_3	mg/L	360	420	420	400
CO_3	mg/L	<10	<10	<10	-
$NH_3(N)$	mg/L	<0.1	<0.1	<0.1	2.5
$NO_2(N)$	mg/L	0.1	-	-	-
$NO_3(N)$	mg/L	3	<1	1	1
SO_4	mg/L	230	300	220	140
TDS	mg/L	910	1060	980	1090
TSS	mg/L	5	<2	<2	2
pH	units	7.0	7.0	7.1	7.0
Sp.Cond.	µmhos	1640	1680	1530	2150
Ra-224s	pCi/L	0.04	0	0	0
Ra-224t	pCi/L	0.04	0.01	11	0
Ra-226s	pCi/L	0.05	0.09	0	0
Ra-226t	pCi/L	0.05	0.09	0	0
Ra-228s	pCi/L	0.36	0.15	0.10	0.18
Ra-228t	pCi/L	0.46	0.16	0.10	0.21
Th-230	pCi/L	0.073	0.079	0.094	0.027
Th-232	pCi/L	0.007	0.003	0.013	0.009
U-238	mg/L	0.201	0.008	0.007	0.006

Table A.18. Concentrations of Chemical and Radiological Parameters in the F Wells on the West Chicago Site, Well F-5

Chemical Species	Unit	1982 2nd Qtr.	1982 3rd Qtr.	1982 4th Qtr.	1983 1st Qtr.
Ag	mg/L	0.009	<0.002	<0.002	0.071
Al	mg/L	0.53	0.56	0.34	0.46
As	mg/L	0.044	0.008	0.004	0.15
B	mg/L	0.33	0.32	0.15	0.28
Ba	mg/L	0.16	0.10	<0.001	<0.02
Ca	mg/L	570	530	500	480
Cd	mg/L	0.003	<0.002	<0.002	0.020
Co	mg/L	0.034	0.009	0.030	0.085
Cr	mg/L	0.018	0.011	<0.001	0.058
Cu	mg/L	0.18	0.18	0.17	0.15
Fe	mg/L	13	1.3	5.2	7.5
Hg	mg/L	<0.001	0.001	<0.00008	<0.0001
K	mg/L	5.1	5.2	6.0	6.1
Mg	mg/L	81	76	86	100
Mn	mg/L	0.95	0.47	0.59	0.83
Mo	mg/L	0.006	<0.002	0.017	0.05
Na	mg/L	180	140	160	160
Ni	mg/L	0.14	0.12	0.22	0.32
Pb	mg/L	0.034	<0.004	<0.001	0.28
Se	mg/L	0.03	0.035	<0.001	0.20
V	mg/L	0.056	0.019	0.035	0.073
Zn	mg/L	0.14	0.15	0.15	0.21
F	mg/L	14	19	19	14
Cl	mg/L	85	65	110	105
HCO_3	mg/L	280	311	330	295
CO_3	mg/L	<3	<10	<5	<5
$NH_3(N)$	mg/L	0.9	0.5	<1	<0.1
$NO_2(N)$	mg/L	<0.1	0.10	34	<0.1
$NO_3(N)$	mg/L	1	1.3	<1	10
SO_4	mg/L	1670	1470	1490	1280
TDS	mg/L	2650	2580	2600	2200
TSS	mg/L	450	83	22	42
pH	units	6.4	6.5	7.2	6.7
Sp.Cond.	µmhos	2630	2840	2930	2590
Ra-224s	pCi/L	-	-	0.04	-
Ra-224t	pCi/L	-	-	-	-
Ra-226s	pCi/L	-0.03	-0.01	-0.002	0.02
Ra-226t	pCi/L	1.03	0.10	0.03	0.10
Ra-228s	pCi/L	-	-	-	-
Ra-228t	pCi/L	<1.9	<1.5	<1.5	<3.7
Th-230	pCi/L	0.023	0.030	0.085	0.028
Th-232	pCi/L	0.003	0.012	0.008	0.003
U-238	mg/L	0.18	0.49	0.28	0.17

Table A.18. Continued

Chemical Species	Unit	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.	1984 1st Qtr.
Ag	mg/L	0.14	0.089	0.029	<0.020
Al	mg/L	0.66	0.59	0.17	0.16
As	mg/L	0.32	0.16	<0.11	0.14
B	mg/L	0.30	0.39	0.35	0.31
Ba	mg/L	<0.02	<0.013	0.015	<0.013
Ca	mg/L	390	460	450	400
Cd	mg/L	0.023	0.015	<0.007	<0.007
Co	mg/L	0.12	0.064	0.039	0.053
Cr	mg/L	0.11	0.047	0.030	0.037
Cu	mg/L	0.19	0.20	0.12	0.070
Fe	mg/L	5.3	0.23	1.3	1.8
Hg	mg/L	<0.0001	<0.00030	0.00034	<0.0005
K	mg/L	6.0	7.0	6.7	4.8
Mg	mg/L	85	82	100	65
Mn	mg/L	0.84	0.66	0.97	0.90
Mo	mg/L	0.072	0.041	0.028	0.035
Na	mg/L	120	100	160	120
Ni	mg/L	0.38	0.23	0.32	0.32
Pb	mg/L	0.46	0.28	<0.068	<0.068
Se	mg/L	0.36	0.20	<0.10	<0.10
V	mg/L	0.12	0.077	0.037	0.022
Zn	mg/L	0.19	0.15	0.16	0.30
F	mg/L	11	14	13	14
Cl	mg/L	111	97	120	140
TOC	mg/L	-	-	7	8.2
HCO_3	mg/L	380	290	360	370
CO_3	mg/L	<5	<19	<10	<10
$NH_3(N)$	mg/L	1.9	0.3	<0.1	1.6
$NO_2(N)$	mg/L	0.14	0.40	0.70	0.1
$NO_3(N)$	mg/L	<1	<1	<1	<1
SO_4	mg/L	910	1140	1500	1020
TDS	mg/L	1890	2160	2690	2010
TSS	mg/L	47	175	74.0	31
pH	units	6.6	6.6	7.8	6.6
Sp.Cond.	µmhos	2210	2950	3150	3070
Ra-224s	pCi/L	0.01	0.064	0.004	0.03
Ra-224t	pCi/L	0.16	0.85	0.32	0.24
Ra-226s	pCi/L	0.01	0.13	0.01	-
Ra-226t	pCi/L	0.14	0.13	0.26	-
Ra-228s	pCi/L	-	-	0.30	0.25
Ra-228t	pCi/L	<1.6	<1.3	≥0.30	≥0.25
Th-230	pCi/L	0.016	0.018	0.012	0.099
Th-232	pCi/L	0.006	0.007	0.006	0.025
U-238	mg/L	0.16	0.43	0.22	0.22

Table A.18. Continued

Chemical Species	Unit	1984 2nd Qtr.	1984 3rd Qtr.	1984 4th Qtr.	1985 1st Qtr.
Ag	mg/L	<0.020	0.16	<0.002	0.006
Al	mg/L	0.15	0.79	1.2	1.3
As	mg/L	<0.11	0.32	<0.06	<0.12
B	mg/L	0.27	0.44	0.85	0.21
Ba	mg/L	<0.013	0.012	0.17	0.019
Ca	mg/L	370	500	450	390
Cd	mg/L	<0.007	0.064	<0.002	<0.004
Co	mg/L	0.041	0.15	0.038	<0.012
Cr	mg/L	0.034	0.14	<0.001	<0.010
Cu	mg/L	0.085	0.16	0.075	0.071
Fe	mg/L	4.2	9.0	4.8	4.9
Hg	mg/L	<0.0003	<0.0005	<0.0005	<0.0005
K	mg/L	5.2	5.1	11	27
Mg	mg/L	79	90	110	84
Mn	mg/L	0.70	1.1	0.85	0.55
Mo	mg/L	0.026	0.11	0.022	0.011
Na	mg/L	120	88	240	160
Ni	mg/L	0.20	0.45	0.34	0.16
Pb	mg/L	<0.068	0.62	<0.08	<0.16
Se	mg/L	<0.10	0.37	<0.08	<0.16
V	mg/L	0.022	0.15	<0.003	0.015
Zn	mg/L	0.28	0.25	0.17	0.085
F	mg/L	14	20	15	17
Cl	mg/L	130	150	120	130
TOC	mg/L	12	23	12	10
HCO_3	mg/L	340	330	400	370
CO_3	mg/L	<10	<10	<10	-
$NH_3(N)$	mg/L	<0.1	<0.1	<0.1	0.7
$NO_2(N)$	mg/L	0.04	-	-	-
$NO_3(N)$	mg/L	4	<1	<1	<8
SO_4	mg/L	900	1260	1360	860
TDS	mg/L	1860	2490	2620	2030
TSS	mg/L	130	21	15	5
pH	units	6.7	6.5	6.6	6.5
Sp.Cond.	µmhos	2810	2780	2950	2900
Ra-224s	pCi/L	0	0	0	0.003
Ra-224t	pCi/L	0	0	0	0
Ra-226s	pCi/L	0	0	0	0.011
Ra-226t	pCi/L	0.04	0	0.003	0.011
Ra-228s	pCi/L	0.008	0.02	0.02	0.06
Ra-228t	pCi/L	0.28	0.05	0.44	0.09
Th-230	pCi/L	0.037	0.028	0.074	0.038
Th-232	pCi/L	0.006	0.008	0.016	0.009
U-238	mg/L	0.201	0.23	0.21	0.362

Appendix A-55
(NRC, 1989a)

Table A.19. Concentrations of Chemical and Radiological Parameters in the F Wells on the West Chicago Site, Well F-6

Chemical Species	Unit	1982 2nd Qtr.	1982 3rd Qtr.	1982 4th Qtr.	1983 1st Qtr.
Ag	mg/L	0.012	<0.002	<0.002	0.10
Al	mg/L	0.3	0.7	0.36	0.66
As	mg/L	0.013	0.010	0.002	0.17
B	mg/L	0.30	0.26	0.31	0.32
Ba	mg/L	0.2	0.11	0.15	<0.02
Ca	mg/L	490	580	570	700
Cd	mg/L	<0.002	0.004	<0.002	0.027
Co	mg/L	0.02	0.014	<0.006	0.065
Cr	mg/L	0.018	0.026	<0.001	0.071
Cu	mg/L	0.13	0.18	0.16	0.20
Fe	mg/L	3	1.3	3.8	4.0
Hg	mg/L	<0.001	<0.001	<0.00008	<0.0001
K	mg/L	3.6	3.0	3.2	4.0
Mg	mg/L	72	65	70	72
Mn	mg/L	0.47	0.27	0.38	0.45
Mo	mg/L	0.007	0.014	0.011	0.063
Na	mg/L	130	84	99	83
Ni	mg/L	0.13	0.08	0.070	0.16
Pb	mg/L	0.022	<0.004	<0.001	0.37
Se	mg/L	0.018	0.025	0.012	0.24
V	mg/L	0.051	0.094	<0.003	0.12
Zn	mg/L	0.25	0.25	0.35	0.45
F	mg/L	13	19	15	18
Cl	mg/L	93	68	82	86
HCO_3	mg/L	260	201	200	360
CO_3	mg/L	<3	<10	<5	<5
$NH_3(N)$	mg/L	3.2	0.4	<1	0.1
$NO_2(N)$	mg/L	<0.1	<0.1	1.0	0.1
$NO_3(N)$	mg/L	2	3	<1	7
SO_4	mg/L	1260	1570	1390	1610
TDS	mg/L	2330	2620	2540	2580
TSS	mg/L	980	230	200	37
pH	units	6.5	6.4	7.0	6.4
Sp.Cond.	µmhos	2380	2280	2870	2810
Ra-224s	pCi/L	-	-	0.20	-
Ra-224t	pCi/L	-	-	-	-
Ra-226s	pCi/L	-0.03	0.11	0.07	0.03
Ra-226t	pCi/L	0.06	1.06	0.14	0.24
Ra-228s	pCi/L	-	-	-	-
Ra-228t	pCi/L	<1.4	<1.3	<0.5	<2.8
Th-230	pCi/L	0.044	0.019	0.029	0.016
Th-232	pCi/L	0.007	0.007	0.004	0.005
U-238	mg/L	0.03	0.04	0.05	0.04

Table A.19. Continued

Chemical Species	Unit	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.	1984 1st Qtr.
Ag	mg/L	0.15	0.11	<0.020	0.027
Al	mg/L	1.1	0.78	0.39	0.49
As	mg/L	0.34	0.18	<0.11	<0.11
B	mg/L	0.39	0.45	0.31	0.39
Ba	mg/L	0.025	<0.013	0.022	<0.013
Ca	mg/L	590	570	600	660
Cd	mg/L	0.025	0.018	<0.007	0.010
Co	mg/L	0.081	0.054	<0.011	0.030
Cr	mg/L	0.13	0.052	0.043	0.042
Cu	mg/L	0.21	0.21	0.090	0.20
Fe	mg/L	1.1	0.12	3.0	1.9
Hg	mg/L	<0.0001	<0.00030	0.00025	<0.0005
K	mg/L	3.1	5.6	3.2	2.7
Mg	mg/L	60	66	64	63
Mn	mg/L	0.19	0.27	0.36	0.35
Mo	mg/L	0.090	0.047	0.036	0.049
Na	mg/L	54	67	76	77
Ni	mg/L	0.17	0.17	<0.038	0.11
Pb	mg/L	0.50	0.35	<0.068	<0.068
Se	mg/L	0.44	0.28	0.14	0.11
V	mg/L	0.19	0.13	0.005	0.092
Zn	mg/L	0.27	0.24	0.34	0.45
F	mg/L	20	18	17	21
Cl	mg/L	40	55	88	99
TOC	mg/L	-	-	8	7
HCO_3	mg/L	200	190	200	200
CO_3	mg/L	<5	<19	<10	<10
$NH_3(N)$	mg/L	0.2	0.1	<0.1	0.4
$NO_2(N)$	mg/L	0.28	0.14	0.04	0.1
$NO_3(N)$	mg/L	6	<1	<1	2.3
SO_4	mg/L	1325	1520	1490	1610
TDS	mg/L	2300	2410	2610	2490
TSS	mg/L	160	47	38.0	20
pH	units	6.2	6.2	6.2	6.2
Sp.Cond.	µmhos	2310	2950	3040	3200
Ra-224s	pCi/L	0.48	0.06	0.01	0.04
Ra-224t	pCi/L	1.92	0.34	1.47	0.52
Ra-226s	pCi/L	-0.03	0.05	0.06	0.05
Ra-226t	pCi/L	0.33	0.41	0.81	0.13
Ra-228s	pCi/L	-	-	0.24	0.24
Ra-228t	pCi/L	<1.5	<2.3	≥0.24	≥0.24
Th-230	pCi/L	0.015	0.013	0.003	0.017
Th-232	pCi/L	0.003	0.004	0.003	0.004
U-238	mg/L	0.075	0.074	0.090	0.095

Table A.19. Continued

Chemical Species	Unit	1984 2nd Qtr.	1984 3rd Qtr.	1984 4th Qtr.	1985 1st Qtr.
Ag	mg/L	<0.020	0.18	<0.002	0.009
Al	mg/L	0.40	0.76	1.2	1.4
As	mg/L	<0.11	0.19	<0.06	<0.12
B	mg/L	0.33	0.42	0.97	0.52
Ba	mg/L	<0.013	0.016	0.17	0.032
Ca	mg/L	590	590	620	550
Cd	mg/L	0.007	0.096	<0.002	<0.004
Co	mg/L	0.017	0.14	0.025	<0.012
Cr	mg/L	<0.026	0.20	0.019	0.017
Cu	mg/L	0.13	0.20	0.14	0.013
Fe	mg/L	2.2	4.9	4.2	0.82
Hg	mg/L	<0.0003	<0.0005	0.0014	<0.005
K	mg/L	3.1	3.5	9	0.93
Mg	mg/L	63	60	73	61
Mn	mg/L	0.29	0.57	0.35	0.17
Mo	mg/L	0.026	0.089	0.070	0.020
Na	mg/L	71	42	110	82
Ni	mg/L	0.080	0.29	0.089	0.048
Pb	mg/L	<0.068	0.72	<0.08	<0.16
Se	mg/L	<0.10	0.26	<0.08	<0.16
V	mg/L	0.062	0.23	0.12	0.096
Zn	mg/L	0.32	0.43	0.26	0.15
F	mg/L	36	22	21	22
Cl	mg/L	160	96	86	72
TOC	mg/L	9.1	15	5.4	8
HCO_3	mg/L	200	210	210	230
CO_3	mg/L	<10	<10	<10	-
$NH_3(N)$	mg/L	<0.1	<0.1	<0.1	1.0
$NO_2(N)$	mg/L	0.1	-	-	-
$NO_3(N)$	mg/L	9	5	<1	4
SO_4	mg/L	1390	1440	1560	1080
TDS	mg/L	2440	2510	2630	2320
TSS	mg/L	2	15	18	110
pH	units	6.2	6.3	6.4	6.3
Sp.Cond.	µmhos	2930	2780	2890	2960
Ra-224s	pCi/L	0.03	0	0	0
Ra-224t	pCi/L	0.44	0	0	0.50
Ra-226s	pCi/L	0.01	0	0	0
Ra-226t	pCi/L	0.11	0	0	0
Ra-228s	pCi/L	0.14	0.03	0.03	0.01
Ra-228t	pCi/L	0.77	0.13	0.35	0.80
Th-230	pCi/L	0.050	0.044	0.072	0.022
Th-232	pCi/L	0.005	0.006	0.013	0.007
U-238	mg/L	0.115	0.10	0.076	0.101

Table A.20. Concentrations of Chemical and Radiological Parameters in the F Wells on the West Chicago Site, Well F-7

Chemical Species	Unit	1984 4th Qtr.
Ag	mg/L	<0.002
Al	mg/L	3.9
As	mg/L	<0.06
B	mg/L	2.8
Ba	mg/L	0.17
Ca	mg/L	530
Cd	mg/L	<0.002
Co	mg/L	0.043
Cr	mg/L	0.039
Cu	mg/L	<0.001
Fe	mg/L	280
Hg	mg/L	<0.0005
K	mg/L	30
Mg	mg/L	520
Mn	mg/L	6
Mo	mg/L	0.051
Na	mg/L	1200
Ni	mg/L	0.58
Pb	mg/L	<0.08
Se	mg/L	<0.08
V	mg/L	<0.003
Zn	mg/L	0.88
F	mg/L	<1
Cl	mg/L	810
TOC	mg/L	94
HCO_3	mg/L	<5
$NH_3(N)$	mg/L	31
$NO_2(N)$	mg/L	-
$NO_3(N)$	mg/L	<1
SO_4	mg/L	4530
TDS	mg/L	8630
TSS	mg/L	670
pH	units	5.6
Sp.Cond.	µmhos	9440
Ra-224s	pCi/L	11.5
Ra-224t	pCi/L	13.6
Ra-226s	pCi/L	1.02
Ra-226t	pCi/L	1.52
Ra-228s	pCi/L	16.1
Ra-228t	pCi/L	23.3
Th-230	pCi/L	0.033
Th-232	pCi/L	0.005
U-238	mg/L	0.003

APPENDIX B

PUBLIC COMMENTS AND IDPH RESPONSES

The Illinois Department of Public Health (IDPH) received comments from Mr. Larry Jensen, United States Environmental Protection Agency (USEPA), Kerr-McGee, and Ms. Maria Hernandez (via U. S. Representative E. (Kika) de la Garza). The following comments were from Mr. Jensen, along with IDPH responses:

United States Environmental Protection Agency Comments

Comment 1. Summary, paragraph 1. This paragraph indicates five National Priorities List (NPL) areas when there are only four. Although the response to comments document states this would be corrected, apparently not all references were modified.

Gamma radiation should not be equated to elements like radon and thorium. Gamma radiation is a characteristic of radioactive emissions, as are alpha particles and beta particles, but it is not an atomic element. External exposure should be treated as a separate route of exposure.

Response 1. In the final document, it will be stated that the West Branch of the DuPage River upstream of its confluence with Kress Creek is included in the West Chicago Wastewater Treatment Plant (WTP) NPL area, while the part of the river downstream of the confluence is included with the Kress Creek NPL area.

The IDPH did not mean to imply that gamma radiation was an element, and is quite aware of its nature. In the final document, the nature of gamma radiation will be clarified.

Comment 2. Page 3, paragraph 1. Again, there are only 4 NPL areas, and the West Branch of the DuPage River is included in the Kress Creek area.

Response 2. Please see response 1.

Comment 3. Page 6, paragraph 2. The way the opening sentence is phrased tends to indicate Kerr-McGee was always the offender, even though they did not take over the site until 1967.

This list of 8 items omits Kerr-McGee being cited in the 1980's for excessive air emissions from their waste piles. The Nuclear Regulatory Commission (NRC) required them to cover the piles as a result.

Response 3. In the final document, the years of the citations and the years of plant ownership by each company will be given.

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Response 3. In the final document, the years of the citations and the years of plant ownership by each company will be given.

Thank you for the additional information about Kerr-McGee being cited for excessive air emissions, and the requirement to cover their waste piles.

Comment 4. Page 7, paragraph 1. Give the standard that 29.5 picoCuries per liter exceeds. This is probably the 10 picoCuries per liter NRC radon-220 standard.

Paragraph 4. The cover was installed because the NRC cited them for thoron (radon-220) decay product emission violations.

Response 4. This information will be added.

Comment 5. Page 24, paragraph 3. Fenceline data supplied to USEPA by the Illinois Department of Nuclear Safety (IDNS) showed levels to 185 microroentgens per hour, not "over 400 microroentgens per hour."

Response 5. According to a fenceline survey by IDNS (Runyon, 1989), gamma levels along the fenceline range from background to over 400 microroentgens per hour. The survey which USEPA cites may have missed a hot spot.

Comment 6. Page 25, paragraph 2, sentence 1. Not all of the radionuclides to which this sentence refers are listed.

Response 6. The sentence will be changed to "...radon daughters, as well as lead-212, radium, thorium, and uranium.

Comment 7. Page 36, paragraph 3. Screening tests at the Elliot Lake, Ontario, Canada radon/thoron chamber in the summer of 1993 showed Landauer alpha track monitors to be highly inaccurate in measuring thoron levels.

Response 7. Thank you for this information, which will be included in the final document.

Comment 8. Page 38, paragraph 4, last sentence. The MCL for alpha in drinking water is 15 picoCuries per liter, not 5 picoCuries per liter, so 9.42 picoCuries per liter is not in violation.

Response 8. In the last quarter of 1992, sampling from the distribution system of the West Chicago public water supply for the USEPA Environmental Radiation Ambient Monitoring System found 29.4 picoCuries per liter of gross alpha and 5.2 picoCuries per liter of radium-226; collection in the last quarter of 1991 found 16.2 picoCuries per liter of gross alpha and 6.9 picoCuries per liter of radium-226; and sampling in the last quarter of 1990 found 16.7 picoCuries per liter of gross alpha and 7.7 picoCuries per liter of radium-226 (USEPA Environmental Radiation Data Reports, 1990-92). The MCL for alpha activity is 15 picoCuries per liter and that for radium is 5 picoCuries per liter, so while diluting deep

groundwater with water from shallow wells has helped the situation, it has not solved the problem.

Comment 9. Page 42, paragraph 2. Without substantiation, the last sentence is conjecture.

Response 9. The IDPH agrees. The sentence will be changed to: "Any study of contamination along Kress Creek near the Kerr-McGee Facility must take into account past impacts from plant operations.

Comment 10. Page 57, paragraph 2. Sentences at the end of this paragraph tend to discredit present Superfund policy documents. Allowance should be made for the transition time from BEIR reports to updated policy. See comment 13 below.

Response 10. In the final document, the last sentence of the paragraph will be changed to "The USEPA is currently developing slope factors for individual radionuclides using BEIR V (1990) and any other new data.

Comment 11. Page 58, Radon. Report 32 by the International Commission on Radiological Protection, "Limits of Inhalation of Radon Daughters to Workers" has placed the thoron decay product dose at 1/3 that for an equal working level month of radon. USEPA (Ellett and Nelson, 1984) advocated 40%.

Response 11. This information will be added.

Comment 12. Page 85, table 1. Mesothorium (radium-228) was also a Lindsay Light and Chemical Company product.

Response 12. This information will be added.

Comment 13. Response to IDPH responses to USEPA Comments 17 and 22 of the Initial Release (agency comment draft). It is unfortunate that these responses attempt to dismiss USEPA risk assessment methodology. While it is true that the March 1993 Health Effects Summary Tables (HEAST) rely upon the BEIR III (1980) risk coefficients, USEPA states in the page 39 footnote to the March 1993 HEAST Annual Update that "...EPA anticipates that the slope factors for radionuclides in HEAST will be modified in the future to incorporate the results of BEIR V (1990) and/or other relevant sources." USEPA attempts to update the HEAST tables annually, based upon the latest research results, as soon as a thorough review is made of new information. USEPA has a high regard for public health and would not consciously nor negligently use parameters that it felt were inappropriate for assessing public health impacts.

Response 13. Paul Charp, Ph.D. health physicist, Agency for Toxic Substances and Disease Registry (ATSDR), recommended against using the current cancer slope factors for

radionuclides because they are based on the BEIR III (1980) report and more recent evidence (BEIR V, 1990) indicates that for various cancers, BEIR III (1980) underestimated the cancer risks of continuous lifetime radiation exposure by 4.4 to 18.3 times.

Kerr-McGee Comments

The IDPH also received comments and supporting documents from Kerr-McGee. The following is a summary of their comments and IDPH responses:

General Comments:

Comment 1. The residential areas do not pose a public health hazard. In the 1980's, Kerr-McGee surveyed 2726 properties in the City of West Chicago, and found 4.3 percent of them had gamma readings of over 30 microroentgens per hour (uR/hr). Kerr-McGee remediated 116 of 117 contaminated properties inside the City of West Chicago. Cleanup was performed until gamma levels were reduced to 15 uR/hr, except for one case where tailings were left under a foundation. One property owner refused access for cleanup. The cleanups met USEPA Part 192 standards. Exposure to radiation in remediated properties does not pose a public health hazard.

Response 1. The remediation of properties inside the City limits was described in the document. For current exposure, the IDPH was concerned about unremediated properties, and not properly remediated ones. This will be clarified in the final document. The IDPH agrees that any properly remediated property should not pose a health risk from excessive radiation exposure. The USEPA has questioned whether the past Kerr-McGee remediation efforts in residential areas have adequately reduced radiation levels, not the IDPH. In the Public Health Assessment, the USEPA was referenced, and the IDPH is not responsible for the statements of any other agency. In the final document, it will be stated that Kerr-McGee believes their past cleanup efforts were adequate to eliminate any health risks from radiation exposure. The wastes also contain up to 18,000 ppm of lead, which may not be well-correlated with radiation levels. Because radiation was the sole cleanup criterion, remediation may have left potentially high lead concentrations.

In the final document, it will be stated that a health assessment evaluates past, present, and possible future scenarios. While radiation exposure in any properly remediated property is currently around background, it is true that excessive exposure may have occurred in the past. In fact, past elevated gamma levels inside residences have been documented. Considering that cancers from radiation (or chemicals) generally occur ten or more years after exposure, past exposure is extremely important.

Comment 2. Kress Creek and the West Branch of the DuPage River pose no significant public health risks.

Response 2. This comment is examined in specific comment 44.

Comment 3. Most of the thorium residuals at the West Chicago Wastewater Treatment Plant (WTP) were removed by Kerr-McGee in the Mid-1980's, and the materials that remain do not pose a public health hazard.

Response 3. The removal of tailings from the WTP is described in the Public Health Assessment. The USEPA has questioned the adequacy of remediation at the WTP and has undertaken a remedial investigation/feasibility study (RI/FS) to evaluate this concern.

Comment 4. The contamination in Reed-Keppler Park is not accessible to the public, and therefore does not pose a public health hazard.

Response 4. According to Mr. Larry Jensen, USEPA, trespassing has occurred inside the fence which surrounds the majority of contamination at Reed-Keppler Park. Furthermore, if the area is not remediated (no action scenario), and sometime in the distant future homes are built on the tailings, people in them would be exposed to unacceptable levels of gamma radiation and probably also radon-220 and radon-222 (the wastes also have uranium). The half-life of thorium is about 14 billion years, so the wastes will remain hazardous essentially forever. It is uncertain whether the City of West Chicago would continue to control the park in the distant future. Also, some tailings are outside of the fence, although the exposure of park users and workers to this radiation is probably negligible, as noted in the document.

Comment 5. The West Chicago Facility should not be part of the public health assessment, and the public is not exposed to elevated gamma radiation or airborne radionuclides from the facility. Gamma radiation decreases to background levels within several hundred feet of the fenceline. Jensen et al. (1982) showed that airborne radionuclide exposure around the facility is negligible.

Response 5. The Kerr-McGee Facility was included in the public health assessment because (1) of community concerns, (2) much more information is available about the contamination in the Kerr-McGee Facility, (3) tailings from the facility were used for fill in Reed-Keppler Park, the WTP, and residential properties, (4) runoff from the facility has contaminated Kress Creek and the West Branch of the DuPage River downstream of the confluence, (5) erosion of tailings along the contaminated bank by the WTP has contaminated the West Branch of the DuPage River, and (6) consequently, contamination in the less-sampled areas is probably similar to that in the Kerr-McGee Facility (chemicals may be diluted by soil).

The USEPA and IDNS differ on the issue of whether gamma levels are elevated beyond the fenceline. Now Kerr-McGee claims that they are. There are homes and offices within 100 feet of the fenceline. Consequently, if (1) gamma levels are elevated for up to several hundred feet past the fenceline and (2) a frame structure provides only 10% shielding, people are likely exposed to elevated gamma radiation levels from the facility.

In the document, the Jensen et al. (1982) study is discussed, and it is stated that exposure to airborne radionuclides around the Kerr-McGee Facility is probably negligible.

Comment 6. The Kerr-McGee Facility has not impacted drinking water sources in the West Chicago Area.

Response 6. The data in the Public Health Assessment, based on years of sampling (original documents referenced), clearly show that this claim is unsubstantiated. The shallow dolomite aquifer under the Kerr-McGee Facility has been impacted. Under the Kerr-McGee Facility, the radium concentration is up to almost twice the MCL. However, as noted in the Public Health Assessment, chemicals found in private wells around the Kerr-McGee Facility (e.g., chloride, sulfate, total dissolved solids) affect the aesthetic qualities of water (e.g., taste, smell) and are not of health concern. The concentrations of chemicals of concern in wells near the Kerr-McGee Facility are mostly unknown. Radioactive contamination was not found in wells of the Joy Street Subdivision, but radionuclide levels in other private wells in the vicinity are unknown.

Comment 7. Lead in the wastes is not a contaminant of concern because leaching studies have shown that it is insoluble.

Response 7. Yes, lead is relatively insoluble and tends to be tightly bound to soil, but this does not mean that it is not of concern. For example, it is also true that the lead in lead paint is relatively insoluble and, if paint chips and dust fall onto soil, the lead will remain in the top inch of the soil profile for a long time, probably over one hundred years. Lead in paint, while relatively insoluble at environmental pH, is quite soluble in the acid of the stomach. In addition, fine lead dust less than one micron in size can penetrate into the alveoli of the lungs, where it cannot be physically removed from the body. All of this deeply inhaled lead is eventually believed to be absorbed. Because of its long half-life in the body (about 27 years), cumulative lead exposure is very important. Consequently, in spite of its relative insolubility, lead in paint has caused elevated lead blood levels in an estimated one to 1.5 million children in this country. Therefore, lead in the wastes cannot be considered not of concern simply because it is relatively insoluble.

Comment 8. Organic compounds are not contaminants of concern.

Response 8. PCB's have been found at the Kerr-McGee Facility, and while they were removed, more PCB contamination may still exist. Consequently, PCB's are **potential** contaminants of concern.

Comment 9. Conclusions about health effects have been drawn without considering the likely dose to the relevant population.

Response 9. Yes they have. Kerr-McGee has chosen to use values for remediated properties or average, rather than maximum values. In some cases, they used short exposure periods rather than constant residential exposure to reach conclusions. This issue is addressed further in some of their specific comments.

Comment 10. The IDPH has relied on obsolete and unreliable information in conducting the Public Health Assessment. The IDPH has ignored a significant body of information about the West Chicago Facility and off-site areas. The IDPH has improperly used the Butler (1965) master thesis for drawing conclusions about hydrogeology of the Kerr-McGee Facility. The IDPH has ignored the extensive past cleanups of the residential areas and the WTP. Numerous statements in the public health assessment lack adequate support. Risk assessment calculations are not given. Personal communications by USEPA, ATSDR, and IDNS staff are not credible sources (namely, Mr. Gary Shafer, Mr. Gulezian, and Mr. Larry Jensen, USEPA; Mr. Dave Ed, IDNS; and Dr. Paul Charp, ATSDR).

Response 11. While accusing the IDPH of using outdated information, Kerr-McGee cited equally old and older documents. Notably, in their risk assessment of radiation, Kerr-McGee systematically cited older material. Newer information (BEIR V, 1990) indicates that for various cancers, BEIR III (1980), the current basis of cancer slope factors for radionuclides, underestimated the cancer risks of continuous lifetime radiation exposure by 4.4 to 18.3 times. The USEPA is currently developing new cancer slope factors using more recent data.

The past residential WTP cleanups are described in the document, contrary to claims of Kerr-McGee.

The IDPH used the Butler (1965) thesis for sampling data, and explicitly stated that he did not adequately investigate groundwater flow. For groundwater flow, the Public Health Assessment used the Nuclear Regulatory Commission (1989) Supplement to the Final Environmental Impact Statement (SFES). It is more recent than the 1986 engineering study which Kerr-McGee cited in their comments.

The comment that statements in the Public Health Assessment lack adequate support because risk calculations are not shown stems from Kerr-McGee not understanding that a health

assessment is qualitative and not quantitative. The data were examined quantitatively, but reported in a qualitative manner to make them more easily understood by the public.

ATSDR, IDNS, and USEPA staff are credible sources of information about the contaminated areas and/or radiation.

Comment 12. The IDPH has misunderstood the hydrogeology of the area:

The clay layers are not absent under the Intermediate Area. While the upper clay layer in a small part of the area is small or absent, the deep clay is thick and continuous. A large number of deep borings have been made and establish both the continuity and extent of the clay layers (Kerr-McGee, 1986).

The direction of groundwater flow has been misinterpreted. The groundwater flow in the upper and middle sand and gravel is not downward, but horizontal toward Kress Creek. The clay layers inhibit downward flow.

During the years of operation, any contamination which may have reached the shallow dolomite aquifer under the Kerr-McGee Facility would have been drawn into the operating well used to supply water for the factory, and would not have spread radially away from the disposal pond(s).

Private wells along Pearl Road draw from the dolomite aquifer and not the overlying glacial aquifer. These wells are not in any respect threatened.

The document has failed to mention that private wells in the area draw from the shallow dolomite aquifer.

Response 12. The Public Health Assessment stated that the upper clay layer was thin to absent in the Intermediate Area (it is absent in boring 560), and not that all clay layers were absent. The horizontal flow of groundwater and inhibition of downward groundwater movement by clay are clearly described in the document. The IDPH used NRC (1989a) for its evaluation of hydrogeology, which is more recent that the Kerr-McGee (1986) engineering report. In NRC (1989a), the drawings show many shallow borings, but only eight deep ones (7 reach bedrock) to cover a forty acre area. The lower clay layer is displayed with dashed lines and question marks. This indicates that it is not well-defined. Furthermore, at boring AGKM-8, the deep clay is only a few feet thick. This means this layer can be thin and may be absent in some areas under or near the Kerr-McGee Facility. According to NRC (1989a), eighteen deep borings have been made at the Kerr-McGee Facility. This is less than one boring per two acres, which is insufficient to adequately characterize the highly variable glacial till. Furthermore, according to Kerr-McGee (1986), no deep borings have been made in the Factory Area, which covers about 8 acres. Consequently, the continuity and thickness of the deep clay under much of the Kerr-McGee Facility has not been adequately

investigated. Furthermore, the deep clay is not present at some locations around the Kerr-McGee Facility, including: (1) about 2400 feet south of the Kerr-McGee Facility (NRC, 1989a), (2) about one mile east of the Kerr-McGee Facility, (3) just east of the Kerr-McGee Facility (southwest corner of Section 10), (4) near the junction of Roosevelt Road and Route 59, (5) one well on Pearl Road, and (6) about one mile northwest of the Kerr-McGee Facility (ISWS well logs, 1990). In all of these cases, the deep clay is present in other nearby wells, sometimes up to 80 feet thick. This indicates the extent and thickness of the deep clay is extremely variable.

ISWS well logs (1990) have no record of the well used by the Lindsay Light and Chemical Company plant before 1953. In that year, a 16 inch diameter, 332 foot deep well was drilled for industrial use. Broken bedrock was encountered at 78 feet, while solid bedrock was encountered at 89 feet. Because the well was cased to 99 feet, water was not drawn from part of the shallow dolomite aquifer (upper 15 to 30 feet of the bedrock). The well extended down to 332 feet, and water was pumped from its bottom. Consequently, much of the water would have been drawn from deeper in the bedrock rather than from the shallow dolomite aquifer. After being used in the factory, this deep water and added industrial contaminants were discharged into the shallow sand and gravel aquifer via the disposal pond(s). Most of the water would have flowed laterally, and contamination of the shallow dolomite aquifer likely occurred in areas where the clay layers were thin or absent. The contaminants may have entered the intermediate sand and gravel in the intermediate area or other locations, where the shallow clay layer is thin to absent. Contaminants may then have moved in this layer and the shallow aquifer to areas near or under the facility where the deep clay is thin to absent. Some of this downward flow may have occurred outside the cone of depression of the Lindsay Light and Chemical Company well, so contaminants may have not been drawn back into the plant. The deep clay is thin under part of the Kerr-McGee Facility and possibly absent, so some contaminants may have reached the shallow dolomite aquifer at the facility, and they may or may not have been drawn into the factory well. Because the hydrology of the Kerr-McGee Facility was not adequately examined during the years of plant operation, the direction of flow in each of the aquifers at that time, and hence, contaminant flow, are unknown.

Contrary to claims by Kerr-McGee, sampling has shown that the shallow dolomite aquifer has been impacted, including total radium at almost twice the MCL. This indicates the clay layers have not adequately protected the shallow dolomite aquifer. The wells along Pearl Road are roughly downgradient of the Kerr-McGee Facility. Also, the log for one of these wells (ISWS, 1990) shows clay to 22 feet, followed by sand and gravel down to the bedrock. Two other wells on Pearl Road, however, have the lower clay layer. Because the deep clay is absent at one location, it cannot protect the shallow dolomite aquifer from contamination in this area.

The document **does** state that most private wells in the vicinity draw from the shallow dolomite aquifer.

Specific Comments

Comment 1. The NPL areas are not owned by Kerr-McGee, Kerr-McGee is not responsible for their contamination, and Kerr-McGee objects to designating them as "Kerr-McGee sites."

Response 1. The USEPA has listed them as Kerr-McGee areas under Superfund. The final draft of the document will state that Kerr-McGee does not own these areas and is not responsible for their contamination.

Comment 2. PCB's are not present at the Kerr-McGee Facility and have never been found in the NPL areas, so they are not chemicals of concern. In the past, PCB-contaminated soil and concrete were found where electrical equipment had been stored during factory operation. These materials were removed and sent to a disposal facility. Subsequently, a leaking transformer was found, and it and all contaminated materials were sent to a disposal facility. Fourteen samples of wastes at the Kerr-McGee Facility did not have PCB's. There is absolutely no reason to believe that there is PCB contamination at the Kerr-McGee Facility.

Response 2. The past discovery of PCB-contaminated soil in an area where electrical equipment was stored and where a transformer was found are both described in the document, as well as the disposal of soil where electrical equipment was stored. The IDNS, NRC, and USEPA did not know the fate of the transformer and associated soil. Thank you for this information. PCB's were not listed as a contaminant of concern, but mentioned as possibly present elsewhere in the wastes. Given the fact the Kerr-McGee Facility covers about 40 acres, it may still contain PCB's. It is also possible that contaminants were used for fill around the vicinity.

Comment 3. It has never been demonstrated that Kress Creek and associated properties were contaminated by the Kerr-McGee Facility.

Response 3. The Kerr-McGee Facility is the only source of thorium contamination within at least a 25 mile radius. Furthermore, except for a couple of samples which may be from tailings used as fill, Kress Creek is not contaminated above the storm sewer, which is polluted and drains from the Kerr-McGee Facility.

Comment 4. IDPH correctly notes that the public is very concerned about the contaminated areas, but this has no bearing on the potential risk posed by contaminants in the NPL areas.

Response 4. A Public Health Assessment is **required** to list and evaluate all health concerns of the public. In fact, this is a primary goal of a Public Health Assessment.

Comment 5. After a "detailed, long-winded, irrelevant discussion of property values," the Public Health Assessment properly states that any effect of contamination on property values is beyond the scope of a Public Health Assessment.

Response 5. There is no detailed, inaccurate, or long-winded discussion of property values in the document. The entire topic was discussed in only two sentences:

"People near the Kerr-McGee Facility have reportedly had difficulty selling their houses, and are concerned the value of their properties will diminish if the proposed Kerr-McGee Facility disposal cell is built. Concerns about property values are not within the scope of this report, which addresses health effects."

Comment 6. In the past, Kerr-McGee sought permanent disposal of the wastes in a cell at the Kerr-McGee Facility, and Kerr-McGee had an adversarial relationship with Envirocare. However, Kerr-McGee is now committed to shipping the material to Envirocare in Utah for disposal and has a contract with them for this action. Kerr-McGee has filed a closure plan with the IDNS which involves shipping the wastes to Utah for disposal. It is incorrect to premise the Public Health Assessment on concerns about a Kerr-McGee Facility disposal cell which no one now seeks to construct.

Response 6. In the final document, it will be stated that Kerr-McGee claims they are now committed to off-site disposal at the Utah facility. The disposal cell was discussed in the document as a proposed disposal method, and was hardly the focus of the assessment. A public health assessment considers all possible future exposure scenarios, so it could not be ignored.

Comment 7. The delay in remediation of contaminated residential properties outside of the City of West Chicago was caused by City officials, who halted removal by preventing transport of the material to the Kerr-McGee Facility using city streets.

Response 7. This is stated in the document, along with the facts that the City agreed not to enforce the ban and Kerr-McGee has not yet applied for the needed permits to perform the cleanups.

Comment 8. The Public Health Assessment incorrectly states that thorium in the wastes may be up to 20 times more concentrated than that in the original ores. Ore processing actually reduced the thorium content about twofold. The average level thorium oxide in monazite ore is 5.8 percent, while its final concentration in the wastes is about 2.7 percent. Also, only 111,000 short tons of monazite ore were processed at the plant over the period of operation.

Response 8. This information will be presented, along with the statement by Dave Ed, IDNS.

Comment 9. There is no evidence that the Bowling Green pond received radioactive contamination.

Response 9. As shown in the document, sampling by Butler (1965) showed the pond was contaminated, although at much lower levels than the disposal ponds.

Comment 10. Contamination of the Joliet St. well does not indicate contamination around the Kerr-McGee Facility, and if it happened, it probably resulted from contaminated shallow groundwater leaking through an eroded well seal.

Response 10. Conclusions about groundwater contamination around the facility were drawn from actual sampling results (as presented in the document) and not this unsubstantiated claim.

Yes, improperly constructed wells or improperly sealed abandoned wells can act as conduits for contamination of deeper groundwater. Thank you for pointing out this potential pathway.

Comment 11. Many of the citations against the facility by the Atomic Energy Commission (AEC) and NRC occurred before Kerr-McGee owned the site.

Response 11. In fairness to Kerr-McGee, this will be clarified.

Comment 12. References to material sent to the Marvin Moore Chemical Company or to Sheffield, IL are irrelevant.

Response 12. People were exposed to contaminants because radioactive material was accidently shipped to the Marvin Moore Chemical Company. This is certainly a relevant health concern.

Comment 13. The incinerator operated at all times within NRC and IEPA permit requirements. The incinerator had a HEPA filter that effectively removed 99.95% of particulate matter. The incinerator was required to release less than 10 kilograms per year, and the concentration in the stack effluent, which was monitored, had to be below 0.0000000000015 microCuries per milliliter for any 24 hour period.

Response 13. Thank you for this information. Little information on incinerator operation was found in IEPA, NRC, or USEPA files.

Comment 14. Kerr-McGee never intended to mine the waste material if the price of thorium were to rise. The Kerr-McGee Facility disposal cell option was selected by Kerr-McGee because it was cheaper and would result in a lower health risk than other alternatives. The total cumulative risk arising from the disposal cell during both construction and the

required ensuing 1,000 year period was found to be 0.0547, while that from off-site alternatives would be at least two to three times higher (NRC, 1989a).

Response 14. The reference to mining of the wastes will be deleted.

The rest of the discussion on this topic stands. Two engineering studies showed that design of the proposed cell may be inadequate to withstand the effects of erosion. Furthermore, to propose that a cell with a designed 1,000 year life could adequately contain radioactive material with a 14 billion year half-life is a contradiction in terms. It is also not reasonable that institutional controls preventing home, business, or industrial use of the site would be effective indefinitely. These are fundamental flaws of the risk analysis in NRC (1989a).

Comment 15. The Public Health Assessment has incorrectly reported that most of the West Chicago Facility wastes are below grade, while most of them are in the above-grade tailings piles. Forty-six borings have shown that deep penetration of wastes are highly unusual.

Response 15. The Public Health Assessment stated that "much," and not "most" of the contamination is below grade. Estimated total amounts of radionuclides in the waste components are listed in the following table from NRC (1989a):

Source and Type of Material	Radium-226 (Curies)	Radium-228 (Curies)	Thorium-230 (Curies)	Thorium-232 (Curies)	Uranium-238 (Curies)
Kerr-McGee Facility					
A. Factory Area					
Process equipment and contaminated material	–	–	–	–	–
Building rubble	N.D.	2.8	0.37	2.8	–
Steel (structural and equipment)	N.D.	0.37	0.0095	0.73	–
Contaminated soil	2.9	0.37	4.9	39	26
B. Intermediate Area					
Contaminated soil	0.016	0.060	0.008	0.060	0.39
C. Disposal Area					
Ore tailings	16	110	3.3	26	0.26
Sludge Pile	4.4	3.0	0.34	2.7	0.79
Sediments, Pond 1	0.82	36	4.6	36	0.76
Sediments, Ponds 2, 3, 4, 5	0.07	1.2	0.15	1.2	0.47
Neutralization and stabilization agents	–	–	–	–	–
Contaminated soil	2.7	7.9	1.14	7.9	1.8
a. Miscellaneous					
Incinerator ash	N.D.	0.02	0.003	0.02	–
Rare earth chemicals	N.D.	0.06	0.008	0.06	–
Temporary detention pond sediments	–	–	–	–	–
Reed-Keppler Park					
Contaminated soil	0.52	5.2	0.61	5.2	–
West Chicago Wastewater Treatment Plant					
Contaminated soil	4.26	24	1.8	24	0.55
Residential Areas					
Contaminated soil	–	–	–	–	–
Kress Creek + West Branch of the DuPage River					
Contaminated soil and sediments	0.07	1.4	–	1.4	0.14
15 Percent contingency	5.0	34	2.4	22	4.6
Total	36	260	19	170	36

N.D. = Not detected.
– = Data not available.

Much of the total radioactive contamination is in the disposal ponds or contaminated soil, which is at or below grade. In addition, transport of all radioactive materials from Reed-Keppler Park, the WTP, residential areas, Kress Creek, and the West Branch of the DuPage River to the Kerr-McGee Facility for construction of an above-ground disposal cell would further increase the total amount of material above grade. Incidently, the issue of the disposal cell resulting in more material above grade was from an IDNS comment, as cited in the text.

In the document, it is stated that the concentrations of radionuclides in soil of the Kerr-McGee Facility tend to decrease with depth.

Comment 16. The storage fee charged by the state would be $2 per cubic foot, and not $10 per cubic foot. The estimate of the total charge is also an exaggeration.

Response 16. The IDPH merely cited a newspaper article, which must have been incorrect. Using the $2 per cubic foot value and the estimated total volume of contaminants at the Kerr-McGee Facility (NRC, 1989a), the total charge would be about $17 million.

Comment 17. Before 1974, the disposal of unknown types of waste may have occurred at Reed-Keppler Park, and this material did not come from Kerr-McGee. Nonradioactive contamination in Reed-Keppler Park likely resulted from these disposal practices.

Response 17. The disposal of unknown types of waste at Reed-Keppler Park is described in the document, as well as the possibility that this may have been a source of nonradioactive contamination. The tailings, however, also have nonradioactive contamination, including lead. The tailings are a likely source of the elevated lead levels found in Reed-Keppler Park.

Comment 18. The Public Health Assessment implies that the City of West Chicago decided not to construct a new swimming pool because of radioactive contamination in the proposed area. In this area, the maximum and average thorium concentrations in surface soil were 37 and 10 picoCuries per gram, respectively. The highest concentration of thorium in subsurface soil, 57 picoCuries per gram, was two feet deep. The USEPA consultant concluded that the risks to park workers and users from this low level of contamination is small.

Response 18. The newspaper article cited in the assessment said that the City decided not to construct the swimming pool because of radioactive contamination. The IDPH agrees that the risk to park users and workers from this level of contamination is small. The new information will be included in the final document.

Comment 19. The assessment of the WTP is outdated. Much of the material has been removed. The USEPA reviewed the cleanup plan, approved the 30 microroentgen per hour

cleanup criterion, and supervised the cleanup. Removal of the material has been documented, and is not just "reported."

Response 19. The removal of material described in the report is not outdated. While the USEPA reviewed the cleanup plan, from personal communications, they are uncertain whether the remediation was performed as planned. This concern, along with contaminants left along the river bank, are why they are doing a Remedial Investigation at the WTP.

Comment 20. The legal history section is irrelevant and has no bearing on a Public Health Assessment. No court has ever found that the West Chicago materials have resulted in any injury to local residents. References to the extreme and unfounded allegations that are the subject of pending litigation should be deleted from the assessment.

Response 20. In the Background section of a Public Health Assessment, a brief synopsis of any legal actions regarding a site is normally included. Most of the legal actions described were by governmental agencies or Kerr-McGee over cleanup proposals, and did not involve extreme allegations. In one case described in the Public Health Assessment, a family sued Kerr-McGee because they blamed the death of a relative from Hodgekin's disease on the tailings. In the document, it is stated that this form of cancer has never been associated with radiation exposure. Nowhere in the document does it say that a court found the radioactive materials caused any injury to local residents.

Comment 21. The Public Health Assessment reports that some homes east of the Factory Area were demolished because of radioactive contamination, and that the yards of these homes are now roped off with a single low chain. The area is actually part of a former Kerr-McGee parking lot which was surveyed and remediated during the past residential cleanups. No access restrictions are necessary because the area is no longer contaminated.

Response 21. Evidently, the IDPH had been misinformed. This will be corrected.

Comment 22. There is no evidence that the Joy Street Subdivision has been contaminated by Kress Creek.

Response 22. Kress Creek runs through this subdivision and contamination along its banks (in the back yards of Joy Street Subdivision residences) has been documented. It is also true that tailings were used as fill in some areas of the subdivision, this will be stated more explicitly in the final document.

Comment 23. The discussion of trespassing by children at the Kerr-McGee Facility is outdated. A six foot chain-link fence topped with barbed wire and 24 hour guard effectively prevent access. Access by a pica child is not possible.

Response 23. As stated previously, the document evaluates past, present, and future exposures. Consequently, it is proper to mention past trespassing. This is especially true before 1957, when one side of the facility was unfenced. Also, a fence reduces access, but does not completely stop trespassing. On one site visit date, there was enough clearance under one gate for small children to squeeze through. As stated in the document, at this time, trespassing by teenagers is more likely than small children. In the distant future, under a no-action scenario or construction of the proposed Kerr-McGee Facility disposal cell, homes may be constructed at the Kerr-McGee Facility. Consequently, yards may be contaminated and exposure of pica children will be possible.

Comment 24. Benzene, toluene, ethyl benzene, and xylenes (BTEX) have not been detected in soil or groundwater samples from the Kerr-McGee Facility. In 1986 sampling by Kerr-McGee found no BTEX in 15 soil borings. BTEX were also not found in groundwater samples from 1984 and 1986. Consequently, neither kerosine nor its BTEX constituents are chemicals of concern.

Response 24. BTEX was mentioned as possibly being at the Kerr-McGee Facility because of past kerosine dumping on the tailings piles. Thank you for the sampling information. However, there were only 15 borings to cover a 40 acre site, which is just over one boring for every three acres. Clearly, this is inadequate to completely characterize the entire Kerr-McGee Facility.

Comment 25. Extensive leachate tests of the wastes have been conducted.

Response 25. Leachate tests were discussed and cited in the document. Because tests of one sample showed more leachable material (of process intermediates), the IDPH thought that more testing was warranted.

Comment 26. The data used in the Public Health Assessment for gamma exposure rates inside the Kerr-McGee Facility are outdated. The most recent gamma survey (1990) found levels from roughly 0.02 to 7 milliroentgens per hour (mR/hr).

Response 26. Considering the half-life of thorium (14 billion years), it is hard to understand how the maximum exposure rate could have been reduced from 100 to 7 mR/hr. It is likely that the more recent survey missed a hot spot.

Comment 27. The air monitoring discussion for the Kerr-McGee Facility is incomplete. Jensen et al. (1982) was only one of several surveys. NRC (1989a) included air monitoring data.

Response 27. Other information was included in the report, as available. Some air monitoring information found in IEPA, NRC, or USEPA files was not used because it was unknown where the samples were taken (e.g., inside a building, on the property, at the

fenceline, or beyond the fenceline). The only air monitoring data in NRC (1989a) were for total suspended particulates, which tells nothing about the concentrations airborne chemicals or their potential health hazards.

Comment 28. The Public Health Assessment discusses an accidental release of hydrogen fluoride during the period of plant operations, but does not explain how it could have any effect on present impacts of the Kerr-McGee Facility. Highly reactive hydrogen fluoride would not persist for 25 years.

Response 28. As previously mentioned, a Public Health Assessment also examines past exposure. To avoid possible confusion, in the final document, it will be stated that hydrogen fluoride is highly reactive and will not persist in the environment.

Comment 29. The Public Health Assessment has erroneously described the well completions at the Kerr-McGee Facility. Both the "B" and "F" wells are completed in the surficial sand and gravel. The intermediate wells, which are completed in the intermediate sand and gravel, are designated "BC" wells and not "F."

Response 29. The depths of these wells were given (and were not in error). The stratum of completion was not given in NRC (1989), and the additional information will be added. NRC (1989a) did not contain information on the intermediate wells, and the additional monitoring data provided by Kerr-McGee (1994) will be added. The terminology for the wells was that used in NRC (1989a).

Comment 30. The "N" wells draw from the uppermost aquifer, are upgradient of the Kerr-McGee facility, and were not impacted by plant operations. They are in a recharge area of for the shallow dolomite aquifer and represent true background conditions. Groundwater flows from the well area southwest toward the Kerr-McGee Facility.

Response 30. Sampling has demonstrated that these wells have been impacted by past plant operations, as shown in the Public Health Assessment. At that time, the discharge of large quantities of water in the disposal ponds likely resulted in groundwater flow quite different from that today.

Comment 31. The groundwater near the Kerr-McGee Facility has not reached steady-state, but its quality has been improving. A statistical analysis by Kerr-McGee (1986) showed that there was a significant time dependent downward trend in the levels of chemicals in the glacial aquifer. More recent monitoring data confirm that contaminant levels continue to decline. This is occurring through natural infiltration and groundwater flow.

Response 31. While Kerr-McGee has persistently claimed that the groundwater quality is improving, monitoring data from NRC (1989a) clearly show great variation and no obvious trend. In Kerr-McGee (1986), the linear regression statistics of Kerr-McGee were given, but

not completely evaluated. Linear regression is a statistical procedure which draws a best-fit straight line through a set of points. Kerr-McGee claimed that groundwater quality under the Facility was improving because linear regression showed a downward trend in time for chloride, fluoride, sulfate, and/or total dissolved solids for 34 of 50 cases. However, Kerr-McGee did not examine the correlation coefficients for their analyses, which indicate how well (or poorly) the data fit their regression lines (i.e., the trend). For shallow and deep wells combined, in only 15/35 = 44 percent of the cases did even half of the data fit their regression equations. For shallow wells, the proportion was 8/22, and for deep wells, the proportion was 7/12. Fifty percent correlation is not very good, and most of the results were even worse. In one case, Kerr-McGee claimed that a downward trend existed, even though only 14 percent of the data fit the regression equation. For shallow and deep wells combined, in only 3/34 = 9 percent of the results did 75 percent of the data fit the regression equations. In other words, in nearly all of the cases, the data did not fit the claimed downward trend very well, and in very few cases did the data indicate an obvious downward trend.

Comment 32. Thorium nitrate only poses an ignition hazard in a solid state, and not when diluted by soil, as it is in the wastes. The fence and guard at the Kerr-McGee Facility prevent public exposure to physical hazards.

Response 32. The ignition risk of thorium nitrate will be clarified.

In the past, trespassing has occurred, in spite of the fence and guard. While security measures certainly help, they cannot insure that no one will ever enter the area and become injured. In addition, before 1957, one side of the Kerr-McGee Facility was unfenced, and on one site visit date, there was enough clearance under a gate to allow small children to squeeze through.

Comment 33. Lead in the wastes of Reed-Keppler Park may have come from sources unrelated to the facility (e.g., municipal waste). Moreover, the Assessment fails to report that the lead concentration in leachate derived from the Reed-Keppler Park soils was only 40 percent of the USEPA maximum permissible concentration.

Response 33. The document states that nonradioactive contamination at Reed-Keppler Park may have originated from unknown, non-facility waste dumped in the old landfill. However, the tailings from the Kerr-McGee Facility have high lead levels, and the tailings were used for fill at Reed-Keppler Park and the WTP, where high concentrations have also been found. Consequently, the tailings are a likely source of the lead found at Reed-Keppler Park.

As previously discussed, lead is toxic, in spite of its low solubility at environmental pH.

Comment 34. The construction of homes on the spoil area of Reed-Keppler Park is unlikely because the area is scheduled for cleanup under Superfund. It is also doubtful that park land would ever be used for residences.

Response 34. This possibility was evaluated as a no-action scenario. A Public Health Assessment evaluates all possible alternatives. NRC (1989a) also included a no-action scenario, and Kerr-McGee did not object to that.

Comment 35. The Public Health Assessment states that surface water at Reed-Keppler Park has not been sampled for nonradiological contaminants. Booth et al. (1982) collected water samples from a small pond northwest of the park, and they did not contain radioactive or nonradioactive contamination.

Response 35. Kerr-McGee is mistaken. While Booth et al. (1982) collected water samples from a small pond northwest of the park, they were analyzed only for radioactive contamination, and not nonradioactive constituents. The information that Booth et al. (1982) did not find radioactive contamination in this pond is given in the Public Health Assessment.

Comment 36. The USEPA estimate of gamma radiation and airborne radionuclide exposures to residents of houses built on the East Area is obsolete because much of this contamination has been removed.

Response 36. In the Public Health Assessment, it will be noted that according to Kerr-McGee, much of the contamination of the East Area has been removed.

Comment 37. At the WTP, groundwater sampling in 1984 reflected conditions before remediation, and has no bearing on present public health impacts. Moreover, contrary to the Public Health Assessment, organic analyses were performed by USEPA in 1985. While methylene chloride, 2-butanone, di-n-butyl phthalate, and butylbenzylphthalate were found, they were also present in the blanks. The USEPA contractor concluded that groundwater beneath the WTP had not been impacted by the West Chicago Materials (CH_2M-Hill 1992 Work Plan).

Response 37. Data after remediation would have been preferable, but was not available. For the organic compounds noted above, blank contamination made the results invalid. Consequently, their levels in the groundwater at the WTP are unknown (as described in the document). The concentrations of some chemicals in downgradient wells were higher than those in upgradient ones, indicating some impact, although below regulatory levels.

Comment 38. For Bolles Opera House, the IDPH neglects to mention that NIOSH found no evidence that a health hazard from mercury exposure existed in the building. In addition, it is not a designated Superfund site, so it is outside the scope of a Public Health Assessment.

Response 38. In the Public Health Assessment, it is stated that except for one sample, the airborne mercury levels in Bolles Opera House were below the OSHA standard for occupational exposure, 50 micrograms per cubic meter. While the mercury levels were not generally at unacceptable levels for the current use of the building, as office space, they were high enough to preclude residential use (the U.S. Center for Disease Control recommended limit for residential use is 0.3 micrograms per cubic meter). Consequently, it is incorrect to say the mercury levels pose no hazard, even if future residential use is unlikely.

It is true that Bolles Opera House was not included in the Superfund sites. This does not mean that it is beyond the scope of a Public Health Assessment. For example, in the Public Health Assessment for another Superfund site, the IDPH evaluated an adjacent landfill and recommended adding it to the Superfund site because (1) the boundary between the two landfills was unclear, (2) disposal in both sites occurred during the same time period, and (3) the waste may be in contact. USEPA subsequently added the adjacent landfill to the Superfund site.

Comment 39. The IDPH relied heavily on the Frame (1984) study of contamination along Kress Creek. An NRC panel of administrative judges found problems with this study. Confidence interval estimates (CIE's) were skewed (e.g., 10 picoCuries per gram may have a 95% CIE range of 4 to 30 picoCuries per gram), which may tend to skew averages upward. Also, as Frame (1984) points out, the computer curve used to calculate thorium levels tends to overestimate concentrations near baseline levels. Frame (1984) reported that the normal gamma background rate of the area was about 8.6 uR/hr. Frigerio et al. (1977), however, found background levels of 12 to 36 uR/hr, with 95% CIE's of 14 to 25 uR/hr. Frigerio et al. (1977) attributed these elevated background levels to regionally high concentrations of thorium, uranium, and daughters.

The Public Health Assessment incorrectly concludes that a pattern of thorium levels with distance downstream is not apparent from the data. Both gamma and thorium concentrations decrease downstream and average slightly above background within 25 meters of the creek. The IDPH has failed to note this and has focused largely on unusual regions of elevated thorium levels. Frame (1984) found only 9/1,508 samples (0.6%) exceeded 200 pCi/g. The systematic gamma survey revealed only 2/405 measurements (0.5%) that exceeded 100 uR/hr, yet IDPH focused on the outliers.

IDPH ignored a comprehensive survey by Kerr-McGee of properties along Kress Creek. Only about 2% of the surveyed area had gamma readings over 50 uR/hr, and only about 2.4% of the total area above 50 uR/hr was over 150 uR/hr. The maximum surface area of any location with over 150 uR/hr was only 600 ft^2. Consequently, areas with high gamma levels are of limited extent, infrequently encountered, and pose negligible risk.

A comprehensive risk assessment by Kerr-McGee has shown that the risk from direct irradiation, consumption of garden produce, or radon-220 inhalation would result in average

doses of 10 millirem/year or less. This is barely above background levels and would not result in an unacceptable health risk.

Response 40. The IDNS has doubts about the quality and accuracy of the Frigerio (1977) report. Furthermore, elevated samples upstream of the outfall suggest that fill may have been used along the stream. In addition, Kerr-McGee used the Frame (1984) sampling results for their risk analyses rather than the Frigerio (1977) report. Incidently, Frigerio (1977) reported the highest gamma level along Kress Creek. In evaluating Kress Creek, gamma radiation levels alone justify classifying it as a Public Health Hazard, regardless of whether thorium concentrations may have been overestimated by Frame (1984).

While Frigerio (1977) concluded that most of the contamination was just below the outfall, subsequent study by USEPA and Frame (1984) found this was not the case. Frame (1984) concluded that there was no pattern of decreasing contamination downstream of the outfall. Data from the Kerr-McGee surveys were used as available, but much of the information was not found in IEPA, USEPA, or IDNS files.

The document DOES give the average levels of contamination at different distances from Kress Creek.

The IDPH evaluated a worst case exposure scenario for Kress Creek, which used the high dose areas. The document also states that the worst case, of someone building a home in the most contaminated soil, is unlikely given the proximity of the creek. However, given the 14 billion year half-life of thorium, home building methods may ultimately make this scenario more likely.

The risk analysis by Kerr-McGee had several problems. For gamma exposure, they used average gamma levels, 25 microroentgens per hour. Maximum occupancy was assumed to be 200 hours per year. Unfortunate placement of a residence could increase the gamma level up to 210 microroentgens per hour and make continuous occupation possible. Continuous residential exposure to gamma radiation at 210 microrem per hour would result in a dose of 1.7 rem per year, assuming a frame structure provides 10% shielding. This is quite a bit higher than the 0.1 rem per year regulatory criterion which Kerr-McGee cites.

On the thoron (radon-220) in homes issue, Dr. Paul Charp, ATSDR, said that the dose calculations of Kerr-McGee were accurate, but he had not seen the thoron emanation rate or wall attenuation values which Kerr-McGee used. Radon-220 monitoring in homes with tailings along foundations or in crawlspaces has shown higher levels than estimated by Kerr-McGee, although not at extraordinarily high levels. Monitoring by Argonne National Laboratory (1983) found slightly elevated radon-220 levels (up to 0.039 WL in the basement and 0.012 WL on the first floor) in some homes, although not at levels of concern (below 0.06 WL). IDNS reported one house with elevated radon levels, although the isotopes were not distinguished. In one home with tailings in the crawlspace having 26 to 930 pCi/g of

thorium, not-detectable to 4.9 pCi/g of uranium, and not-detectable to 130 pCi/g of radium, Kerr-McGee found up to 0.564 WL of radon-220 in the crawlspace and 0.228 WL of radon-220 in the living room, which are high enough to be of concern. Remediation reduced the concentrations to below levels of concern (levels not given). In addition, the USEPA estimated that in the future, if someone built a house on the spoil area of Reed-Keppler Park, it would have about 0.3 WL of radon-220. Consequently, while most homes built on or near tailings probably do not have elevated radon-220 levels (past, present, future), those built on high concentrations of thorium may be at increased risk of having high radon-220 levels.

The IDPH had listed the ingestion of contaminants through the consumption of vegetables grown in tailings as a potential pathway. The IDPH and Dr. Paul Charp, ATSDR, agree that because of the low solubility and bioavailability of thorium and lead, this route should result in negligible exposure.

Comment 41. The IDPH unjustifiably discounted Kerr-McGee ambient radionuclide monitoring data based on the Mausner (1964) report. Kerr-McGee did not own the property at that time, so there is no logical connection between the Mausner (1964) findings and subsequent air monitoring by Kerr-McGee.

Response 41. In the final draft, it will be clarified that the American Potash and Chemical Company owned the property at the time of the Mausner (1964) study.

Comment 42. The IDPH improperly discounted the groundwater modeling in NRC (1989). The modeling study included detailed sensitivity analysis that quantified the uncertainties in the results. Moreover, the IDPH has misunderstood the importance of the NRC comment that the model was developed for confined aquifers. Although confined aquifers may be different than unconfined aquifers when subjected to time-variant stresses, water movement in both types of aquifers is the same when, as here, the aquifers are at steady-state with regard to flow conditions. The NRC selection of the model was thus appropriate, and the results of the modeling are valid.

Response 42. As cited in the Public Health Assessment, in their comments on the NRC (1989) SFES, USEPA (NRC, 1989) said that the model was designed for confined aquifers, and not unconfined ones like under the Kerr-McGee Facility. They concluded that the results cannot be considered valid without additional testing of the model. For one thing, a model for a confined aquifer assumes lateral flow, while an unconfined aquifer has vertical components (i.e., a model for an unconfined aquifer takes up and down groundwater movement into account). Furthermore, given the variability and uncertainty of the geology around the Kerr-McGee Facility, no estimate of migration rates to surrounding private wells can be considered reliable. This latter point was a major reason the modeling estimates were not used.

Comment 43. Recommendations for the use of protective equipment by remediation workers is unnecessary because the Kerr-McGee closure plan includes a full description of protective clothing and dust control procedures, which meets all Federal and State worker protection standards.

Response 43. The recommendation for protective clothing is included in any Public Health Assessment where remediation workers may be exposed to harmful levels of contaminants.

Comment 44. For lead, IDPH failed to mention that a USEPA contractor did a worst-case exposure for lead along the West Branch of the DuPage River. The scenario assumed that the most highly exposed individual stops once per week for four months of the year, or 20 times per year. This individual stops for one hour in an area where thorium tailings are near the surface and incidently ingests 0.1 grams of contaminated soil. The resulting lead intake would be below the suggested guidelines of 0.6 mg per day and below the USEPA Drinking Water Standards for continuous exposure. The radiation dose is similar to the potential dose from other present day uses of Reed-Keppler Park or the WTP. Consequently, even in this worst-case scenario, the public health implications are negligible.

Response 44. There are several problems with this argument. While an adult would ingest about 0.1 grams of soil, a pica child would ingest about 5 grams. Children are much more susceptible to lead than adults because of increased absorption, decreased elimination, and increased sensitivity of their developing nervous systems. Also, while occasional exposure may occur in a recreational user, contamination in yards may result in daily exposure through much of the year. While residential use of the WTP is unlikely, as noted in the Public Health Assessment, yards are contaminated with tailings. In addition, the USEPA (1986) RI pre-dates the lowering of the lead drinking water standard from the MCL of 50 parts per billion (ppb) to the Action Level of 15 ppb, and it also pre-dates the lowering of the definition of lead poisoning from 25 to 10 micrograms per deciliter by the U.S. Centers for Disease Control. Consequently, Kerr-McGee used outdated standards in basing their comment. In addition, ATSDR considers lead a no-threshold hazardous substance, because no level has been found below which harmful effects have not been observed.

Comments of Ms. Maria Hernandez

The IDPH received a copy of a letter from the office of U.S. Representative E. (Kika) de la Garza to the USEPA concerning a telephone conversation with Ms. Hernandez on January 13, 1994. In the conversation, Ms. Hernandez said the following (names of individuals have been deleted):

Her husband worked in a factory in West Chicago, IL in the 1950's and 1960's, and so did his father.

At that same factory, a man was walking under some overhead tubes when one ruptured and the acids that poured out dropped on the man. He was burned to a crisp. He was reduced to nothing. He had to be buried in a child's coffin.

Her husband's father died of cancer.

Her husband has had a knot in the back of his head since the time he worked at the factory. He has not been able to cure it. His body shakes, his left arm and side of his body and leg shake without stopping.

They recently read an article in the Monitor (June 1993) stating that in a West Chicago, Illinois subdivision, it was discovered that nuclear chemical powder had been dumped, the subdivision was built on top, some of the chemical had filtered into the water system, and some of the children that were born to families living in that subdivision were being born with birth defects.

Her husband remembers being one of the workers that shovelled that nuclear chemical powder.

Response: The unfortunate death of the man under the ruptured pipe was evidently caused by concentrated acid (possibly hydrofluoric acid), and was not caused by radiation. Concentrated acids are very corrosive. Any acids from plant operations are no longer present, as they are neutralized by chemicals in soil and do not persist in the environment.

It is uncertain whether radiation has caused cancer in past workers at the Kerr-McGee Facility. It is impossible to distinguish radiation-induced cancers from those which occur naturally. Instead, cancer rates in an exposed group must be compared to an unexposed control (or background exposure, in the case of radiation, since some exposure occurs naturally). One study of cancer in plant workers is described in this Public Health Assessment. The study could not establish any link between radiation exposure and cancer rates.

The cause of tremors in her husband is uncertain, but may have a chemical cause. Exposure to low levels of radiation would not result in tremors. The tailings have high concentrations of lead. In adults, exposure to lead can cause weakness in the extremities, as well as tremors. A month or more after exposure ends, most lead remaining in the body will be in the bones, and it takes about 27 years for half of it to be eliminated. Consequently, lead persists in the body long after exposure has ended. Lead paint is also a possible source of lead that should be considered. Most homes built before 1950 had it, and latex paint (low in lead) became more common in the 1950's, but lead paint was not banned until 1978. Organic solvents were used in some plant processes, and they can also cause neurological problems. Most of these chemicals would not persist long in the body once exposure ends; however, given sufficient exposure, the neurological effects may be permanent. The IDPH

recommends that Mr. Hernandez visit a doctor familiar with occupational exposure to chemicals, including lead and organic solvents. Their personal physician, toxicologists in the state health department of Texas, or a university medical school may provide a referral.

As described in this Public Health Assessment, tailings (which are more the consistency of sand than powder) were used for fill in many residential areas of West Chicago. The primary completed or potential exposure routes are direct exposure to gamma radiation, inhalation of radon in homes with tailings along foundations, dermal contact with and ingestion of contaminated soil, and surface contact with potentially polluted surface water. Groundwater contamination has occurred around the Kerr-McGee Facility because of past thorium and rare earth processing, however, it is mostly not known whether chemicals of concern have reached private wells at levels which may cause adverse health effects. Water of the Joy Street Subdivision does not contain elevated concentrations of radionuclides, but the levels of other possible chemicals of concern are unknown. It is unlikely that the small amounts of tailings in residential areas would not cause groundwater contamination. While birth defects (especially decreased mental development) can occur from exposure to radiation, they have been observed only at much higher levels than are possible from exposure to the Kerr-McGee wastes.