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final

NUREG-75/096

environmental statement

related to construction of

WOLF CREEK GENERATING STATION UNIT 1

KANSAS GAS AND ELECTRIC COMPANY AND KANSAS CITY POWER AND LIGHT COMPANY

OCTOBER 1975

Docket No. STN 50-482

U. S. Nuclear Regulatory Commission • Office of Nuclear Reactor Regulation

NUREG-75/096

OCTOBER 1975

FINAL ENVIRONMENTAL STATEMENT

BY THE

U.S. NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR REGULATION

FOR

WOLF CREEK GENERATING STATION

PROPOSED BY

KANSAS GAS AND ELECTRIC COMPANY AND
KANSAS CITY POWER AND LIGHT COMPANY

DOCKET NO. STN 50-482

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SUMMARY AND CONCLUSIONS

This Environmental Statement was prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation.

1. This action is administrative.

2. The proposed action is the issuance of a construction permit to Kansas Gas and Electric Company and Kansas City Power and Light Company for the construction of the Wolf Creek Generating Station (WCGS), Docket No. STN 50-482.

   The station will employ a pressurized water reactor to produce up to approximately 3425 megawatts thermal (MWt). A steam turbine generator will use this heat to provide 1150 MWe (net) of electrical power capacity. A design power level of 3579 MWt is anticipated at a future date and is considered in the assessments contained in this statement.

   The exhaust steam will be cooled by the flow of water in a closed-cycle system incorporating a newly constructed cooling lake utilizing makeup water from John Redmond Reservoir. Blowdown from the cooling lake will be discharged into Wolf Creek which in turn flows into the Neosho River.

3. Summary of environmental impacts and adverse effects:

   a. A total of 10,500 acres is proposed for the WCGS site. Construction related activities would disturb about 200 acres, not including the 5090 acres inundated by the Wolf Creek cooling lake which is proposed in conjunction with the station. A smaller lake would require a 6440-acre site and inundate 2500 acres. (4.1 and 9.2.1.2)

   b. Approximately 180 miles of transmission lines will be constructed which will affect approximately 3126 acres. (4.1.3)

   c. A new rail access route will be constructed from the Missouri Pacific Railroad to the plant site. The right-of-way will be about ten miles long, 125 ft wide, and will require approximately 150 acres. A makeup water line, approximately two miles long with a 100 ft right-of-way will be constructed from a pump house immediately below the spillway of the John Redmond Reservoir. A new access road will be built to Sherwood Cemetery which will require about 2.5 acres of land. (4.3.1.2)

   d. Station construction as proposed will affect approximately 50 households, requiring the removal of 25. A smaller lake would affect 32 households and require the removal of 16. Traffic on local roads will increase due to construction and commuting activities. Influx of construction workers' families is expected to cause no major housing or school problems. There will be a demand for increased services in Coffey County. (4.4.1)

   e. The total flow of circulating and service water will be 1256 cfs which will be taken from and returned to the Wolf Creek cooling lake. Makeup water for the cooling lake will be obtained from the John Redmond Reservoir. A minimum of 41 cfs will be pumped from the reservoir to the cooling lake. When the water level in the John Redmond Reservoir is at or above its conservation level of 1039 ft MSL, water will be pumped to the cooling lake at a variable rate up to a maximum of 120 cfs. During periods of drought the total dissolved solids (TDS) in Wolf Creek cooling lake will increase by a factor of about three. Blowdown from the cooling lake will cause increases in TDS levels in the Neosho River. Maximum increases will occur in the Neosho River during post-drought periods, at which time TDS levels may increase to 500 ppm. The thermal alterations and increases in total dissolved solids concentration will not significantly affect the aquatic productivity of Wolf Creek cooling lake or the Neosho River. (5.3.2)

   f. The overall impact of construction activities on Wolf Creek prior to filling of the cooling lake will be a reduction in aquatic populations in the lower half of the creek. When the cooling lake is filled, approximately 15 stream miles of Wolf Creek will be lost as running water aquatic habitat and approximately 7 stream miles of Wolf Creek below the dam will be severely altered. The loss of aquatic biota in this section of Wolf Creek will be more than compensated for by the establishment of aquatic biota in the cooling lake through natural colonization and introduction of game fish. Construction of WCGS may temporarily reduce aquatic populations in the Neosho River for several miles below the John Redmond Dam. Such reductions will most likely be temporary and near the site if staff recommendations for limiting total suspended solids (TSS) are observed. (4.3.2)

g. During post drought periods, withdrawal of makeup water could significantly reduce flows available in the Neosho River. This would extend the effective length and severity of drought conditions for resident biota below the John Redmond Reservoir. Populations of the endangered (American Fisheries Society Threatened Species List) Neosho madtom will be further stressed, perhaps beyond their capacity to recover. The highfin carpsucker, gravel chub, river redhorse and bluesucker are now rare or depleted in Kansas and will also be subject to significant reductions in populations. Aquatic communities may experience considerable shifts in species composition. (5.5.2.1)

h. Entrainment of phytoplankton, zooplankton, and ichthyoplankton in the circulating water system may reduce the overall productivity of the cooling lake although the extent of this reduction cannot be estimated. Some mortality of juvenile and adult fish in the cooling lake will result from impingement on traveling screens of the circulating water intake structure. Populations of some species may be significantly reduced. The low approach velocities to the screens should minimize impingement losses for some species. Chemical discharges during operation of the Wolf Creek Generating Station should not significantly affect aquatic biota in the cooling lake. However, hydrogen sulfide may appear in the hypolimnion of the cooling lake - possibly in concentrations sufficient to affect biota. (5.5.2.3)

i. Phytoplankton, zooplankton, and fish in the waters below John Redmond Dam will be subject to entrainment in the makeup water intake system. Entrainment losses should not significantly reduce phytoplankton and zooplankton populations in the John Redmond Reservoir. The effect of entrainment and impingement on fish populations in the canal below John Redmond Dam cannot be estimated but low approach velocities will minimize losses. (5.5.2.2)

j. The proposed cooling lake will displace rare native prairie habitat for two species of wildlife (plains harvest mouse and badger) which are rare in the upper and middle Neosho River basin. A 2500-acre lake will displace less native prairie habitat. (5.5.1.2)

k. Level fluctuations of the proposed lake would cause extensive mudflats to develop during dry climatic periods. Woody vegetation which invades these areas will be killed when reinundated, leaving as much as 500 acres distributed around the perimeter of the lake inhabited by dead shrubs and trees of various ages. (5.5.1.2).

l. The risk associated with accidental radiation exposure is very low. (7)

m. No significant environmental impacts are anticipated from normal operation releases of radioactive materials. The estimated maximum integrated dose to the population of the United States due to operation of the station is 553 man-rems/year, less than the normal fluctuations in the 21,000,000 man-rems/year background dose this population would receive. (5.4)

4. Principal alternatives considered:

   a. Purchase of power

   b. Alternative energy systems

   c. Alternative sites

   d. Alternative heat dissipation methods

5. The following Federal, State, and local agencies were asked to comment on the Draft Environmental Statement which was issued in July 1975:

Advisory Council on Historic Preservation

Department of Agriculture

Department of the Army, Corps of Engineers

Department of Commerce

Department of Health, Education, and Welfare

Department of Housing and Urban Development

Department of the Interior

Department of Transportation

Energy Research and Development Administration

Environmental Protection Agency

Federal Power Commission

Office of the Governor, State of Kansas

Chairman, Coffey County Commission

6. The cooling lake proposed by the applicant is oversized in some respects for the power plant. The applicant has justified the size of the lake based on economics relating to the addition of future generating capacity on the site. The staff has analyzed the costs involved with initially constructing a smaller lake and then expanding that lake to accommodate additional capacity and has compared these costs to the costs associated with the construction and operation of the proposed lake (Sect. 9.2). The staff agrees that the proposed lake does offer economy relating to future expansion and that the environmental impacts of the large lake are acceptable and in some cases less than those associated with the smaller lake. The staff considered the thermal and water storage characteristics of the lake to be the critical environmental factors after expansion. The heat load of a second unit identical to the first was used as an example to analyze the lake characteristics after plant expansion (Sect. 5.3). Based on this analysis and a brief review of other considerations, the staff knows of no reason why future plant expansion would be environmentally unsuitable.

   The staff will again judge the environmental suitability of the site for future plant expansion after such expansion has been defined and applied for. The impacts of construction and operation with respect to expansion will be required to meet the applicable standards and criteria in effect at that time.

7. On the basis of the analysis and evaluation set forth in this statement, after weighing the environmental, economic, technical, and other benefits of the Wolf Creek Generating Station against environmental and other costs and considering available alternatives, it is concluded that the action called for under the National Environmental Policy Act of 1969 (NEPA) and 10 CFR Part 51 is the issuance of a construction permit for the facility subject to the following limitations for the protection of the environment:

   a. The applicant shall take the necessary mitigating actions, including those summarized in Sect. 4.5 of this Environmental Statement, during construction of the station and associated transmission lines to avoid unnecessary adverse environmental impacts from construction activities.

   b. In addition to the preoperational monitoring programs described in Sect. 6.1 of the Environmental Report, with amendments, the staff recommendations included in Sect. 6.1 of this document shall be followed.

   c. The applicant shall establish a control program which shall include written procedures and instructions to control all construction activities as prescribed herein and shall provide for periodic management audits to determine the adequacy of implementation of environmental conditions. The applicant shall maintain sufficient records to furnish evidence of compliance with all the environmental conditions herein.

d. Before engaging in a construction activity not evaluated by the Commission, the applicant will prepare and record an environmental evaluation of such activity. When the evaluation indicates that such activity may result in a significant adverse environmental impact that was not evaluated or that is significantly greater than that evaluated in this Environmental Statement, the applicant shall provide a written evaluation of such activities and obtain prior approval of the Director of Reactor Licensing for the activities.

e. If unexpected harmful effects or evidence of irreversible damage are detected during facility construction, the applicant shall provide to the staff an acceptable analysis of the problem and a plan of action to eliminate or significantly reduce the harmful effects or damage.

f. The applicant must adhere to its plan for selective basal application of herbicides, thereby prohibiting broadcast application from aircraft or ground rigs which might result in serious impacts upon nontarget areas.

g. At the present time the applicant has no plans for the development of recreational uses of the proposed cooling lake. It is the staff's opinion that a feasibility study should be undertaken by the applicant to explore the possible benefits associated with public access and use of the cooling lake. The completed study should be contained in the application for an operating license.

h. The applicant's facility design shall include equipment to control releases of radioactive material in liquid and gaseous effluents in conformance with 10 CFR 50, Appendix I and the "as low as practicable" requirements of 10 CFR 50.34a.

i. The applicants shall finalize their contractual arrangements with the Kansas Water Resources Board for purchase of the assumed 55.84% of total storage from the John Redmond Reservoir prior to issuance of a limited work authorization or a construction permit.

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FOREWORD

This Environmental Statement was prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation (staff) in accordance with the Commission's regulation, 10 CFR Part 51, which implements the requirements of the National Environmental Policy Act of 1969 (NEPA).

The NEPA states, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice.
- Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of the NEPA calls for preparation of a detailed statement on:

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Pursuant to 10 CFR Part 51, the NRC Office of Nuclear Reactor Regulation prepares a detailed statement on the foregoing considerations with respect to each application for a construction permit or full-power operating license for a nuclear power reactor.

When application is made for a construction permit or a full-power operating license, the applicant submits an environmental report to the NRC. In conducting the required NEPA review, the staff meets with the applicant to discuss items of information in the environmental report, to seek new information from the applicant that might be needed for an adequate assessment, and generally to ensure that the staff has a thorough understanding of the proposed project. In addition, the staff seeks information and inspects the project site and surrounding vicinity. Members of the staff may meet with state and local officials who are charged with protecting state and local interests. On the basis of all the foregoing, and other such activities or inquiries as are deemed useful and appropriate, the staff makes an independent assessment of the considerations specified in Section 102(2)(C) of the NEPA and in 10 CFR Part 51.

This evaluation leads to the publication of a draft environmental statement, prepared by the Office of Nuclear Reactor Regulation, which is then circulated to Federal, State, and local governmental agencies for comment. A summary notice is published in the Federal Register of the availability of the applicant's environmental report and the draft environmental statement. Interested persons are also invited to comment on the draft statement.

After receipt and consideration of comments on the draft statement, the staff prepares a final environmental statement, which includes a discussion of questions and objections raised by the comments and the disposition thereof; a final benefit-cost analysis, which considers and balances the environmental effects of the facility and the alternatives available for reducing or avoiding adverse environmental effects with the environmental, economic, technical, and other benefits of the facility; and a conclusion as to whether - after the environmental, economic, technical, and other benefits are weighed against environmental costs and after available alternatives have been considered - the action called for, with respect to environmental issues, is the issuance or denial of the proposed permit or license or its appropriate conditioning to protect environmental values.

Single copies may be obtained as indicated on the inside front cover. Mr. D. C. Scaletti is the NRC Environmental Project Manager for this statement. Should there be questions regarding the contents of this statement, Mr. Scaletti may be contacted at the following address:

Division of Reactor Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
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1. INTRODUCTION

1.1 THE PROPOSED PROJECT

Pursuant to the Atomic Energy Act of 1954, as amended, and the Commission's Regulations in Title 10, Code of Federal Regulations, an application was filed by the Kansas Gas and Electric Company and Kansas City Power and Light Company (hereinafter referred to as the applicant) for a construction permit to build a pressurized water nuclear reactor designated as the Wolf Creek Generating Station Unit 1 (Docket Number STN 50-482) which is designed for initial operation at approximately 3425 megawatts thermal (MWt) with a net electrical output of approximately 1150 megawatts. The proposed facility is to be located on a site in Coffey County, Kansas, approximately 53 miles south of Topeka, 90 miles east-northeast of Wichita, and 75 miles southwest of Kansas City, Kansas.

10 CFR Part 51 requires that the Director of Nuclear Reactor Regulation or his designee analyze the report and prepare a detailed statement of environmental considerations. It is within this framework that this environmental statement related to the construction of the Wolf Creek Generating Station (WCGS) has been prepared by the Division of Reactor Licensing, U.S. Nuclear Regulatory Commission.

Major documents used in the preparation of this statement were the applicant's Preliminary Safety Analysis Report (PSAR),[1] Environmental Report (ER),[2] and supplements thereto issued for WCGS.

Independent calculations and sources of information were also used as a basis for the assessment of environmental impact. In addition, some of the information was gained from visits by the staff to the WCGS site and surrounding areas in 1974.

The applicant plans to add a second unit to WCGS at a later date. This environmental statement should not be construed as an assessment of the environmental impacts of this second unit. However, certain problem areas which may develop with the addition of a second unit, particularly those which could be avoided by proper planning and design at this stage, have been pointed out in various parts of the statement.

As a part of its safety evaluation leading to the issuance of construction permits and operating licenses, the Commission makes a detailed evaluation of the applicant's plans and facilities for minimizing and controlling the release of radioactive materials under both normal conditions and potential accident conditions, including the effects of natural phenomena on the facility. Inasmuch as these aspects are considered fully in other documents, only the salient features that bear directly on the anticipated environmental effects are repeated in this environmental statement.

Copies of this Final Environmental Statement and the applicant's Environmental Report (ER) are available for public inspection at the Commission's Public Document Room, 1717 H Street, N.W., Washington, D.C., and the Office of the County Clerk at the Coffey County Court House, Burlington, Kansas.

1.2 STATUS OF REVIEWS AND APPROVALS

To construct WCGS and the related facilities, the applicant is required to apply for and receive certain permits, licenses, and other authorizations from a number of Federal and State agencies and, in some cases, from regional and local agencies. Certain of these permits and licenses are listed in Table 1.1.

Table 1.1. Federal, state, and local authorizations required for construction and operation of the Wolf Creek Generating Station

Agency	Permit or approval	Status
	Federal	
Nuclear Regulatory Commission	Construction permit	Submitted April 1974
	Operating license	Future
National Ocean Survey	Notification 90 days prior to disturbance of survey monuments	Future
Department of the Army	FWPCA Sect. 404	Submitted October 1975
	State	
Kansas Water Resources Board	Contract for water storage in John Redmond Reservoir	Future
Division of Water Resources, Kansas State Board of Agriculture	Water rights for supplying the cooling lake	Submitted
	Permits to construct dams and dikes	Submitted
Kansas Department of Health and Environment	FWPCA Sect. 401	Approved September 1975
	FWPCA Sect. 402	Future
Kansas State Corporation Commission	Approval for plan specifications and routes of transmission line rights-of-way	Submitted April 1974
Kansas Forestry, Fish and Game Commission	Collection permits for birds, mammals, and fish in the vicinity	Approved
	Permits or approvals as required during construction and operation	Future
Kansas State Highway Commission	Permits for highway right-of-way crossings	Future
	Local	
	(No local authorizations required)	

REFERENCES FOR SECTION 1

1. Kansas Gas and Electric Company and Kansas City Power and Light Company, *Preliminary Safety Analysis Report, Site addendum for Wolf Creek Generating Station, Unit 1,* Docket No. STN 50-482, July 26, 1974, and subsequent amendments.

2. Kansas Gas and Electric Company and Kansas City Power and Light Company, *Environmental Report, Wolf Creek Generating Station, Unit 1*, Docket No. STN 50-482, May 1974; Revision 1, July 22, 1974; and Revision 2, September 13, 1974.

2. THE SITE

2.1 SITE LOCATION

The applicant plans to locate Wolf Creek Generating Station (WCGS) and its associated cooling lake in Coffey County, Kansas, approximately 75 miles southwest of Kansas City, 53 miles south of Topeka, and 90 miles east-northeast of Wichita, Kansas, as shown in Fig. 2.1. Figure 2.2 shows the relationship of the site to the surrounding area. The immediate plant area is shown in Fig. 2.3.

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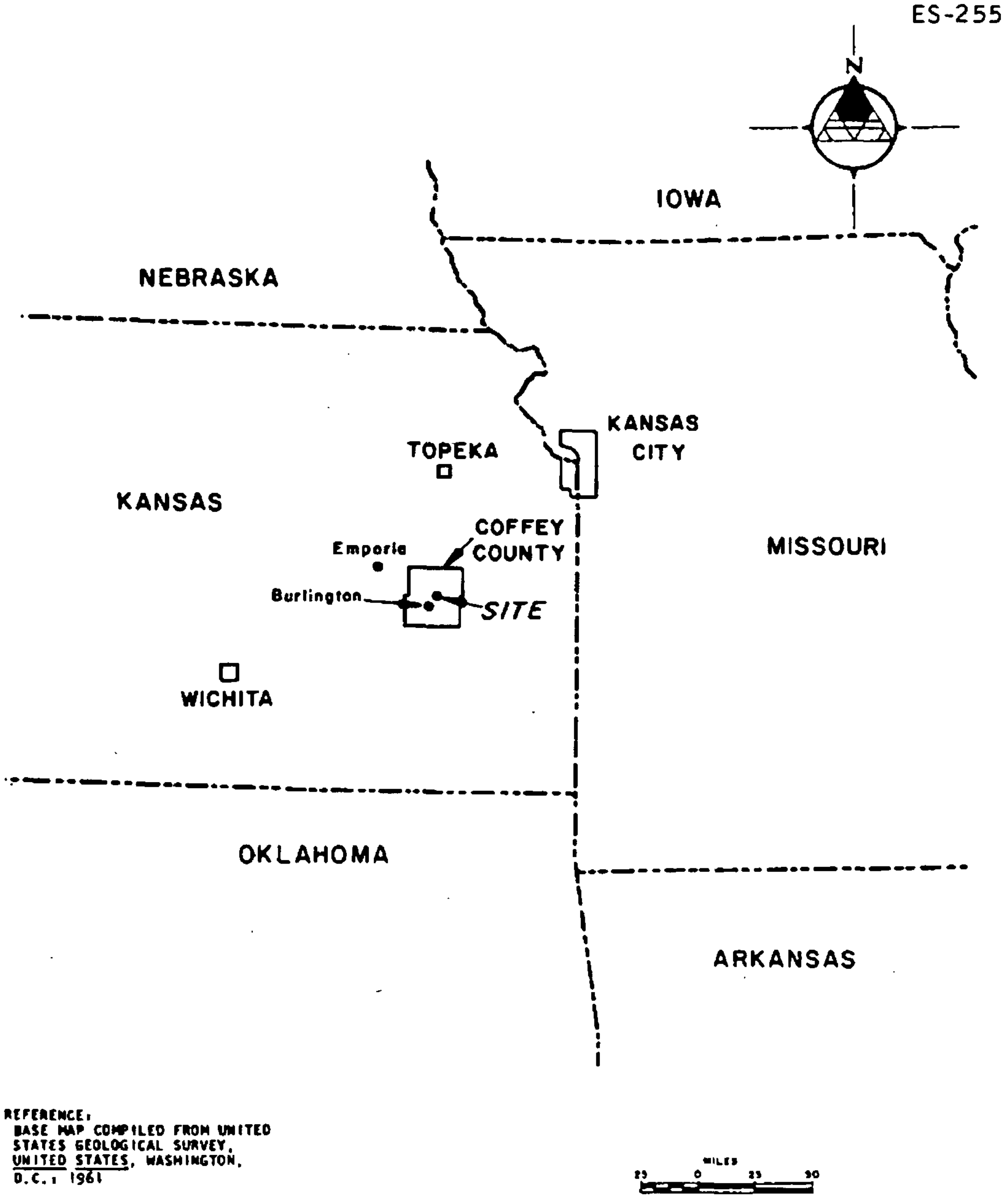

Fig. 2.1. Regional site location. Source: ER, Fig. 2.1-1.

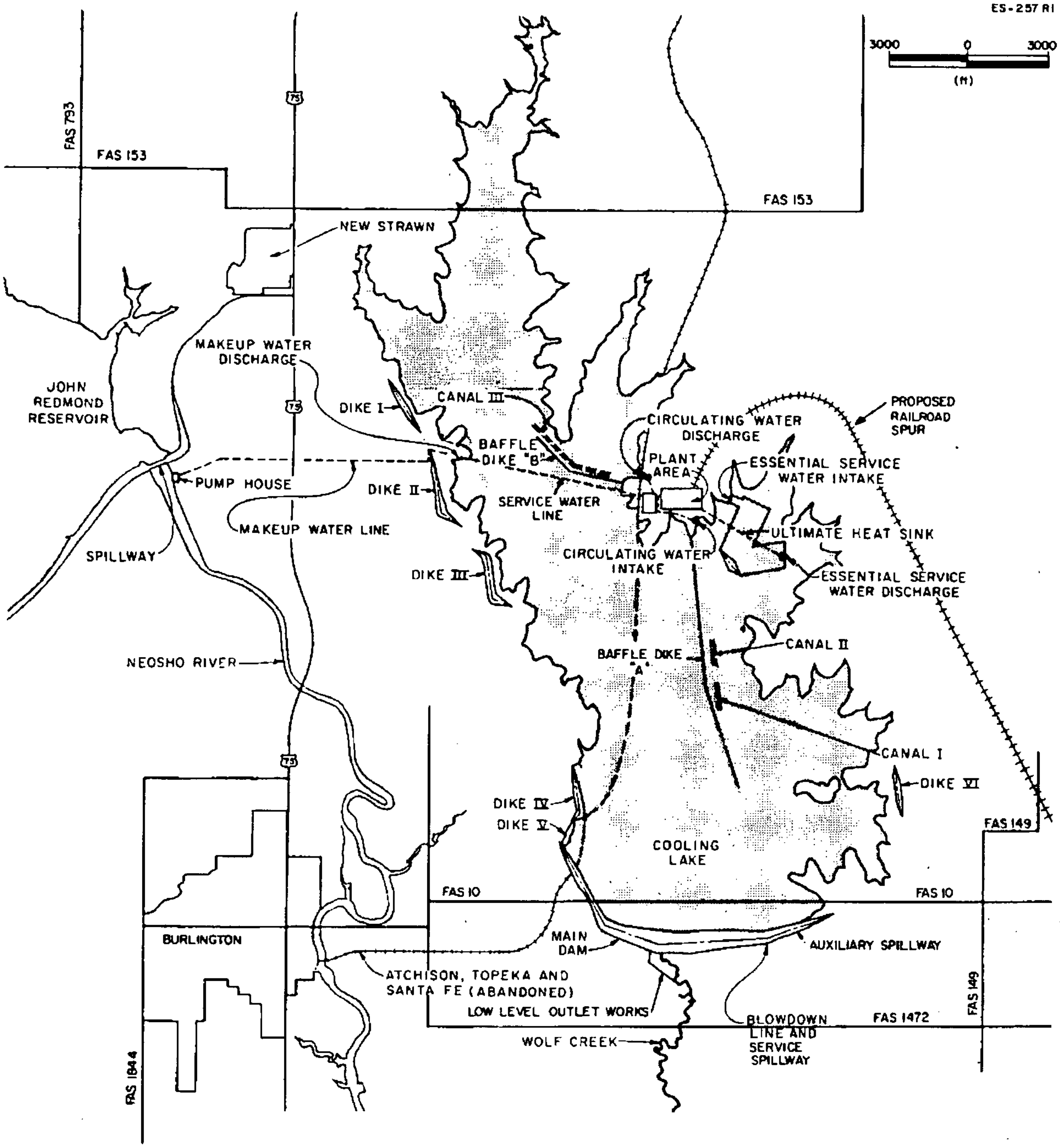

Fig. 2.2. Location of site within Coffey County, Kansas. Source: ER, Figs. 2.1-2 and 3.4-2.

The proposed plant site is to lie within an area of 10,500 acres of land. At present there are no roadway or railway networks within the immediate vicinity of the proposed plant, and according to the applicant, there is no commercial water traffic on the nearby John Redmond Reservoir or the Neosho River. The present site land use is shown in Fig. 2.4. According to present plans, construction of the cooling lake will inundate approximately 5090 acres of land, and approximately 200 additional acres will be affected by construction of the plant, the dam and related facilities.

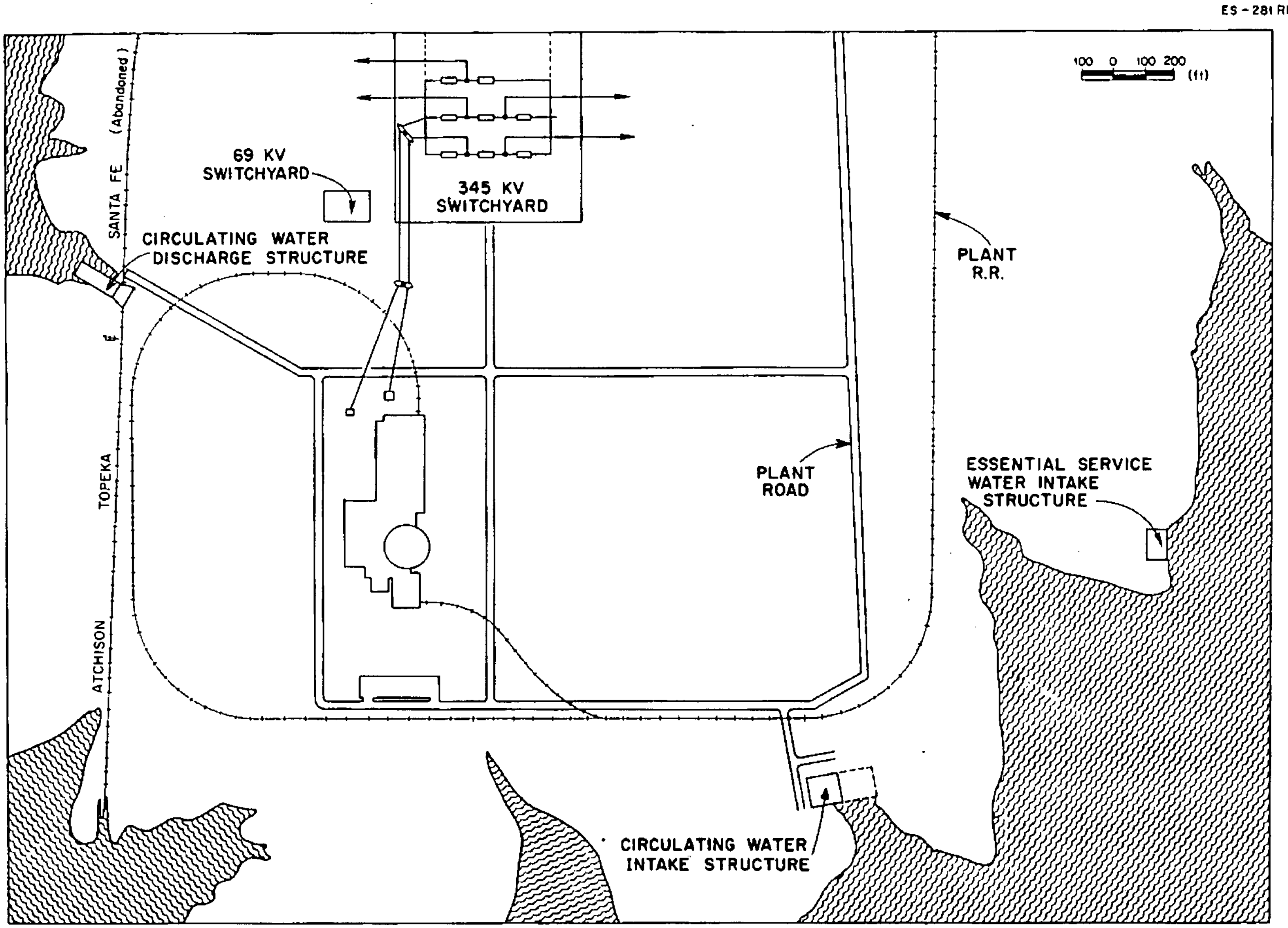

Fig. 2.3. Arrangement and location of plant structures. Source: ER, Fig. 3.1-2.

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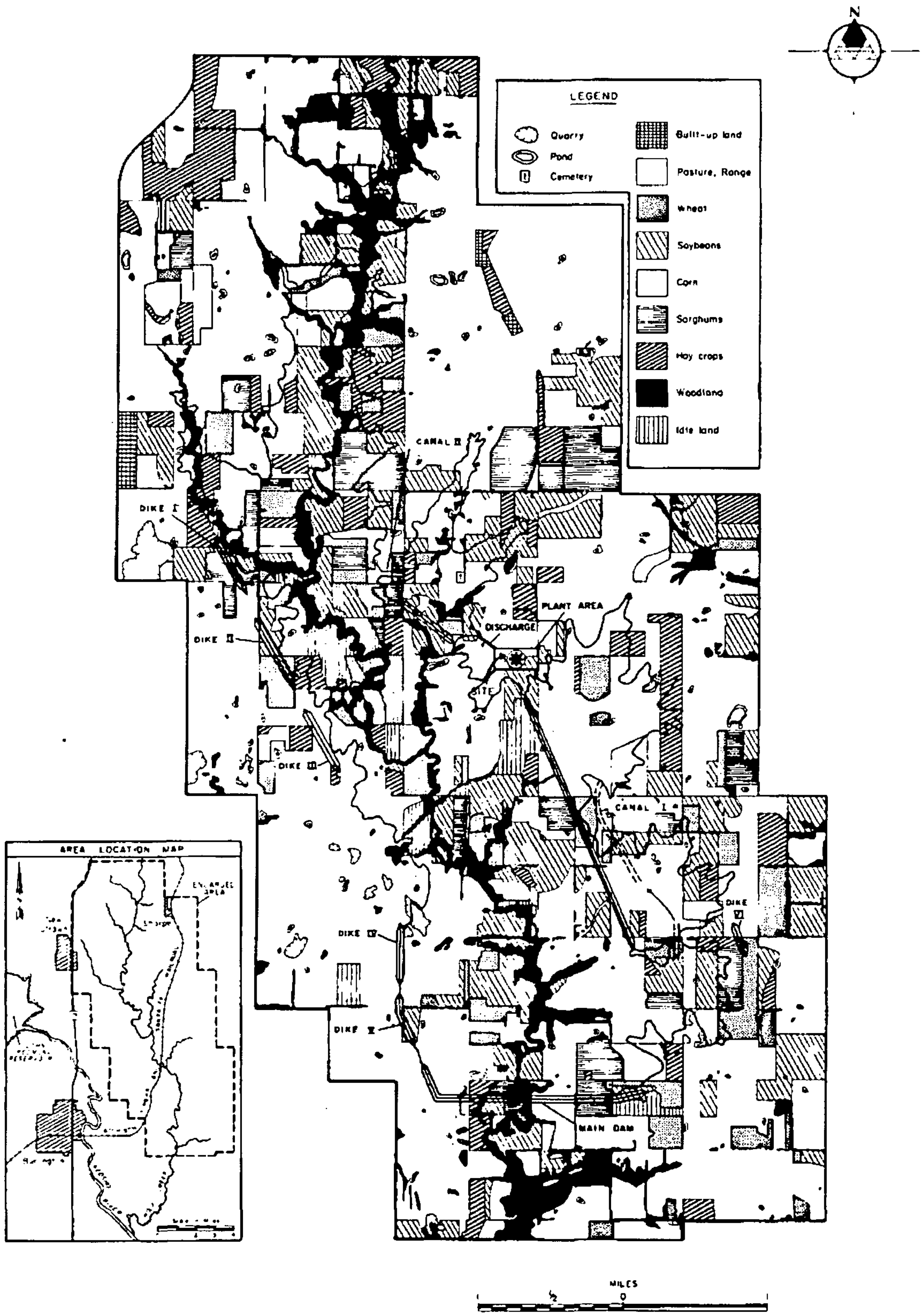

Fig. 2.4. Site land usage. Source: ER, Fig. 2.2-8.

2.2 REGIONAL DEMOGRAPHY AND LAND AND WATER USE

2.2.1 Regional demography

The area of the proposed site is predominantly a low population density, rural agricultural area. The population of both the rural areas and the communities that serve the rural economy has generally declined over the past ten years. Within a radius of ten miles of the proposed plant the estimated 1970 population was 4059; within five miles it was 2537. The only incorporated communities within ten miles of the proposed site are Burlington, 3.5 miles to the southeast, and New Strawn, three miles to the northwest. Data from the applicant for the estimated population for the years 1970, 1980, 1990, 2000, 2010, and 2020 within a ten-mile radius of the proposed facility are included in Table 2.1. Population figures for the same years within a 50-mile radius of the proposed site are presented in Table 2.2.

Table 2.1. Projected population within 10 miles of reactor

Sector	Year	0–1	1–2	2–3	3–4	4–5	5–10	10-mile total
Grand total	1970	6	32	111	836	1552	1522	4059
	1980	0	16	48	2710	1953	1287	6014
	1990	0	14	39	2720	2007	1169	5949
	2000	0	9	30	2710	1991	1015	5755
	2010	0	8	27	2761	2116	966	5878
	2020	0	6	21	2815	2243	918	6003

Source: ER, Table 2.2-2, p. 5 of 5.

Table 2.2. Projected population within 50 miles of reactor

Sector	Year	10-mile total	10–20	20–30	30–40	40–50	50-mile total
Grand total	1970	4059	7922	49,552	40,147	62,154	163,834
	1980	6014	6827	50,655	38,911	65,711	168,118
	1990	5949	6353	54,609	40,014	71,226	178,151
	2000	5755	5667	56,304	39,254	74,275	181,255
	2010	5878	5211	58,250	39,509	79,523	188,371
	2020	6003	4783	59,810	39,467	84,788	194,851

Source: ER, Table 2.2-3, p. 5 of 5.

The nearest schools are operated by the Unified School District 244 in Burlington and are all located approximately 4.3 miles southwest of the proposed site. According to the applicant, student enrollment and staff at the Burlington schools totaled around 780 in 1973. Two other educational facilities exist within a five-mile radius of the proposed plant. An unoccupied school building located 3.4 miles northwest of the site is planned for use as a special school for disabled children. The expected population of this school according to the applicant is 12 students, two teachers, and one staff psychiatrist. The other facility, a 400-acre outdoor laboratory for environmental education located 4.3 to 5.7 miles west-northwest of the site, has no building, and is used for outdoor education by visiting students from the Burlington schools.

The Coffey County Hospital, located 3.7 miles southwest of the proposed site, is the only hospital within five miles of the proposed site area. It has a maximum complement of 20 beds and 56 employees, although the staff is usually smaller. The Golden Age Lodge of Burlington is a nursing home located 3.7 miles southwest of the proposed site which, during April 1973, had 100 residents and about 60 permanent and part-time employees.

Public recreation sites near the area include the Flint Hills National Wildlife Refuge (6.8 miles to 20.8 miles west to northwest), John Redmond Reservoir (3.5 miles west), and several smaller camping and picnicking facilities, the nearest of which is the Pleasant Valley Tourist Farm (3.2 miles west-southwest).

At present, there are two small manufacturing plants within five miles of the proposed plant site. Glassco and Strahn Boats, Inc. have three and 30 employees, respectively. Both plants manufacture recreational water craft. There are several facilities within five miles of the proposed site for storage of petroleum products, grains, and fertilizer. No personnel are present at these facilities except during loading and unloading periods. These industrial facilities and others in the area are varied, but all tend to be small.

2.2.2 Land use

The majority of the land in Coffey County is used for agricultural purposes. According to the applicant, the agricultural activities of the area are devoted to (1) the cultivation of crops, of which the principal ones are soybeans, corn, wheat, alfalfa, and sorghum, and (2) livestock raising. Range is the largest category of land use and is used for livestock.

Dairy production is a relatively minor livestock activity within a five-mile radius of the site. The applicant lists the total number of dairy cows within Coffey County as 1154 during 1973. The closest herd (40 cows) is 1.8 miles west of the site; the nearest individual dairy cow is 1.5 miles north of the site.

2.2.3 Water use

Present water use in the region is primarily for domestic and livestock purposes. In the immediate vicinity of the site, water usage is confined to shallow, low-yield domestic and livestock wells, most of which obtain water from the upper weathered bedrock units (ER, p. 2.2-28).

2.2.3.1 Groundwater

Information on the location, type, capacity, and use of all wells in the vicinity of the site is given in ER, Fig. 2.2-20; ER, Table 2.2-10; and PSAR, Sect. 2.4. Most of the wells in the area intercept groundwater in the weathered rock zone.

Information on the larger capacity wells within 20 miles of the site is also given in ER, Fig. 2.2-21 and ER, Table 2.2-11. No groundwater will be contaminated by plant effluents because all effluents from the site will be discharged into the Neosho River.

2.2.3.2 Surface water

Information on the locations, owners, and rates of water use for Coffey County is given in ER, Table 2.2-12. Incorporated municipal water supply systems below Coffey County to the state line utilizing the Neosho River as the source of supply are listed in ER, Table 2.2-13, and all rural water districts in Kansas utilizing the Neosho River as a source of supply are listed in ER, Table 2.2-14.

2.3 HISTORIC AND ARCHAEOLOGICAL SITES AND NATURAL LANDMARKS

2.3.1 Historic sites and natural landmarks

There are no natural or historic landmarks, sites, or places within five miles of the WCGS area listed in the National Register of Historic Places or the National Registry of Natural Landmarks.

2.3.2 Archaeological sites

The archaeological potential of the WCGS area was assessed in a study for the applicant by the Archaeology Laboratory of Wichita State University, and compared to similar areas in eastern Kansas, the study found the archaeological remains along Wolf Creek to be unimpressive. However, based on the National Register criteria concerning "the potential for scientific knowledge," five of the 17 sites studied (ER, Fig. 2.3-3) were recommended for excavation and salvage. The applicant has committed to further test, evaluate, or excavate these five sites prior to the construction of the cooling lake.

2.4 GEOLOGY AND SEISMOLOGY

2.4.1 Geology

The physiographic setting of the eastern Kansas region is shown in Fig. 2.5. The site is located within the Osage Plains Section of the Central Lowland Province, which is characterized by low to moderate relief.

The Osage Plains Section, which compromises the site and most of the regional area, is characterized by relatively low relief, gently dipping rock strata, and east-facing escarpments. Bedrock is present at or near the earth's surface and consists of alternating beds of limestone, shale, and sandstone which dip gently to the west and northwest. The major rivers in the area are entrenched and drain from the northwest to the southeast.

Additional geological details are provided by the applicant (ER, Sect. 2.4 and PSAR, Sect. 2.5) and are discussed more fully in the staff's Safety Evaluation Report.

2.4.2 Seismology

Earthquake activity in the region can be classified as low to moderate, and no physical evidence exists that the site has experienced major seismic activity during recent times.

Additional seismic details are provided by the applicant in ER, Sect. 2.4.5; ER, Table 2.4-2; and PSAR, Sect. 2.5.

2.5 HYDROLOGY

2.5.1 Surface water

2.5.1.1 Wolf Creek watershed

Wolf Creek, which will be impounded by the proposed Wolf Creek dam, flows in a southerly direction and is a tributary of the Neosho River. The drainage area contributing to the cooling lake site (including the lake itself) is about 27.4 sq miles (ER, Sect. 2.5).

Wolf Creek is ungaged and no stream flow records are available. The applicant has estimated the expected Wolf Creek stream flow by adjusting gage records obtained for the Neosho River at Council Grove, Strawn and Iola, and at Madison on the Verdigris River. The adjustment factor was based on the ratio of the respective drainage areas. The applicant has estimated the monthly stream flow of Wolf Creek at its confluence with the Neosho River as follows:

January	— 400 acre-ft	July	— 2800 acre-ft
February	— 510 acre-ft	August	— 560 acre-ft
March	— 940 acre-ft	September	— 980 acre-ft
April	— 1050 acre-ft	October	— 905 acre-ft
May	— 1575 acre-ft	November	— 420 acre-ft
June	— 1710 acre-ft	December	— 280 acre-ft

The estimated average monthly flow is about 1020 acre-ft (17.0 cfs) (ER, Sect. 2.5).

The drought of record for the Neosho River basin began in November 1951, lasting through March 1957. The discharge from Wolf Creek was zero cfs for much of this period; the estimated seven-day, ten-year, low flow is also zero cfs (ER, Sect. 2.5).

Since Wolf Creek is ungaged and flood records are not available, the staff has prepared an estimate of maximum annual floods at the mouth of Wolf Creek. The procedure is that of the U.S. Geological Survey;[1] the results are shown on Fig. 2.6.

2.5.1.2 Neosho River watershed

The Neosho River rises in Morris County, Kansas, draining about 5790 sq miles before entering northeastern Oklahoma. There are three major reservoirs upstream of the Neosho River–Wolf Creek confluence; Council Grove, Marion, and John Redmond Reservoirs.

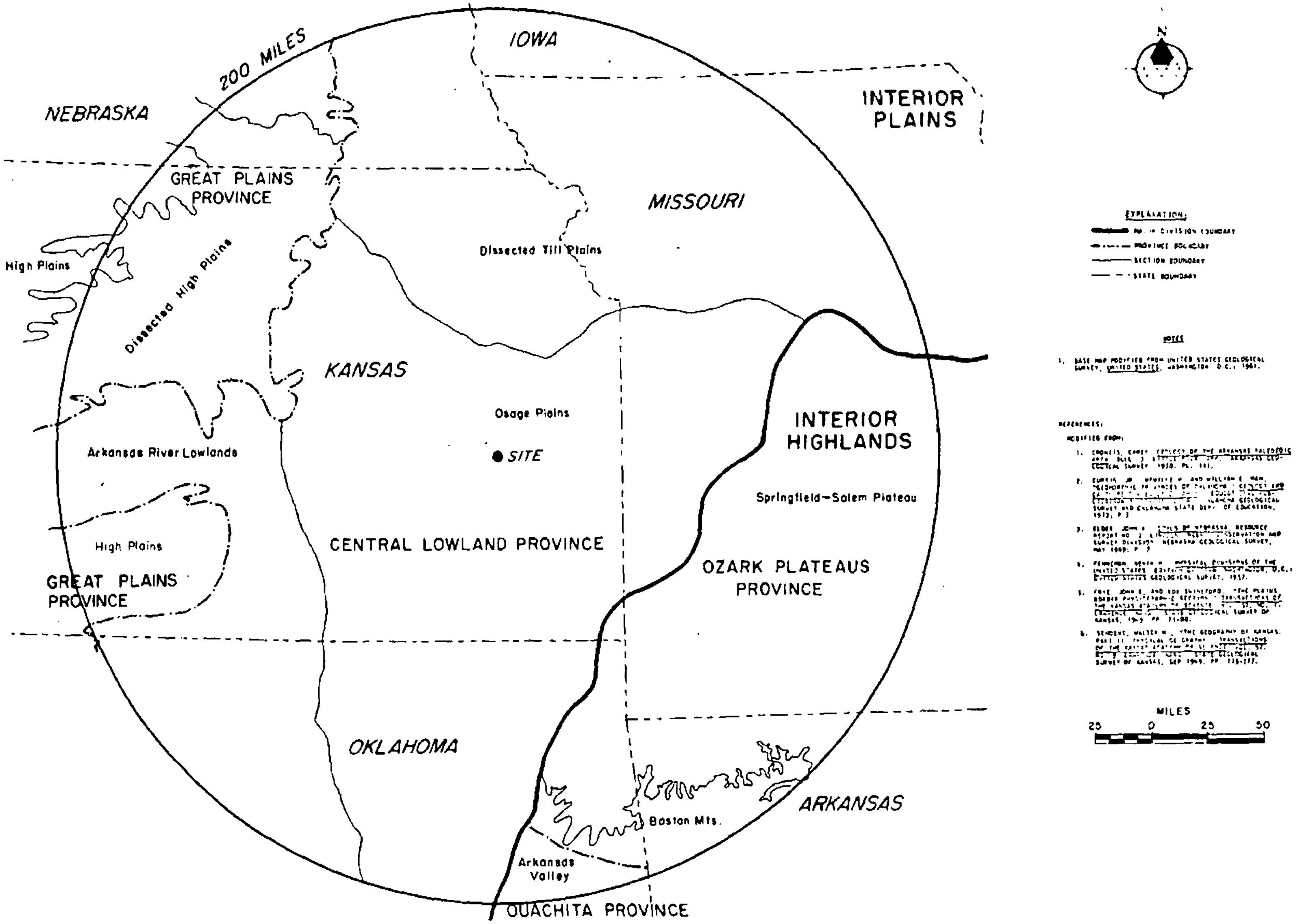

Fig. 2.5. Regional physiographic map. Source: ER, Fig. 2.4-4.

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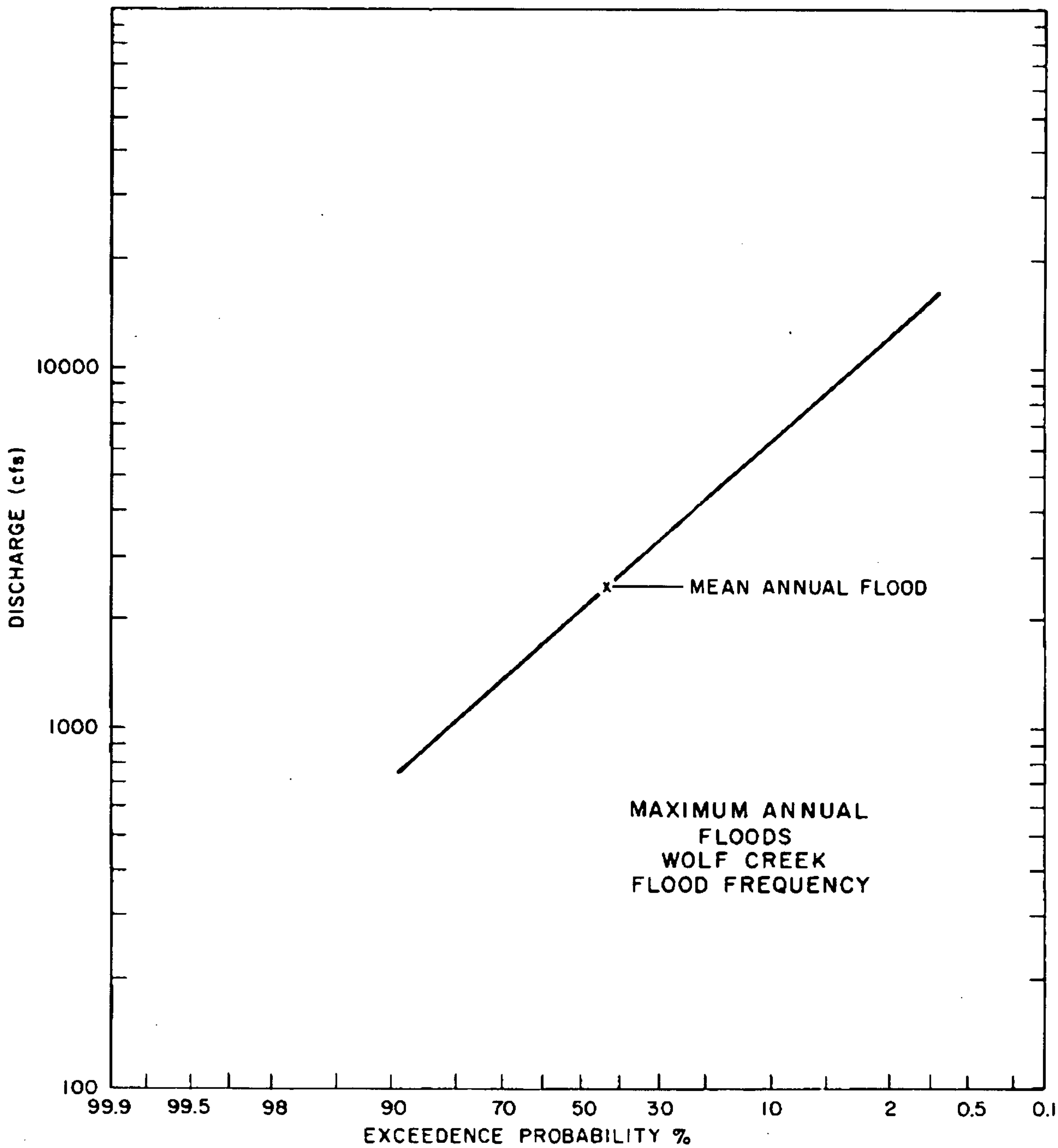

Fig. 2.6. Estimates of Wolf Creek flood frequency.

John Redmond Reservoir

The dam is located on the Neosho River at river mile 343.7 and is about four miles southwest of WCGS. The reservoir was designed for flood control, water quality control, recreation, fish and wildlife, and future water supply. The maximum allocation for flood control and conservation storage is 588,100 acre-ft and 82,100 acre-ft, respectively.

Filling of the John Redmond Reservoir began on September 7, 1963; regulated storage began on September 1, 1964.[2] The maximum pool elevation was 1066.8 ft MSL on October 16, 1973. The minimum pool elevation (since regulation of storage began) was 1032.1 ft MSL with a volume of 30,970 acre-ft on September 1, 1964.

Council Grove Reservoir

The dam is located on the Neosho River at river mile 449.7. The reservoir is designed for flood control, conservation, and related beneficial uses. The maximum allocation for flood control and conservation storage is 76,600 acre-ft and 50,100 acre-ft, respectively. Regulated storage began October 9, 1964 (ER, Sect. 2.5). The maximum pool elevation was 1283.7 ft MSL on July 11, 1969.

Marion Reservoir

The dam is located on the Cottonwood River at river mile 126.7. The reservoir was designed for flood control, water quality control, recreation, fish and wildlife, and future water supply. The allocation of storage for flood control and conservation storage is 60,000 acre-ft and 86,600 acre-ft, respectively. Regulated storage began February 26, 1968, and the conservation pool was filled May 25, 1969. Maximum pool elevation was 1356.7 ft MSL on October 13, 1973.

Stream flows

Table 2.3 shows the maximum and minimum flows of record for selected stream gages on the Neosho River and tributaries. All gages shown are upstream of the Wolf Creek—Neosho River confluence with the exception of Burlington and Iola.

Historical floods

Based on the period of record of Table 2.3, the flood of record on the Neosho River occurred in July of 1951. Using drainage area as a basis for interpolation, the peak discharge would have been about 404,500 cfs near the mouth of Wolf Creek. This assumes that John Redmond Reservoir was not constructed, as was the case. The Neosho River has a channel capacity near the site of about 16,000 cfs. Since 1963, flow at this point has been completely regulated by the John Redmond Reservoir.

The WCGS will be well above the flood potential for the Neosho River.

2.5.2 Groundwater

The site region is described by Meinzer[3] as a part of central lowlands of the interior plains physiographic province and division, respectively. The groundwater province is defined as the South Central Paleozoic. Meinzer said of the province, "The ground conditions are, in general, rather unsatisfactory. The principal sources of supply are the Paleozoic sandstones and limestone. Throughout considerable parts of the province the Paleozoic supplies are meager or of poor quality. Deep Paleozoic water is highly mineralized. In many of the valleys large supplies are obtained from glacial outwash and other alluvial sands and gravels."[3]

The applicant has sponsored a groundwater investigation in the site region (ER, p. 2.5-5 through 2.5-9; and PSAR, p. 2.4-31 through 2.4-40). The aquifers are classified as alluvial, soil and weathered bedrock, and consolidated bedrock.

The regional alluvial aquifer comprises silts, sands, and gravels. The Neosho River passes within about three miles of the site. The alluvium in the valley ranges from one to ten miles in width.

Table 2.3. Selected gage records of the Neosho River and tributaries

Gage	Drainage area (square miles)	Location (river miles)	Period of record	Record discharge			
				Maximum		Minimum	
				Flow (cfs)	Time	Flow (cfs)	Time
Neosho River							
at Council Grove, Ka.	250	448.0	Oct. 1938–Sept. 1965	121,000	July 11, 1951	0	a
at Americus, Ka.	622		June 1963–Sept. 1965	6,380	Sept. 21, 1965	0	Each year
at Strawn, Ka.	2933	356.5	June 1948–June 1963	400,000	July 11, 1951	0[b]	1954–1957
at Burlington, Ka.	3042	338.4	June 1961–Sept. 1965	26,800	Sept. 13, 1961	1.1	1963[b]
near Iola, Ka.	3818	284.4	Aug. 1895–Sept. 1965[c]	436,000	July 13, 1951	0[b]	1936 and 1956
Cottonwood River							
near Marion, Ka.	329	123.9	Oct. 1938–Sept. 1965	66,000	July 11, 1951	0	a
near Florence, Ka.	754	102.4	June 1961–Sept. 1965	46,000	June 10, 1965	5.5	Oct. 11, 1964
at Cottonwood Falls, Ka.	1327	66.7	Apr. 1932–Sept. 1965	196,000	July 11, 1951	0[b]	1955–1957
near Plymouth, Ka.	1740	39.2	Mar. 1963–Sept. 1965	57,000	June 5, 1965	8.7	Oct. 21, 1964
Cedar Creek							
near Cedar Point, Ka.	110	9.4	Oct. 1938–Sept. 1965	52,400	June 29, 1951	0	d
Four Mile Creek							
near Council Grove, Ka.	55	4.4	Mar. 1963–Sept. 1965	5,480	Sept. 21, 1965	0[b]	1963–1964

[a]Several years.
[b]Occasionally, in year(s) shown.
[c]No record from December 1903 to October 1917.
[d]Occasionally.

Source: United States Geological Survey, "Surface Water Supply of the United States," Part 7, Lower Mississippi River Basin, Annual Publication, 1965.

The soil and weathered bedrock aquifer is reported to comprise weathered shale, siltstone, sandstone and limestone, and the soils derived from them. The weathered zone may be up to 40 ft thick. The overlying alluvial aquifer is hydraulically connected to the lower weathered bedrock aquifer. Recharge to both is from local precipitation percolating through the soil. Thus, the water table elevation is responsive to local precipitation-drought conditions. Within a five-mile radius of the site, well surveys identified 142 dug wells in the two water-table aquifers (ER, Figs. 2.2-10 and 2.2-12).

The bedrock aquifers are composed of sandstones and limestones. Recharge to the aquifers is principally from precipitation at the outcrop of the formations, east of the proposed site. Some downward movement from the overlying aquifers may result in recharge of the bedrock aquifers. However, the rise of the water level in the applicant's test holes above the upper boundary of the formation strongly suggests the presence of an aquiclude at a depth of about 40 ft. The aquiclude is composed of shale beds that limit vertical permeability.

Groundwater movement is in a southwesterly direction from the plant site towards the Neosho River. The water table contour is a muted image of the surface topography. The piezometric surface of the deeper aquifers reflects the gradient of the parent formation. In all cases the gradient is generally from the site toward the Neosho River.

Use of groundwater in the site area is discussed in Sects. 4.2.2 and 5.5.2 of this statement.

2.5.3 Water quality

2.5.3.1 Surface water

The applicant sponsored surface water studies to establish baseline water quality information. The locations of the sampling stations including John Redmond Reservoir are shown in Fig. 2.7. Chemical and biological analyses were performed to identify the baseline. Algal bioassays were performed to identify the growth-support potential of the local surface water. The analyses are based on sampling accomplished in March, June, September, and December 1973.

The concentration of selected chemical parameters identified by the applicant is compared with earlier (water year October 1965 to September 1966) analyses by others[4] in Table 2.4 and Fig. 2.7.

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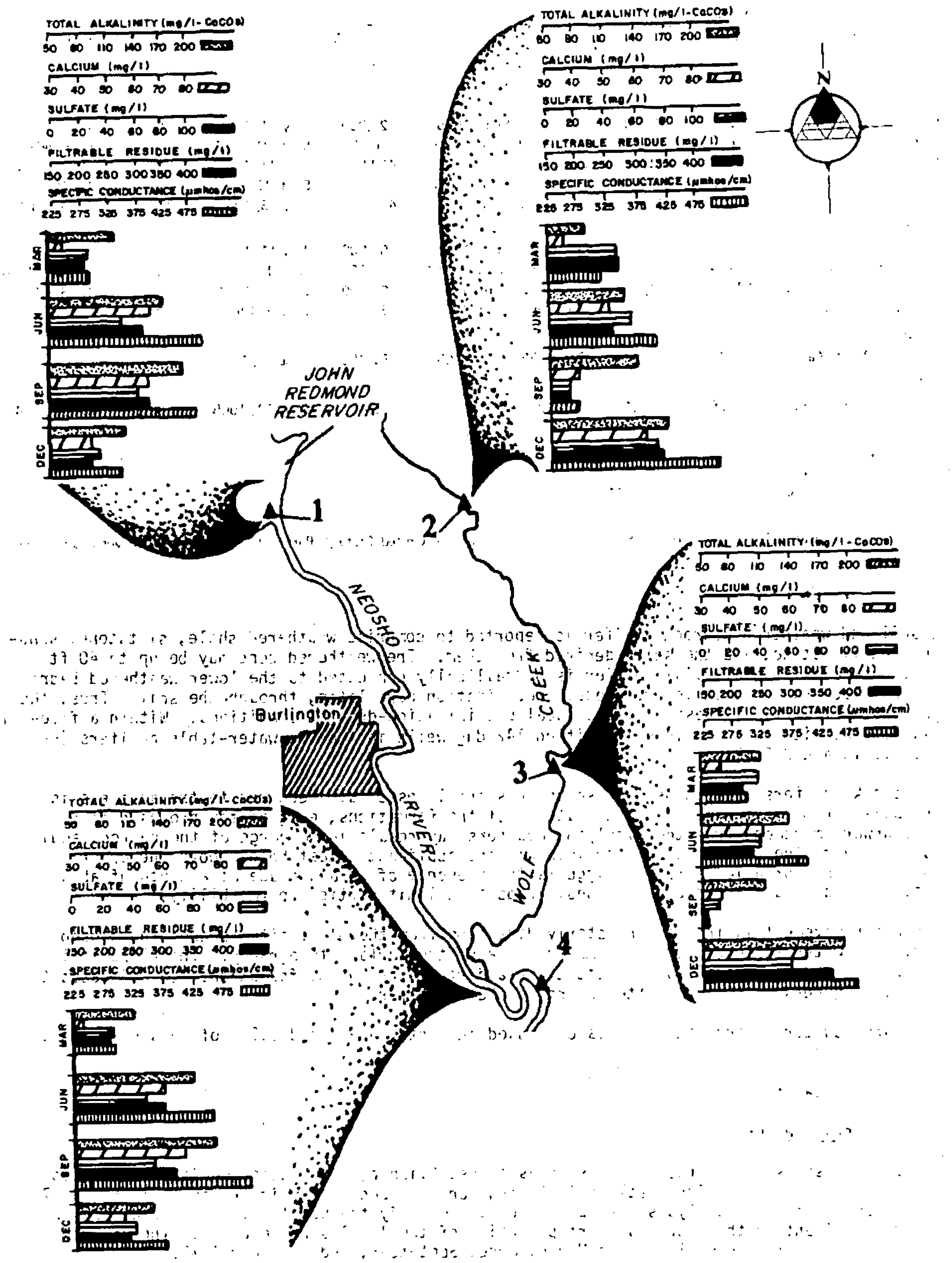

Fig. 2.7. Summary of major chemical constituents of John Redmond Reservoir and Wolf Creek. Source: ER, Fig. 2.5-16.

Table 2.4. Water quality of the Neosho River at Burlington, Kansas (water year October 1965–September 1966)

Date of collection	Discharge (cfs)	Chemical analyses, in parts per million: Silica	Iron	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Nitrate	Boron	Dissolved solids (residue at 180°C): Parts per million	Tons per acre-foot	Tons per day	Hardness, as $CaCO_3$: Calcium, Magnesium	Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
Oct. 25, 1965	396	11		70	16	12	4.8	264	0	40	13	0.3	3.6	0.16	310	0.42	331	240	32	0.3	470	8.1
Dec. 27	292	4.2		93	23	20	4.0	303	0	94	25	0.3	0.7	0.19	418	0.57	330	326	78	0.5	620	7.9
Jan. 31, 1966	252	3.3		86	24	19	4.2	276	0	85	26	0.2	1.1	0.12	380	0.52	259	313	87	0.5	620	8.1
Feb. 28	312	2.5		80	26	19	3.6	261	0	94	26	0.2	0.9	0.13	396	0.54	334	306	92	0.5	640	7.9
Apr. 4:																						
At 1045	284	2.3		88	22	21	3.6	264	0	102	26	0.3	3.1	0.10	398	0.54	305	310	94	0.5	630	8.1
At 1145	269	2.0	0.01	88	19	21	3.8	259	0	93	26	0.2	3.6	0.10	384	0.52	279	292	80	0.5	640	8.1
May 9	360	4.8		69	16	18	3.8	224	0	67	18	0.3	3.1	0.10	320	0.44	311	238	54	0.5	510	7.6
June 14	455	5.4		53	9.7	13	3.8	173	0	44	14	0.4	4.0	0.07	259	0.35	318	172	30	0.4	390	7.6
July 19	63	2.2		54	15	13	4.0	173	0	56	17	0.4	1.3	0.07	264	0.36	44.8	196	54	0.4	420	8.0
Aug. 22	136	2.0		61	13	21	4.5	200	0	63	20	0.4	2.7	0.10	282	0.38	104	206	42	0.6	470	7.9
Sept. 26	30	1.5		62	17	16	4.3	188	0	62	21	0.4	2.2	0.13	289	0.39	23.3	224	62	0.5	470	7.9

Source: United States Geological Survey, *Quality of Surface Waters of the United States, 1966*, Geological Survey Water-Supply Paper 1994, U.S. Government Printing Office, Washington, D.C., 1971.

A summary of the applicant's aquatic nutrient analyses is shown in Fig. 2.8 (ER, Table 2.5A-2). The applicant has compared the quality of the surface water at the sampling stations with the Kansas State Board of Health Regulations revised in March 1973 (ER, Sect. 2.5).

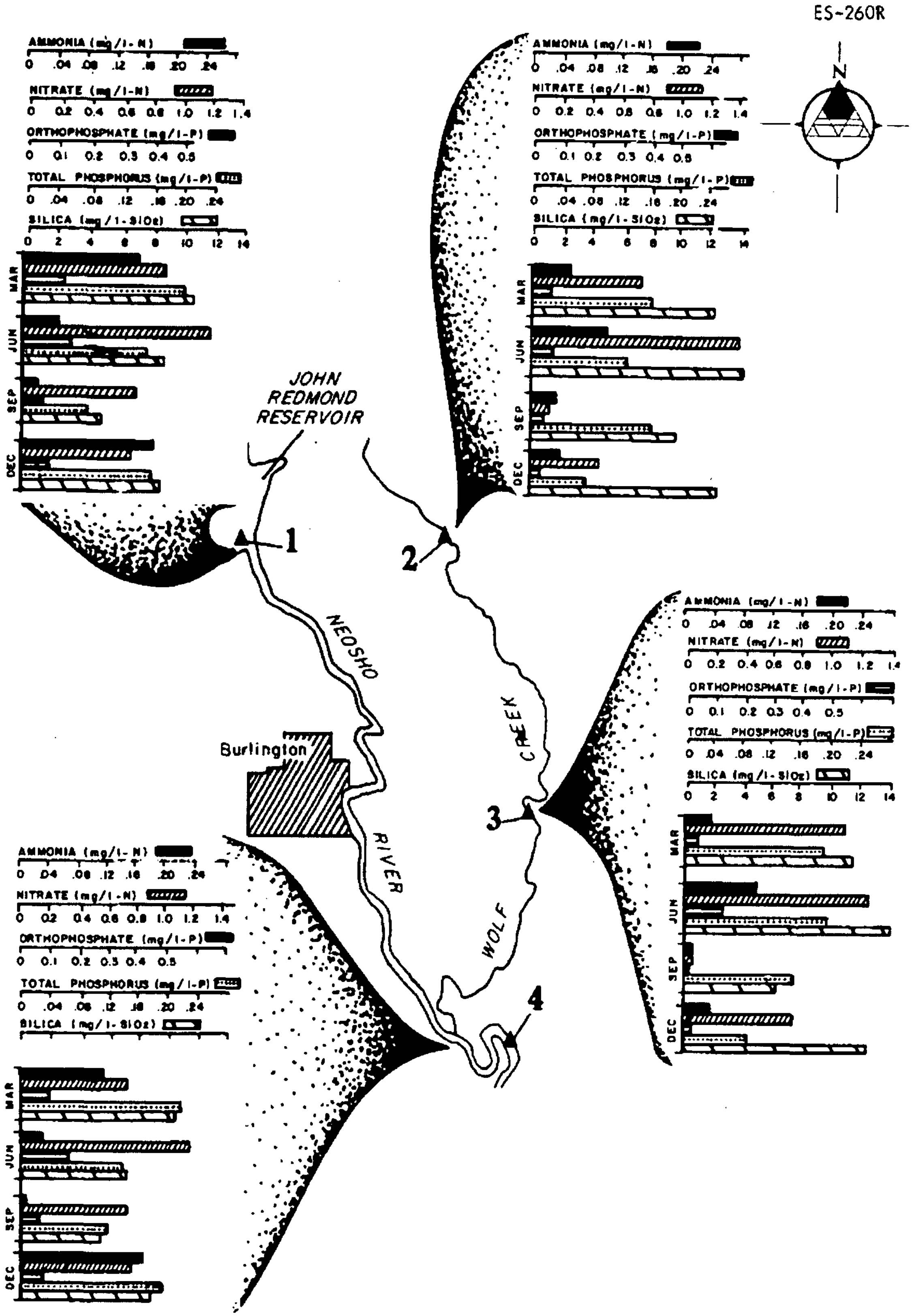

Fig. 2.8. A summary of aquatic nutrients in John Redmond Reservoir and Wolf Creek. Source: ER, Fig. 2.5-15.

2.5.3.2 Groundwater

The applicant sponsored groundwater quality studies in the vicinity of the site. Chemical quality data for these waters are presented in ER, Tables 2.5A-3 and 2.5A-4. Many of the wells in the area contain high dissolved solids. Of 32 samples from eight wells, 23 exceed the U.S. Public Health Service drinking water standard of 500 mg/liter total solids. Similarly, 12 of the samples exceed the standard of 250 mg/liter for sulphate (ER, Sect. 2.5).

2.6 METEOROLOGY

2.6.1 Regional climatology

The climate at the Wolf Creek site, located about 50 miles south of Topeka, Kansas, can be described as continental, characterized by rapid changes in temperature and marked extremes and resulting in hot summers and cold winters. The site lies near the principal track of winter and spring storms that move northeast and east through the region.

2.6.2 Local meteorology

Climatological data from Topeka, Chanute (about 40 miles south-southeast of the site), Garnett (about 25 miles east of the site), Ottawa (about 35 miles northeast of the site), and Emporia (about 30 miles west-northwest of the site) and available onsite data have been used to assess local meteorological characteristics of the site. Mean monthly temperatures at the site may be expected to range from about 29°F in January to about 80°F in July.[5,6] Record maximum and minimum temperatures of 118°F and -28°F have been reported at Ottawa.[6] The hottest summer of record at Topeka occurred in 1936 when temperatures of 100°F or higher were recorded on 59 days.[5]

Annual average precipitation in the site area is about 32 in., with about 71% occurring in the period April through September.[5,6] The maximum mean monthly precipitation of about 4.5 in. occurs in June. The maximum 24-hr rainfall at Topeka was about 8.1 in. in September 1909.[5] Annual snowfall averages near 20 in., while 16 in. of snow in 24 hr was reported at Topeka in November 1929.[5]

Wind data from the 10-m level at the Wolf Creek site for the period June 1, 1973 through May 31, 1974 indicate a prevailing wind direction from the south (20%), with winds from the south-southeast, south, and south-southwest totaling about 42% (Fig. 2.9). Ten years (1955-1964) of wind data from Chanute also indicate prevailing winds from the south, occurring about 16.5% of the time. Mean wind speeds at the site, Topeka, and Chanute are all about 11 mph. The "fastest mile" wind speed reported at Topeka was at least 81 mph in June 1958.[5]

2.6.3 Severe weather

Due to the location of the site with respect to the principal storm tracks, severe weather is not uncommon. Thunderstorms can be expected to occur on about 59 days per year, being most frequent in May, June and July.[5]

During the period 1955-1967, 50 tornadoes were reported in the one-degree latitude-longitude square containing the site, giving a mean annual frequency of 3.8.[7] The computed recurrence interval for a tornado at the plant site is 340 years.[8] May is the month with the highest frequency of tornado occurrences.[7]

The maximum observed hailstone in the United States was reported at Coffeyville Kansas, (about 80 miles south of the site). This hailstone weighed 1.67 lb and measured 17.5 in. in circumference. The applicant has also examined *Storm Data*[9] for the period 1959-1973, and stated that hailstones of 9 in. in circumference or greater are not uncommon.

The applicant also examined *Storm Data*[9] for the period 1959-1973 for occurrences of icing conditions, and stated that accumulations of up to 1.5 in. of ice have occurred several times within 50 miles of the site.

In the period 1936-1970, there were only about two atmospheric stagnation cases totaling about nine days reported in the site area.[10]

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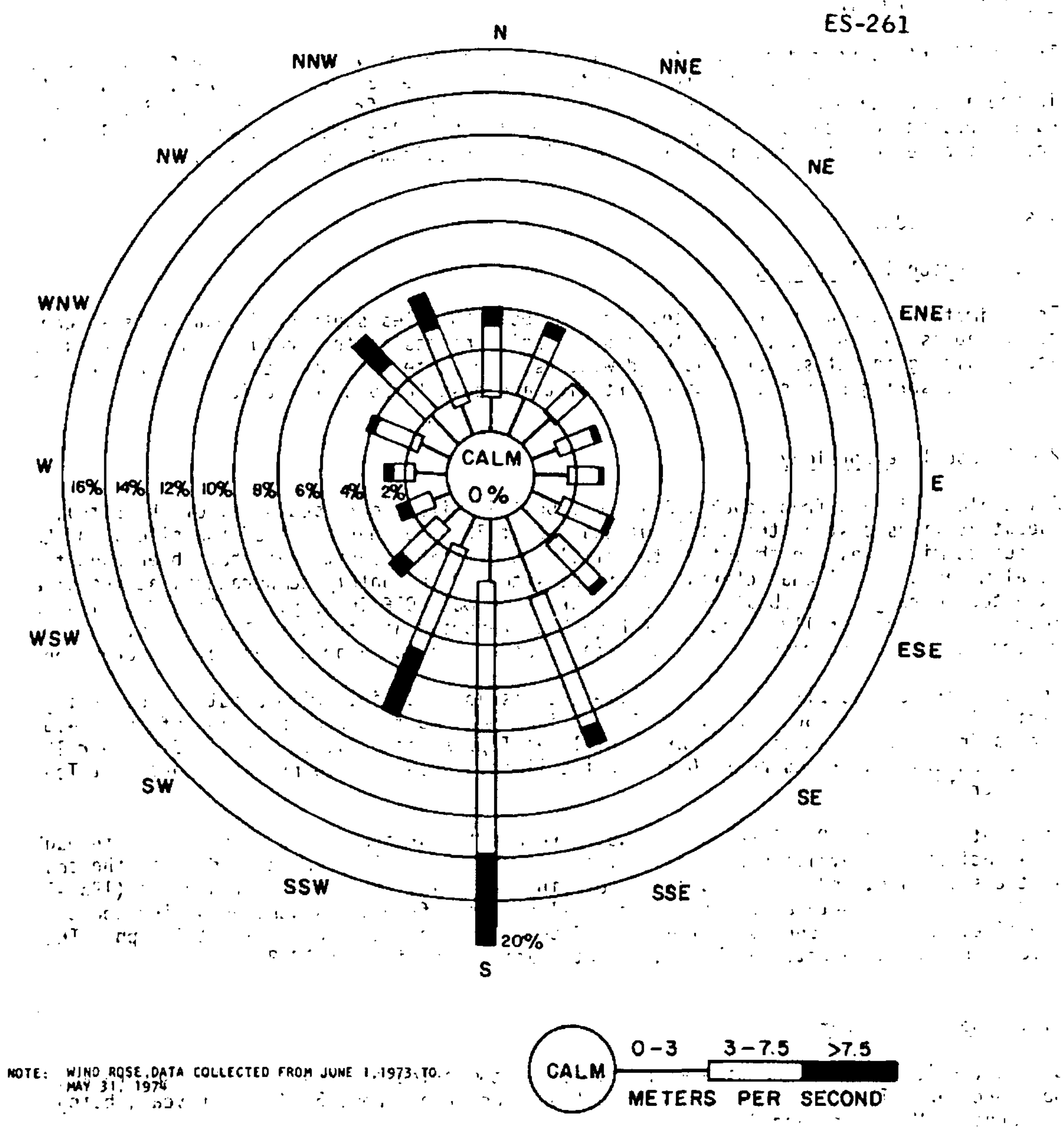

Fig. 2.9. Annual wind rose at 10 meter level for Wolf Creek Generating Station. Source: PSAR, Fig. 2.3-24b.

2.7 ECOLOGY OF THE SITE AND ENVIRONS

2.7.1 Terrestrial

The major features of the terrestrial ecosystems of the Wolf Creek site are summarized in this section with material drawn primarily from Sect. 2 of the ER. Plant classifications follow those of Gray[11] and animal classifications were prepared independently using several references.[12-15]

2.7.1.1 Soils

Seventeen different soil series occur on the site (ER, Figs. 2.2-19A to 2.2-19C). Land use capabilities in terms of agricultural potential, wildlife habitat, and general construction characteristics are presented for each soil series in Tables 2.2-8 and 2.2-9 of the ER.

Rather than include a detailed discussion, attention is focused on a few diagnostic soil characteristics (Appendix Table B.1). The 17 soils series are combined into four groups based upon the type of bedrock material found in the soil profile: alluvium, limestone, shales, or sandstone. Alluvial and shale soils are the most productive cropland areas of the site (ER, Table 2.2-8). Complete soil descriptions are provided by the applicant (ER, Sect. 2.2.2.8).

2.7.1.2 Producers

A summary of land classification units and plant associations of the site is presented in Table 2.5. A vegetation map (Fig. 2.4) was developed from quantitative survey data, aerial photography, and qualitative observations. The area is heavily agricultural with only 12% of the area occupied by fairly mature natural plant associations.

Interactions of topography, drainage, soil moisture, soil fertility, and perturbations, both natural and human-induced, have resulted in seven distinct plant communities at the site: (1) cropland, (2) open pasture, (3) abandoned fields, (4) mixed-shrub pastures, (5) bluestem prairie, (6) northern floodplain forest, and (7) oak-hickory forest. The applicant refers to the latter two categories as a single unit called the "lowland woods." Figure 2.10 depicts a cross sectional diagram of a stream basin which shows topographic relationships of the three potentially climax plant communities of the site[16,17] (ER, Fig. 2.2-19B). Successional relationships of the plant communities of the site are depicted in Fig. 2.11.

Table 2.5. Summary of land classification and plant associations of the Wolf Creek site

Classification	Land: Acres	Land: Percent
Man dominated		
Cropland		
Soybeans	1,625	16
Wheat	703	7
Hay	683	6
Sorghum	591	5
Corn	363	4
Abandoned fields	303	3
Total	4,268	41
Range		
Total	4,836	46
Miscellaneous		
Ponds	88	1
Roads	57	<1
Gravel pits	30	<1
Cemetery	4	<1
Total	179	1
Subtotal	9,283	88
Natural plant communities		
Abandoned railroad right-of-way (ungrazed bluestem prairie)	28	<1
Woodlands	1,189	11
Northern floodplain forest		
Oak-hickory forest		
Subtotal	1,217	12
Grand total	10,500	100

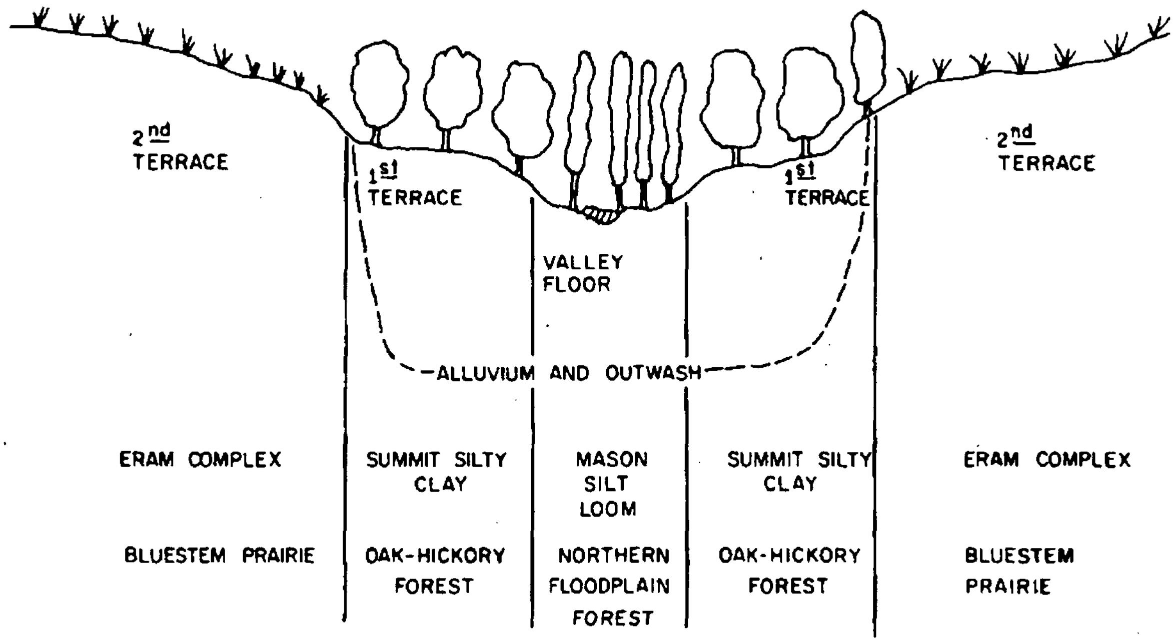

Fig. 2.10. Diagrammatic cross section of study area portion of Wolf Creek in Kansas, showing general distribution of climax vegetation and soils.

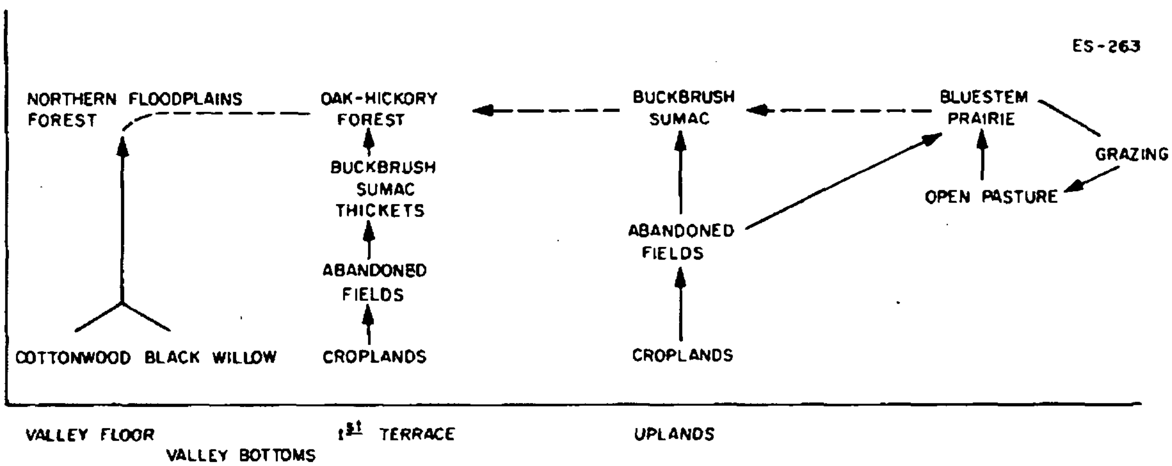

Fig. 2.11. Successional relationships of plant communities found at the site.

Bluestem prairie

Bluestem prairie is typically composed of tall grasses and many species of forbes. In Kansas, bluestem prairie occurs mainly on the eastern uplands but may also occur on floodplains of rivers and streams in the west.[18]

Currently the major areas where fairly mature bluestem prairie occurs are along old railroad rights-of-way. Dominant and common associates species typical of bluestem prairie are depicted in Appendix Table B.2. At the site there are approximately 28 acres of embankments next to an old Atchison, Topeka, and Santa Fe right-of-way. Only eight of the 42 species found along the railroad right-of-way (ER, Table 2.7-21) are listed as dominants or common associates for the bluestem prairie.[18]

Large areas of the bluestem prairie which occur on hillsides are presently used as range. Approximately 46% of the site (4836 acres) is presently classed as range (open pasture or mixed-shrub pasture).

Northern floodplain forest

The northern floodplain forest is composed of low to tall broadleaf deciduous forest trees often draped with vines. The undergrowth is usually dense and occasionally this forest is interrupted by freshwater marshes with grass communities. The forest becomes narrower and lower in a westerly direction and often less dense. Also the number of species declines markedly from east to west.

Northern floodplain forest occurs on alluvial soil, floodplains, and stream banks, wherever seepage water from permanent or intermittent streams is available. Since this community is frequently inundated for varying periods of time, all of the climax species have some degree of flood tolerance.

Dominant and common associate species of northern floodplain forest are listed in Appendix Table B.2. This association, a subunit of the "lowland woods," occurs at the site as a very narrow belt of vegetation adjacent to Wolf Creek.

Oak-hickory forest

Oak-hickory forest is a medium-tall to tall, multilayered, broadleaf deciduous forest that occurs on the first and second terraces adjacent to streams and on steep valley sides (Fig. 2.10). These areas are seldom flooded and most of the species are intolerant to flooding. With the advent of settlers to the area, grass fires were reduced and oak-hickory forest began expanding into the grasslands.[19,20]

Dominant and common associate species of mature oak-hickory forests are depicted in Appendix Table B.2. In the upper area of the site, Wolf Creek has very steep walls and flooding normally does not occur above the rims of the banks. Thus most of the forested area in this part of the site is an oak-hickory forest. The oak-hickory forest at the site is quite young, with many floodplain forest species remaining as seral individuals.

The alluvial bottomlands (oak-hickory forest areas) are being more extensively cultivated than the uplands. Approximately 41% of the site and proposed cooling lake is currently being used as farmland. Acreage is utilized for row crops (soy beans, sorghums, and corn), broadcast crops (wheat and oats), and forage (grasses and/or legumes from which hay is harvested).

Regularly, croplands are abandoned for one to five years and become dominated by various weedy herbaceous species. At the present time only 3% of the site is classified as abandoned fields. The status of this idle land is subject to change as it is either returned to cultivation or allowed to proceed through secondary succession to a climax oak-hickory forest.

2.7.1.3 Consumers

Section 2.7 (Tables 2.7-25 to 2.7-41) of the ER contains lists of the vertebrate and invertebrate consumer species observed in the WCGS site area. Surveys of vertebrate and invertebrate consumers were conducted with respect to the vegetational communities of the site (lowland woods, bluestem prairies, open pasture, and mixed-shrub pasture).

The site is within the Illinoian biotic province. The fauna is a mixture of prairie and forest species; also, the area is inhabited by forest edge animals. The narrow stream-bottom forests are therefore important to large forest animals that require extensive home ranges for grazing, browsing, and hunting.[20] Typical common forest edge species include deer, cottontail rabbits, bobwhites, raccoon, opossum, red fox, coyote, striped and spotted skunk, meadow jumping mouse, Franklin ground squirrel, and many small perching birds.[20]

Potential and observed herps, mammals, and birds are tabulated in Appendix Tables B.3 to B.5. Important game species sighted include opossum, eastern fox squirrel, eastern cottontail, white-tailed deer, snow goose, mallard, blue-winged teal, bobwhite, and mourning dove. A former game species sighted that is presently protected due to overhunting is the upland game plover. Data gathered from area counts (ER, p. 2.7-34) indicate that the density of eastern fox squirrel is slightly higher than values reported by Preno and Labisky[21] in predominately agricultural areas in Illinois. Data gathered during May-June breeding counts of eastern cottontails and bobwhites along a 20-mile census route indicate the population densities were similar to the relatively high level of abundance reported by Preno and Labisky[21] in Illinois.

Fur bearing mammals sighted by the applicant at the site included raccoon and the striped skunk. Colonies of beaver occur in the John Redmond Reservoir and have been extensively studied by Myers.[22]

Seventy-three species of birds were sighted by the applicant (ER, Table 2.7-30) of which four species were migrants, 33 species were found year around, 27 during the winter only, and nine during the summer only. Sixteen mammals, four amphibians, three turtles, one lizard, and two snakes have been observed at the site. The greatest number of species and highest densities occurred in natural communities (bluestem prairie and lowland woods).

Rare, endangered, threatened, peripheral, status undetermined, and sensitive species

Rare and endangered organisms native to Eastern Kansas are listed in Appendix Table B.6. No endangered species were sighted by the applicant and only two species reported as rare in the upper and middle Neosho River were found: plains harvest mouse (*Reithrodontomys montanus*) and badger (*Taxidea taxus*). Both species were found in the bluestem prairie along the abandoned railroad right-of-way. Ten species of birds that are presently showing population declines were observed at the site.[23]

2.7.2 Aquatic

The following discussion draws upon published scientific literature, including papers specifically concerned with this site, unpublished theses and unpublished data provided by the Kansas Forestry, Fish and Game Commission, and data collected in the baseline monitoring program (ER, Sects. 2.5 and 2.7).

Construction and operation of WCGS will affect three bodies of water: (1) Wolf Creek, which will be dammed to create a cooling lake, (2) John Redmond Reservoir (on the Neosho River), which will supply makeup water to the cooling lake, and (3) the Neosho River, which will receive blowdown from the cooling lake via Wolf Creek.

2.7.2.1 General descriptions of Wolf Creek, the Neosho River, and John Redmond Reservoir

Wolf Creek

The 26.6 meandering miles of Wolf Creek drain a watershed of about 35 sq miles. The creek is typically about 6 to 10 ft wide and ranges from 2-in. (riffles) to 4-ft deep (pools), but flood stage may increase the width to 20 or 30 ft and the depth by several feet. Bottom substrates consist of silt and clay in pool areas (approximately 75% of the length of Wolf Creek) and gravel in riffle areas (25%) (ER, p. 2.7-14).[24] Average monthly flow is estimated to be 17 cfs with an estimated high monthly average of 47 cfs in July (ER, p. 2.5-1; 2.5-3). Flow often ceases completely, particularly in September, leaving pools as temporary refuges for aquatic life until flow resumes (ER, p. 2.5-1; 2.5-3; 2.5-13). Organisms inhabiting Wolf Creek must endure the drastic fluctuations in flow, chemistry, and temperature so often characteristic of small intermittent temperate streams.[25] In order to sustain populations in an intermittent stream like Wolf Creek, organisms must exploit moist interstitial spaces of the stream bed, leaf litter, and undersurfaces of rocks, or aestivate as resistant eggs, larvae, or pupae.[26] Water quality data for Wolf Creek are presented in Figs. 2.7 and 2.8 and in ER, Appendix 2.5A.

Neosho River

The sluggish, meandering Neosho River (gradient averages about 1.5 ft/mile at the site) and its tributaries drain a watershed of about 5793 sq miles in Kansas[27] (ER, p. 2.5-2). Operation of John Redmond Dam has regulated flow near the site since 1963. The average yearly flow over the period 1922-1964 was 1337 cfs with a high monthly flow of 34,098 cfs and a low of zero.[28] Near the site, particularly 1.5 miles below its confluence with Wolf Creek, the river banks rise about 20 to 30 ft and are heavily wooded. The bottom of the main channel is hard — mainly gravel, rocks and clay — while silt and organic detritus characterize the substrate near the shoreline[29] (ER, p. 2.7-14). Water quality data for the Neosho River near the site are presented in Fig. 2.8 (ER, Appendix 2.5A).

Results of man's activities are currently stressing the Neosho River and John Redmond Reservoir ecosystems: (1) effluents from sewage treatment plants (at least five upstream of John Redmond Reservoir), (2) runoff from livestock feedlots, and (3) fertilized cropland runoff.[27] These rich sources of phosphates and nitrates undoubtedly contribute much to the high concentrations of these nutrients found in John Redmond Reservoir and the Neosho River. Natural stresses on the Neosho River system include flooding, drought, and high turbidity.

John Redmond Reservoir

The John Redmond Reservoir merits consideration not only because it will be subject to impacts of plant operation, but also because it is the nearest example of a colonized impoundment. Thus, data from John Redmond Reservoir may suggest the type of environment to be expected in the proposed cooling lake.

This highly turbid flood-control reservoir has a surface area of about 7800 acres and an average depth of only 7.2 ft at conservation pool level. The shallow depth in concert with a relatively low shoreline development and a fetch of three or four miles for prevailing winds results in complete thermal mixing most of the year.[29] Dissolved oxygen measurements in both the reservoir and the Neosho River were never less than 7 mg/liter; however, dissolved oxygen levels in Wolf Creek dropped to 1.1 mg/liter in some of the pools in September, a reflection of stagnant conditions and high biochemical oxygen demand existing at that time (ER, Table 2.5A-2). Nutrient levels in both John Redmond Reservoir and the Neosho River almost always exceeded those required for the development of nuisance algal blooms (0.01 mg/liter inorganic phosphorus and 0.30 mg/liter inorganic nitrogen during growing season).[30] Orthophosphate concentrations varied from 0.044 to 0.15 mg/liter as phosphorus while nitrate concentrations varied from 0.70 to 1.2 mg/liter as nitrogen. Table 2.5A-2 of the ER presents other water quality data for John Redmond Reservoir. Figure 2.8 summarizes aquatic nutrient concentrations for John Redmond Reservoir, Wolf Creek, and the Neosho River.

2.7.2.2 Producers

Macrophytes

A listing and frequency of occurrence of plants found on the site area are depicted in Table 5.18.

Periphyton

Periphytic algae provide food and shelter for both invertebrates and vertebrates alike. The sampling of John Redmond Reservoir and Wolf Creek from April to December 1973 yielded 113 algal taxa (Species list: ER, Table 2.7A-1). Ninety-three taxa, representing 21 of 32 total genera, were diatoms (Bacillariophyta), seven were green algae (Chlorophyta), and 13 were bluegreens (Cyanophyta). The applicant's findings are summarized in Appendix Table C.1.

Existing stresses on periphyton populations result primarily from water-level changes that alternately expose and deeply submerge periphyton and from high flow velocities induced by floods that scour away both periphyton and substrate (ER, p. 2.7-6).

Phytoplankton

Phytoplankton are often the most important primary producers in lake and reservoir ecosystems. Quarterly sampling in John Redmond Reservoir, Wolf Creek, and the Neosho River over one year yielded a total of 203 phytoplankton taxa representing 66 genera. The applicant has presented a complete listing of taxa in ER, Table 2.7B-1. Diatoms comprised from 56 to 96% of total phytoplankton at all sampling stations during the four seasonal sampling periods (ER, Table 2.7-7). Figure 2.12 summarizes primary productivity, chlorophyll *a* concentration, and total phytoplankton abundance for each station during the sampling period.

Stephanodiscus astraea, a centric diatom often abundant in eutrophic waters,[31] was plentiful in the John Redmond Reservoir and the Neosho River during March, June, and September 1973, along with other species of *Stephanodiscus*. *Nitzschia paleacea* and unidentified species of *Nitzschia* and *Navicula* contributed the greatest numbers to the phytoplankton of Wolf Creek during all sampling periods.

Green algae comprised from less than 1.0 to about 26% of the total phytoplankton, depending upon location and season. *Chlamydomonas* sp. was the most abundant green algae recognized by the applicant.

Blue-green algae never made up more than 3% of total phytoplankton in Wolf Creek during the sampling period. The maximum contributions to that of the Neosho River and John Redmond Reservoir were about 11% and 15% respectively (September). *Merismopedia tennissima* was the most abundant blue-green alga. An earlier study of John Redmond Reservoir from 1964 to 1965 indicated *Oscillatoria* as one of the most dominant species of all phytoplankton present.[27]

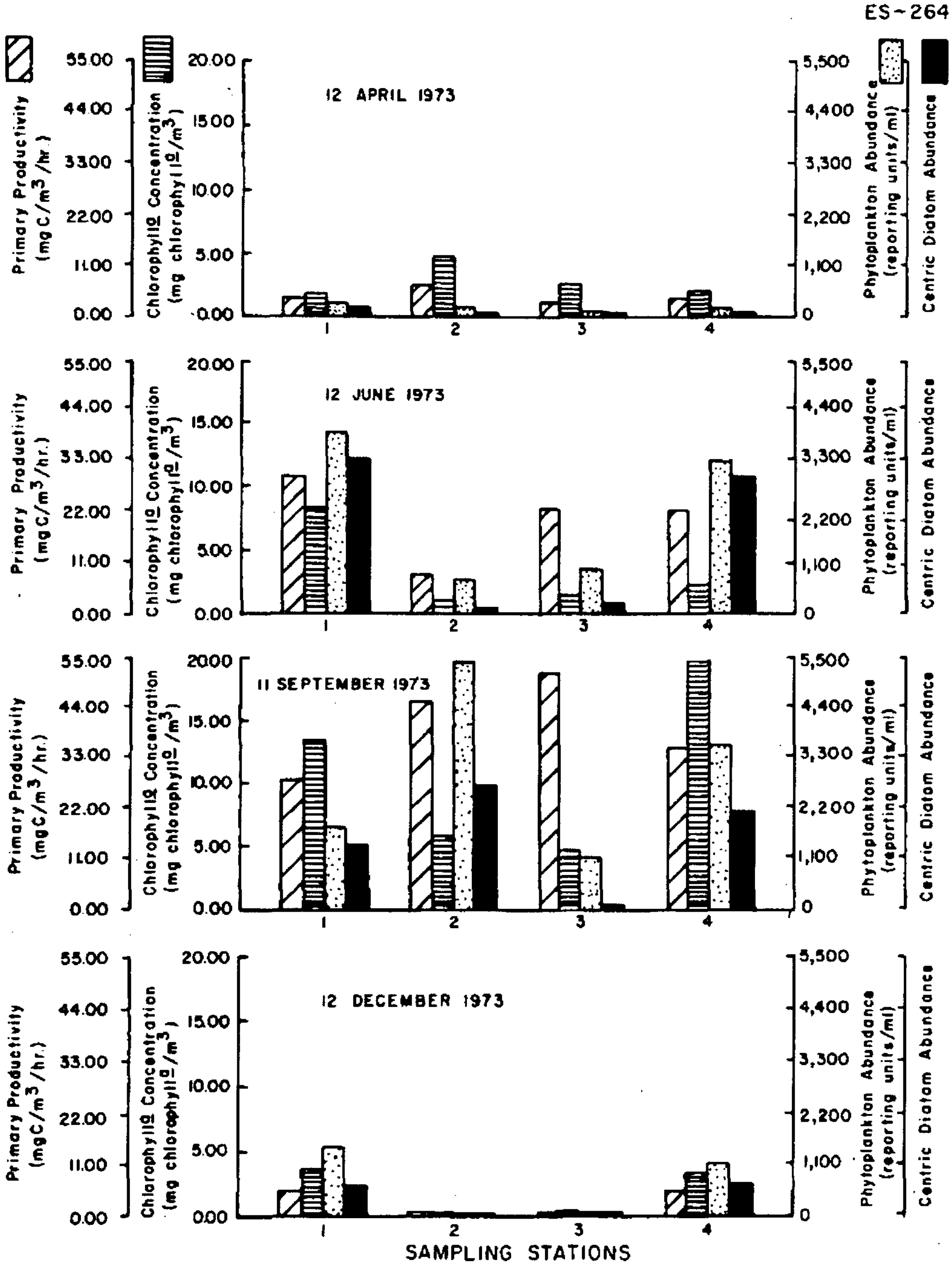

Fig. 2.12. Primary productivity, chlorophyll *a* concentrations, centric diatom abundance, and total phytoplankton abundance. Source: ER, Fig. 2.7-1.

2.7.2.3 Consumers

Zooplankton

Zooplankton generally constitute the major grazers of phytoplankton. The zooplankton in turn are preyed upon by larval and juvenile fish, planktivorous adult fish, and by other zooplankters such as *Cyclops* and *Leptodora*.

Sampling conducted by the applicant indicates total zooplankton abundance varies widely among seasons and sampling stations (Table 2.6). The Neosho River exhibited considerably lower zooplankton densities than John Redmond Reservoir during each sampling period (Table 2.6). These lower densities resulted from the loss of strictly lentic species upon introduction into the lotic waters of the Neosho River. Another factor leading to mortality is the ingestion of large quantities of silt by plankters where the turbulent discharge from the reservoir enters the Neosho River and kicks up silt.[31]

Table 2.6. Total zooplankton abundance for John Redmond Reservoir, Neosho River, and Wolf Creek, Kansas, March through December, 1973

Date of collection	Total number of organisms/m³			
	Sampling station 1[a]	Sampling station 2[a]	Sampling station 3[a]	Sampling station 4[a]
March 27	2,374	657	408	498
June 12	88,783	21,190	4,378	26,804
September 10	56,785	144,428	112,822	50
December 10	8,768	1,596	680	3,034

[a]Sampling station 1: John Redmond Reservoir – open water near dam.
Sampling station 2: Wolf Creek – near upper end of future impoundment.
Sampling station 3: Wolf Creek – near future dam location.
Sampling station 4: Neosho River – below confluence with Wolf Creek.
Source: ER, Table 2.7-10.

As might be expected, the copepods and cladocerans together provided a majority of the individuals in all samples, ranging from 63.8 to 99.9% of total zooplankton. Fifteen species of copepods and 25 species of cladocerans were identified in the study area during the one-year sampling period. An additional four species of cladocera and several rotifer taxa from John Redmond Reservoir were identified by Prather and Prophet in the summer of 1968.[32]

The dominant species was the cladoceran *Bosmina longirostris* which comprised up to 69% of the total zooplankton in temporary pools of Wolf Creek during September. Figure 2.13 compares Wolf Creek zooplankton community composition with that of John Redmond Reservoir.

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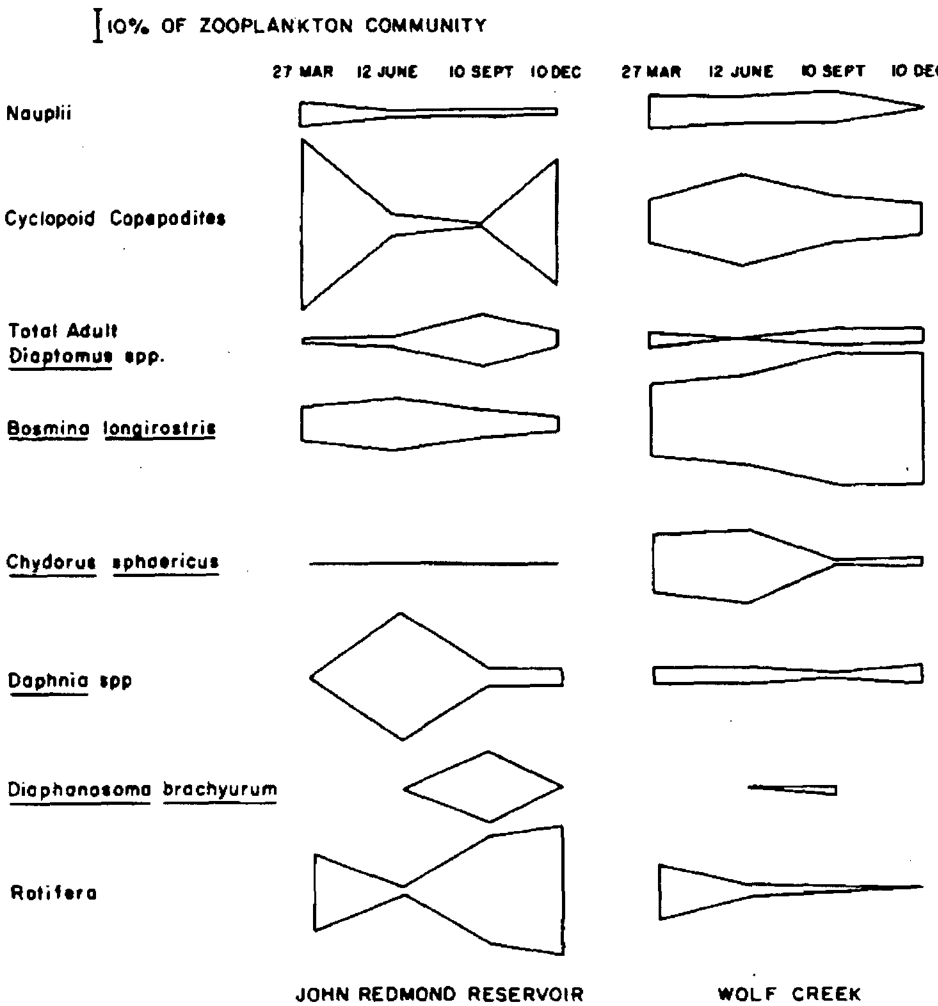

Fig. 2.13. Zooplankton community composition in John Redmond Reservoir and Wolf Creek, 1973. Source: ER, Fig. 2.7-2.

Benthos

Benthic organisms are important food items in the diet of many fish. Quarterly sampling conducted by the applicant revealed a total of 96 species of benthic macroinvertebrates representing 47 families in the study area. This relatively rich species diversity is typical of many midwestern lakes, rivers, and streams (ER, p. 2.7-14). Even so, 75% of the total benthos are blackfly larvae, tubificid worms, and chironomid midges (ER, Appendix 2.7A).

Among the most important factors in determining abundance and species composition of the benthos in lakes and reservoirs are temperature, dissolved oxygen, time of year, and physical characteristics of the substrate. The bottom of John Redmond Reservoir is an ooze of fine silt (ER, p. 2.7-14), which is characteristic of shallow reservoirs with few tributaries. Important benthic fauna include numerous tubificid worms and insect larvae of *Chironomus, Coelotanypus, Tanypus*, and *Chaoborus punctipennis*. These organisms constituted at least 93% of the reservoir benthos at each sampling period.

Wolf Creek enjoys the greatest benthic species diversity, most likely due to the variety of microhabitats[26] offered by several substrates (silt, clay, rocks, gravel, etc.) and current velocities. Among the dominant taxa during at least one season of the year were nematodes, tubificids, blackfly larvae (up to 6105/m^2 in March), chironomids such as *Orthocladius* sp. (Diptera), and fingernail clams (*Sphaerium transversum*). Other less numerous aquatic insects included mayflies, odonates, true flies, stoneflies, beetles, bugs, and caddisflies. Much of the benthic fauna in Wolf Creek is representative of clean streams.[33]

Species diversity analyses of benthic fauna in John Redmond Reservoir from September 1971 to August 1972 indicated the presence of moderate pollution.[34] The major sources of pollution in John Redmond Reservoir, as previously enumerated, are feedlot runoff, effluent from upstream sewage plants, and cropland runoff.

The substrate of rich, silty organic detritus in the Neosho River supports a benthic fauna of somewhat less diversity. However, lack of data from March and June due to flooding probably resulted in some of this apparently reduced diversity. High flows in December reduced total density of benthos by 96.3% (ER, p. 2.7-15).

Important benthic taxa in the Neosho River included *Hexagenia* nymphs, *Ablabesmyia* larvae (Diptera), Ceratopogonidae larvae, *Polypedilum* larvae (Diptera), and Hydra (Cnidaria).

Fish

A total of 30 species of fish was collected from the study area during the one-year sampling program: 16 species from John Redmond Reservoir, 22 from Wolf Creek, and 15 from the Neosho River. Eight of the species collected were common to all three bodies of water. The red shiner (*Notropis lutrensis*) was most abundant, accounting for 38% of all fish caught. The other most common species found in all three bodies of water included orangespotted sunfish (*Lepomis humilis*), white crappie (*Pomoxis annularis*), and the bullhead minnow (*Pimephales vigilax*).

The Endangered Species Committee of the American Fisheries Society[35] lists two fishes known to have occurred in the Neosho River near the site[36] (the Neosho madtom, *Noctυrus placidus*, and the river redhorse, *Moxostoma carinatus*) as endangered and depleted, respectively. The Neosho madtom is endemic to the Neosho River basin and the lower part of the Illinois River and has the smallest range of any Kansas fish.[36]

The Conservation Committee of the Kansas Academy of Science lists four other fish of the Neosho River as rare, endangered, or peripheral species in Kansas, but not nationally. These are the gravel chub, *Hybopsis x-punctata* (endangered); the highfin carpsucker, *Carpiodes velifer*, known in Kansas only from Neosho County (endangered); the blue sucker, *Cycleptus elongatus* (rare); and the spotted gar, *Lepisosteus osculatus*, known in Kansas only from Neosho County (periphery of range).[37]

Eleven species collected exclusively from Wolf Creek included black bullheads, bluegills, largemouth bass, blackstripe topminnows, golden redhorse suckers, bluntnose minnows, log perch, and johnnydarters. The staff feels that this last species may have been a misidentified blunt-nosed darter (*Etheostoma chlorosomum*) since the johnnydarter has never been reported from the Neosho watershed. Recent independent sampling efforts resulted in the collection of blunt-nosed darters, an orange-throated darter, yellow bullheads, and red-finned shiners.[38]

The most frequently caught fish in John Redmond Reservoir were white bass (76 total), redshiners (75), ghost shiners (74), gizzard shad (54), river carpsuckers (23), white crappie (20), and channel catfish (13). In the Neosho River, bullhead minnows (92), red shiners (42), ghost shiners (35), and white crappie (18) dominated the catch. A species list with numbers of each species captured from each sampling station is presented in Appendix Table C.2. Habitat, food, and spawning preferences for each species are also provided in Appendix Table C.2. Twenty-seven species known to have occurred in or near the site area but not observed by the applicant are listed in Appendix Table C.3.

Soon after impoundment, the fry or fingerlings of largemouth bass, channel catfish, walleye, striped bass, bluegill, and crappie were introduced into John Redmond Reservoir.[39] White crappie, white bass, and walleye experienced rapid growth during the first two or three years while no striped bass are known to have been taken. Bullheads and channel catfish have provided good fishing in the reservoir proper, and tailwaters have yielded apparently satisfactory numbers of walleye, white bass, channel catfish, flatheads, and crappie to anglers. The mouths of tributaries emptying into John Redmond Reservoir provided good fishing for largemouth bass in 1967.[39]

In addition to the expected gizzard shad, channel and flathead catfish, drum, and carp, the use of rotenone in Kennedy Cove in August 1969 yielded longnose gar, bigmouth buffalo, spotted bass, green sunfish, and a slender-headed darter,[39] the latter perhaps an accidental one that drifted down from a tributary. None of the last five fish were observed in John Redmond Reservoir by the applicant.

Test nettings (gill and fyke nets) in John Redmond Reservoir were performed in late November 1973 by the Kansas Forestry, Fish, and Game Commission.[40] Their findings are summarized in Table 2.7. Game fishes comprised about 39% by weight of all fish collected, while rough fish contributed about 51%. Panfishes (mainly white crappie) and forage fishes (mainly gizzard shad) each contributed 5% by weight to the total catch. The presence of gizzard shad seems to be a requirement for white bass populations in reservoirs of this region.[36]

Table 2.7. Test netting results at John Redmond Reservoir on November 28, 29, and 30, 1973

Species	Number	Percent of total number	Total weight (lbs)	Percent of total weight
Game fishes				
White bass	59	8.27	55.70	23.48
Channel catfish	24	3.37	37.88	15.96
Total	83	11.64	93.58	39.44
Panfishes				
Black bullhead	1	0.14	0.11	0.05
White crappie	221	31.00	11.97	5.04
Total	222	31.14	12.08	5.09
Forage fishes				
Golden shiner	1	0.14	0.05	0.02
Gizzard shad (<8 in.)	319	44.74	11.61	4.89
Total	320	44.88	11.66	4.91
Rough fishes				
River carpsucker	27	3.79	25.71	10.84
Smallmouth buffalo	5	0.70	7.73	3.26
Bigmouth buffalo	1	0.14	8.06	3.40
Freshwater drum	16	2.24	10.70	4.51
Carp	18	2.52	55.34	23.33
Northern redhorse	1	0.14	0.59	0.25
Gizzard shad (>8 in.)	20	2.81	11.82	4.98
Total	88	12.34	119.95	50.56
Grand total	713	100.00	237.27	100.00

Source: Kansas Forestry, Fish and Game Commission, "Test Netting Results at John Redmond Reservoir on November 28, 29, 30, 1973," collections by T. W. Gengerke, Kansas Forestry, Fish and Game Commission (unpublished).

The major man-induced stresses on the John Redmond Reservoir and the Neosho River are enumerated in Sect. 2.7.2.1. In the past, feedlot runoff has resulted in serious fish kills in the Neosho River and in John Redmond Reservoir. A kill on April 5, 1967, numbered more than 125,000 fish of which more than 18,000 were walleyes.[39] The majority of these were gravid females of 4 lb or more. Up to 5000 channel and flathead catfish were also among the dead. Since then, State legislation has been passed which has presumably reduced the frequency and extent of fish kills due to feedlot runoff.[39,41]

In addition to the 30 species of fish collected by the applicant, at least 25 others, including the rare and endangered species referred to previously, are listed as having occurred in the Neosho River in or near the study area.[36] Most of the species listed in Appendix Table C.2 were collected either in the Neosho River in Coffey County or barely outside the county line.

Cross and Braasch, in a comparative study of fish abundance in the upper Neosho River system for the years 1952 and 1967, found serious losses in diversity of fish fauna over that 15-year span. Abundance declined precipitously for at least 20 species, including the endangered Neosho madtom, due in part to feedlot pollution[42] and drought conditions.

Probably as a result of the brevity and low frequency of sampling periods (one of two days each season), the applicant acquired no data regarding ichthyoplankton in any of the bodies of water. This aspect receives further consideration by the staff in Sect. 6.1.3.

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3. THE STATION

3.1 EXTERNAL APPEARANCE

A view of the station from the northwest is shown in Fig. 3.1. Prominent features are the reactor containment vessel, the turbine-generator building, and the auxiliary building. The domed roof containment vessel will be about 234 ft high and the turbine-generator building will be about 150 ft high. The electrical switchyard will be located just to the north of these buildings.

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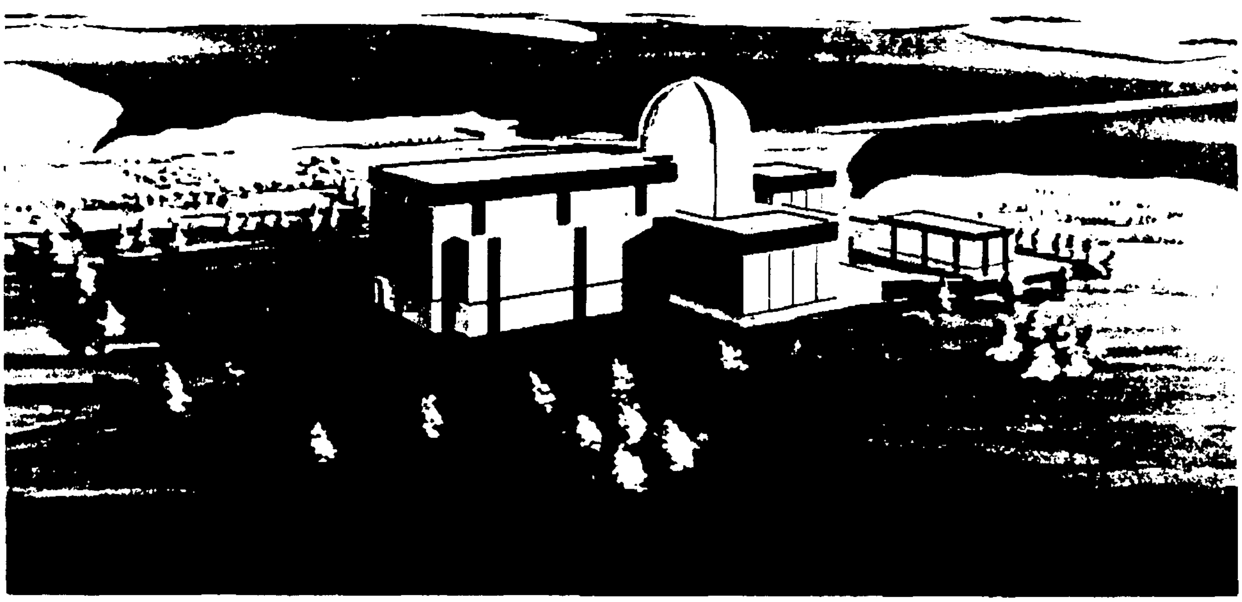

Fig. 3.1. View of Wolf Creek Generating Station from the northwest. Source: ER, Frontispiece.

The upper part of the station will be visible from U.S. Highway 75, which is 2.75 miles west. The station also will be visible from a number of local roads in the area, some of which will pass within 1.5 miles of the station.

3.2 REACTOR, STEAM-ELECTRIC SYSTEM, AND FUEL INVENTORY

The station will consist of a pressurized nuclear reactor steam supply system supplied by Westinghouse Electric Corporation and a turbine-generator supplied by General Electric Company. The plant buildings will be designed by Bechtel Associates Professional Corporation, the power block architect-engineer, and the remainder of the site will be designed by Sargent and Lundy Engineers, the site architect-engineer.

The nuclear steam supply system will consist of a reactor vessel and four primary coolant loops, each with a circulating pump and a steam generator. The rated reactor core power level is 3411 MWt and the pumps will add 14 MWt to produce a rated nuclear steam supply system power level of 3425 MWt. The nuclear steam supply system is anticipated to reach ultimately a power level of 3579 MWt. The net turbine generator output is a nominal 1150 MWe. The expected inplant usage is approximately 70 MVA.

The core of the reactor will contain 193 fuel assemblies, each of which will contain 264 fuel rods consisting of cylindrical uranium dioxide pellets sealed inside zirconium alloy tubes. The total mass of uranium dioxide in the core will be 111.4 tons.

At design power, water pressurized to 2250 psia will be heated to 617°F (325°C) in the reactor core and pumped inside the steam generator tubes. Here the pressurized water will transfer its heat to the steam system water to produce steam having conditions of 965 psia and 541°F at the turbine throttle.

3.3 STATION WATER USE

Condenser cooling will be the primary use for water at the station. At full power operation the condensers will use 1178 cfs of cooling water, which will rise in temperature 30.0F° (16.7C°). The station also will require 78 cfs cooling water to cool the miscellaneous plant equipment. The essential service water system will provide 33.5 cfs of the water required for a safe plant shutdown. It will operate following an accident and/or loss of offsite power. Other miscellaneous water requirements are shown in Fig. 3.2.

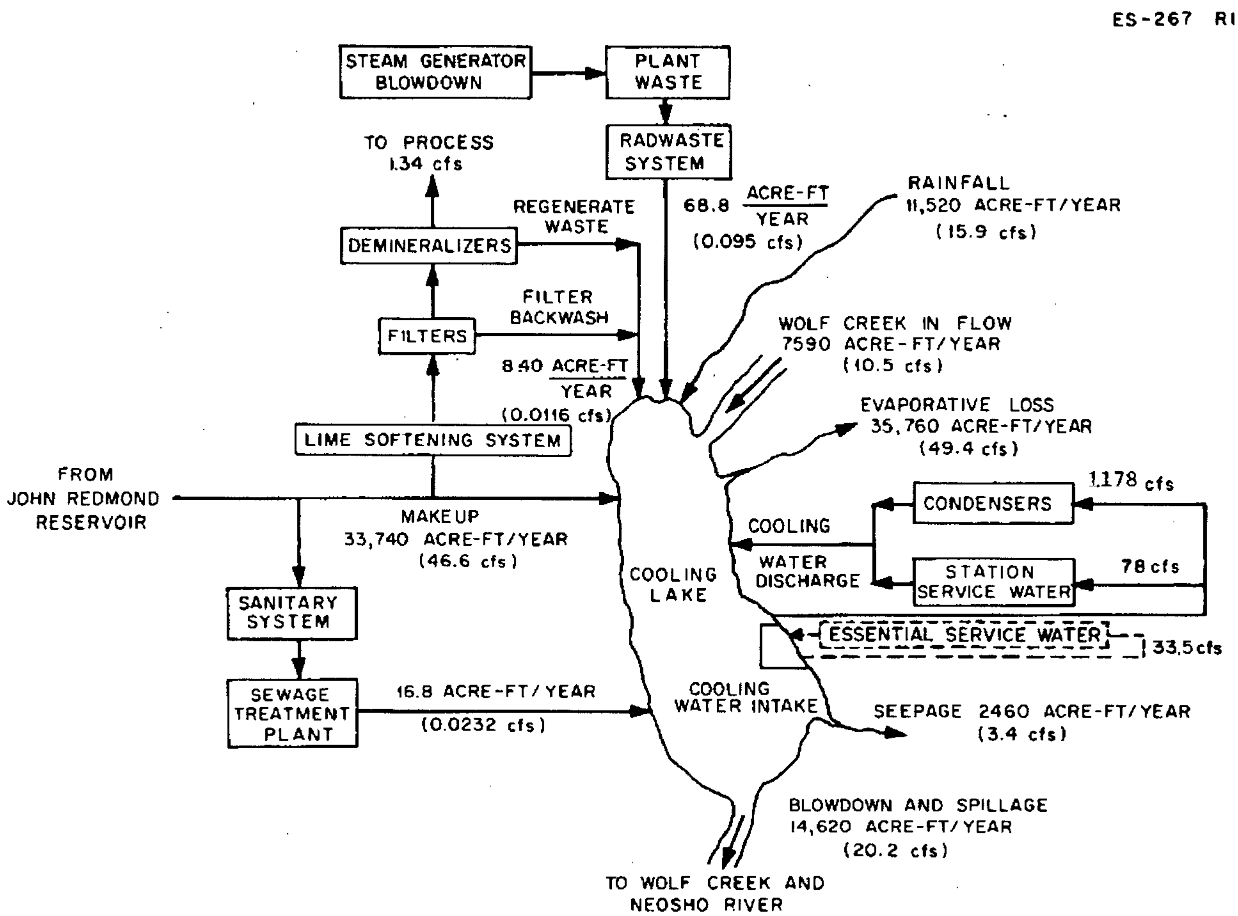

Fig. 3.2. Predicted average water budget for Wolf Creek Generating Station. (Note: 1 cfs = 450 gpm = 725 acre-ft/year.)

Makeup water for the cooling lake will be obtained from John Redmond Reservoir. A minimum of 41 cfs will be pumped from the reservoir to the cooling lake. When the water level in John Redmond Reservoir is at or above its conservation level of 1039 ft MSL, water will be pumped to the cooling lake at various rates up to a maximum of 120 cfs. Potable water to be used for the station's sanitary purposes also will be obtained from John Redmond Reservoir.

3.4 HEAT DISSIPATION SYSTEM

3.4.1 General description

Circulating and service water for the station will be drawn from and returned to Wolf Creek cooling lake. An ultimate heat sink within the lake will be formed by a small dam (submerged during normal reactor operation) that will dissipate the reactor afterheat in case there is insufficient water in the main cooling lake. Rainfall and runoff in Wolf Creek drainage area will not be sufficient to accommodate the natural and induced evaporative water losses in the cooling lake (Fig. 3.2). Makeup water, therefore, will be pumped from John Redmond Reservoir into Wolf Creek cooling lake. Normally, cooling lake water will be discharged at a rate of 3.5 cfs to lower Wolf Creek and the Neosho River to help maintain the cooling lake water quality. During droughts there will be no discharge of water from the cooling lake. Following a drought, water will be discharged from the cooling lake at a rate of 40 cfs into lower Wolf Creek and the Neosho River, as permitted by Neosho River flows, for periods up to several years.

3.4.2 Station cooling system description

During operation all of the station cooling water will be pumped into the station through the circulating water intake structure and released to the lake through the discharge structure as shown in Fig. 2.2. When the plant is shut down during an emergency, 33.5 cfs of cooling water (essential service water) will be pumped into the station through the essential service water intake structure and discharged back into the lake through the essential service water discharge structure as shown in Fig. 2.2.

A sketch of the circulating water intake structure is shown in Fig. 3.3. Three of the four 393-cfs-capacity pumps will provide the 1178 cfs of circulating water flow. Two of the three 39-cfs-capacity pumps will provide the 78 cfs of service water flow. The invert of this structure will be at 1056 ft MSL. The normal water elevation in Wolf Creek cooling lake will be at 1087 ft MSL. The applicant (ER, page 3.3-3) states that the lowest probable cooling lake water level will be 1084.8 ft MSL with the reactor operating at a mean annual plant factor of 75%. If another unit is installed at the station at a later date, the applicant states that the lowest probable cooling lake water level will be 1075.6 ft MSL when both units are operating at a mean annual plant factor of 75% (ER, p. 3.4-2). The cooling lake level below which operation of the reactor will be stopped is 1070 ft MSL. This is the surface level of the ultimate heat sink (PSAR, p. 2.4-28a).

The circulating and the service water will flow from the cooling lake through trash racks into bays where the traveling screens will be located as shown in Fig. 3.3. The trash racks will be used for removing the larger debris. When the smaller debris collected on the traveling screens results in an increase in the differential pressure across the screens, they will be rotated and washed clean. The staff has calculated the velocities of the water approaching and within this intake structure (Table 3.1). At the cooling lake water level of 1075.6 ft MSL, the velocity of the water approaching the traveling screens will be about 1.0 fps and that passing through the trash racks will be about 1.2 fps. For operation of the station below this cooling lake water level, the applicant (ER, p. 3.4-2) states that these circulating water flow rates will be maintained or fish impingement at the intake structure will be monitored.

Table 3.1. Staff-calculated velocity of circulating water in the intake structure

	Circulating water intake velocity at indicated lake level (fps)			
	1070.0 ft	1075.6 ft	1084.8 ft	1087.0 ft
Approach to trash rack	1.08	0.77	0.52	0.49
Through trash rack	1.62	1.15	0.79	0.73
Approach to traveling screens	1.43	1.02	0.69	0.64
Through traveling screens	2.85	2.04	1.39	1.29

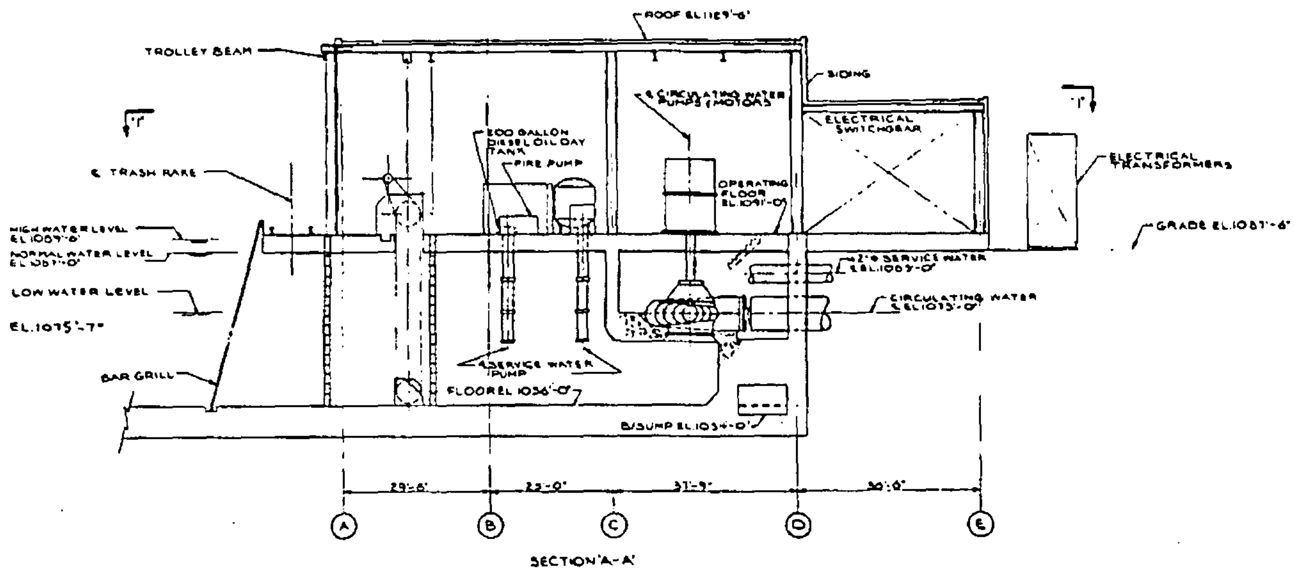

Fig. 3.3. Circulating water intake structure for Wolf Creek Generating Station. Source: Based on information from ER, Fig. 3.4-4.

The circulating water will be pumped from the intake structure through a 12-ft-diam pipe to the steam condenser, which is designed to increase the circulating water temperature 30F° (16.7C°) at full operating load. The warmed water then will flow from the condenser through a 12-ft-diam pipe to the outfall structure. Holdup times of the circulating water in the inlet pipe, the condenser, and the outlet pipe will be about 3 min, 18 sec, and 2 min, respectively.

At the discharge structure the circulating water will be released into a well having its crest at 1100 ft MSL. The water will then flow over the crest of this well and down into the cooling lake on a 40-ft-wide concrete apron having a slope of 1 ft vertical per 4 ft horizontal.

The 78 cfs of service water will be pumped from the intake structure to the power plant through a 42-in.-diam pipe. There it will be heated about 10F° (5.6C°) and discharged into the 12-ft-diam pipe containing the circulating water flowing from the steam condenser to the outfall structure.

When required, the essential service water for the station will be pumped by one of the two 33.5-cfs pumps in the essential service water intake structure located at the ultimate heat sink shown in Fig. 2.2. It will flow to the plant through a 30-in.-diam pipe and back to the ultimate heat sink through two separate 42-in.-diam pipes. The essential service water will then discharge from these pipes to the ultimate heat sink. Additional details of the essential service water intake and discharge structures are provided by the applicant (PSAR, Figs. 3.8-1 through 3.8-3).

The essential service water will flow into the essential service water intake structure through 8 by 8 ft openings. These openings will be submerged and covered with 3/8 in. mesh screens having 1/4 in. openings. The staff calculated that the velocity of the water approaching these screens will be 0.5 fps and that passing through the screens will be 1.2 fps.

3.4.3 Wolf Creek cooling lake

Wolf Creek cooling lake will be formed by constructing an earth rolled dam across Wolf Creek and six earth rolled dikes about the perimeter of the lake, as shown in Fig. 2.2. The main dam will be located about seven stream miles from the Wolf Creek and Neosho River confluence. The crests of the main dam and the perimeter dikes will be at 1100 ft MSL. The main dam will have a service spillway with an ogee crest of 1088 ft MSL. An auxilary (emergency) spillway will be located about 1500 ft east of the service spillway and will have a crest elevation of 1090.5 ft MSL. Low-level outlet works and the blowdown line (60-in.-diam and 24-in.-diam pipes, respectively) will be located in the west abutment of the dam. The entrance to the low-level outlet works will be installed at an elevation of 1035 ft MSL. Within the lake two baffle dikes having crests at 1094 ft MSL and three canals having inverts at 1070 ft MSL will be built to prevent short circulating of the water flowing from the circulating water discharge to the circulating water intake. Other details of the cooling lake, including its topography, are provided by the applicant (ER, Fig. 3.4-2).

WCCL = 7.95 sq. miles surface area   19.45 sq. miles of WC drainage excluding WCCL

About 27.4 sq miles of the 35-sq-mile Wolf Creek basin will be upstream of the main dam. Monthly water runoff rates in Wolf Creek at the main dam site have been estimated by the applicant using the October 1947-September 1971 flow data obtained in the rivers in the vicinity of Wolf Creek (PSAR, Table 2.4-18).

The area and capacity curves for Wolf Creek cooling lake are shown in Fig. 3.4. A summary of the volumes and surface areas for Wolf Creek cooling lake at elevations of interest is given in Table 3.2.

The bottom surfaces of the cooling lake canals will be at 1070 ft MSL and will be 215 ft wide. Slopes of the canal sides will be 1 ft vertical per 3 ft horizontal. Table 3.3 gives the staff's calculated water velocity at the normal water level and at the applicant's predicted low water level. The staff assumed the volumetric water rate in these canals to be 1256 cfs with one operating unit and 2512 cfs with two operating units. The water velocity will be 0.3 fps when the cooling lake water level is at 1084.8 ft MSL.

Makeup water for Wolf Creek cooling lake will be pumped from the makeup water intake structure located on the east bank of the Neosho River about 750 ft downstream of the John Redmond Dam. The makeup water will be pumped through a 54-in.-diam pipe which follows the route indicated in Fig. 2.2, to a discharge structure located on the west side of Wolf Creek cooling lake. Water will be drawn into the intake structure from a canal, which will run along the east side of the Neosho River bed from John Redmond Dam to just downstream of the makeup water intake structure. The invert of this canal at the intake structure will be 995 ft MSL.

Normally water will be fed to this canal from the water released or flowing over the John Redmond Dam spillway crest (1033 ft MSL). If there is insufficient water being released over the spillway crest, additional water will be released through the two 24-in.-diam pipes passing through the dam. If the amount of water being released is still insufficient, additional water will be released through the 30-in.-diam pipe passing through the dam. The portions of these pipes passing through the dam were installed at an elevation of 1016.5 ft MSL. The 30-in. pipe was installed to provide water for industrial uses and the 24-in. pipes were installed to permit water releases to the Neosho River.

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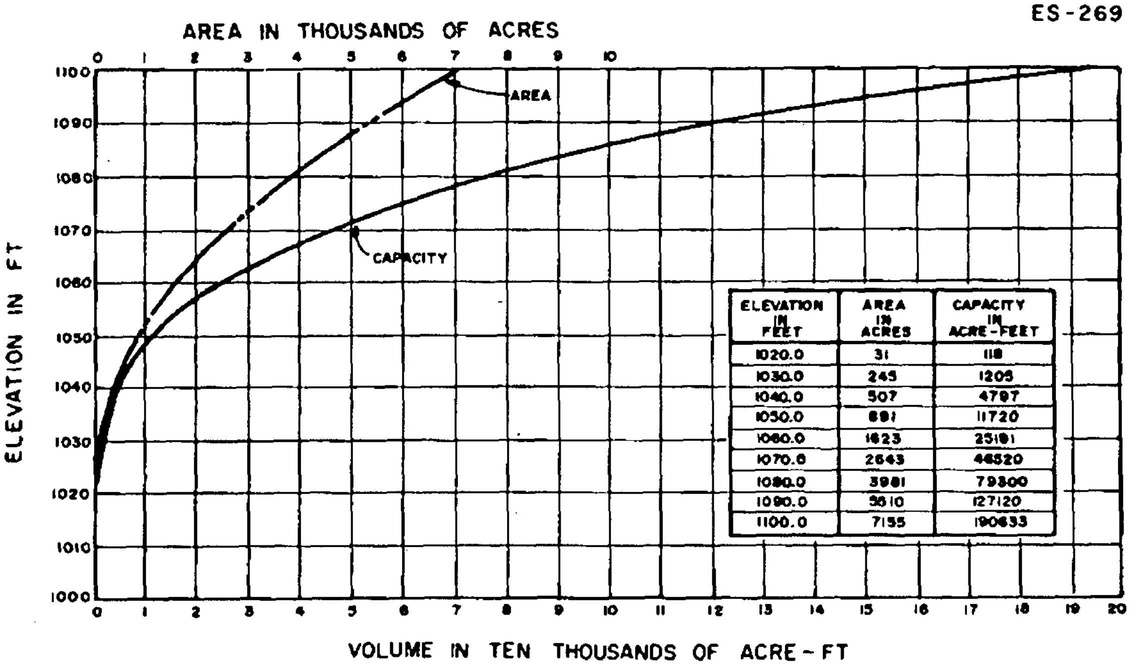

Fig. 3.4. Area and capacity curves for Wolf Creek cooling lake. Source: ER, Fig. 3.4-9, Revision 2.

Table 3.2. Volume and surface-area of Wolf Creek cooling lake

	Elevation (ft MSL)	Acre-ft	Acres
Probable minimum operating level with one operating unit	1084.8	99,900	4750
Probable minimum operating level with two operating units	1075 6	63,200	3390
Normal operating level	1087	111,280	5090
Probable maximum flood level[a]	1095.2	157,900	6350

[a]Source: PSAR, p. A-19.

Table 3.3. Staff-calculated water velocity in Wolf Creek cooling lake canals

	Canal water velocities at various lake levels		
Lake level (ft MSL)	1075.6	1084.8	1087.0
Velocity (fps), 1 unit	0.97	0.33	0.28
Velocity (fps), 2 units	1.94	0.66	0.56

The openings of the three pipes passing through the dam are flush with the upstream face of the dam. Trash racks installed in front of these openings consist of 0.75 x 6-in. bars (0.75 in. normal to flow), mounted horizontally on 11-in. centers and 0.5 x 1-in. bars (0.5 in. normal to flow) mounted vertically on 10.5-in. centers. Water will flow by gravity through these pipes and will drop into the canal just below the dam.

At a 100-cfs flow rate, the velocity of water flowing only through the two 24-in. pipes would be 15.9 fps. With water flowing through all three pipes, this velocity would be less.

The makeup water intake structure will be somewhat similar in appearance to the circulating water intake structure shown in Fig. 3.3. Water will be drawn through a trash rack and three bays containing traveling screens to the makeup water pumps. Three 40-cfs pumps will be installed in this structure, and the traveling screens will be common to all the pumps. The invert of this structure will be the same as that of the makeup water canal (995 ft MSL). The water level in this canal is assumed to be normally at 1007.5 ft MSL, but it could drop to 1003.5 ft MSL (ER, Fig. 10.2-8). During the standard project flood, it could be as high as 1028.5 ft MSL. The staff calculated the water velocities in the makeup water intake structure at these elevations (Table 3.4). The maximum water velocity through the trash rack would be 0.50 fps.

Table 3.4. Staff-calculated velocity of makeup water in the intake from the canal

	Water intake velocity at indicated canal levels (fps)		
	1003.5 ft	1007.5 ft	1028.5 ft
Approach to trash rack			
40 cfs flow rate	0.11	0.08	0.03
120 cfs flow rate	0.36	0.23	0.09
Through trash rack			
40 cfs flow rate	0.17	0.11	0.03
120 cfs flow rate	0.50	0.34	0.13
Approach to traveling screens			
40 cfs flow rate	0.14	0.10	0.04
120 cfs flow rate	0.42	0.29	0.11
Through traveling screens			
40 cfs flow rate	0.28	0.19	0.07
120 cfs flow rate	0.84	0.57	0.21

At the discharge structure, makeup water will be released into a well having its crest at 1099 ft MSL. The makeup water then will flow over the crest of this well down into the cooling lake on a 10-ft-wide concrete apron having a slope of 1 ft vertical per 4 ft horizontal. Two 400-gpm pumps are located in the well of this discharge structure for the purpose of providing potable water to the plant and makeup water to the demineralizing system (Appendix A, p. A-20).

Flow through the low-level outlet works and the blowdown line will be controlled by valves located within the dam (ER, Fig. 3.4-2b). Water will flow into the 60-in.-diam pipe through a 12 x 9 x 9-ft trash rack that will be fabricated of 5/6 x 2-in. bars (5/6 in. normal to flow) mounted on a 20-in.-vertical by 8.5-in.-horizontal pitch. The water velocities through the 60-in. pipe will be 0.2 and 2.0 fps for 3.5-and 40-cfs blowdown rates, respectively.

Normally, at a short distance downstream of the entrance, the blowdown water will flow into a 24-in.-diam branch pipe that will be parallel to the 60-in. pipe. It will then flow back into the 60-in. pipe just downstream of the control valves and then discharge to a stilling basin located at the foot of the dam. The water velocities in the 24-in. pipe will be 1.1- and 12.7-fps for 3.5- and 40-cfs blowdown rates, respectively.

The blowdown water will flow from the stilling basin through a cut down to the Wolf Creek stream bed and on to the Neosho River. When the cooling lake discharge rate is 3.5 cfs, the depth of water in lower Wolf Creek will vary from 0.2 to 1.7 ft and the width will be about 25 ft. For a cooling lake discharge rate of 40 cfs, the lower Wolf Creek water depth will vary from 1.0 to 3.1 ft and the average width will be 32 ft.

3.5 RADIOACTIVE WASTE SYSTEMS

During the operation of Wolf Creek Generating Station, radioactive materials will be produced by fission and by neutron activation of corrosion products in the primary coolant. From the radioactive materials produced, small amounts of gaseous and liquid radioactive wastes will enter the waste streams. These streams will be processed and monitored for radioactivity within the station to reduce the quantities of radionuclides ultimately released to the atmosphere and to the cooling lake. The waste handling and treatment systems to be installed at the station are discussed in the SNUPPS Preliminary Safety Analysis Report dated June 1974, and the applicant's Environmental Report dated May 1974. These documents contain an analysis of the treatment systems and an estimate of the expected annual release of radioactive effluents.

In the following paragraphs, the waste treatment systems are described and an analysis is given based on the staff model of the applicant's proposed radioactive waste systems.. The model has been developed from a review of available data from operating nuclear power plants, adjusted to apply over an assumed 40-year plant operating life. The staff's liquid source terms are calculated by means of a revised version of the ORIGEN Code which is described in ORNL-4628.[1] Staff gaseous source terms are calculated by means of the STEFFEG Code.[2] The principal parameters used in our source term calculations are given in Table 3.5. The bases for these parameters are given in WASH-1258.[3]

On April 30, 1975 the Nuclear Regulatory Commission announced its decision in the rulemaking proceeding (RM 50-2) concerning numerical guides for design objectives and limiting conditions for operation to meet the criterion "as low as practicable" for radioactive material in light-water-cooled nuclear power reactor effluents. This decision is implemented in the form of a new Appendix I to 10 CFR 50.

To effectively implement the requirements of Appendix I, the NRC staff is presently reassessing the parameters and mathematical models used in calculating releases of radioactive materials in effluents in order to comply with the Commission's guidance. In the interim, until such reassessment is completed and can be applied to the Wolf Creek Station, the staff has prepared upper bound estimates of the potential effect on the estimated radiological environmental impact set forth in the FES. The dose estimates discussed in Section 5.4 used revised estimates of expected annual releases of radioactive materials in effluents from the Wolf Creek Station.

On the basis of information presently available on the technology to reduce radioactive effluent releases, the Wolf Creek Station can be designed to meet the requirements of Appendix I.

The siting of a second identical unit, utilizing a separate radioactive waste system, would require doubling the calculated source terms.

3.5.1 Liquid wastes

The liquid radioactive waste will be processed on a batch basis to permit optimum control of releases. Prior to being released, samples will be analyzed to determine the types and amounts of radioactivity present. Based on the results of the analysis, the waste will be released under controlled conditions to the cooling lake or retained for further processing. Radiation monitors will automatically terminate liquid waste discharges if radiation measurements exceed a predetermined level in the discharge line. A simplified diagram of the liquid radioactive waste treatment systems is shown in Fig. 3.5.

Table 3.5. Principal parameters and conditions used in calculating releases of radioactive material in liquid and gaseous effluent from Wolf Creek Generating Station

Reactor power level (MWt)	3565
Plant capacity factor	0.80
Failed fuel[a]	0.25%
Primary system	
Mass of coolant (lb)	2.13×10^6
Letdown rate to CVCS (gpm)	75
Shim bleed rate (gpm)	1.3
Leakage rate to secondary system (lb/day)	110
Leakage rate to auxiliary building (lb/day)	160
Leakage rate to containment building (lb/day)	240
Secondary system	
Steam flow rate (lb/hr)	1.51×10^7
Mass of steam/steam generator (lb)	8.5×10^3
Mass of liquid/steam generator (lb)	9.6×10^4
Secondary coolant mass (lb)	2.13×10^6
Rate of steam leakage to turbine building (lb/hr)	1.7×10^3
Steam generator blowdown rate (gpm)	18.2
Dilution flow (gpm)	5×10^3
Containment building volume (ft^3)	2.5×10^6
Frequency of containment purges (per year)	4
Iodine partition factors (gas/liquid)	
Leakage to containment building	0.1
Leakage to auxiliary building	0.005
Steam leakage to turbine building	1
Steam generator (carryover)	0.01
Main condenser air ejector	0.0005

Decontamination factors (liquids)

	I	Cs, Rb	Mo, Tc	Y	Others
Boron recovery system	10^5	2×10^3	10^5	10^4	10^4
High conductivity waste treatment system	10^3	2×10^3	10^5	10^4	10^4
Low conductivity waste treatment system	10^2	10^3	10^5	10^4	10^3
Steam generator blowdown treatment system	10^2	20	10^2	10	10^3

	All nuclides except iodine	Iodine
Waste evaporator DF	10^4	10^3
BRS evaporator DF	10^3	10^2

	Cation[b]	Anion[b]	Cs, Rb
Mixed bed demineralizer DF (H^+OH^-)[c]	10^2(10)	10^2(10)	2(10)
Mixed bed demineralizer DF ($LiBO_3$)[d]	10	10	2

(Note: for two demineralizers in series, or for a polishing demineralizer, the DF for the second demineralizer is given in parentheses)

	Removal factor
Removal by plateout	
Mo, Tc	10^2
Y	10

[a]This value is constant and corresponds to 0.25% of the operating power fission product source term.

[b]Does not include Cs, Mo, Y, Rb, Tc.

[c]Applies to all mixed bed demineralizers except CVCS letdown demineralizer.

[d]CVCS letdown demineralizer.

The chemical and volume control system (CVCS) will process primary coolant from the letdown heat exchangers. In the staff evaluation of the radionuclide removal provided by the CVCS, the principal components considered were two mixed-bed demineralizers and one cation demineralizer. The boron recovery system (BRS), a CVCS subsystem, will process a portion of the CVCS flow (shim bleed) for boron control along with equipment drain wastes collected inside the reactor containment in the reactor coolant drain tank. The principal BRS components considered in the evaluation were two mixed-bed demineralizers, an evaporator, an anion demineralizer, and three holdup tanks.

Miscellaneous radioactive wastes collected outside the reactor containment will be processed through the liquid waste processing system (LWPS). The LWPS will segregate and process wastes according to their chemical makeup. High conductivity wastes will be processed through a subsystem consisting of a floor drain tank, a charcoal absorber (for removal of organics), a mixed-bed demineralizer, an evaporator, and a waste monitoring tank. Low conductivity wastes will be processed through a subsystem consisting of a waste holdup tank, an evaporator, a mixed-bed demineralizer, and an evaporator condensate tank. Turbine building floor drain wastes will be monitored and discharged to the cooling lake without treatment if radioactivity is below a predetermined level. If necessary, the waste can be diverted to LWPS for processing.

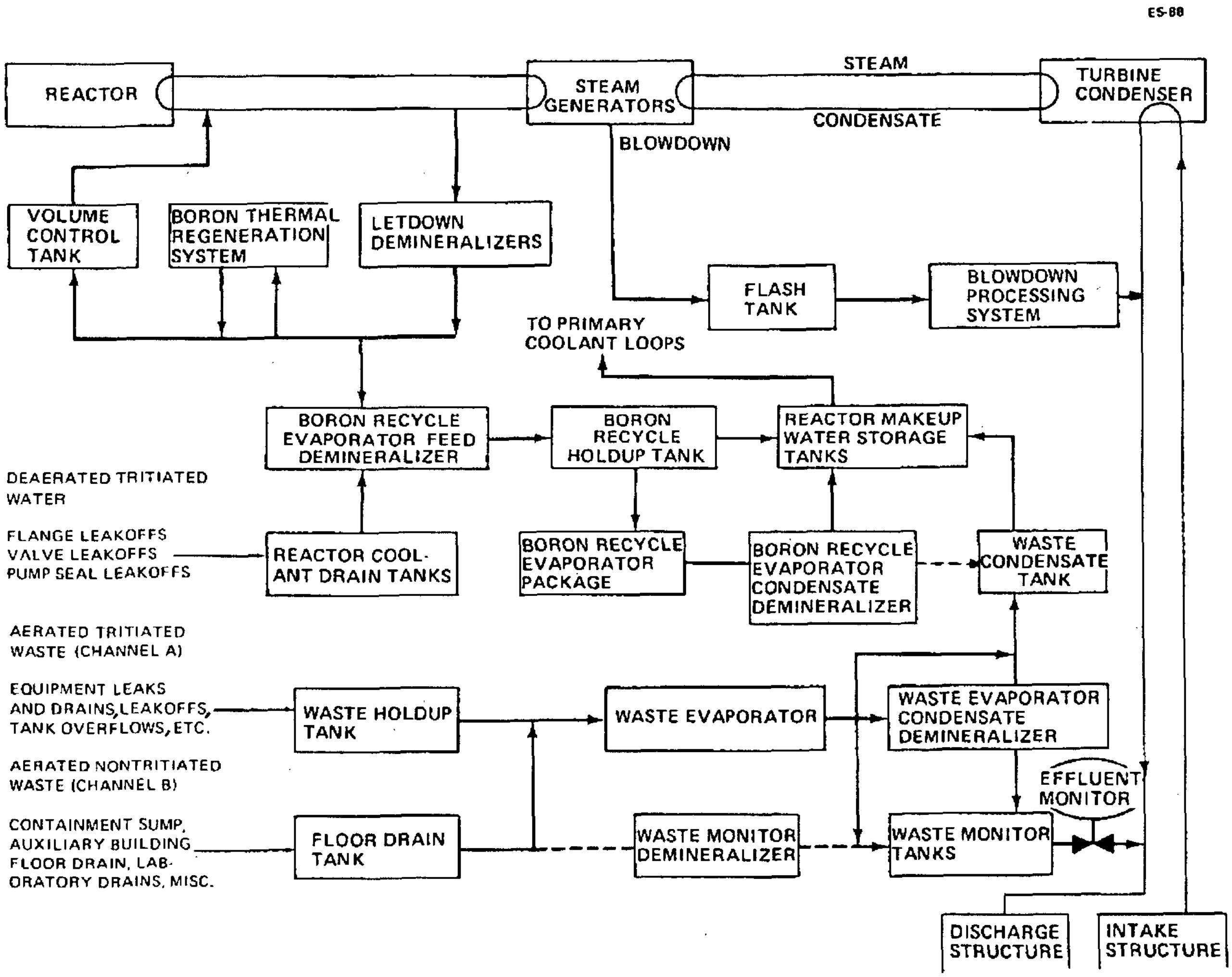

Fig. 3.5. Diagrams of liquid radioactive waste treatment systems.

Blowdown wastes from the steam generators will be monitored for radioactivity. Based on the secondary coolant activity, steam generator blowdown wastes will either be recycled directly to the condenser, discharged, or processed through two mixed-bed demineralizers and recycled to the condenser or discharged. Detergent (laundry and decontamination) wastes are processed through a waste treatment system which includes a holdup tank, a reverse osmosis unit, and a waste monitoring tank. The following paragraphs contain the staff evaluation of the liquid waste system and the calculated liquid source term.

3.5.1.1 Chemical and volume control system (CVCS)

A letdown stream of approximately 75 gpm of primary coolant will be removed from the reactor coolant system for processing through the CVCS. The letdown stream will be cooled through the letdown heat exchangers, reduced in pressure, filtered, and processed through one of the two mixed-bed demineralizers in the Li_3BO_3 form. A cation demineralizer will be valved into the process stream when further purification is required. The processed letdown stream will be collected in the volume control tank and reused in the plant. In the staff's evaluation of the purification provided by this portion of the CVCS, an input flow of 75 gpm at primary coolant activity was assumed and the decontamination factors listed in Table 3.5 for the CVCS mixed-bed demineralizer were applied. Ten percent of the letdown stream was assumed to pass through the cation demineralizer.

Approximately 1.7% of the purified letdown flow will be processed through the BRS for boron control. The staff estimated the BRS input from the CVCS letdown stream to be 1840 gpd at approximately 1.0 primary coolant activity (PCA). Primary coolant grade water from equipment drains, equipment leakoffs, and from relief valves inside containment will be collected in the 350 gal reactor coolant drain tank. The staff estimated the BRS input from the reactor coolant drain tank to be approximately 360 gpd at PCA. The 1840-gpd shim bleed and 360-gpd reactor and equipment drain tank wastes will be collected in one of two 56,000 gal-recycle holdup tanks. The staff applied the decontamination factors listed in Table 3.5 for the preholdup mixed-bed demineralizer to the streams entering the recycle holdup tanks. The decay time provided by the holdup tanks was calculated to be approximately 20 days based on 2200 gpd input flow, filling one tank to 80% capacity while the second tank is being processed. Liquid collected in the recycle holdup tanks will be processed batchwise through a 15-gpm evaporator. The concentrated bottoms will be either pumped to the boric acid makeup tank for reuse in the plant or to the solid waste management system (SWMS) for disposal. In the staff's evaluation the concentrated evaporator bottoms were considered to be processed through the solid waste system. The evaporator condensate will be processed through an anion demineralizer to remove radionuclides entrained in moisture carry-over, and either collected in the reactor makeup water storage tank for reuse in the plant or diverted to the waste recycle tanks in the LWPS for sampling and discharge. The staff used the decontamination factors in Table 3.5 for the BRS evaporator and BRS condensate demineralizer. Holdup time due to processing was calculated to be 2.1 days based on processing the contents of one recycle tank filled to 80% capacity through the BRS evaporator at 15 gpm. The staff assumed that 90% of the evaporator condensate will be recycled for reuse in the plant while 10% will be discharged for tritium control and to maintain the plant water balance. The applicant assumed total recycle of the BRS stream in his evaluation.

3.5.1.2 Liquid waste processing system (LWPS)

Low conductivity wastes, primarily from equipment drains outside the reactor containment, will be collected in a 10,000-gal waste holdup tank, processed through a 35-gpm evaporator and mixed-bed demineralizer, collected and monitored in a 5000-gal evaporator condensate tank, and pumped to the reactor makeup water storage tank for reuse, recycled to the recycle or waste holdup tanks for reprocessing, or pumped to the waste monitoring tank for monitoring and release to the cooling lake. Based on information submitted by the applicant and parameters for liquid waste volumes and activities given in WASH-1258,[3] the staff estimated the total flow in this system to be 200 gpd at 1 PCA. The collection time in the waste holdup tank was calculated to be 20 days based on filling the holdup tank (5000 gal) to 80% capacity at 200 gpd. Since there is only a single holdup tank and the contents of the tank may be processed while the tank is being filled, only 50% of filling time was used in calculating the holdup time. The system processing time was calculated to be 0.08 days based on the evaporator design flow rate of 35 gpm. High conductivity wastes (primarily from floor drains, nondetergent decontamination operations, and radiochemistry lab drains) will be collected in a 10,000-gal floor drain tank, sampled to determine the degree of processing required, processed as necessary through a mixed-bed demineralizer, an evaporator or both, collected and monitored in a 5000-gal waste monitoring tank, and released to the cooling lake. If the radioactivity is above a predetermined level, the waste will be recycled for additional treatment. In calculating releases from the LWPS, all waste was assumed to be processed once through the evaporator and demineralizer before release. Based on information submitted by the applicant and parameters for liquid waste volumes and activities given in WASH-1258,[3] the total flow in the system was estimated to be 1340 gpd at 0.051 PCA. The collection time in the floor drain tank was calculated to be 3 days based on 50% of the time needed to fill the single floor drain tank to 80% capacity at 1340 gpd. The staff calculated the system processing time to be 0.08 days based on the evaporator design flow rate of 35 gpm. In both systems the evaporator bottoms and demineralizer resins will be disposed of as solid waste. There will be no regeneration of demineralizer resins.

The applicant proposes to recycle all of the clean wastes to the primary system. In the staff's evaluation, 10% of the clean wastes and 100% of the dirty wastes were assumed to be discharged. On this basis, and using the parameters given in Table 3.5, the staff calculated releases from the LWPS to be approximately 0.3 Ci/year, excluding tritium and dissolved gases. The principal liquid source terms are given in Table 3.6. The applicant calculated LWPS releases to be 0.004 Ci/year. The difference between the staff's calculated releases and those of the applicant is due primarily to differences in estimates of short-lived fission product release. The applicant estimated a holdup time of about 30 days based on lower estimates of input volumes to the LWPS, while the staff calculated a holdup time of 3 days.

3.5.1.3 Turbine building floor drains and detergent wastes

Wastes collected by the turbine building floor drain system contain radioactive materials resulting from secondary system leakage. The applicant has indicated that these wastes will not be treated prior to discharge. Based on the assumption of a 5-gpm leak rate at main stream activity (0.001 secondary coolant concentration), the staff calculated a release of approximately 0.05 Ci/year, excluding tritium, from this source.

Table 3.6. Wolf Creek Generating Station liquid source term

Nuclide	Ci/yr	Nuclide	Ci/yr
Na-24	0.00002	Mo-99	0.0092
P-32	0.00001	Tc-99m	0.0087
P-33	0.00004	Te-127m	0.00005
Cr-51	0.00017	Te-127	0.00006
Mn-54	0.00007	Te-129m	0.00024
Mn-56	0.00027	Te-129	0.00015
Fe-55	0.00017	I-130	0.00055
Fe-59	0.00010	Te-131m	0.00012
Co-58	0.0018	Te-131	0.00002
Co-60	0.00050	I-131	0.32
Ni-63	0.00002	Te-132	0.0023
Nb-92	0.00003	I-132	0.015
Sn-117m	0.00001	I-133	0.14
W-187	0.00012	I-134	0.0004
Np-239	0.00004	Cs-134m	0.00012
Br-82	0.00013	Cs-134	0.03
Br-83	0.00019	I-135	0.025
Rb-86	0.00008	Cs-136	0.01
Rb-88	0.00133	Cs-137	0.02
Rb-89	0.0007	Ba-137m	0.01
Sr-89	0.00006	Cs-138	0.0001
Sr-91	0.00001	Cs-139	0.0003
Y-91m	0.00010	Ba-139	0.00002
Y-91	0.00057	Ba-140	0.00006
Y-92	0.00002	La-140	0.00006
Zr-95	0.00001	Ce-141	0.00001
Nb-95	0.00001	Others	0.00012
		Total (except H-3)	0.6 Ci/yr
		H-3	350 Ci/yr

Detergent wastes generated from laundry and decontamination operations will normally be released to the circulating water discharge. If the radioactivity level is above a predetermined level, the wastes will be processed through a reverse osmosis unit and, if necessary, the LWPS. The staff assumed that all waste will be processed through the reverse osmosis unit only prior to release. Based on the assumption of 450 gpd of detergent waste at 10^{-4} μCi/cc and a decontamination factor of 30 for the reverse osmosis unit, the staff calculated a release of 0.002 Ci/year, excluding tritium, from this source.

3.5.1.4 Steam generator blowdown

Blowdown from the steam generators will normally be returned directly to the condenser, but there will be provisions to discharge the blowdown to the environment without processing. If the radioactivity level in the material being released to the environment exceeds a predetermined level, flow will be terminated automatically by one of two radiation monitor controlled valves. The blowdown will then be processed through a system consisting of two mixed-bed demineralizers and either recycled to the condenser or released to the environment. The staff assumed the blowdown rate would be approximately 18 gpm (0.06% of the main steam flow rate) at secondary coolant activity and that 10% of this flow will be released to the environment after processing. Based on these assumptions, approximately 0.04 Ci/year, excluding tritium, will be released from this source.

3.5.1.5 Liquid waste summary

Based on the staff's evaluation of the liquid waste systems, the releases of radioactive materials in liquid wastes were calculated to be approximately 0.29 Ci/year, excluding tritium and dissolved gases. This release was normalized, using the parameters in WASH-1258,[3] to 0.6 Ci/year to account for equipment downtime and anticipated operation occurrences. The tritium release was calculated to be approximately 350 Ci/year. The applicant estimated the liquid releases to be approximately 0.08 Ci/year, excluding tritium and dissolved gases, and 100 Ci/year for tritium.

The staff calculated that whole body and critical organ doses will be less than 5 millirem/year at or beyond the site boundary, and that the proposed systems will be capable of limiting the release of radioactive materials in liquid effluents to less than 5 Ci/year.

3.5.2 Gaseous waste

The principal source of radioactive gaseous wastes will be gases stripped from the primary coolant in the BRS. Additional sources of gaseous wastes will be main condenser air removal system offgases, ventilation exhausts from the auxiliary fuel and radwaste buildings, and gases collected in the reactor containment building. The principal system for treating gaseous wastes will be the gaseous waste processing system (GWPS). The GWPS will collect and store gases stripped from the primary coolant and gases vented from tanks and systems containing radioactive fission gases. The GWPS consists of two compressors, two catalytic recombiners, and eight gas decay tanks. Ventilation air from the fuel, auxiliary and radioactive waste buildings, and offgases from the main condenser air ejectors will be processed through charcoal adsorbers prior to release. The reactor containment atmosphere will be recirculated through HEPA filters and charcoal adsorbers prior to release. Ventilation air from the turbine building will be released without treatment. Ventilation air from the containment, auxiliary, and fuel buildings and gaseous wastes from the condenser air removal system will be exhausted through the unit vent on top of the containment building. Ventilation air from the radioactive waste and turbine buildings will be exhausted through the radioactive waste and turbine building roof vents, respectively. The gaseous waste and ventilation treatment systems are shown schematically in Fig. 3.6.

3.5.2.1 Gaseous waste processing system (GWPS)

The GWPS will be designed to collect and process gases stripped from the primary coolant along with cover gases from miscellaneous tanks. Gaseous inputs will include a continuous 0.7 scfm hydrogen purge of the CVCS volume control tank and smaller quantities of radioactive gas from the boron recycle evaporator, reactor coolant drain tank, and the recycle holdup tanks. Input gases will be processed in a closed loop containing two waste gas compressors, two catalytic hydrogen recombiners, and eight 600-ft^3 gas decay tanks (six for normal operation and two for startup and shutdown). The system will be designed for continuous recycle of radioactive gases that will be released to the atmosphere after a 90-day holdup in the system. On this basis the staff calculated the GWPS releases to be approximately 320 Ci/year for noble gases and negligible (10^{-4} Ci/year) for iodine-131.

3.5.2.2 Containment ventilation system

Radioactive gases will be released inside the reactor containment when primary system components are opened or when leakage occurs from the primary system. The gaseous activity will be sealed within the containment during normal operation, but will be released during containment purges. Prior to purging the containment, the containment atmosphere will be recirculated through the containment atmospheric control system (CACS) at about 20,000 cfm. The CACS will consist of two parallel trains, each containing HEPA filters and an activated charcoal adsorber. Purge effluent will be released from the plant vent after passing through HEPA filters and being monitored for radioactivity. The containment airborne activity was calculated based on 240 lb/day of primary coolant leakage to the containment and a partition factor of 0.1 for radioiodine. Based on four purges of the containment per year, the staff calculated releases from the containment to be approximately 1000 Ci/year for noble gases and 0.16 Ci/year for iodine-131.

3.5.2.3 Ventilation systems for other buildings

Radioactive material will be introduced into the plant atmosphere due to leakage from equipment processing or holding radioactive materials. Ventilation air from the auxiliary and fuel buildings will be processed through HEPA and charcoal filters, monitored for radioactivity, and released through the plant vent. Ventilation air from the radioactive waste building will be processed in the same manner and released through the radioactive waste building roof vent. Ventilation air from the turbine building will be monitored for radioactivity and released without treatment.

The staff estimates that 160 lb/day of primary coolant will leak to the auxiliary and radioactive waste buildings. Since the letdown heat exchangers will be located inside the reactor containment, all leakage was assumed to be cold, and a partition factor of 0.001 for radioiodine was applied. On this basis the staff calculated the auxiliary and radioactive waste building releases to be approximately 47 Ci/year for noble gases and 0.0044 Ci/year for iodine-131. The applicant calculated the auxiliary and radioactive waste building releases to be approximately 1270 Ci/year for noble gases and 0.002 Ci/year for iodine-131. The difference between the staff's estimate for noble gas release and that of the applicant is due principally to the applicant's assumption that the noble gases in the GWPS will be continually recycled and that 100 scfm/year will leak from the GWPS into the radioactive waste building.

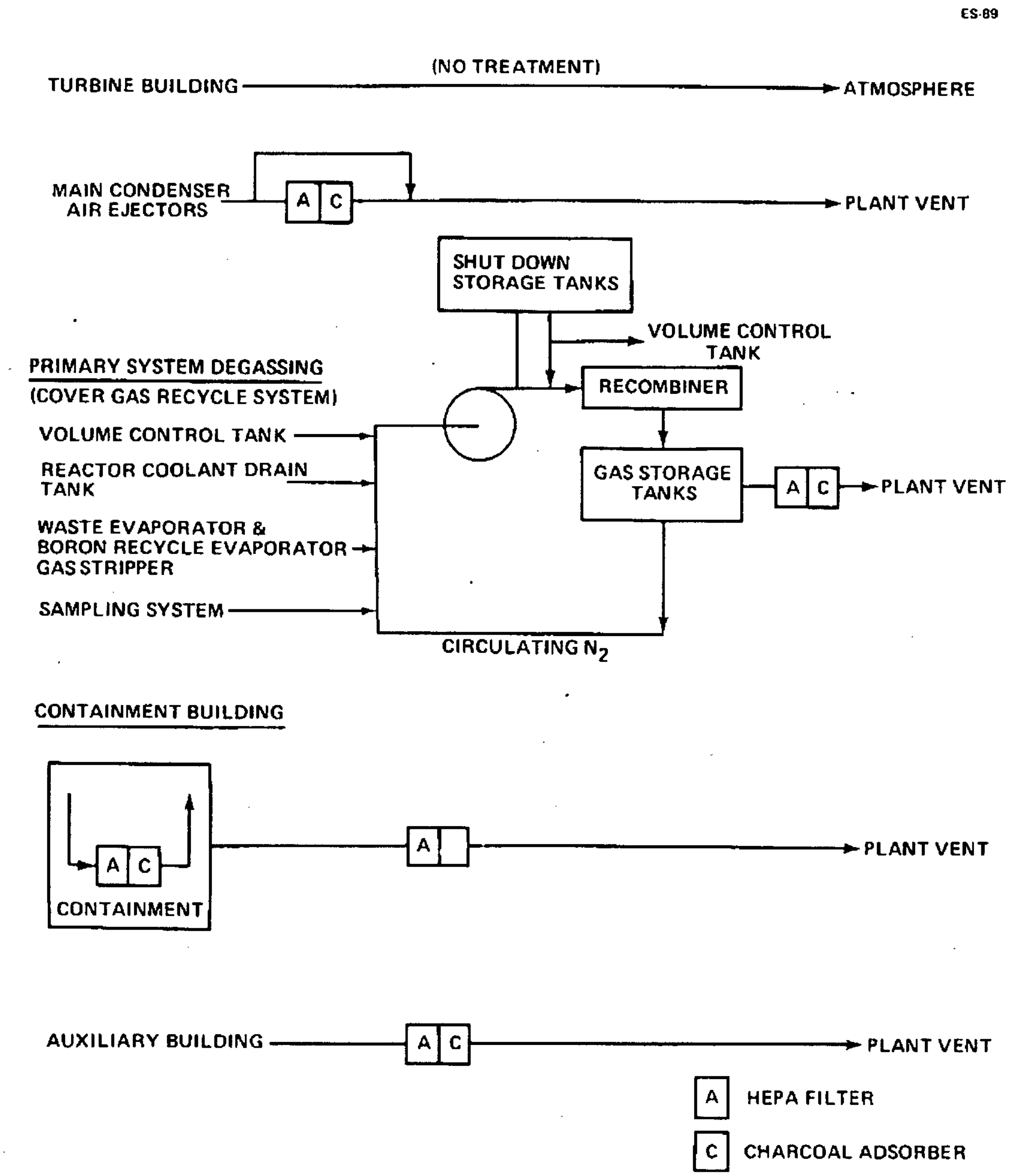

Fig. 3.6. Gaseous waste and ventilation treatment systems.

The staff estimates that 1700 lb/hr of steam will leak to the turbine building atmosphere and all noble gases and radioiodine released with the steam will remain airborne. On this basis the turbine building vent releases were calculated to be less than 1 Ci/year for noble gases and 0.0068 Ci/year for iodine-131. The applicant calculated the turbine building releases to be negligible for noble gases and iodine-131.

3.5.2.4 Steam releases to the atmosphere

The turbine bypass capacity to the condenser will be approximately 40%. According to the staff's analysis, steam releases to the environment due to turbine trips and low power physics testing will have a negligible effect on calculated source terms.

3.5.2.5 Main condenser offgas releases

Offgas from the main condenser air ejectors will contain radioactive gases resulting from primary to secondary system leakage. Iodine will be partitioned between the steam and water in the steam generators and between the condensing and noncondensing phases in the main condenser. Main condenser offgas will be processed through a charcoal adsorber prior to release. The staff considered 110 lb/day of primary to secondary system leakage, partition factors for radioiodine of 0.01 and 0.0005 in the steam generator and main condenser, respectively, and iodine decontamination factor of 10 for the charcoal adsorber on the offgas line. On this basis, the main condenser offgas releases were calculated to be approximately 28 Ci/year for noble gases and 0.0028 Ci/year for iodine-131. The applicant calculated the releases from the main condenser to be approximately 155 Ci/year for noble gases and 0.004 Ci/year for iodine-131.

3.5.2.6 Gaseous waste summary

Based on the staff's evaluation of the gaseous waste treatment systems, the total releases of radioactive materials in gaseous wastes were calculated to be approximately 1400 Ci/year for noble gases and 0.18 Ci/year for iodine-131. The principal sources and isotopic distribution are given in Table 3.7. The applicant estimated the gaseous releases to be approximately 1500 Ci/year for noble gases and 0.05 Ci/year for iodine-131.

Table 3.7. Wolf Creek Generating Station gaseous source term,[a] Ci/yr.

		Building ventilation				
	Decay tanks	Containment	Auxiliary	Turbine	Air ejector	Total
Kr-83m	a	a	a	a	a	a
Kr-85m	a	7.8	1.8	a	1	11
Kr-85	310	1.5	a	a	a	31.0
Kr-87	a	1.7	1.3	a	a	3
Kr-88	a	11	3.7	a	2	17
Kr-89	a	a	a	a	a	a
Xe-131m	4.1	3.5	a	a	a	8.1
Xe-133m	a	18	a	a	a	18
Xe-133	1.8	940	35	a	22	1000
Xe-135m	a	a	a	a	a	a
Xe-135	a	34	4	a	3	41
Xe-137	a	a	a	a	a	a
Xe-138	a	a	1	a	a	1
I-131	a	0.16	0.0044	0.0068	0.0028	0.18
I-133	a	0.12	0.0064	0.0043	0.004	0.13
H-3						1050
C-14						8
Particulates						0.06

[a]Less than 1 Ci/year/unit noble gases, less than 10^{-4} Ci/year/unit iodine.

Based on the staff's evaluation of the applicant's proposed gaseous radioactive waste treatment system, the annual air dose due to gamma radiation at or beyond the site boundary will not exceed 10 millirads; the annual air dose due to beta radiation at or beyond the site boundary will not exceed 20 millirads; the annual thyroid dose to an individual will not exceed 15 millirems, considering the location of nearest actual cow; and the annual total quantity of iodine-131 released will not exceed 1 Ci.

3.5.3 Solid wastes

The solid waste management system (SWMS) will be designed to process two general types of solid wastes, "wet" wastes that require solidification and packaging and "dry" solid wastes that require packaging only. "Wet" solid wastes will consist mainly of spent filter concentrates and will contain radioactive materials removed from liquid streams during processing. "Dry" solid wastes will consist mainly of low activity ventilation air filters, contaminated clothing and paper, and miscellaneous items such as laboratory glassware and tools. Miscellaneous solid wastes, such as irradiated primary system components, will be handled individually based on size and activity. The principal sources of spent demineralizer resins will be four 30-ft^3 CVCS evaporator condensate demineralizers, two 30-ft^3 LWPS demineralizers, and four 75-ft^3 steam generator blowdown demineralizers. Spent resins from these demineralizers will be collected in the 4000-gal SGB spent resin storage tank and the 2600-gal LWPS spent resin storage tank, sluiced to a solidification agent and catalyst, and solidified in 55-gal drums.

Concentrated wastes from the two 35-gpm LWPS evaporators and the 15-gpm CVCS boric acid evaporator will be pumped from their respective concentrate holdup tanks to the 750-gal solidification holdup tank. Concentrates from the solidification holdup tank and solidification agent will be pumped simultaneously to the shipping containers for solidification. Catalysts will be added in the shipping container. Based on staff evaluations of PWRs with similar liquid waste systems, approximately 4500 ft^3 of wet solid wastes will be generated annually. These are estimated to contain approximately 6000 Ci of radioactivity, principally Cs-137 and Cs-134. The applicant estimates that 7400 ft^3 of wet solid wastes containing 9500 Ci of radioactivity will be shipped offsite each year.

Dry solid wastes will be packaged in 55-gal drums. Compressible wastes, for example, clothing and contaminated rags, will be compressed using a hydraulic baler. The dry solid wastes are estimated to be approximately 450 drums/year containing a total of 5 Ci of radioactivity. The applicant's estimates are essentially the same.

3.5.3.1 Solid waste summary

Based on the staff's evaluation of the solid waste system, the system design will accommodate the wastes expected during normal operations, including anticipated operational occurrences in accordance with existing NRC, local and Federal regulations. The wastes will be packaged and shipped to a licensed burial site in accordance with NRC and Department of Transportation regulations. Based on these findings, the staff concludes that the solid waste system is acceptable.

3.6 CHEMICAL AND BIOCIDE WASTES

The operation of Wolf Creek Generating Station will result in chemical wastes that will be discharged into the Neosho River. The chemical wastes can be considered to result from (1) the concentration effect on the dissolved solids in the makeup water because of evaporation in the cooling lake (Table 3.8) and (2) those chemicals added to various reactor systems which will eventually be dumped into the Neosho River via the cooling lake (Table 3.9).

Table 3.8. Increase in chemical concentration of effluent to Neosho River due to cooling lake concentration

Chemical parameter	Maximum concentration in Neosho River[a] (mg/liter)	Maximum concentration in cooling lake[b] (ppm)	Incremental increase in Neosho River[c] (ppm)
Biological oxygen demand	2.7	9.9	1.3
Chemical oxygen demand	2.4	88	12
Dissolved oxygen (DO)	14.1		
Sulfate (SO_4^{2-})	56	787[d,e]	139
Chloride (Cl^-)	17.5	64	9
Nitrate (NO_3^-)	1.2	4.4	0.6
Phosphate (PO_4^{3-})	0.16	0.59	0.08
Total dissolved solids (TDS)	326	1200[e]	174

[a]ER, Table 2.5A-2.

[b]Based on concentration cycle to give a TDS concentration of ~1200 mg/liter and assuming maximum TDS concentration in John Redmond Reservoir of 540 ppm, Sargent and Lundy Report.

[c]Based on 32 cfs river flow and 8 cfs blowdown which is the maximum permissible to give sulfate and TDS concentration in the river water of 250 and 500 mg/liter, respectively.

[d]Based on concentration cycle plus added H_2SO_4.

[e]ER, Table 3.6-3.

Table 3.9. Chemicals added to liquid effluents during plant operation

Chemical	Total discharge (Max) (lb/day)	Concentration in effluent to cooling lake (ppm)
Sulfate, SO_4^{2-}	65,229[a]	9.1
Sodium Na^+	2,070	0.3
Chlorine	95	
Free chlorine		0.04
Chlorine reaction products (Cl^-, chloramines, etc.)		0.16

[a] ER, Table 3.6-2.

3.6.1 Circulating water system

The applicant plans to use chlorine to control biofouling in the main circulating water system. For a discussion of the applicant's chlorination scheme and the staff's recommendations, see Sect. 5.5.2.3.

3.6.2 Nonnuclear regenerative waste

The makeup water requirements for the station will be met by utilizing demineralization techniques (ER, Sect. 3.6.5). Makeup water from John Redmond Reservoir will be passed through demineralizer trains which will be regenerated using NaOH and H_2SO_4. The regeneration wastes will be treated in a waste treatment basin before being pumped into the circulating water system for discharge to the cooling lake. The applicant estimates that an average of 75,000 gal/day will be processed. The wastes will contain a total dissolved solids (TDS) concentration of about 8200 ppm. The process will involve the usage of about 3100 lb/day of H_2SO_4 and 1800 lb/day of NaOH. Note, however, that the pumped waste will be essentially neutral and will contain the H_2SO_4 and NaOH as a neutral salt (Na_2SO_4).

3.7 SANITARY WASTES AND OTHER EFFLUENTS

The applicant has indicated (ER, Sect. 3.7.1) that a package waste treatment plant suitable for 2000 workers will be installed on the site. During the construction phase the unit will operate as a contact stabilization system handling 30,000 gal/day. For permanent use the plant will operate as an extended aeration system handling 15,000 gal/day. The effluent from both operational modes will be given tertiary treatment (filtration and recirculation) followed by chlorination and will meet State requirements for Wolf Creek with regard to effluent standards and dissolved oxygen.

3.8 TRANSMISSION SYSTEMS

An extensive description of the transmission lines is given by the applicant (ER, Sect. 3.9). A summary description is given below.

The Wolf Creek Generating Station will require construction of transmission line connections to the Kansas Gas and Electric Company (KG&E) and Kansas City Power and Light Company (KCPL) systems. The connection to the KG&E system will extend 95.7 miles in a west-southwest direction from the generating station substation to the existing KG&E Rose Hill substation. The connection to the KCPL system will extend northeast 48.4 miles and enter an existing transmission line corridor 22.5 miles long to the existing Craig substation near Kansas City. A connection will also be made to the line that links the Benton substation near Wichita and the LaCygne Plant, but this line is not a part of this project. Construction of the Wolf Creek cooling lake will necessitate relocation of the Athens-Burlington and the LaCygne-Benton transmission lines. Present plans include tapping the Athens-Burlington line to supply initial power for construction. The tap will extend east out of the Wolf Creek substation, then south and along the east side of the cooling lake to the Athens-Burlington transmission line.

The routes of the transmission lines are indicated in Fig. 3.7. Other information on the lines is given in Table 3.10. The total acreage for which right-of-way agreements or access will be necessary is 3127.

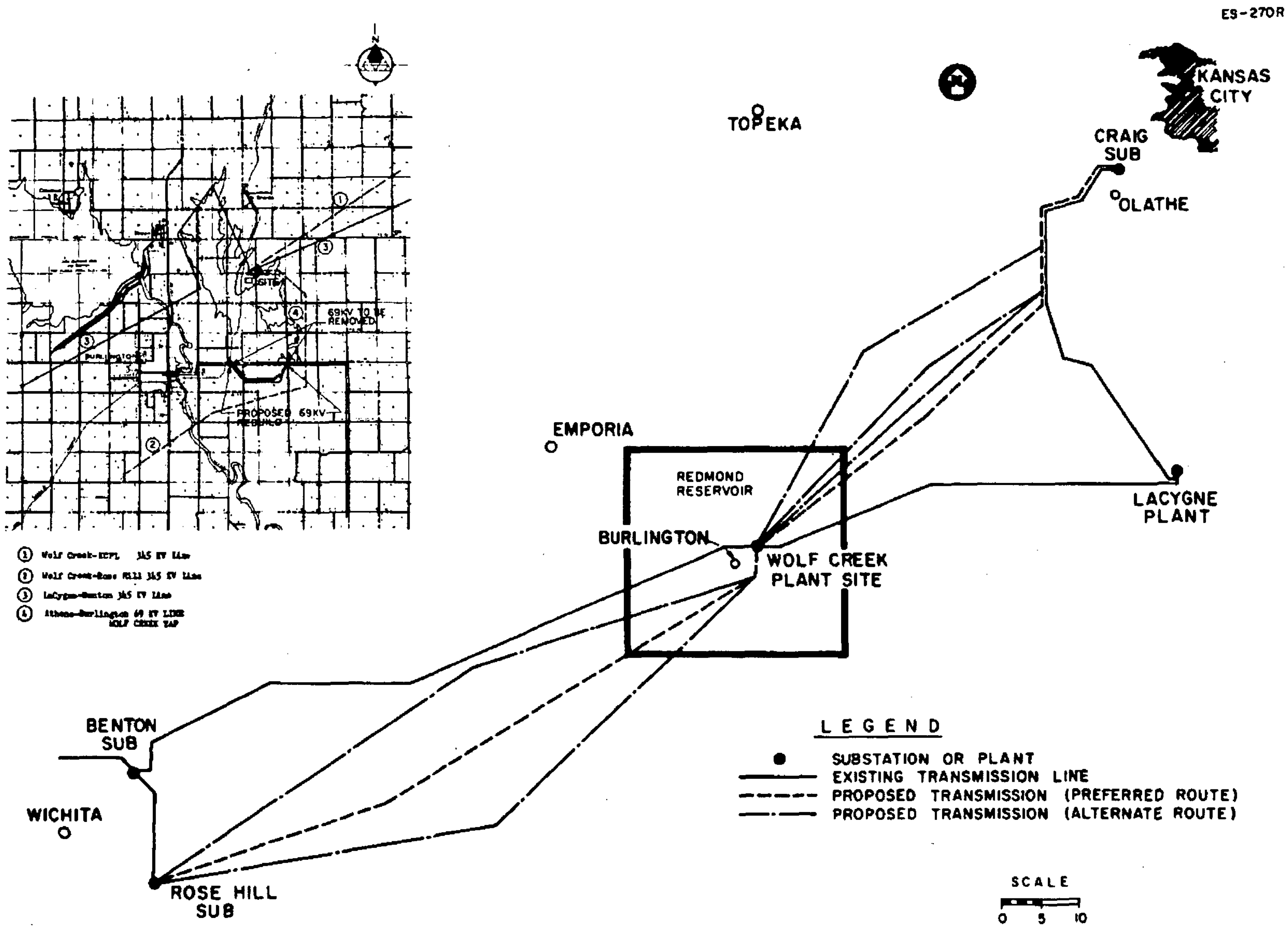

Fig. 3.7. Transmission line routes and right-of-way alignments. Source: ER, Figs. 3.9-1 and 3.9-2.

Table 3.10. Transmission lines

Transmission lines	Distance (miles)	Width of right-of-way (ft)	Voltage (kV)	Towers				
				Type	Height (ft)	Span (ft)	Estimated number	Acreage
WCGS – Rose Hill line	95.7	150	345	Wooden[a] H frame	75–115	600–800	697.5 @7.5/mile	1740.8
WCGS – Craig line	70.9	160[b]	345	Wooden[c] H frame	75–115	600–900	500 @7/mile	1211.4
Wolf Creek tap of Athens-Burlington line, including relocated line	6.9	50	69	Wooden wishbone type	50–60	325–350	80 @16/mile	41.8
Relocated LaCygne-Benton line	7.3	150	345	Wooden[a] H frame	80–122	630–1009	49 @7/mile	132.7

[a]Steel swing-angle towers will be used to negotiate angles.
[b]The width of the right-of-way will be 260 ft after the line enters the dual right-of-way corridor.
[c]H-frame tangent 3-pole and 6-pole structures will be used to negotiate the angles.

Between Rose Hill and Wolf Creek, three Federal highways, U.S. 77, 54, and 75, approximately 93 State, county, and township roads, and five railroads will be crossed by the transmission lines. One Federal highway, U.S. 59, will be crossed between Wolf Creek and the junction with the LaCygne-Craig lines, as well as 55 State, county, and township roads and two railroads. U.S. Highway 56, Interstate Highway 35, 22 State, county, and township roads, and two railroads will be crossed by the transmission line route between the Wolf Creek-LaCygne junction and Craig.

The transmission line right-of-way from Wolf Creek to Rose Hill crosses the Walnut River, the Fall River, the Verdigris River, and the Neosho River; the route from Wolf Creek to Craig crosses the Marais des Cygnes River. The applicant has planned these river crossings in areas not visible from major highways. The lines will not cross any major public lakes. Various farm ponds will be spanned; these crossings will be kept high and most of the natural low growth will be left.

No large communities are close to the proposed transmission lines. The lines will largely avoid heavily populated areas and will generally pass through the center of sections of land, thus minimizing their appearance from roads. However, due to the dominant flat-to-gently-rolling terrain, transmission lines can be seen from great distances (2-8 miles) throughout much of this region in Kansas.

The transmission lines will not pass in the proximity of established or frequently visited scenic areas, historical monuments, or parks. The applicant has promised that appropriate steps will be taken to avoid or preserve any archaeological site that occurs within the transmission right-of-way. The main visual impact will be on local traffic and residences. The transmission lines will cross approximately 170 state, county, and township roads and will be within 1000 ft of approximately 148 rural residences.

3.9 TRANSPORTATION CONNECTIONS

3.9.1 Railroad spur

A new railroad spur will be constructed from the Missouri Pacific Railroad northwest to the plant site. Although the final alignment of the route has not been determined, the right-of-way will be approximately 10 miles long, 125 ft wide, and will require approximately 150 acres of land. According to the applicant, the route primarily traverses range and croplands; however, some loss of natural riparian vegetation will occur where the right-of-way crosses Tauckett Creek, Crooked Creek, Scott Creek, and Long Creek.

3.9.2 Access road

The principal connection between U.S. Highway 75 and the plant site will have to be improved to accommodate an increased volume of heavily laden trucks. Widening of this connection may be necessary to speed the flow of traffic. The road does not cross any known historical or archaeological sites.

3.9.3 Pipelines

A water line will be constructed from a pump house immediately below John Redmond Dam to a discharge structure on the west side of the cooling lake, and an 8-in. line carrying potable water and the makeup demineralizer feedwater will pass under the lake from this point to the Wolf Creek Generating Station. The impacts resulting from construction of the makeup water pipeline are discussed in Sect. 4.3.1.2.

REFERENCES FOR SECTION 3

1. M. J. Bell, *Oak Ridge Isotope Generation and Depletion Code*, ORNL-4628, Oak Ridge National Laboratory, Oak Ridge, May 1973.

2. F. T. Binford and T. Hamrick, "Analysis of Power Reactor Gaseous Waste Systems," 12th AEC Air Conference Proceedings, August 1972.

3. USAEC Report WASH-1258, vol. 2, Apps. A, B, U.S. Atomic Energy Commission, Washington, D.C., July 1973.

4. ENVIRONMENTAL EFFECTS OF SITE PREPARATION AND OF STATION AND TRANSMISSION FACILITIES CONSTRUCTION

4.1 IMPACTS ON LAND USE

The site area illustrated in Fig. 2.2 consists of approximately 10,500 acres. The largest single commitment of land will be the cooling lake which will affect approximately 5090 acres. The amount of land altered by site preparation and plant construction will be 135 acres for the generating station and 60 acres for the dam and dikes.

4.1.1 Station facilities

According to the applicant, the primary and immediate environmental effects associated with site preparation and construction of the Wolf Creek Generating Station will be the alteration of existing terrain features and disturbances to terrestrial biota. Terrestrial vegetation and wildlife populations will be affected during clearing, excavating, and land filling activities associated with construction of the cooling lake, dam and spillway, generating station, and other related facilities.

Wildlife populations and plant communities displaced by the plant, cooling lake, and associated earth-fill structures will be permanently lost. A description of the floral and faunal components associated with the predominant land uses in the site area is presented in Sect. 2.7. The environmental effects on biotic populations in the construction areas are regarded as unavoidable and irreversible for the life of the plant.

The steel rails from an abandoned railroad within the site boundary have been salvaged. Two cemeteries will be affected by the cooling lake. Sherwood Cemetery, in the southern part of the site, would be inundated by the cooling lake unless moved. In accordance with the local cemetery board's decision, the graves and markers in Sherwood Cemetery will be relocated. The Stringtown Cemetery will be outside the cooling lake and the exclusion area; however, a new access road to the cemetery will be required, and a proposal to do so will be reviewed with the Stringtown Cemetery Board.

Existing road systems and bridges will be used during the construction period. Some roads will be upgraded so that heavy equipment and construction materials can be moved to the site with no adverse effect to road surfaces. Dust, smoke, and noise due to construction activities will not have a significant effect on people in the residential areas of Burlington and New Strawn. However, the noise will affect local residents within two miles of the plant site, but this will only be temporary.

No natural or historic landmarks, sites, or places listed in the National Register of Historic Places and the National Register of Natural Landmarks are located within a five mile radius of WCGS (Sect. 2.3). Except for one site, all archaeological sites that were discovered on lands to be purchased for the project occur within the cooling lake basin and will be inundated. Prior to inundation, the most significant sites will undergo further evaluation or excavation.

The expected effects of site preparation and plant operation which are social and economic in nature are discussed in Sect. 8.2.

4.1.2 Wolf Creek cooling lake

The cooling lake for WCGS will be created by constructing one main earth rolled dam and six perimeter dikes. The top of the dam will be at an elevation of 1100 ft MSL. Approximately 60 acres will be affected during construction of the dam and dikes associated with the cooling lake. The main dam will be constructed on rock exposed by excavating 1,700,000 cubic yards of material. The excavated material will be disposed of at the Wolf Creek site. It is projected that construction of the main dam will require the following quantities of material for construction: (1) 5,227,000 cubic yards of alluvial soil (clay) from borrow areas in the Wolf Creek Watershed within the basin of the proposed impoundment; (2) 378,000 cubic yards of sand obtained from local sources; (3) 184,000 cubic yards of rock obtained from local quarries; and (4) 3,600 cubic yards of concrete.

The effects on vegetation in the cooling lake basin after inundation will be completely irreversible for the life of the plant. This will involve range and farm lands. The land use classification and acreage of property within the 5090 acre cooling lake, as supplied by the applicant, are shown in Table 4.1. Land immediately adjacent to the proposed cooling lake will be modified during the construction phase. This land, however, is subject to restoration.

Table 4.1. Changes in acreage of land classification units and plant association as a result of construction on the site[a]

Land unit	Preconstruction acreage	Station construction	Dam construction	Cooling lake	Total	Post construction acreage	Percent loss
Man dominated							
Cropland							
Soybeans	1,625	85	27	781	893	732	55.0
Wheat	703		5	323	328	375	47.0
Hay	683		3	253	256	427	37.0
Sorghum	591		5	326	331	260	56.0
Corn	363		2	214	216	147	60.0
Abandoned fields	303	8		240	248	55	82.0
Subtotal	4,268	93	42	2137	2272	1996	53.0
Range[b]	4,836	42	13	2130	2185	2651	45
Miscellaneous							
Ponds	88			39	39	49	44
Roads	57			31	31	26	54
Gravel pits	30				0	30	0
Cemetery	4			1	1	3	25.0
Subtotal	179			71	71	108	40
Natural plant association							
Bluestem prairie[c]	28			20	20	8	71
Woodlands[d]	1,189		5	736	741	448	62
Subtotal	1,217		5	756	761	456	63
Total	10,500	135	60	5094	5289	5211	50

[a]Based on ER, Sect. 4.
[b]Range includes open pasture and mixed shrub pasture.
[c]Bluestem prairie is listed as abandoned railroad right-of-way in ER.
[d]Woodlands include oak-hickory forest and northern floodplain forest.

4.1.3 Transmission lines

The area affected by the transmission lines is described in Sect. 3.8. The staff believes that transmission line construction can be accomplished without a significant long-term or permanent adverse effect on agricultural production along the rights-of-way and adjoining properties. A small area of land will be taken out of production permanently (land occupied by transmission line tower bases), but this should amount to less than 1% of the total 3127 acres that will be traversed by the transmission line rights-of-way (see Table 4.2).

During construction, temporary disruption of agriculture will result from the movement of vehicles along the rights-of-way and the temporary storage of tower materials. After completion of construction, the ground surface will be graded, planted or otherwise treated, or prepared so that the effects of vehicular movement will not cause erosion or affect restoration to agricultural use. Although a limited number of temporary access roads will be needed to initially construct the rights-of-way, no permanent access or maintenance roads will be constructed along any portion of the route.

4.1.4 Access road and railroad spur

Since the plant area itself is very close to a major highway, the access road will be short and its impact insignificant. A new railroad spur will be constructed from the Missouri Pacific Railroad northwest to the plant site. The total area disturbed by the spur will be approximately 150 acres.

4.1.5 Pipeline relocation

A water line will be constructed from a pumphouse immediately below John Redmond Dam to an outfall structure on the west side of the cooling lake (Fig. 2.2) and an 8-in. water line carrying potable water and makeup demineralizer feedwater will pass under the lake from this point to the Wolf Creek Generating Station. Construction of the 8 inch pipeline should require the excavation of approximately 100 cubic yards of material. About 100 cubic yards of alluvial soil (clay) will be required to backfill the pipeline at the crossing of Wolf Creek. The pipelines will be buried so that above-ground land uses will be only temporarily disturbed.

Table 4.2. Changes in acreage of land classification units as a result of construction of transmission lines, makeup water pipe line, railroad spurs, and new access roads

Land unit	Transmission lines[a]		Makeup water line[b]		Railroad spur		Access roads[c]		Total
	Percent of right-of-way	Acreage	Percent of right-of-way	Acreage	Percent of right-of-way	Acreage	Percent of right-of-way	Acreage	
Cropland	37	1159	20	6	60	90	56	1	1256
Rangeland	55	1729			36	54	12	<1	1284
Woodlands	7	205			4	6			210
Bluestem prairie							32	<1	0.8
Waterways	0.5	19							19
Roads	0.5	15	70	21					36
Recreation			10	3					3.0
Total	100	3127	100	30	100	150	100	<3	3309

[a] Data based on ER, Tables 3.9-1 to 3.9-3.
[b] Linear feet and acreage altered outside the cooling lake, staff estimates.
[c] Stringtown and Sherwood cemeteries.

4.2 IMPACTS ON WATER USE

4.2.1 Surface water

Construction of the makeup water facilities at John Redmond Reservoir will result in local increases in TSS (total suspended solids), and some interference with recreation for a period of one to 1.5 years (ER, Q8.6). The makeup water intake structure will be constructed on rock exposed by excavating approximately 32,000 cubic yards of rock. This material will be hauled from the area after excavation and disposed of at the Wolf Creek plant site. The makeup intake structure will be constructed of approximately 1,950 cubic yards of concrete. After construction of the structure, about 5,000 cubic yards of alluvial soil (clay), originating from borrow areas in the basin of the proposed Wolf Creek impoundment, will be backfilled around the structure. The impact of TSS on John Redmond Reservoir and the Neosho River is discussed in Sect. 4.3.2. Sports fishermen will find the popular Dam Site South Recreation Area's east bank unsuitable for fishing, picnicking, and camping, due to construction activities. The west bank will be subject to noise and visible construction acitivity (ER, Q8.6). Fishing success from this bank may be reduced. Construction of the cooling lake dam will lead to more extensive increases in TSS in Wolf Creek and in the Neosho River below its confluence with Wolf Creek (Sect. 4.3.2). Filling of the cooling lake will require makeup water at the rate of 41 to 120 cfs from John Redmond Reservoir for 25 to 64 months. These withdrawal rates comprise from 2.7 to 8.2% of the average flow (1467 cfs) through John Redmond Reservoir (ER, Table Q5.9-2). The impacts of makeup withdrawal are addressed in Sect. 5.5.2.

4.2.2 Groundwater

Excavations at the plant site will require localized dewatering of aquifers to an elevation of about 1057 ft MSL for a period of about two years (ER, p. 4.1-11). The aquifers involved are primarily the Heumader shale and Plattsmouth limestone members. Weathered Jackson Park shale member will contribute a very small area to be dewatered. The localized drawdowns will be limited mainly to the immediate site area. No wells tapping the above aquifers outside the site area should experience any significant impacts due to dewatering (ER, p. 4.1-12a). Groundwater at the site will return to normal levels after completion of construction. No groundwater will be used for construction (ER, p. 4.1-12a).

4.3 EFFECTS ON ECOLOGICAL SYSTEMS

4.3.1 Terrestrial

4.3.1.1 Station site and cooling lake

Clearing for construction and site development constitutes an unavoidable disturbance of the immediate environs. Table 4.1 presents a summary of the changes in acreage of land classification units and natural plant association as a result of construction on the site. Of the 10,500 acres examined by the applicant, approximately 50% of the habitat will be altered, with 48% due to Wolf Creek cooling lake, 1% due to the station construction, and 1% due to dam construction. Because the area covered by the dams and dikes is a small percentage of the entire acreage to be covered by the cooling lake, the impact of their construction will be minimal when compared to the construction and filling of the lake. According to present plans, the fill material for the earthwork will come from the region which will become the lake bottom. The remaining 50% of the site (5211 acres) will not be altered by construction. Of this, 4647 acres are used for agricultural purposes, 108 acres for miscellaneous purposes, and 456 acres are in natural plant communities. The applicant plans, to the extent possible, to continue in production agricultural land outside the cooling lake and the exclusion area (ER, Sect. 8.2.2.3). This may account for as much as 30% of the acquired land (3150 acres).

The proposed on-site electrical distribution facilities appear to be planned so as to minimize the accidental electrocution of large raptors. The towers which are planned for the rerouting of the existing 69-Kv line should not result in losses of large birds due to electrocution. Since the towers which are to be erected for transmission lines will be taller than existing distribution lines, it is unlikely that large birds will perch on them when higher perches are available. Therefore, the possibility of loss from electrocution on existing distribution lines is minimal.

4.3.1.2 Railroads, pipelines, and transmission lines

Wolf Creek site development will necessitate a concomitant growth in transmission line facilities, makeup water pipelines, roads, and a railroad spur. Clearing for construction of these facilities constitutes an additional unavoidable disturbance of the environment. Table 4.2 presents a summary of the changes in acreage of land classification units as a result of this construction.

A new railroad spur will be constructed from the Missouri Pacific Railroad to the plant site. The right-of-way will be about 10 miles long, 125 ft wide, and will require approximately 150 acres. The proposed route will cross four streams resulting in about 8 acres of woodlands being cleared. An additional 144 acres of farmland (range and cropland) will be removed from production.

A makeup water line, approximately two miles long and 100 ft wide will be constructed from a pumping house immediately below the spillway from John Redmond Reservoir. For most of its length, the route of the pipeline will be immediately adjacent to an existing county road. Since the pipeline will be buried, the six acres of farmland will be only temporarily altered.

New cemetery access roads will affect approximately 2.5 acres (1.7 acres of farmland and 0.8 acre of bluestem prairie).

The physical details of the transmission systems have been discussed in Sect. 3.8. A detailed description is found in ER, Sect. 3.9. Approximately 180 miles of transmission lines will be constructed which will affect approximately 3127 acres. Most of the rights-of-way will be maintained in present land use except where the line transverses woodlands and areas occupied by tower bases (ER, Q4.9-1). Thus, land permanently altered will include approximately 205 acres of woodland and 27 acres of farmland (11 acres of cropland and 16 acres of rangeland). This constitutes only a 6% loss of habitat along the corridors.

4.3.1.3 Impact on natural plant communities

Plant communities of the type found are not unique in the region. Originally only 15% of the bluestem prairie, 14% of the northern floodplain forest, and 2% of the oak-hickory forest of the continental United States were found within Kansas[1,2] (Table 4.3). However, mature bluestem prairie is quite rare today. Presently 0.01% of the original prairie within a five-mile radius of the site still remains. The land practices in this area of Kansas are not significantly different from other areas where bluestem prairie originally dominated. Thus any action that would promote the expansion of the bluestem prairie would be beneficial to the survival of this prairie habitat.

Riparian woodlands existing within the proposed cooling lake will be cleared to ensure proper intake flow and to reduce potential sources of nutrient enrichment. Although these wooded areas are not unique to the region, they compose approximately 5% of the woodlands of Coffey County and 16% of the woodlands within five miles of the site. Clearing of wooded areas has not been as extensive as that for prairies. The loss of northern floodplain forest within the State has been more extensive than the upland oak-hickory forest (Table 4.3). The northern floodplain forest of Coffey County occurs mainly along the Neosho River and extends up Wolf Creek to the upper limits of inundation by the Neosho River flood waters. Young oak-hickory forest occupies most of the stream banks of Wolf Creek. At the present time, 99% of the original oak-hickory forest on the site remains. Clearing of the 741 acres of these woodlands will reduce this remaining oak-hickory habitat to 37%. No reduction in floodplain forest is expected from construction activities. The staff considers that the reduction of the oak-hickory woodland of this region will result in a 5% reduction of woodland species in Coffey County.

Table 4.3. Summary of land changes within Kansas

	Kansas	Coffey County	Within five miles of site	Site
Presettlement percentage of the system found in:[a]				
Bluestem prairie	15	.5	.06	.01
Oak-hickory forest	2	.004	.002	.0009
Northern floodplain forest	14	.4	.05	
Preconstruction percentage of the system remaining in:[b]				
Bluestem prairie	c	c	.01	.03
Woodlands	24	17	33	99
Oak-hickory forest	35			
Northern floodplain forest	17			
Post construction loss for:[d]				
Bluestem prairie	c	c	56	71
Woodlands	.07	5	16	63

[a]Acres in subdivision/total acres in United States.

[b]Acres presently found in subdivision/original acres of subdivision.

[c]Unavailable.

[d]Acres lost within that subdivision due to construction/preconstruction acreage of system.

Sources:

1. A. W. Kuchler, "Potential Natural Vegetation of the Coterminous U.S.," *Amer. Geog. Soc. Pub.* 36 (1964).
2. A. W. Kuchler, "A New Vegetation Map of Kansas," *Ecology* 55: 586–604 (1974).

Because of the abundance of rangeland and cropland resources in the site area and throughout the State of Kansas, the loss of these habitats will not have any major impact.

During filling of the cooling lake, the flow of Wolf Creek will be eliminated for a period of 25 to 64 months, depending upon weather conditions at that time. This will allow more flood intolerant species to establish along the stream banks in the region between the dam and the Neosho River. However, if floods again become more common after the lake is filled, more typical riparian vegetation may return.

4.3.1.4 Impacts on soils

In a construction project of this magnitude some erosion problems are inherent. Water erosion occurs when there is extensive runoff of precipitation over exposed land surfaces. The kind of soil and the type of vegetation growing on it have a major effect on the runoff. The applicant plans to conduct erosion control measures around construction sites. Temporary diversions will be constructed to intercept and divert runoff. When appropriate, temporary sediment basins will be built to detain runoff and trap sediments. Temporary vegetative cover crops will be established and maintained to stabilize exposed soils, steep slopes, or dry exposure.

Wind erosion problems will be mitigated by spraying water periodically on clear or graded areas subject to wind erosion.

4.3.1.5 Impacts on producers

Impacts on the native flora are mostly direct, resulting in the death and destruction of all plants growing in areas that will be cleared or inundated by the cooling lake. Impacts from habitat destruction are much greater on species restricted to a single habitat than on those species found in many different kinds of habitats. Based on the number and kinds of habitats in which the species occurred (ecosystem distribution code), each species of Appendix Table B.2 was assigned to one of 13 ecological groups. Table 4.4 provides the numbers of potential and observed species for each of these ecological groups. Impacts on the native flora from habitat alteration will be greatest from the loss of the bluestem prairie habitat since 52% of the potential plant species involved are restricted to a single plant association, bluestem prairie (Table 4.4). Species observed at the site which will be sensitive to habitat alteration include Missouri gooseberry (*Ribes missouriensis*) restricted to the oak-hickory forest and overlooked pussy's toes (*Antennaria neglecta*) restricted to bluestem prairies. At the present time, these species are not considered rare or endangered, thus impact will be minimal. Construction on developed lands at the site is considered to have a minimal impact on the native flora. Most existing plants are agricultural or horticultural varieties or weedy species.

Table 4.4. Number of potential and observed dominant and common associate species of ecological groups at Wolf Creek

Ecological group	No. of ecosystems observed in the U.S.[a]	Bluestem prairie		Oak–hickory forest		Northern floodplain forest	
		Potential	Observed	Potential	Observed	Potential	Observed
Ubiquitous sp.	70	2	1				
Grassland–open woodland sp.	54–58	4	2				
Great plain grassland sp.	15–19	4	2				
Tall grass–midgrass prairie sp.	9	4	1				
Oak savanna–tall grass prairie sp.	8	4	1				
Bluestem prairie sp.	1	20	1				
Eastern forest sp.	19–27			10	5	5	3
Eastern forest–neotropical sp.	25			1	1	1	1
Eastern deciduous–southern forest sp.	15			4	3	7	7
Eastern deciduous forest sp.	9			5	3	8	6
Lake–eastern deciduous forests sp.	17			2	0		
Oak–hickory forest sp.	1			7	1		
Northern floodplain forest sp.	1					11	0
Total		38	8	29	13	32	17

[a]Number of potential plant associations in which the species has been reported growing [Source: A. W. Kuchler, "Potential Natural Vegetation of the Coterminous U.S.,", *Amer. Geog. Soc. Pub.* 36 (1964)].

4.3.1.6 Impacts on consumers

Impacts on local fauna are identified as both direct and indirect. Direct effects are the mortality of invertebrates, amphibians, reptiles, and small mammals. Larger, more mobile mammals and most birds will migrate from the construction area as human activities increase. The more adaptable species would be expected to return as construction activities subside.

Indirect effects of construction activities on consumer population occur through loss of suitable habitat. The impact from the loss of habitat is much greater on species restricted to a single habitat than on species found in many different kinds of habitats. Based on the numbers and kinds of habitats in which the species occurred (habitat distribution code), each species of Appendix Tables B.3 to B.5 was assigned to one of 22 ecological groups. Table 4.5 provides the numbers of potential and observed species for each of these ecological groups. Historically, impacts on the native fauna of the area have been to eliminate those species restricted to a single habitat. Originally 7% of the wildlife was restricted to a single habitat. Currently only one of these 19 species (hairy woodpecker) was sighted by the applicant. The present fauna is made up mainly of wide ranging terrestrial species (Table 4.5). Only 15% of the wildlife fauna of the local area are species that will be able to use the Wolf Creek cooling lake. In some of the protected bays of the cooling lake, marshes will develop. When this

Table 4.5. Number of potential and observed faunal species of ecological groups at Wolf Creek

Faunal species	Number of habitats	Total		Farm-yard		Crop-land		Pas-ture		Prairie		Brush-lands		Wood-lands		Stream		River		Pond		Marsh		Lake		Percent[a]	Percent[b]
		P[c]	O[c]	P	O	P	O	P	O	P	O	P	O	P	O	P	O	P	O	P	O	P	O	P	O		
Generally ubiquitous	12–16	29	15	12	7	11	6	6	3	8	5	7	6	9	9	14	9	10	6	6	4	15	7	5	4	11	16
Farmland-wetland	6–10	24	10	6	5	16	8	3	2	11	4					7	4	8	5	7	5	18	8	10	5	9	10
Ubiquitous terrestrial	7–11	60	25	29	15	25	12	23	9	23	10	26	13	40	17											22	26
Farmyard-woodland	2–6	32	15	32	15									30	13											12	16
Farmland-brushland	5–7	6	3	2	1	4	1	5	2	4	2	5	2													2	3
Farmland	3–5	10	4	5	1	9	4	7	3	9	3															4	4
Farmyard-city	2	8	2	8	2																					3	2
Cropland	1	1	0			1	J																			0.4	0
Grassland	2	1	0					1	0	1	0															0.4	0
Prairie-desert	4	4	0							4	0															1	0
Prairie	1	3	0							3	0															1	0
Brushland-woodland-wetland	7–11	12	6									6	2	8	5	6	3	5	3	1	0	5	3	1	0	4	6
Brushland-woodland	5–6	7	2									6	2	5	2											3	2
Brushland	2–3	1	1									1	1													0.4	1
Woodland	2–4	15	3											15	3											5	3
Forest	1	10	1											10	1											0.4	0.1
Swamp	1	1	0											1	0											0.4	0
Ubiquitous wetland	5–6	37	8													24	5	21	4	21	6	15	3	25	6	14	8
River	1	3	0															3	0							1	0
Lentic wetland	2–4	6	0																	1	0	6	0	1	0	2	0
Pond-marsh	2	2	1																	2	1	2	1			0.7	1
Pond	1	1	0																	1	0					0.4	0
Total		273	96	94	46	66	31	45	19	63	24	51	26	118	50	51	21	47	18	39	16	61	22	42	15		
% Potential species for each habitat.				34		24		16		23		19		43		19		17		14		22		15			
% Observed species for each habitat.				48		32		20		25		27		52		21		18		16		22		15			

[a]Percent of potential species for each ecological group.
[b]Percent of observed species for each ecological group.
[c]P, potential species; O, observed species.

happens, the number of observed species that can use the lake will increase to 22%. Large numbers of waterfowl from the central flyway are using John Redmond Reservoir at the present time. Many of these will be attracted to Wolf Creek cooling lake. Wildlife of ecological groups which will be drastically reduced at the site are prairie-desert species, prairie species, woodland species, and forest species. Thus 32 of the 273 potential species will be essentially eliminated from the site. However, only four of these species were observed: hairy woodpecker, raccoon, eastern fox squirrel, and pine vole. None of these are listed as rare or endangered (Appendix Table B.6). Of the 32 species whose habitat is being eliminated from the site, five are rare in the upper and middle Neosho River basin, two are threatened in Kansas, one is officially listed as threatened for the United States (greater prairie chicken, *Tympanuchus cupido pinnatus*), but is quite common in Eastern Kansas, and two show declining populations (Appendix Table B.6).

Nine species of wildlife restricted to lentic habitats (ponds, marshes, and/or lakes) will be benefited by this increased lake habitat. Of these nine species, black rail (*Porzana jamaiciensis*) is rare in the upper and middle Neosho River basin, and Virginias rail (*Rallus limicola*) and American bittern (*Botaurus lentiginosus*) are sensitive species (Appendix Table B.6). None of these species presently occurs at the site. At the present time, blue-winged teal (pond-marsh species) is the only species occupying the site from the groups restricted to lentic environments. Upon completion of the site, about 135 acres will be developed and landscaped. This area will provide habitat for 48% of the observed species. Eight of these species are restricted to an urban complex (farmyard-city species of Table 4.5). Only two of these species, chimney swift and house sparrow, occupy the site at the present time.

Species occurring only in croplands, pastures, and/or brushlands account for 9% of the fauna. Because of the abundance of this habitat in the site area and throughout the State of Kansas, the loss of these habitats will not have any major impact on the fauna.

No endangered species were present at the site but two species rare to the upper and middle Neosho River basin and ten species of birds which have declining populations[3] were sighted. Plains harvest mouse (*Reithrodontamys montanys*) and badger (*Taxidea taxus*) were found in the bluestem prairie along the abandoned railroad right-of-way.

Fourteen specimens of plains harvest mouse were killed during the preliminary baseline studies conducted by the applicant. The greatest numbers of harvest mouse were captured along the bluestem prairie railroad right-of-way. Since the food of the harvest mouse includes the seeds, grains, fruits, and green vegetation of native plants (rarely of cultivated plants),[4] the staff concludes that destruction of 71% of the native bluestem prairie will eliminate this species from the site unless suitable habitat is developed in the exclusion area prior to flooding. Furthermore, sampling of population should be done only with live traps, and the existing railroad right-of-way should not be disturbed until necessary.

The badger's food consists chiefly of small rodents such as ground squirrels, prairie dogs, mice, and pocket gophers. Much of the badger's preferred food has become rare in this part of Kansas. Franklin ground squirrel, a rare species in Kansas, occurs only in relict areas of tall grass prairie of which bluestem prairie is an example. Currently at the site, the badger is dependent upon the high level of small rodent populations found in the bluestem prairie along the railroad right-of-way. With destruction of this habitat, much of the badger's food source will be eliminated, resulting in the extinction of the badger at the site.

Eight of the ten bird species that are currently declining in numbers[3] at the site are predators of small birds, mammals, insects, or fish. Plant materials provide food for the other two species, redheaded woodpecker, and Eastern bluebird. These ten birds are common widespread species which, because of effects of chemicals on breeding biology, are declining in numbers. Habitat alteration is probably not the primary cause for declining population. However, house wrens show a preference to lowland woods (Appendix Table B.5). Habitat destruction will further reduce population of this farmyard-woodland species.

4.3.2 Aquatic

Construction of the Wolf Creek dam and the makeup structure in or immediately downstream from John Redmond Reservoir will provide the major construction impacts on aquatic communities of the area. Specifically, increased total suspended solids (TSS), which for the purposes of this discussion will be equated with turbidity, and the resulting siltation will be major effects. Further, dam closure will change about 15 stream miles of running water habitat above the dam into reservoir habitat and impose drought conditions on seven stream miles of Wolf Creek below the dam.

4.3.2.1 Siltation and turbidity

Siltation and high TSS resulting from dam construction will produce a temporary but significant impact on Wolf Creek and the Neosho River. The magnitude of this impact will vary directly with rainfall. Several investigators have characterized the effects of siltation and turbidity. Among the more serious effects of siltation[5-8] and the resulting increase in turbidity in aquatic ecosystems are: (1) diminished penetration of light and thus reduced photosynthesis, eventually resulting in a lowered carrying capacity; (2) death of fish eggs, larvae, and probably adult fish by inhibition of gas exchange (abrasion, clogging, and inflammation of gill membranes) and reduction in food and ability to find it; (3) reduction of dissolved oxygen; and (4) reduction in available habitats and spawning grounds for invertebrates and fish through deposition on the stream bottom.

While streams of deforested watersheds have experienced turbidities of up to 56,000 ppm, some investigators believe as low as 3000 ppm mud or silt is dangerous to aquatic organisms.[6,7] Table 4.6 summarizes the results of a study of turbidity effects on largemouth bass and sunfish in 39 farm ponds after the second growing season.

Table 4.6. Effects of turbidity on yield of largemouth bass and sunfish in 39 farm ponds

Farm ponds	Turbidity	Yield (lb/acre)
Clear ponds	<25 ppm	161.5
Intermediate ponds	25–100 ppm	94
Muddy ponds	100–185 ppm	29.3

Source: E. H. Hollis, J. G. Boone, C. R. De Rose, and G. J. Murphy, "A Literary Review of the Effects of Turbidity and Siltation on Aquatic Life," Staff Report Dept. of Chesapeake Bay Affairs, Annapolis, Maryland, December 1964.

The staff expects most of the above effects to occur to a limited extent during and after rainfall. Approximately seven stream miles of Wolf Creek between the proposed dam and its confluence with the Neosho River will be subject to the greatest trauma from siltation and turbidity. The normally greater flow of the Neosho River is expected to significantly reduce the impact on its waters and biota by dilution of the silt-laden water of Wolf Creek. Nevertheless, the danger exists that flow from Wolf Creek could rival that of the Neosho River when the silt load and turbidity of Wolf Creek are greatest. If, for example, the water level in John Redmond Reservoir were low when heavy rains suddenly occurred, outflow from the reservoir would presumably be severely limited while flow from uncontrolled Wolf Creek could approach 1000 cfs or more (ER, Fig. 2.5-3), sending a slug of water high in TSS into a Neosho River of relatively reduced flow.

The probability of heavy rains occurring over the site area during construction is high. The region receives approximately 38 in. of rainfall annually, with May through September being the wettest months. Rain occurs about 94 days of the year (PSAR, p. 2.3-8). Heaviest rains are usually generated by thunderstorms, of which approximately 67% occur in the months May through August. The site area can be expected to average about 50 to 60 thunderstorms a year based on an average annual 58 storms at Topeka and 55 storms at Wichita (PSAR, Table 2.3-3). Table 4.7 shows the maximum rainfall measured over various time intervals for Topeka and Wichita. Nearly 3 in. of rain fell in 30 min in August 1949. On the basis of these data, the staff concludes that TSS in Wolf Creek waters during construction will reach extremely high levels during and immediately after heavy rains, on the order of many thousands of milligrams per liter.

Table 4.7. Maximum short period rainfall for Topeka and Wichita, Kansas

Time interval	Topeka		Wichita	
	Rainfall (in.)	Date	Rainfall (in.)	Date
5 min	0.67	9/14/30	0.66	9/06/11
10 min	1.19	8/13/49	1.10	6/14/31
30 min	2.92	8/13/49	2.31	7/31/50
60 min	4.16	8/13/49	3.28	7/31/50
12 hr	7.71	9/06/09	7.89	9/06/11
24 hr	8.08	9/06/09	7.99	9/06/11

Sources:

1. PSAR, Table 2.3-1.
2. U.S. Weather Bureau, "Maximum Recorded United States Point Rainfall for 5 Minutes to 24 Hours for 296 First Order Stations," *Dept. of Commerce, Technical Paper No. 2*, (1963).

In addition to the 15 fish species inhabiting the Neosho River near the site (ER, Table 2.7E-1), Cross[10] lists another 22 or more species found in the Neosho River within or very near Coffey County. All of these fish must be considered subject to adverse effects due to siltation and high TSS should the above conditions arise. One of these fish, the Neosho madtom, *Noturus placidus*, has been listed as "endangered" by the Endangered Species Committee of the American Fisheries Society.[11] This small catfish is endemic to the Neosho River system and has the smallest range of any fish species in Kansas. Populations have declined in recent years due to drought, habitat destruction, and feedlot runoff.[10,12,13] This fish prefers the gravel bars of shallow riffles[10,13] and would thus seem particularly sensitive to siltation.

In light of the potential for damage to biota of the Neosho River from siltation and TSS[5-8] should heavy rains occur, the staff will require that TSS and rainfall be monitored under all weather conditions, including rain storms, for the remaining period prior to the start of construction and during the entire period of construction. Specifically, the staff will require that TSS be monitored in Wolf Creek upstream of all construction work. Sufficient control measures, including sediment retention basins, must be employed such that TSS in construction runoff to lower Wolf Creek does not exceed that measured upstream of construction by more than 80 mg/liter. Compliance with these measures should provide adequate protection for biota of the Neosho River. Activities associated with the construction of the power block must meet the EPA TSS limitation of 50 mg/liter (40 CFR Part 423.4).

Measures to be undertaken by the applicant to reduce these adverse effects are described in Sect. 4.5.

Makeup intake structure

The relatively small size of the proposed structure suggests that siltation and turbidity arising from this activity will be quite localized. The applicant will be held to his commitments to use sediment basins and/or other measures for reducing siltation and TSS during construction (Sect. 4.5.2).

All benthic organisms and their habitats on the immediate site of the proposed intake structure will of course be lost. The staff does not view this loss as significant in view of the total benthic area of the cooling lake and the river available for bottom-dwellers.

4.3.2.2 Effects of dam closure on lower Wolf Creek

After closure of the dam, the six or seven stream miles of Wolf Creek below the dam will depend solely on runoff from the remaining watershed for maintaining flow during the 25 to 64 months needed to fill the cooling lake. This remaining watershed is not expected to maintain flow in a stream that has shown itself to be intermittent in the past. For a few months a series of temporary pools should persist in the stream bed, but eventually most of these too will probably dry up during extended dry periods. Fish trapped in these pools will die, but many fish will have avoided entrapment by moving downstream. On resumption of adequate flow, these fish may then repopulate the stream. Most of the macroinvertebrate populations inhabiting Wolf Creek will be decimated, but enough individuals may survive in the interstitial spaces of the stream bed, under rocks and leaf litter, or as aestivating pupae and larvae to replenish their populations when flow returns. Other species will reestablish themselves through recruitment from downstream and from "aerial plankton" fallout once flow returns.

4.3.2.3 Effects of dam closure above the dam

Closure of the Wolf Creek dam will change roughly 15 miles of meandering stream habitat (representing about six acres of flowing water) into 5090 acres of primarily shallow-lake habitat (ER, p. 4.1-10). This represents approximately 55% of the total length of Wolf Creek. Several small tributaries will also be inundated. This extreme transformation constitutes the major impact of plant construction on the aquatic ecosystem and will last for the life of the cooling lake.

A pronounced change in species composition and density will follow the change from a stream to a lake ecosystem habitat. Obligate rheophilic (preferring or requiring current) species will rapidly disappear from the lake area as flowing water disappears. Fishes currently inhabiting Wolf Creek that will not survive impoundment include the stonerollers, suckermouth minnows, blunt-nosed darters, golden redhorse, and probably the shorthead redhorse.[10,15] Logperch, green sunfish, blackstripe topminnows, and bluntnose minnows are also likely to succumb to encroachment by lentic waters judging from their habitat preferences.[10,15] Among the benthic macroinvertebrates found in Wolf Creek, many species of stoneflies, mayflies, caddisflies, blackflies (Simuliidae), megaloptera, prosobranch gastropods, and crayfish will fail to adapt to the new lentic environment (ER, p. 4.1-7).

Periphyton populations that are likely to be depressed by the impoundment if not excluded are those of some *Nitzschia* ssp., *Navicula* spp., *Achnanthes* spp., *Cocconeis placentula*, and *Melosira varians* (ER, p. 4.1-9). Those phytoplankters of Wolf Creek derived from these periphytic species can be expected to suffer reduced abundance accordingly.

Colonization of the cooling lake

Facultative organisms. Figure 4.1 illustrates a pattern of colonization typical of new cooling lakes. Facultative organisms in Wolf Creek that are capable of exploiting both stream and lake habitats will be among the pioneering life forms in the new cooling lake. Among the macroinvertebrates in Wolf Creek surviving impoundment and colonizing the new lentic habitat will be oligochaetes such as *Limnodrilus*; chironomids such as *Chironomus*, *Coelotanypus* and *Orthocladius*; and nematodes. Other opportunists in Wolf Creek expected to exploit the new cooling lake include the fingernail clam (*Sphaerium*), the phantom midge (*Chaoborus*), and the Chironomid (*Procladius*) (ER, p. 4.1-7; Table 2.7D-2). Eventually some mayfly and dragonfly populations may become established, but it is likely that chironomids and oligochaetes will continue to dominate the benthos as they have done in John Redmond Reservoir. The latter organisms will therefore be major constituents of the diet of some fishes.

Approximately one-third of the cooling lake will be littoral area which should provide a variety of substrates (trees, rocks, mud, man-made structures) for a periphytic community likely to be dominated by the green filamentous algae, *Cladophora*, *Stigeoclanium*, and *Spirogyra* (ER, p. 4.1-9). Periphytic diatoms are likely to be well represented by *Gomphonema*, *Cymbella*, and *Achnanthes*. Periphyton will be a major food item for many benthic invertebrates and some fish such as carp and river carpsucker (ER, p. 2.7-6).[10]

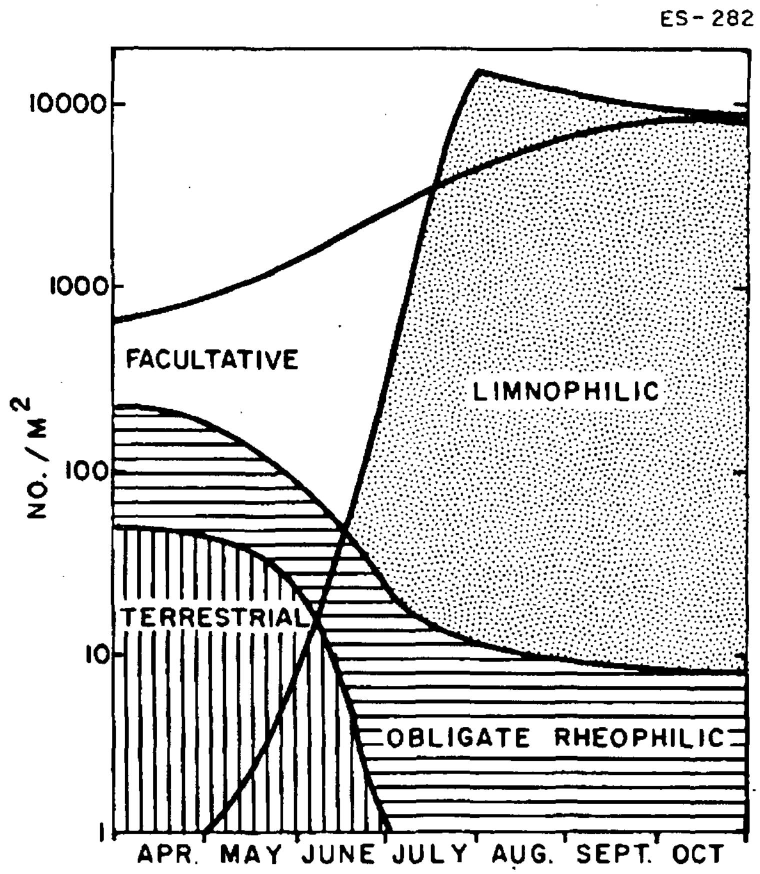

Fig. 4.1. Typical pattern of colonization in a new reservoir. Source: C. G. Patterson and C. H. Fernando, "The Macro-Invertebrate Colonization of a Small Reservoir in Eastern Canada," *Verh Internat. Verein Limnol.* 17: 122-136 (1969).

High nutrient concentrations in the new cooling lake, due to their release from the submerged bottomlands and vegetation, should give rise to a richly developed phytoplankton community as has occurred in John Redmond and many other reservoirs.[16,17] Major contributions to the new phytoplankton community are expected from Wolf Creek which experiences high populations in pools, and the numerous farm ponds that will be inundated. On the basis of the phytoplankton communities that have developed in other reservoirs, particularly John Redmond Reservoir, one might expect species of *Stephanodiscus, Synedra, Cyclotella, Melosira,* and *Fragilaria* to be among the more abundant diatoms, especially during late fall, winter, and early spring (ER, p. 4.1-8).[18] Blue-greens may reach high densities in the warm summer months, especially species of *Oscillatoria, Microcystis, Coelosphaerium, Aphanizomenon,* and *Anabaena* (ER, p. 4.1-8).[19] Prophet[20], in a study of John Redmond Reservoir, indicated that the phytoplankton was dominated by the green alga *Pediastrum* sp. and the blue-green *Oscillataria* sp. The principal grazers of this richly developed phytoplankton will, of course, be the zooplankton, including cladocerans already present in Wolf Creek and John Redmond Reservoir such as *Daphnia, Bosmina,* and *Chydorus* ssp. and copepods such as *Diaptomus silciloides*[21] (ER, p. 4.1-8). Rotifers likely will be abundant. The probable abundance of plankton, both plant and animal, is expected to provide the necessary energy and nutrients for rapid growth of fish populations as has occurred in other new impoundments.[22]

Facultatives, such as red shiners, bullhead minnows, carp, river carpsuckers, smallmouth buffalo, and white crappie, and fishes inhabiting inundated farm ponds such as channel catfish and bluegill, will probably contribute most to early fish populations (ER, Table 2.7E-1).[23] Eventually, recruitment from John Redmond Reservoir via the makeup pipeline will likely lead to the establishment of populations of gizzard shad (a planktivore), white bass, walleye, drum, and possibly flathead catfish. Although no quantitative predictions of fish populations or species composition can be made, the history of fish populations in other reservoirs indicates that growth of both population and individuals (particularly those of game fishes) will be extremely rapid for the first year or two after impoundment since habitat and food are plentiful and unexploited. After four or five years, predation pressure and probably other factors presumably reduce zooplankton standing crops, resulting in reduced game fish populations and increased rough fish populations (up to 75 to 80% by weight).[22,23] The activities of some rough fish such as the destruction of spawning habitat and eggs by carp will probably contribute to the decline of game fish populations.

Some expected limnological features of the new cooling lake. In some respects, the early history of the cooling lake should be similar to that of John Redmond Reservoir. For example, decaying submerged vegetation may drive summer oxygen concentrations down to zero in the hypolimnion as occurred in John Redmond Reservoir during the rare occasions of thermal stratification.[16,20] Thermal stratification is expected to occur much more frequently and to achieve greater stability in Wolf Creek cooling lake than in John Redmond Reservoir because of the former's greater depth (average depth of 21 ft compared to less than 8 ft for John Redmond Reservoir at conservation level), more irregular shore line, and relatively narrower shape which reduces wind-induced wave action. These same factors will also significantly reduce turbidity relative to John Redmond Reservoir. Other factors mitigating turbidity include settling out of many of the suspended solids in John Redmond Reservoir by the time the water enters the makeup diversion. Since nutrients such as phosphates and nitrates are not likely to be limiting in the cooling lake, the increased light penetration due to lower turbidity is expected to significantly boost phytoplankton and periphyton production, leading to greater standing crops of zooplankton and fish. Studies of Missouri River reservoirs indicate that turbidity is the major limiting factor of phytoplankton abundance in the reservoirs.[18]

The cooling lake will not be directly affected by feedlot runoff to the extent of John Redmond Reservoir since no feedlots exist in the Wolf Creek watershed. Another important difference between the two reservoirs will be the relative rates of flow through them. John Redmond Reservoir, with a "normal" capacity[16] of 56,500 acre-ft and an average discharge[24] of more than 1300 cfs has a much lower storage ratio (volume of reservoir/volume discharge) than the proposed cooling lake with its normal capacity of 111,000 acre-ft and an average discharge of only 25.5 cfs (ER, p. 10.1-2; Table 3.3-1). Thus a significantly greater buildup of TDS is predicted for the cooling lake (ER, Table 3.6-2). This rise in TDS will be discussed in more detail in Sect. 5. The greater flushing action of John Redmond Reservoir is probably a significant factor in the reduction of phytoplankton densities in that reservoir. The cooling lake will lose very little phytoplankton through discharge.

4.3.2.4 Effect of sanitary waste discharges

During construction, 30,000 gal of sanitary wastes per day (0.05 cfs) will be discharged directly into Wolf Creek. These wastes will have received chlorination (maximum free residual of 1 mg/liter in effluent) and tertiary treatment that should remove most of the nutrients. On the basis of an average flow in Wolf Creek of 17 cfs or 10,988,093 gal/day, the discharge of treated wastes is not expected to have any significant impact. After dam closure, there may be some impact on Wolf Creek immediately below the dam as the effluent will constitute a significant part of the total stream flow at that point.

4.4 IMPACTS ON PEOPLE

4.4.1 Physical impacts

At least 25 households involving 52 to 85 persons will have to be relocated; however, proposed alignments of the rights-of-way for the railroad spur, road, pipelines, and transmission lines will be so located that no farm homes or other households will suffer displacement (ER, Sects. 4.2.1 and 8.2.2).

Construction activity will involve clearing, transporting dirt for fill, and grading. This activity will be noticeable particularly during the early stages of site preparation. Blasting will be necessary and will degrade the local air quality to some extent. The site is sufficiently remote from the nearest major population centers so that the noise of blasting and heavy machinery should be no more than a minor nuisance (ER, Sect. 8.2.2.8).

Truck traffic associated with construction was discussed in Sect. 4.1. The impact on local roads will be significant, requiring the upgrading of some roads to accept heavy equipment. In addition, traffic congestion will increase significantly, requiring traffic control at major intersections and road improvements to meet peak demands. This congestion, together with the need to relocate some roads, will cause some temporary inconvenience (ER, Sect. 8.2).

4.4.2 Population growth and construction worker income

New Strawn, which was incorporated in 1971, has a population of 225. Burlington's population declined slightly from 2113 in 1960 to 2099 in 1970 (ER, p. 2.2-1). The population of Coffey County declined from 8403 in 1960 to 7397 in 1970, a 12% decline.[26]

Estimates of the distribution of the project work force during the 1979 period of peak employment indicate that 21% will reside in Coffey County, 67% will reside within the intermediate impact area (within a 75-mile radius of the site), and about 12% will live beyond the intermediate impact area (ER, Table 8.1-7 and Sect. 8.1.2.2.1.2). An analysis of data pertaining to the work force for the nearby LaCygne plant showed that while workers came from 387 different communities in nine states, about 89% came from Kansas, Missouri, Gulf Coast cities, and West Texas. A similar distribution is anticipated for the Wolf Creek plant. Other large projects in the general region showed that about 50% of the work force lived within 50 miles of the project (ER, Sect. 8.1).

Estimates indicate that, during the 1979 period of peak employment, approximately 77 workers and their families will have moved into Coffey County and about 132 families will have relocated in the intermediate impact area. Based upon the statewide average of 2.96 persons per family, the applicant estimates that 228 persons will relocate to Coffey County and 391 will relocate in the intermediate area by peak 1979. When the effects of the employment multiplier are considered, the increase in population is anticipated to amount to 364 in Coffey County and 625 in the intermediate impact area (ER, Sect. 8.2.2.1). From these figures an estimated 93 in Coffey County and 160 in the intermediate area will be children between the ages of six and 17 who will require public school facilities (ER, Sect. 8.2.2.1.1).

The estimates of disposable income derived from construction employment for the immediate and intermediate impact areas and the general region for the period 1976-1982 are presented in Tables 4.8 and 4.9. Related information concerning the estimated annual construction payroll and the estimated residential distribution of the workers at peak level is given in Tables 4.10 and 4.11, respectively.

4.4.3 Impact on community services

The availability of housing in Coffey County and the seven adjacent counties was studied (ER, p. 8.2-9). In general, much of the unoccupied housing in Coffey County is old and probably substandard. There is a new subdivision in the town of New Strawn with 165 lots of which 70 have already been sold. There is a 14-pad trailer park in existence and a new one planned with up to 300 spaces. Burlington, the largest community in the county, has a small number of mobile home sites and hotel and motel space available. Four other small communities in the county have a few units each for sale or rent (ER, pp. 8.2-9).

In the intermediate impact area, a significant problem is not expected with respect to a demand for housing. Each of the major towns in the area was surveyed and found to have between 1 and 5% of total housing available for rent or sale. At the peak of employment at the project, the increase in population is estimated at about 0.1% of the present population of the area and thus should be easily absorbed.

Table 4.8. Estimated project payroll contributions to disposable income during construction phase — 1975—1981 (thousands)[a]

	1976	1977	1978	1979	1980	1981	1982	Total
Immediate impact area (Coffey County)	$135	$2158	$4,508	$6,622	$5,542	$3,361	$191	$22,517
Intermediate impact area	562	8989	18,773	27,575	23,080	13,998	796	93,773
General region	227	3637	7,596	11,157	9,338	5,664	322	37,941

[a]These estimates are derived from estimated employment schedules, projected worker distribution, and wage rates developed in ER, Sect. 8.1.2.2, Tables 8.1-6 and 8.1-7. Estimated disposable income was obtained by reducing payrolls by 23% to account for taxes, social security, and other nonvoluntary payroll deductions.

Source: ER, Table 8-1-11.

Table 4.9. Estimated total annual increase in local area disposable income derived from project payrolls and multiplier effect (thousands)[a]

Year of initial spending	Year of initial spending and subsequent respending immediate impact area (Coffey County)									
	1976	1977	1978	1979	1980	1981	1982	1983	1984	Total
1976	$140.6	$ 74.0	$ 1.3	$	$	$	$	$	$	$ 215.9
1977		2837.0[b]	603.7[b]	11.7	0.1					3,452.5
1978			6051.1	1,138.6	22.7	0.4				7,212.8
1979				8,987.4	1576.1	31.2	0.4			10,595.1
1980					7748.8	1096.4	21.5	0.4		8,867.1
1981						4871.4	496.0	10.0	0.1	5,377.5
1982							296.3	9.3	0.1	305.7
Total:	$140.6	$ 2911.0	$ 6656.1	$10,137.7	$ 9347.7	$ 5999.4	$ 814.2	$19.7	$0.2	$ 36,026.6

Year of initial spending	Year of initial spending and subsequent respending intermediate impact area									
	1976	1977	1978	1979	1980	1981	1982	1983	1984	Total
1976	$584.6	$ 308.0	$ 6.1	$ 0.1	$	$	$	$	$	$ 898.8
1977		11,821.1	2,510.2	49.7	0.8					14,381.8
1978			25,199.6	4,742.1	94.0	1.7				30,037.4
1979				37,425.7	6,561.2	129.7	2.7			44,119.3
1980					32,267.8	4,568.5	90.4	1.5		36,928.2
1981						20,288.4	2,066.9	40.9	0.7	22,396.9
1982							1,235.3	37.4	0.7	1,273.4
Total	$584.6	$12,129.1	$27,715.9	$42,217.6	$38,923.8	$24,988.3	$3,395.3	$79.8	$1.4	$150,035.8

[a]This table is based on the disposable income estimates developed in Table 8.1–11 and on the assumption that four rounds of respending will occur each year (see Appendix 8A).

[b]Example: The estimates of $2,837 thousand is the sum of the initial expenditure during 1977 plus three rounds of respending during 1977. The estimate of $603.7 thousand represents the increase in disposable income in 1978 due to subsequent respending of 1977 income.

Source: ER, Table 8.1–12.

Table 4.10. Estimated annual construction payroll

Year	Annual payroll (millions)
1976	$ 1.2
1977	19.2
1978	40.1
1979	58.9
1980	49.3
1981	29.9
1982	<1.7
	$200.3

Source: ER, Table 8.1-6.

Table 4.11. Estimated residential distribution of construction workers (at peak level of 1745 in 1979)[a]

Impact area	Present residents		Relocating Workers				Total	
			Permanent[b]		Temporary[c]			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Immediate	138	11	77	37	156	56	371	21.3
Intermediate	905	72	132	63	123	44	1160	66.5
General region	214	17	[d]				214	12.2
Total:	1257	100	209	100	279	100	1745	100.0
Percent:	72		12		16		100	

[a]These estimates are based on analyses of occupational characteristics of populations in the general region of the proposed plant site and on studies of locations of workers employed on the construction of the La Cygne plant in Kansas, the Riverside plant in Oklahoma, the Columbia Generating Station Number 2 in Wisconsin, and the De Cordova Bend Plant in Texas.

[b]Involves family relocation.

[c]Includes weekend commuters.

[d]No workers assumed to relocate to the General Region.

Sources:

1. U.S. Bureau of The Census, 1972a, b, and c.
2. ER, Table 8.1-7.

Water and sewage facilities in New Strawn are being expanded to serve 2000 people, and the capacities in Burlington are presently greater than twice the peak loads. In the intermediate impact area, all towns surveyed for housing reported adequate water and sewage capacities (ER, p. 8.2-10). The other communities of Coffey County have adequate water and sewage systems, with some expansion capability available.

Traffic will increase several fold on local roads (ER, p. 8.2-14a). Thus, road maintenance and construction will cause an impact on county resources.

Only one hospital exists within five miles of the site — a 20-bed facility in Burlington.

4.4.4 Impact on local institutions

The Wolf Creek Generating Station will come under the jurisdiction of Coffey County and the Burlington School District, No. 244, while part of the cooling lake will extend into the Waverly School District No. 243 (ER, p. 8.1-19). Tax liabilities for transmission lines will accrue in favor of seven other counties (ER, p. 8.1-21). The applicant estimates that the total valuation of WCGS will be approximately $1030 million, with an assessment rate of 30% as required by Kansas law. The assessed valuation of the plant will be about $300 million compared to the total assessed value of property in Coffey County of over $27 million. Because of the requirements of the Kansas tax law, the county will experience considerable benefits by a gradual increase in tax revenues while property owners will benefit even more through a reduction in the tax rate. During construction when the facilities will be assessed at 20% of cost, the revenues from WCGS will be several times greater than the present $1.6 million now collected by Coffey County (ER, p. 8.1-20).

School authorities believe that the Coffey County school system can readily accommodate the estimated 93 school age children who will require access to public schools. These students would represent a 5.5% increase over a three-year period, which might require two additional employees per year, although this may be modified by projected declines in school population owing to lowered birth rates. In the intermediate impact area the addition of a few hundred students to a student population of 160,000 is expected to have a minimal effect (ER, p. 8.2-8).

The staff visited local officials in Coffey County during a site visit in May 1974. The officials there were aware of the potential local impacts that might result from the construction of WCGS and were taking steps to meet such impacts.

4.4.5 Impact on recreational capacity of area

The nearby John Redmond Reservoir and other nearby lakes and reservoirs provide adequate water-related recreational facilities. There will probably be a brief disruption of the use of some of the John Redmond facilities (e.g., picnic grounds) during the period of construction of the makeup water intake for the cooling lake. This will be of a temporary nature lasting perhaps as long as 1.5 years in the case of the pump house construction (ER, Q8.6). During low flow periods, water withdrawal from the reservoir will be limited severely and thus should not affect the water level. There are other recreational areas, e.g., parks, swimming pools, golf courses, within relatively short distances (ER, p. 2.2-5).

No plans have been made for the development of the cooling lake or any other part of the site for recreational purposes. However, it is the staff's opinion that a feasibility study should be undertaken by the applicant to explore the possible benefits associated with public access and use of the cooling lake.

4.5 MEASURES AND CONTROLS TO LIMIT ADVERSE EFFECTS DURING CONSTRUCTION

4.5.1 Applicant commitments

The following is a summary of the commitments made by the applicant to limit adverse effects during construction of the proposed station.

1. Measures to minimize erosion sedimentation during site preparation and construction.

   a. Temporary sediment basins will be built at appropriate places to detain runoff and trap sediments.

   b. Spoil areas will be kept graded, reasonably flat, and compacted by normal construction traffic.

   c. Water will be sprayed on bare soil to minimize wind erosion during dry periods.

   d. Grass will be seeded on the periphery of major spoil areas to control water erosion, if necessary.

   e. Grading and drainage of the plant site will be designed to avoid erosion during the construction period.

   f. Temporary vegetative cover crops will be established and maintained to stabilize exposed soils, steep slopes, or dry exposure.

2. Disposal of waste materials.

   a. Sanitary wastes of construction personnel will be treated onsite and released to Wolf Creek. Under conditions of average and low flows the applicant will meet the following water quality standards and dissolved oxygen levels which are at least as restrictive as State standards (Appendix F).

      Bacteria: Fecal coliform shall not exceed a geometric mean of 200/100 ml of sample, and no more than 10% of total samples during any 30-day period shall exceed 400/100 ml sample.

      Dissolved oxygen: Shall be maintained at or above 5 mg/liter (except for 4 mg/liter for short periods of time within a 24 hr period). Dissolved oxygen concentration less than the above levels shall not be due to man-made point source waste discharges.

      Ammonia: Man-made point source waste discharge shall not cause the undissociated ammonium-hydroxide concentration of the waters of Wolf Creek to exceed 0.15 mg/liter as *N*.

      Oil and grease: All waters shall be essentially free of visible oil and grease. Dissolved or emulsified grease concentrations shall be kept below levels that will interfere with established beneficial uses.

      Solids: There shall be no man-made deposits of solids in the waters of Wolf Creek, either organic or inorganic, which will be detrimental to established beneficial use.

      Turbidity: There shall be no turbidity increase in waters of Wolf Creek, other than that of natural origin, that will cause substantial visible contrast with the natural appearance of the water.

      Temperature: Heat of artificial origin shall not be added to Wolf Creek in excess of the amount that will raise the temperature of the water more than 5°F above natural conditions.

pH: Man-made point source waste discharge shall not cause the pH of Wolf Creek water to vary below 6.5 or above 8.5.

Taste and odor producing substances: Taste and odor producing substances shall be limited to concentrations in the receiving water that will not interfere with the production of potable water by reasonable water treatment processes, or impart unpalatable flavor to fish, or result in noticeable offensive odors in the vicinity of the water, or otherwise interfere with established beneficial use of the water.

Color: Man-made point source discharges of color-producing substances shall be limited to concentrations that will not be detrimental to established beneficial use of the receiving water.

Toxic substances: Toxic substances or synergistic effects of toxic substances from man-made point sources shall be limited to concentrations in the receiving water that will not be harmful to human, animal, plant, or aquatic life, or otherwise interfere with established beneficial use of the water.

Chlorine: Effluent will contain a maximum residual of 1 mg/liter of free chlorine and will not exceed 10 mg/liter of five day BOD or 12 mg/liter of suspended solids.

b. Debris from construction activities will be removed from the site and disposed of or used on site in a manner that is in compliance with local and State regulations.

3. Measures to minimize the effect of transmission line construction.

a. Following guidelines for protecting the environment and minimizing possible adverse impacts on present and foreseeable land uses,[25] routes were specifically selected to avoid populated, recreational, forested, visually sensitive areas, and sensitive archaeological areas to the extent possible.

b. Visual impacts of transmission lines will be reduced where feasible by routing the lines so that they are screened by trees and hills. The H frame structures will be made of wood and weathered to a light gray color so as to blend into the sky line.

c. Although limited temporary access roads will be needed to initially construct the rights-of-way, no permanent access or maintenance roads will be constructed along any portion of the route.

d. Herbicide application will be basically by the dormant spray methods (selective basal stump spray and dormant stem spray). The applicant will substitute an acceptable herbicide if EPA hearings on the use of herbicides prevent the continued use of 2-4-5-T.

e. Vegetation clearing along transmission rights-of-way will be limited and selective.

4. Traffic and dust control.

a. Traffic control measures will be implemented as required to control traffic at certain intersections during peak traffic hours. These include a local patrolman to control light timing. Staggered work hours for different work crews may be employed to lessen congestion.

b. The principal connection between U.S. Highway 75 and the plant will be upgraded to accommodate heavily loaded trucks.

5. Other mitigative measures.

a. Most of the surface area of the plant site will be improved and planted following construction.

b. Personnel and vehicle access into areas that are to remain in a natural state will be restricted by installing fences, off-limits signs, and access control gates.

c. Prior to construction of the cooling lake, the most significant archaeological sites will undergo further evaluation or excavation.

4.5.2 Staff evaluation

Based on a review of the anticipated construction activities and the expected environmental effects therefrom, the staff concludes that the measures and controls committed to by the applicant, as summarized above, are adequate to ensure that adverse environmental effects will be at a minimum practicable level if combined with the following additional precautions:

1. Specifically, the staff will require that TSS be monitored in Wolf Creek upstream of all construction work. Sufficient control measures, including sediment retention basins, must be employed such that TSS in construction runoff to lower Wolf Creek does not exceed that measured upstream of construction by more than 80 mg/liter. Compliance with these measures should provide adequate protection for biota of the Neosho River. Activities associated with the construction of the power block must meet the EPA TSS limitation of 50 mg/liter (40 CFR 423.4). The staff recommends that sediment retention basins be drained between periods of rain when TSS is lowest in order to increase capacities for subsequent storm runoff. Drainage rate should be controlled to minimize scouring and erosion in Wolf Creek.

2. In areas such as the pipeline route where excavation operations remove topsoil and replace it with subsoil, organic matter or selected fertilizers shall be added as necessary to correct subsoil deficiencies and thus promote revegetation.

3. Used oil should be collected in containers for reuse, including pickup by oil reclaimers, if feasible.

4. Metal scrap material should be collected in a trash disposal area for pickup by scrap dealers.

5. The concrete mix plant area should be kept free of refuse and accumulative debris.

6. Limbs and other cleared debris along transmission lines should be mulched or made into brush piles in order to provide wildlife habitat.

7. In riparian woodlands, initial clearing for transmission line corridors should be done in such a manner as to leave all roots of woody plants intact so that the interlaced roots can help prevent bank erosion.

8. All spoil from earth excavation necessary for transmission line tower installation should be spread, graded around tower site, or hauled to designated fill areas.

9. Denuded areas along transmission lines subject to erosion should be planted to adapted grass species to accelerate succession and to prevent erosion.

10. Construction of transmission lines should be scheduled to avoid unharvested fields whenever possible. Whenever it is necessary to disturb or destroy field crops, farm operators should be adequately compensated.

11. Dust control measures will comply with State and local regulations during operation of the concrete mix plant.

12. A perimeter buffer zone of natural vegetation should be retained around the lake.

13. Dry weather wetting of unpaved haul roads and access areas should be required to reduce local particulate burden.

14. If possible, approximately 100 acres of trees should be left standing in coves above 1072 ft MSL of the cooling lake to provide habitat for benthic organisms and for fish spawning and shelter.

15. A control program should be established by the applicant to provide for a periodic review of all construction activities to assure that those activities conform to the environmental conditions set forth in the construction permit.

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24. U.S. Army Corps of Engineers, Tulsa, Oklahoma District, *Reservoir Regulation Manual for Council Grove, Marion, and John Redmond Reservoirs, Upper Grand (Neosho) River, Kansas*, June 1969.

25. U.S. Department of the Interior, *Environmental Criteria for Electric Transmission Systems*, U.S. Government Printing Office, Washington, D.C., 1970.

26. U.S. Bureau of the Census, U.S. Census of Population, *Number of Inhabitants* Final Report PC(1)-A1 U.S. Summary 1970.

5. ENVIRONMENTAL EFFECTS OF OPERATION OF THE STATION AND TRANSMISSION FACILITIES

5.1 IMPACTS ON LAND USE

5.1.1 Station operation

The WCGS is situated in an area largely devoted to low intensity farming. Removal of this rural land from its present agricultural use could result in about a 3% decrease in agricultural production in Coffey County. Using 1972 crop yields and December 1973 prices, the total value of production of this land would be about $1 million. Land outside the cooling lake and the exclusion area may still be used for agricultural purposes. Approximately 50 rural households will be affected by the establishment of the plant, cooling lake, and related facilities (ER, p. 8.2-22). Of these, 25 households will require removal. Previous use of this land and the impacts of construction were discussed in Sects. 4.1 and 4.3.

5.1.2 Transmission lines

The transmission line rights-of-way will cross land largely devoted to grazing and agriculture. Land used primarily for grazing comprises approximately 55% of the total 3127 acres on the Rose Hill-Craig transmission line rights-of-way. About 37% of this land is used for crop production, and 7% is heavily wooded. The presence of transmission lines is not expected to significantly affect agricultural production. Heavily wooded areas will be cleared as required. The transmission lines will largely avoid heavily populated areas; however, due to the dominant flat-to-gently-rolling terrain, transmission lines will be seen from great distances.

5.2 IMPACTS ON WATER USE

5.2.1 Surface water

The Kansas Water Resources Board intends to purchase an undivided 55.84% of the total storage space in the John Redmond Reservoir from the U.S. Army Corps of Engineers under the provisions of the Federal Water Supply Act of 1958 (P.L. 85-500 as amended). This percentage of storage space is estimated to be 34,900 acre-ft after adjustment for 50 years of sediment deposit. The applicant is negotiating to purchase this storage from the Water Resources Board. The staff's thermal analysis is predicated on the availability of 34,900 ft of storage. Kansas Water Resources Board is negotiating to purchase storage space in the Council Grove and Marion Reservoirs from the Corps of Engineers.

Kansas Statutes Annotated 82a-1305 gives the Kansas Water Resources Board the right to contract for the withdrawal of water from the reservoirs at a rate not exceeding the reservoir storage space yield capability during a drought having a 2% chance of occurrence in any one year with the reservoir in operation. The right to water stored in John Redmond Reservoir has been granted to the Kansas Water Resources Board by the Division of Water Resources, Kansas Department of Agriculture, by the assigned right number 5, file number 22, 197-AR-5.

The Kansas Water Resources Board has estimated that the 2% chance drought total yield capability for John Redmond Reservoir is 73 cfs.[1] Thus, 55.84% of this reservoir storage space available to the State of Kansas will yield (0.5584 x 73) 40.76, or about 41 cfs of water. The Kansas Water Resources Board estimate is based on the correlations for river flow frequency and reservoir storage requirements to sustain a given yield as stated in the Kansas Water Resources Board Technical Reports 1, 2, and 4.[2-5] Also assumed for this estimate is zero flow into the John Redmond Reservoir from the Council Grove, Marion, and the proposed Cedar Point Reservoirs.

Kansas Gas and Electric Company has made a number of applications to the Kansas Department of Agriculture, Division of Water Resources, for water rights in the Neosho River Basin.[6] These include the application for the right to divert water from the Neosho River at the John Redmond Reservoir, applications for the right to divert water from the Council Grove and the Marion Reservoirs' storage, and the application for the right to impound the water draining from the Wolf Creek Basin into the cooling lake. As stated above, the Kansas Water Resources Board intends to purchase storage space in the Marion and Council Grove Reservoirs. It is the staff's understanding that the Kansas Gas and Electric Company plans to withdraw their applications for water in these storage spaces once they have signed their contract for the purchase of water from the Kansas Water Resources Board. If not, a public hearing will be held to determine whether or not Kansas Gas and Electric Company's applications for water in these storage spaces should be approved.

The applications to the Department of Agriculture by Kansas Gas and Electric Company to divert water from the Neosho River will allow the applicant to divert the excess water being spilled from the John Redmond Reservoir to the Wolf Creek Generating Station at any rate up to the amount of water being spilled from the John Redmond Reservoir, less the water being released for the prior downstream water rights and the minimum flow requirements. The applicant is planning to withdraw water from the John Redmond Reservoir and the Neosho River through an intake structure to be located just downstream of the John Redmond Dam. The applicant plans to withdraw water at this point at the rate of 41 cfs when the John Redmond Reservoir water surface elevation is below the conservation level of 1039 ft MSL, and at varying rates up to a maximum of 120 cfs when the water surface elevation is at or above the conservation level (ER, pp. 2.5-4e and 12.1-4).

First priority for the water flowing by natural means (rainfall runoff) into John Redmond Reservoir is given to the prior water rights holders, located downstream of the John Redmond Reservoir. These prior water rights holders have rights only to this first water inflow into the reservoir, not to the water present in the reservoir storage. Thus, if the reservoir water inflow is less than the water rights, the water available for the prior water rights holders is limited to the rate that the water is flowing into the reservoir. These prior water rights are estimated to be 15 cfs for all months except June through August, when they are 44 cfs (ER, Table 2.5-3p).

Water must be available from the portions of the water storage space retained by the U.S. Army Corps of Engineers in Council Grove, Marion, and John Redmond Reservoirs for release to maintain the Neosho River water quality at Council Grove, Emporia, and Chanute, Kansas. Currently, the minimum river flow rates set to maintain the water quality at these communities are those set forth in a supplemental statement prepared in 1952 to a report of the Public Health Service, "A Study of Public Water Supply and Stream Pollution in the Grand (Neosho) River Basin and the Need and Justification for Low-Flow Regulation from Conservation Storage in Proposed Flood Control Reservoirs," dated August 1940.[7] These minimum water flow requirements vary from 4 to 8 cfs at Council Grove, Kansas; from 7 to 16 cfs at Emporia, Kansas; and from 21 to 48 cfs at Chanute, Kansas (ER, Tables 2.5-3h and 2.5-3r). Recently, the Kansas Water Resources Board expressed the opinion that the river water quality at these cities in the future would not be maintained by specifying these minimum flow rates, but that water would be released from the reservoir storage space in sufficient amounts to maintain the river water quality at these communities (Appendix A, p. A-42 and A-43). They stated that this probably would reduce the amount of water that would have to be released from the reservoir storage space during a drought.

The applicant analyzed the behavior of the John Redmond Reservoir with water being diverted from it to the Wolf Creek Generating Station using the monthly hydrological and meteorological data for the period of January 1951 through December 1960 (ER, p. 2.5-4b through 2.5-4f). This time range included the period-of-record drought. It was assumed that water would be diverted from the reservoir to the station at the rate of 120 cfs when the reservoir water level is at or above 1039 ft MSL and 41 cfs when the reservoir water level is below 1039 ft MSL. Natural evaporation rates from John Redmond and the upstream reservoirs were assumed to be the same as those measured at the Fall River Dam, Kansas (ER, Table 2.5-3e). It was assumed that water would be released from the Marion Reservoir for water quality purposes at a constant rate of 5.5 cfs and from the Council Grove Reservoir at the rates currently specified by the U.S. Army Corps of Engineers for the same purpose at Council Grove, Kansas (ER, Table 2.5-3h). Further no transmission losses were assumed for this water when it flows from the upstream reservoirs to the John Redmond Reservoir.

The applicant's analysis assumed that water would be released for water rights and water quality purposes currently required for Chanute, Kansas, as discussed above and that the local drainage area between the John Redmond Reservoir and Chanute contributes to these water quality flows at Chanute. If the flow at Chanute from this local drainage area is less than the minimum water quality flow presently specified for Chanute, the difference was assumed to be made up for by the release of water from the John Redmond Reservoir.

The John Redmond Reservoir water levels determined by the applicant in this analysis are shown in Fig. 5.1. The minimum water level was determined to be 1030.3 ft MSL, which is equivalent to 12,700 acre-ft remaining in the John Redmond Reservoir storage space.

The staff used the data presented in the applicant's analysis and in the applicant's response to the DES comments to calculate flow rates in the Neosho River immediately downstream of the John Redmond Dam with and without the water being diverted to the Wolf Creek Generating Station for the time from January 1951 through December 1959. Results of these calculations are summarized in Table 5.1. It can be seen that while there is a reduction of flow during some portions of the period-of-record drought, there would have been no change in the down-river flow during the worst part of the drought because the water surface in the John Redmond Reservoir, naturally, would have been below the conservation level. In this case, water is released downstream only for the previous water rights and for water quality purposes which are the same with or without the presence of the Wolf Creek Generating Station.

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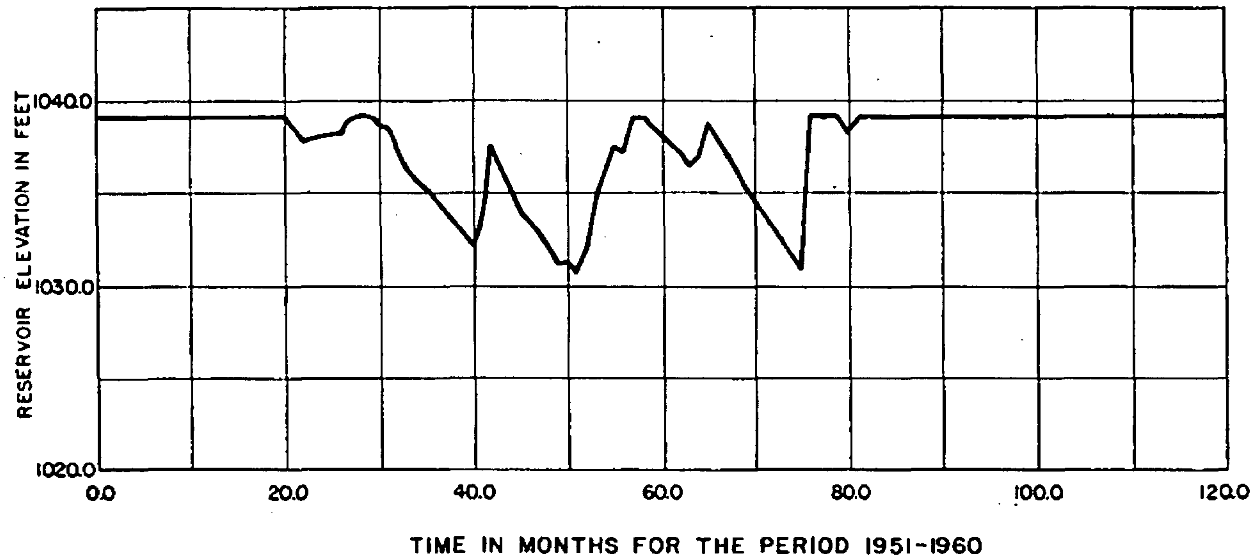

Fig. 5.1. Predicted John Redmond Reservoir water surface elevations with Wolf Creek Generating Station in operation (for the years 1951 through 1960). Source: ER, Fig. 2.5-5a.

Water will be evaporated from Wolf Creek cooling lake at a rate of 35,760 acre-ft/year. The staff estimates that evapotranspiration losses from the area that will be covered by the cooling lake are about 13,390 acre-ft/year. Thus the water losses due to Wolf Creek Generating Station will be 22,370 acre-ft/year. Makeup withdrawal may cause adverse impacts on the biota and water quality of the Neosho River during drought conditions and on the biota of John Redmond Reservoir through entrainment and impingement. Section 5.5.2 addresses these impacts in detail.

Other than the possibility of small reductions in the sport fishery in John Redmond Reservoir, the staff foresees no significant adverse impacts on recreation in the site area. A small area of the east bank of the Neosho River below John Redmond Dam will no longer be available to fishermen and campers because of the location of the makeup facilities.

5.2.2 Groundwater

No groundwater will be used for operation of the WCGS. However, the cooling lake will provide continuous recharge to the rock and soil under and near the site. Groundwater levels will rise. In the case of the Plattsmouth Limestone Member, the applicant calculated a 45.8-ft rise 100 ft from the cooling lake 50 years after filling. Two miles from the site the rise in groundwater would be less than 0.4 ft (ER, Sect. 5.1.7). The calculated times for cooling lake water to move through one mile of Plattsmouth Limestone Member and Jackson Park Shale Member are 6000 years and 1020 years, respectively (ER, Sect. 5.1.7.3). Seepage from the cooling lake may affect groundwater quality. However, due to the slow groundwater movement and water table gradients, the staff concludes that groundwater users outside the site boundary would not be affected.

Table 5.1. Flow rates in the Neosho River immediately downstream of the John Redmond Dam without and with the Wolf Creek generating station

	Flow rates								
	1951	1952	1953	1954	1955	1956	1957	1958	1959
January									
Without WCGS (cfs)	210.1	514.0	68.4	28.0	24.0	25.7	21.0	344.0	310.2
With WCGS (cfs)	90.1	394.0	15.0	28.0	24.0	25.7	21.0	222.3	190.2
Percentage[a]	57	23	78	0	0	0	0	35	39
February									
Without WCGS (cfs)	351.1	347.4	55.0	26.0	15.0	28.0	21.0	519.0	449.7
With WCGS (cfs)	231.1	227.4	15.0	26.0	15.0	28.0	21.0	399.0	312.9
Percentage[a]	34	35	73	0	27	0	0	23	30
March									
Without WCGS (cfs)	571.8	2698	163.8	23.0	27.0	25.8	27.4	3773	418.9
With WCGS (cfs)	451.9	2578	15.0	23.0	27.0	25.8	27.4	3653	298.9
Percentage[a]	21	4	91	0	0	0	0	3	29
April									
Without WCGS (cfs)	1030	3457	100.3	28.0	15.0	15.0	535.1	1545	1025
With WCGS (cfs)	910.6	3337	15.0	28.0	15.0	15.0	138.1	1427	905.1
Percentage[a]	12	3	85	0	0	0	74	8	12
May									
Without WCGS (cfs)	6738	1487	392.0	15.0	15.0	391.0	5343	1273	4027
With WCGS (cfs)	6620	1367	333.5	15.0	15.0	15.0	4964	1153	3908
Percentage[a]	2	8	15	0	0	96	7	2	3
June									
Without WCGS (cfs)	5867	337.7	60.0	311.7	175.1	46.4	2613	1674.6	742.5
With WCGS (cfs)	5757	217.8	44.0	44.0	44.0	46.4	2493	1555	622.5
Percentage[a]	2	36	27	86	75	0	5	7	16
July									
Without WCGS (cfs)	28,270	112.8	56.0	62.8	267.7	41.1	609.8	4117	3452
With WCGS (cfs)	281,150	48.2	56.0	62.8	44.0	41.1	489.8	3998	3332
Percentage[a]	0.4	57	0	0	84	0	20	3	3
August									
Without WCGS (cfs)	2104	153.5	60.0	65.1	67.7	55.0	178.3	715.9	473.3
With WCGS (cfs)	1984	79.7	60.0	65.1	55.0	55.0	65.0	596.6	353.4
Percentage[a]	6	48	0	0	19	0	64	17	25
September									
Without WCGS (cfs)	6465	24.0	40.1	36.3	313.5	36.0	274.8	1301	392.7
With WCGS (cfs)	6345	24.0	40.1	36.3	15.0	36.0	154.8	1192	272.7
Percentage[a]	2	0	0	0	95	0	44	8	31
October									
Without WCGS (cfs)	1282	24.0	26.5	30.2	279.8	24.0	572.1	525.0	2689
With WCGS (cfs)	1162	24.0	26.5	30.2	193.4	24.0	452.1	405.0	2569
Percentage[a]	9	0	0	0	31	0	21	23	4
November									
Without WCGS (cfs)	913.1	15.0	25.3	21.7	24.5	21.0	730.4	563.0	425.8
With WCGS (cfs)	793.1	15.0	25.3	21.7	24.5	21.0	620.4	443.0	305.8
Percentage[a]	13	0	0	0	0	0	16	21	28
December									
Without WCGS (cfs)	513.0	56.9	27.0	21.5	23.7	21.0	278.6	172.5	472.4
With WCGS (cfs)	393.0	15.0	27.0	21.5	23.7	21.0	158.6	86.1	352.4
Percentage[a]	23	74	0	0	0	0	43	50	25

[a]Percentage figures are reductions in flow due to plant operation.

5.3 EFFECTS OF OPERATION OF HEAT-DISSIPATION SYSTEM

5.3.1 Applicant's thermal analysis

The applicant analyzed the behavior of Wolf Creek cooling lake, using the hydrological and meteorological data for the period January 1949 through December 1964. The applicant assumed that there would always be a minimum of 41 cfs of makeup water from John Redmond Reservoir and that there would be up to 120 cfs of makeup water available from this reservoir when the level is at or above the conservation level of 1039 ft MSL. The combined circulating and service water flow rate and temperature rise were assumed to be 1256 cfs and 28.8°F (16°C), respectively, when the station is operating at full load. For the purpose of these analyses, the applicant assumed that the plant factor would be 62.5% for the months of October through May and that it would be 100% for the months of June through September.

The applicant determined the lake surface temperatures, natural and forced evaporation rates, water levels, and TDS and sulfate concentrations. Particular attention was given to the time between January 1951 and December 1959 which contains the regional period-of-record drought. This was to assure that there would be sufficient water in the cooling lake to dissipate the station's waste heat during this time.

The model employed by the applicant to predict Wolf Creek cooling lake behavior using historical hydrological and meteorological data was the LAKET computer program of Sargent and Lundy Engineers. This program uses a one-dimensional model based on the work of Frank D. Masch and Associates,[8] Water Resources Engineers, Inc.,[9] and Harbeck et al.[10]

Average monthly natural and forced water evaporation rates in Wolf Creek cooling lake using the 1949-1964 hydrological-meteorological data are shown in Table 5.2. The average total evaporation rate from the lake is 49.4 cfs, which is equivalent to 35,760 acre-ft/year. The calculated average seasonal water budget for the lake during the same period is shown in Table 5.3. Slightly less than two-thirds of the water makeup is from John Redmond Reservoir; the remainder is provided by rainfall and Wolf Creek inflow. About two-thirds of the cooling lake water loss is by evaporation; the remainder is discharged to lower Wolf Creek. The predicted average annual water budget is shown in Fig. 3.2 where the average makeup water withdrawal rate from the John Redmond Reservoir is 33,740 acre-ft/year.

Table 5.2. Average monthly Wolf Creek cooling lake evaporation rates (cfs) at a 62.5% plant factor for October through May and a 100% plant factor for June through September

	Natural	Forced	Total
January	11.05	10.47	21.52
February	10.15	7.68	17.83
March	17.17	8.27	25.44
April	24.31	8.63	32.94
May	33.12	10.66	43.78
June	44.99	20.42	65.41
July	53.58	24.79	78.37
August	58.95	29.35	88.30
September	52.34	30.35	82.69
October	38.51	23.29	61.80
November	26.09	18.55	44.64
December	14.09	13.99	28.08
Average	32.15	17.26	49.41

Source: ER, Table 3.4-6.

For the time between January 1951 through December 1959, the applicant determined that the cooling lake water levels would have been those shown in Fig. 5.2. This curve shows that a minimum lake surface level of 1084.8 ft MSL would have occurred in 1954. For these calculations, the water makeup rates from John Redmond Reservoir were assumed to be 120 cfs during January 1951 through June 1952 and June 1957 through December 1959, 45 cfs during July 1952, and 41 cfs during August 1952 through May 1957. Blowdown rates from Wolf Creek cooling lake were assumed to be 3.5 cfs during January 1951 through July 1952, zero during August 1952 through March 1957, and 40 cfs during April 1957 through December 1959. Seepage from the lake was assumed to be 3.5 cfs at all times.

Table 5.3. Average seasonal Wolf Creek cooling lake water budget (cfs) at a 62.5% plant factor for October through May and a 100% plant factor for June through September

	Makeup from John Redmond Reservoir	Rainfall and Wolf Creek runoff	Evaporation	Blowdown and spillage	Seepage
Winter	41.5	10.2	22.6	19.2	3.5
Spring	38.3	32.8	34.1	18.4	3.5
Summer	53.4	39.8	77.5	22.1	3.5
Fall	53.2	22.3	63.0	21.2	3.5
Average	46.6	26.4	49.4	20.2	3.5

Source: ER, Table 3.3-1.

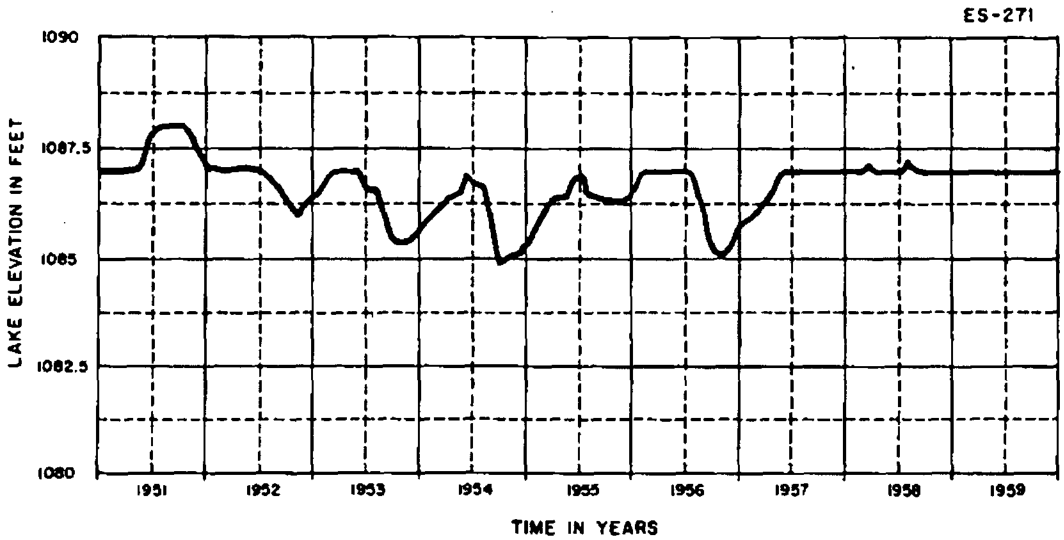

Fig. 5.2. Wolf Creek cooling lake drawdown analysis during 1951-1959 period – Plant at 62.5% plant factor for October through May and 100% plant factor for June through September.

Surface temperature distributions in the cooling lake as determined by the applicant are shown in Table 5.4 (see Fig. 5.3 for the location of the points referenced in the table). It can be seen that the maximum temperature at the plant discharge would be 117°F, and that at the plant inlet would be 88.3°F.

5.3.2 Staff's thermal analysis

The staff determined water evaporation rates, lake levels, and temperature distributions in Wolf Creek cooling lake by using the model of Ryan and Harleman.[11] Hydrological and meteorological data for the period January 1951 through December 1973 were used in the staff analysis. The staff assumed that the combined circulating and service water flow rate and the temperature rise are 1256 cfs (2518 cfs for two units) and 28.8°F (16.0°C) for the station operating at full load; 1178 cfs of circulating water having a temperature rise of 30.0°F (16.7°C) and 78 cfs of service water having a temperature rise of 10.0°F (5.6°C).

Gross water evaporation rates from Wolf Creek cooling lake were determined by the staff assuming that the plant is operating at 100% plant factor for June through September and 62.5% for the remainder of the year. Results of these calculations (Table 5.5) show that the average water evaporation rate from Wolf Creek cooling lake would have been 33,240 acre-ft/year or 45.9 cfs for one unit operation and 44,854 acre-ft/year or 61.9 cfs for two-unit operation. The evaporation rates are in agreement with those predicted by the applicant, therefore the staff concludes that the applicant's values are acceptable.

Table 5.4. Wolf Creek cooling lake temperatures (°F) at 100% plant factor and cooling lake surface at 1087 ft above mean sea level

Location[a]	Plant discharge	A	B	C	D	Plant inlet
Maximum[b]	117.0	100.3	91.1	88.3	88.3	88.3
1 Percentile[c]						
Winter	78.0	63.1	55.3	48.9	48.9	48.9
Spring	111.4	90.1	83.3	82.7	82.7	82.7
Summer	116.0	99.2	90.1	86.9	86.9	86.9
Fall	105.7	88.9	81.0	77.3	77.3	77.3
50 Percentile[c]						
Winter	68.9	55.4	47.8	35.9	35.9	35.9
Spring	93.3	74.5	66.6	64.6	64.6	64.6
Summer	108.6	89.1	86.5	80.4	80.4	80.4
Fall	88.0	71.6	64.2	61.0	61.0	61.0

[a]See Fig. 5.2.
[b]ER, Fig. 3.4-7.
[c]ER, Table 3.4-4b.

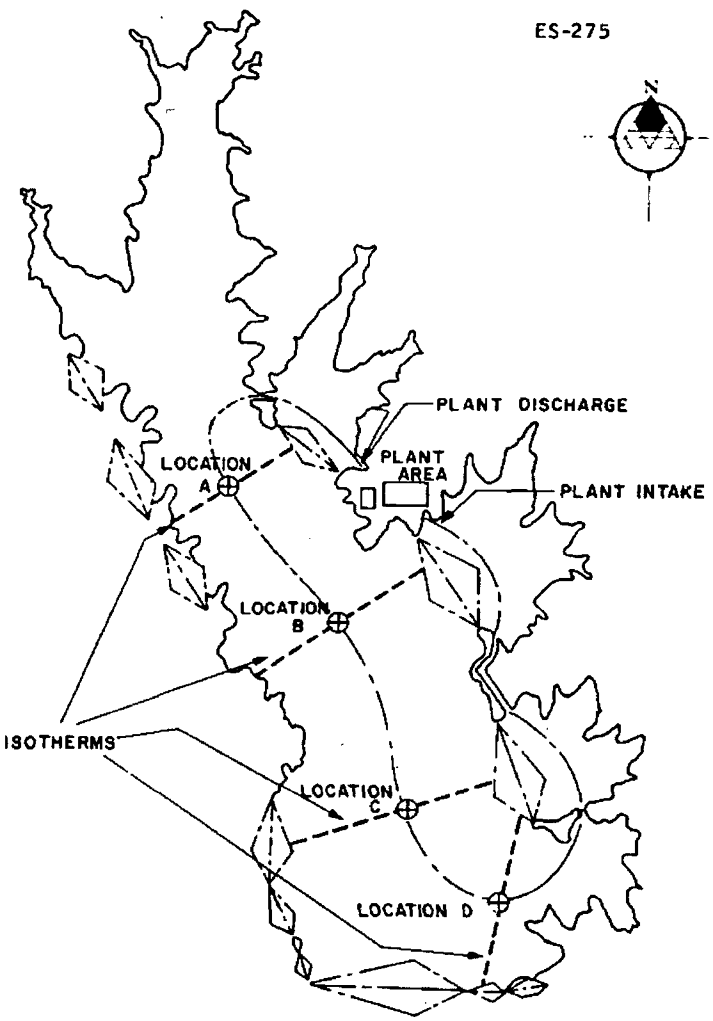

Fig. 5.3. Location of points on Wolf Creek cooling lake referenced in Table 5.~~3~~4. Source: ER, Fig. 3.4-7A.

Table 5.5. Staff's evaluation of water evaporation from Wolf Creek cooling lake at a 62.5% plant factor for October through May and 100% plant factor for June through September

Year	Total evaporation rate (acre-ft/year) 1 Unit	2 Units	Year	Total evaporation rate (acre-ft/year) 1 Unit	2 Units
1951	30,291	40,996	1962	32,690	44,222
1952	35,630	47,483	1963	36,256	48,040
1953	35,978	48,635	1964	34,610	46,293
1954	37,013	49,511	1965	30,955	42,504
1955	36,854	48,750	1966	33,839	45,442
1956	36,859	49,177	1967	30,753	42,280
1957	31,994	43,364	1968	31,947	43,442
1958	32,369	43,507	1969	29,934	41,347
1959	33,552	44,818	1970	32,600	44,151
1960	32,897	44,148	1971	32,715	44,269
1961	32,313	43,676	1972	31,158	42,613
			1973	31,364	42,975

Average (acre-ft/year) 1 unit = 33,242; 2 units = 44,854

Water surface levels in Wolf Creek cooling lake were determined by the staff for the period January 1951 through December 1960. The staff calculated that the minimum water levels would be those shown in Table 5.6, where it can be seen that a minimum cooling lake water level of 1085.2 ft MSL would have occurred in September 1953 for one-unit operation and a minimum cooling lake water level of 1081.4 ft MSL would have occurred in October 1956 for two-unit operation. These values are higher than those predicted by the applicant in Fig. 5.2, and ER, p. 3.4-2. The staff concludes that the applicant's value is acceptable.

Table 5.6. Staff's evaluation of low Wolf Creek cooling lake water levels for the period 1951–1960 at a 62.5% plant factor for October through May and 100% plant factor for June through September

Condition	Water level (ft MSL)	Month
Lowest water level, 1 unit	1085.2	September 1953
Lowest water level, 2 units	1081.4	October 1956
Second lowest water level, 1 unit	1085.4	September 1954
Second lowest water level, 2 units	1082.4	September 1954

The staff calculations were based on a water makeup rate from John Redmond Reservoir of 41 cfs for July 1952 through May 1957 and 120 cfs for the rest of this time period. Blowdown rates were assumed to be 3.5 cfs for January 1951 through July 1952, zero for August 1952 through March 1957, and 40 cfs for April 1957 through December 1960. The seepage rate was assumed to be 3.5 cfs at all times.

Temperature calculations by the staff show that the highest temperatures in Wolf Creek cooling lake would have occurred in the month of July. The staff found that 1968 was a typical year during the 23-year period and the lake surface temperatures for the plant operating at 75% plant factor during 1968 would have been those shown in Table 5.7. Increasing the plant factor of a single unit to 100% during July 1968 would increase the maximum temperature from 103.3 to 110.5°F. The addition of a second unit at 100% plant factor during July 1968 would cause the temperature within each isotherm to increase by an average of 2-3F°, resulting in the entire lake surface being used in the cooling process. The highest lake surface temperatures were found to occur in July 1954 and July 1969 and are included in Table 5.7. Comparing the surface temperatures in Table 5.7 with those of the applicant (Table 5.4), the temperatures predicted by the staff are slightly lower than those of the applicant. Therefore, the staff concurs with the applicant that the Wolf Creek cooling lake surface temperatures will not exceed those shown in Table 5.4.

Table 5.7. Staff's evaluation of Wolf Creek cooling lake surface temperatures (°F)

Fraction of lake area within isotherm	1968 at 75% plant factor — 1087-ft MSL lake level				July 1968 at 100% plant factor — 1087-ft MSL lake level		July 1969 at 100% plant factor — 1087-ft MSL lake level		July 1954 at 100% plant factor — 1084.8-ft MSL (1 unit), 1075.6 ft MSL (2 units) lake level[a]	
	January		July							
	1 Unit	2 Units	1 Unit	2 Units	1 Unit	2 Units	1 Unit	2 Units	1 Unit	2 Units
0.00	52.2	56.9	103.3	104.7	110.5	112.4	114.5	116.3	114.0	118.2
0.07	47.6	45.1	87.9	91.3	89.9	94.3	93.3	97.9	93.2	99.5
0.11	45.1	44.6	87.1	90.7	88.9	93.5	92.4	97.1	91.9	98.9
0.21	39.7	43.5	85.6	89.4	86.8	91.7	90.4	95.3	89.8	97.5
0.31	37.5	42.4	84.4	88.3	85.4	90.2	89.1	93.9	88.4	96.2
0.41	35.9	41.5	83.5	87.3	84.2	89.0	88.0	92.7	87.4	95.1
0.51	33.8	40.6	82.9	86.4	83.4	87.8	87.3	91.5	86.6	94.1
0.61	32.0	39.7	82.4	85.7	82.8	86.9	86.7	90.7	86.1	93.3
0.71	32.0	38.9	82.1	85.1	82.4	86.2	86.4	90.0	85.7	92.5
0.81	32.0	38.2	81.9	84.6	82.0	85.5	86.0	89.3	85.4	91.8
0.91	32.0	37.5	81.9	84.2	82.0	85.0	86.0	88.8	85.4	91.1
1.00	32.0	37.0	81.9	83.8	82.0	84.6	86.0	88.4	85.4	90.4
Equilibrium	32.0	32.0	81.4	81.4	81.4	81.4	85.6	85.6	85.1	85.1

[a]1075.6 ft MSL is the applicant's predicted probable minimum operating level for 2 units; 1084.8 ft MSL is the applicant's predicted probable minimum operating level for 1 unit.

Staff calculations show that the cooling lake will stratify during the summer months for one-unit operation and to a lesser extent for two-unit operation. Figure 5.4 gives the predicted vertical temperature profiles in Wolf Creek cooling lake during 1968 with the plant operating at a 75% plant factor. The calculations indicate that the lake usually will start to stratify during March and will remain stratified until September.

During the calendar year 1968 (a typical year), the circulating water intake and discharge temperatures and the cooling lake equilibrium temperatures would have been those shown in Fig. 5.5. The maximum temperature will occur during the summer months. Circulating water intake temperatures also approach equilibrium temperatures during the summer since the heat exchange coefficient between the cooling lake water surface and the atmosphere increases with temperature.

Differences between cooling lake blowdown temperatures (T_B) and the equilibrium temperatures (T_E) calculated by the staff are shown in Tables 5.8 and 5.9. The Neosho River temperatures (T_N) can be assumed to be equal to the equilibrium temperatures for these comparisons, i.e., $T_B - T_N \cong T_B - T_E$. Blowdown temperatures will exceed the equilibrium temperatures in the winter, as expected, but will be less than the equilibrium temperatures in the summer since part of the blowdown will be discharged from the bottom of the lake. At 32°F, water will start to freeze. Therefore, when calculated values for T_E dropped below 32°F, the staff assumed $T_B - T_E = T_B - 32$, and when calculated values for both T_B and T_E dropped below 32°F, it was assumed that $T_B - T_E = 0$.

The Kansas Department of Health and Environment Regulations 28-16-28, Water Quality Criteria for Interstate and Intrastate Waters of Kansas (Appendix F) state that man-made point sources cannot elevate the temperature of the receiving water above 90°F and that heat of artificial origin shall not be added to a stream in excess of the amount that will raise the temperature of the water more than 5F° above natural conditions. The same regulations allow for a mixing zone for each individual discharge, but a continuous zone of passage must be provided in streams, reservoirs, or lakes when mixing zones are allowed. Because of varying local physical and chemical conditions and biological pheonomena, no single general value can be given on the percentage of the river width necessary for a zone of passage. However, the regulations state, as a guideline, mixing zones should be limited to no more than one-fourth of the cross-sectional area and/or volume of flow of a stream or reservoir, leaving at least three-fourths free as a zone of passage.

Tables 5.8 and 5.9 show that during the summer months the blowdown water temperature will be less than the river water temperature. Therefore, the cooling lake blowdown will not cause the Neosho River water temperature to rise above 90°F. With one operating unit installed, the blowdown water temperature, with a few exceptions, will be less than 5F° above the river water temperature. Table 5.8 shows that the largest difference of 7.8F° would have occurred in December 1971. Table 5.9 shows that with two operating units installed blowdown water temperature will exceed the Neosho River water temperature by more than 5F° during most of the winter months. The greatest difference of 14F° would have occurred again in December 1971.

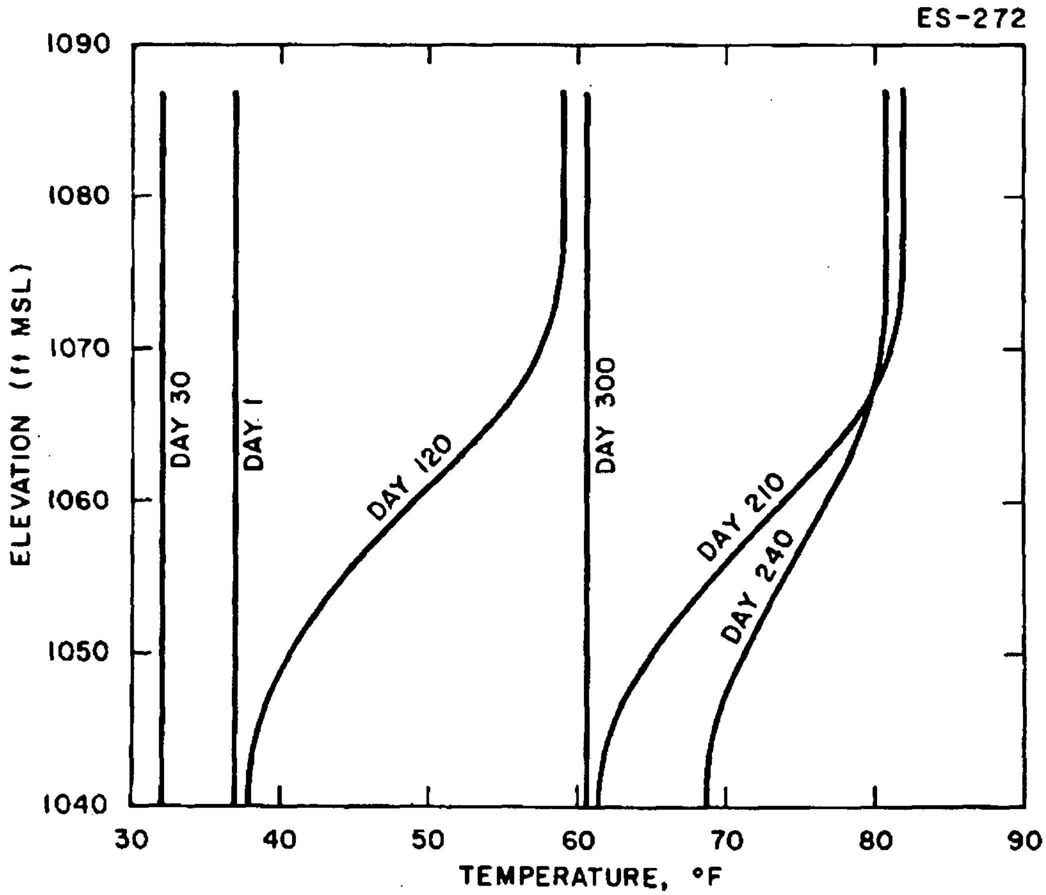

Fig. 5.4. Staff estimates of the vertical temperature profiles in Wolf Creek cooling lake for a typical year (1968) at 75% plant factor.

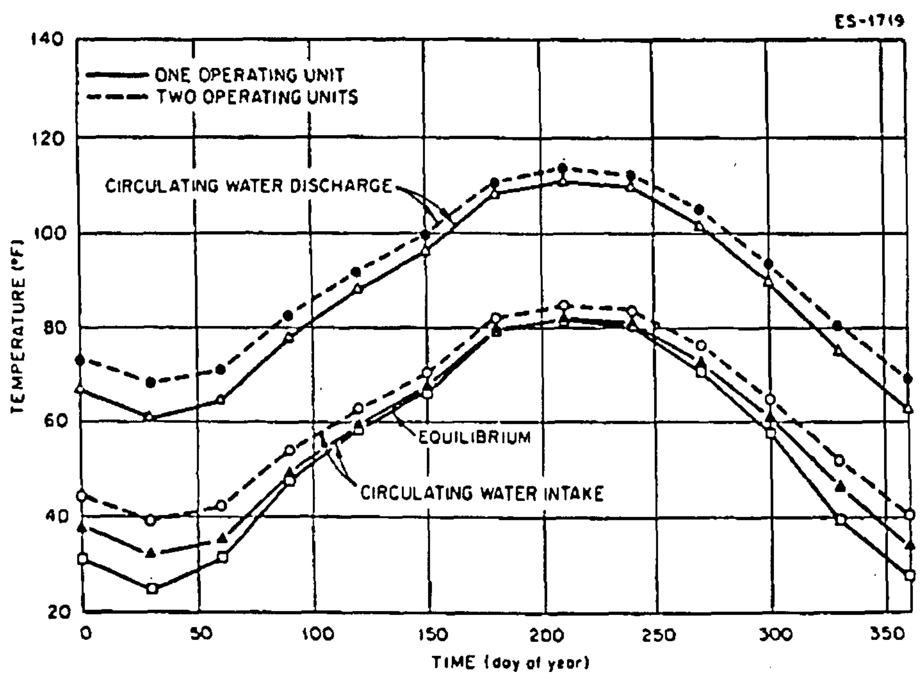

Fig. 5.5. Staff estimates of the variation of the circulating water intake and discharge temperatures and equilibrium temperatures during the year 1968 at a 100% plant factor. (Cooling lake water level at 1087.0 ft MSL).

Table 5.8. Staff's evaluation of the difference between the blowdown water temperature and the equilibrium temperature for Wolf Creek cooling lake with one unit operating at 100% plant factor

Year	January	February	March	April	May	June	July	August	September	October	November	December
1951	0.3[a]	−1.2	−5.7	−15.6	−27.3	−23.0	−23.1	−13.9	2.0	3.1	6.1	2.4[a]
1952	2.1[a]	−3.8	−4.5	−17.8	−24.4	−28.8	−18.4	−10.6	0.9	4.1	4.7	5.2[a]
1953	3.9[a]	−2.3	−9.2	−11.9	−21.8	−28.0	−19.8	−10.4	1.2	2.8	5.1	5.6
1954	0.2[a]	−10.0	−5.8	−21.5	−20.5	−25.3	−23.1	−11.5	0.3	2.7	4.2	6.0
1955	2.7[a]	1.1[a]	−9.8	−25.4	−24.3	−19.9	−24.5	−12.9	0.7	2.8	5.4	1.6[a]
1956	0.0[b]	−0.6[b]	−12.1	−17.6	−26.5	−27.5	−21.8	−11.1	0.9	1.6	4.4	5.6
1957	0.0[b]	−4.1[b]	−9.9	−17.6	−24.2	−24.9	−25.0	−12.4	2.1	3.6	4.8	4.7
1958	2.9[a]	0.2	−5.8	−20.4	−28.9	−25.1	−20.5	−14.9	0.1	3.1	3.9	3.7[a]
1959	0.0[b]	0.0[b]	−12.9	−19.3	−26.1	−26.2	−19.6	−13.9	1.4	3.5	5.1	4.4
1960	0.8[a]	0.0[b]	−0.6	−23.7	−27.2	−26.3	−22.3	−14.2	−1.8	3.1	4.3	3.9[a]
1961	0.1[a]	−2.6	−9.5	−14.7	−20.8	−25.6	−21.1	−12.7	1.4	2.5	4.8	0.6[a]
1962	0.0[b]	−0.6[b]	−8.4	−19.9	−30.4	−25.4	−20.1	−11.7	1.8	2.5	5.1	5.8[a]
1963	0.0[b]	0.0[b]	−15.7[b]	−21.8	−24.7	−26.7	−21.4	−10.8	−0.1	1.5	4.5	0.0[b]
1964	0.0[b]	−1.5	−6.8	−19.9	−26.7	−24.2	−21.6	−9.1	−0.8	4.2	4.6	4.9[a]
1965	2.9[a]	3.0[a]	0.3	−22.9	−27.8	−23.8	−21.4	−11.0	1.8	3.6	5.8	5.8
1966	0.0[b]	−0.6[a]	−13.9	−15.7	−25.2	−25.0	−24.7	−10.0	1.8	3.5	5.2	5.2[a]
1967	2.9[a]	2.0	−12.0	−20.8	−18.6	−24.1	−21.2	−10.2	2.5	3.5	6.4	6.3[a]
1968	0.3[a]	0.5[a]	−13.7	−19.7	−21.1	−26.4	−20.4	−12.0	1.1	3.3	6.8	2.3[a]
1969	0.0[b]	−1.7[b]	−7.3	−23.8	−27.0	−22.8	−24.5	−11.7	0.8	4.5	5.8	5.4[a]
1970	0.0[b]	−2.8[b]	−8.3	−21.6	−29.2	−24.5	−20.6	−14.5	1.1	4.3	5.7	6.4
1971	0.0[b]	0.0[b]	−11.7[b]	−23.1	−24.6	−29.1	−19.0	−11.9	0.5	3.0	5.3	7.8
1972	0.0[b]	−0.1	−13.6	−19.4	−24.8	−25.1	−17.6	−11.6	−0.1	4.3	6.1	1.2[a]
1973	0.0[b]	−1.9	−15.1	17.7	−22.6	−25.8	−21.8	−13.4	2.2	2.9	5.6	4.3[a]

[a] Equilibrium temperature assumed to be 32°F.
[b] Blowdown temperature assumed to be 32°F.

Table 5.9. Staff's evaluation of the difference between the blowdown water temperature and the equilibrium temperature for Wolf Creek cooling lake with two units operating at 100% plant factor

Year	January	February	March	April	May	June	July	August	September	October	November	December
1951	6.9[a]	5.6	1.1	−8.7	−19.7	−14.7	−14.8	−6.2	5.1	6.8	11.1	8.2[a]
1952	8.1[a]	2.4	1.9	−11.1	−16.8	−20.5	−10.4	−4.0	4.6	8.1	9.5	13.3[a]
1953	12.5[a]	4.3	−2.3	−4.8	−14.5	−20.1	−12.0	−3.5	3.8	6.4	9.7	10.9
1954	7.0[a]	−3.0	1.3	−14.4	−12.8	−17.3	−15.2	−4.4	3.3	6.1	8.5	11.6
1955	11.0[a]	7.2[a]	−3.4	−18.3	−16.3	−11.9	−16.9	−5.7	3.5	6.2	10.1	7.6[a]
1956	4.3[a]	4.1	−5.0	−10.4	−18.8	−19.2	−13.6	−4.0	3.3	4.7	8.7	11.2
1957	3.8[a]	0.3	−2.9	−10.4	−16.4	−16.7	−16.8	−5.0	5.5	7.5	9.5	10.0
1958	9.3[a]	6.6[a]	0.8	−13.2	−20.5	−16.1	−12.1	−7.4	4.1	6.7	8.2	9.7
1959	2.7[a]	3.1[a]	−7.1	−12.7	−18.7	−18.2	−11.8	−6.8	4.1	7.1	9.9	9.7
1960	7.2[a]	6.0[a]	5.6	−16.5	−18.8	−17.5	−16.6	−6.4	4.0	6.7	8.6	9.3[a]
1961	6.6[a]	4.0	−2.7	−7.8	−13.8	−18.1	−13.4	−5.7	4.0	5.7	9.3	6.9[a]
1962	0.9[a]	0.9	−3.9	−14.2	−23.1	−17.3	−12.2	−4.8	4.8	5.9	9.6	11.6[a]
1963	0.0[b]	0.5[a]	−11.6	−16.6	−17.6	−19.0	−13.6	−4.0	4.1	4.6	8.7	5.5[a]
1964	5.8[a]	4.8	−0.5	−13.3	−19.3	−16.4	−14.0	−2.4	4.3	8.4	9.1	11.1[a]
1965	9.7[a]	9.7[a]	6.3	−16.8	−20.1	−15.5	−13.3	−4.7	4.9	7.6	10.7	11.2
1966	6.1[a]	5.9	−6.6	−8.2	−17.3	−16.5	−16.3	−2.5	6.0	7.3	10.0	11.6
1967	9.4[a]	8.4	−5.3	−13.2	−10.7	−16.2	−13.0	−2.7	6.5	7.3	11.7	12.4[a]
1968	7.4[a]	7.5[a]	−6.2	−11.7	−12.8	−17.9	−12.0	−4.5	5.3	7.1	12.0	8.5[a]
1969	5.2[a]	4.0	0.1	−16.0	−18.2	−13.8	−16.0	−3.8	5.1	8.7	11.0	11.9[a]
1970	4.4[a]	2.1	−1.0	−13.9	−20.6	−15.5	−12.2	−7.0	4.8	8.5	10.6	12.5
1971	5.8[a]	6.4[a]	−3.9	−15.0	−15.9	−20.2	−10.2	−4.2	4.4	6.8	9.9	14.0
1972	6.2[a]	6.4	−6.5	−11.8	−16.7	−16.6	−9.4	−4.5	4.5	8.4	11.3	7.6[a]
1973	6.5[a]	4.9	−7.7	−9.7	−14.5	−17.5	−13.5	−6.0	5.7	6.8	10.1	10.2[a]

[a] Equilibrium temperature assumed to be 32°F.
[b] Blowdown temperature assumed to be 32°F.

For the cases where the blowdown water temperature exceeds the Neosho River water temperature by greater than 5F°, a mixing zone will be required. Assuming the blowdown stream as a point source and no transfer of heat to the atmosphere, the widths of the mixing zone within the 5F° isotherm were calculated using a two-dimensional model.[12] The dispersion coefficients for this calculation were determined from the following relation:[13]

$$D_y = 0.25\ u_*\ d\ ,$$

where D_y is the dispersion coefficient, u_* is the river velocity, and d is the river depth. A Manning coefficient of 0.05 was assumed in calculating the river shear velocity.

The maximum percentages of the river width occupied by the mixing zone with the 5F° isotherm are shown in Fig. 5.6. These percentages were determined for 3.5- and 40-cfs blowdown rates for initial temperature differences between the blowdown and river water of 8, 10, 14, and 20F°. Figure 5.6 points out that for 3.5-cfs blowdown rates, less than 15% of the river width will be occupied by the mixing zone within the 5F° isotherm for Neosho River flow rates as low as 50 cfs. For 40-cfs blowdown rates, higher river flow rates are necessary to limit the maximum width of the mixing zone. In this case, to limit this mixing zone to 25% of the total river width, the calculations indicate that the Neosho River flow rate must be at least 120, 150, 210, and 300 cfs for blowdown temperature excesses of 8, 10, 14, and 20F°, respectively. Therefore, the Neosho River flow rate and the blowdown water temperature excess must be known before blowdown water can be released to the river at a rate of 40 cfs.

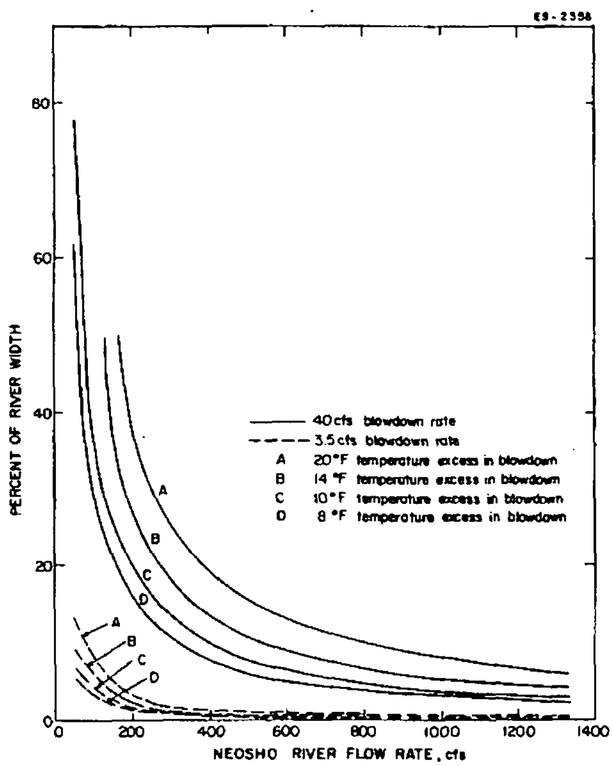

Fig. 5.6. Maximum percentage of the Neosho River width within the 5F° isotherm.

5.3.3 Staff conclusions

The staff has evaluated the thermal aspects of the proposed lake for one- and two-unit operation. Results of this analysis indicate that sufficient water storage and surface area would be available to cool two units of the size of the proposed plant through the period of record drought. Results of thermal analyses by the staff and the applicant are essentially in agreement. In addition, the staff concludes that the assumptions used by the applicant are both reasonable and conservative, although the staff calculations showed that the cooling lake will stratify during the summer months.

The staff concludes that 3.5 cfs blowdown from the cooling lake meets the temperature standards specified in the Water Quality Criteria for Interstate and Intrastate Waters of Kansas, even when the Neosho River flow is as low as 50 cfs. However, when the cooling lake blowdown rate is 40 cfs, the staff concludes that the Neosho River flow rates must be considerably greater to assure compliance with the temperature standards.

Operation of WCGS will result in an increase in the total dissolved solids content in the Neosho River downstream of the Wolf Creek-Neosho River confluence. This is discussed in Sect. 3.6.

5.4 RADIOLOGICAL IMPACTS

5.4.1 Impact on biota other than man

5.4.1.1 Exposure pathways

The pathways by which biota other than man may receive radiation doses in the vicinity of a nuclear power station are shown in Fig. 5.7. Two recent comprehensive reports[14,15] have been concerned with radioactivity in the environment and these pathways. They can be read for a more detailed explanation of the subjects that will be discussed below. Depending on the pathway being considered, terrestrial and aquatic organisms will receive either approximately the same radiation doses as man or somewhat greater doses. Although no guidelines have been established for desirable limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for these species.[16]

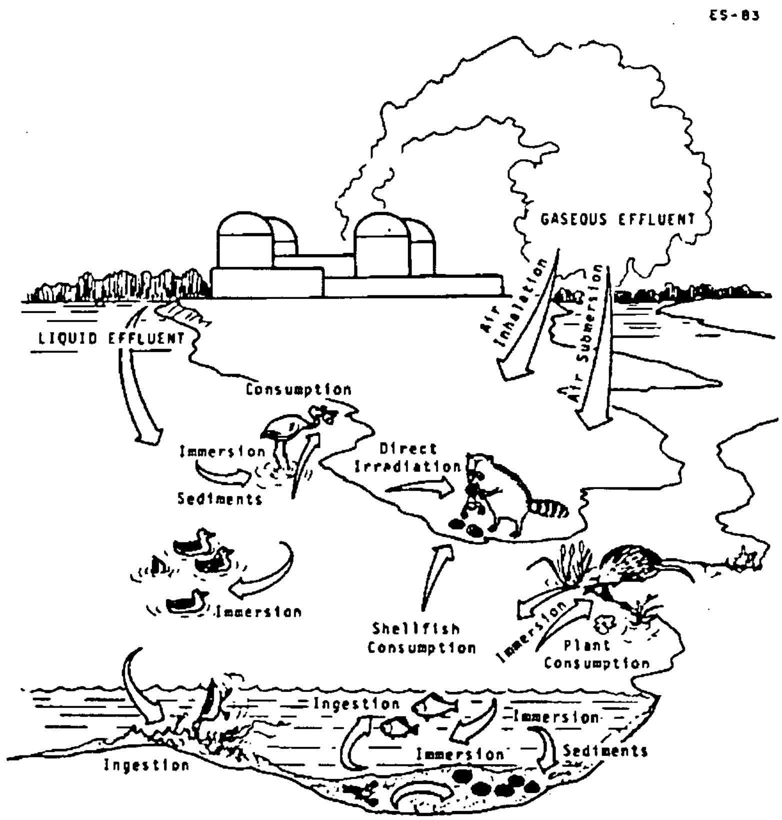

Fig. 5.7. Exposure pathways to biota other than man.

5.4.1.2 Radioactivity in the environment

The quantities and species of radionuclides expected to be discharged annually by Wolf Creek Generating Station in liquid and gaseous effluents have been estimated by the staff and are given in Tables 3.6 and 3.7, respectively. The basis for these values is discussed in Sect. 3.5. For the determination of doses to biota other than man, specific calculations are done primarily for the liquid effluents. The liquid effluent quantities, when diluted in the Wolf Creek discharge, would produce an average gross activity concentration, excluding tritium, of 0.038 pCi/ml in the plant discharge area. Under the same conditions, the tritium concentration would be 23 pCi/ml.

Doses to terrestrial animals, such as rabbits or deer, due to the gaseous effluents are quite similar to those calculated for man (Sect. 5.4.2).

5.4.1.3 Dose rate estimates

The annual radiation doses to both aquatic and terrestrial biota including man were estimated on the assumption of constant concentrations of radionuclides at a given point in both the water and air. Radiation dose has both internal and external components (Fig. 5.7). External components originate from immersion in radioactive air and water and from exposure to radioactive sources on surfaces, in distant volumes of air and water, in equipment, etc. Internal exposures are a result of ingesting and inhaling radioactive materials.

Doses will be delivered to aquatic organisms living in the water containing radionuclides discharged from the power station. This is principally a consequence of physiological mechanisms that concentrate a number of elements that can be present in the aqueous environment. The extent to which elements are concentrated in fish and aquatic plants upon uptake or ingestion has been estimated. Values of relative biological accumulation factors (ratio of concentration of nuclide in organisms to that in the aqueous environment) of a number of water-borne elements for several organisms are provided in Table 5.10.

Table 5.10. Freshwater bioaccumulation factors

Element	Fish	Invertebrates	Plants
	(pCi/kg organism per pCi/liter water)		
C	4,550	9,100	4,550
Na	100	200	500
P	100,000	20,000	500,000
Sc	2	1,000	10,000
Cr	200	2,000	4,000
Mn	400	90,000	10,000
Fe	100	3,200	1,000
Co	50	200	200
Ni	100	100	50
Zn	2,000	10,000	20,000
Rb	2,000	1,000	1,000
Sr	30	100	500
Y	25	1,000	5,000
Zr	3	7	1,000
Nb	30,000	100	800
Mo	10	10	1,000
Tc	15	5	40
Ru	10	300	2,000
Rh	10	300	200
Ag	2	770	200
Sn	3,000	1,000	100
Sb	.1	10	1,500
Te	400	150	100
I	15	5	40
Cs	2,000	100	500
Ba	4	200	500
La	25	1,000	5,000
Ce	1	1,000	4,000
Pr	25	1,000	5,000
Nd	25	1,000	5,000
Pm	25	1,000	5,000
Sm	25	1,000	5,000
Eu	25	1,000	5,000
Gd	25	1,000	5,000
W	1,200	10	1,200
Np	10	400	300
Pu	4	100	350
Am	25	1,000	5,000
Cm	25	1,000	5,000

Source: S. E. Thompson, C. A. Burton, D. J. Quinn, and Y. C. Ng, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," UCRL-50564, Rev. 1 (1972).

Doses to aquatic plants and fish living in the immediate area of the discharge due to water uptake and ingestion (internal exposure) were calculated to be 29 and 49 millirads per year, respectively. The discharge region concentrations were those given above and it was assumed that these organisms spent all of the year in water of maximum concentrations. All calculated doses are based on standard models.[17] The doses are quite conservative since it is highly unlikely that any of the mobile life forms will spend a significant portion of their life spans in the maximum activity concentration of the discharge region. Both radioactive decay and additional dilution would reduce the dose at other points.

External doses to terrestrial animals other than man are determined on the basis of gaseous effluent concentrations and direct radiation contributions at the locations where such animals may actually be present. Terrestrial animals in the environs of the station will receive approximately the same external radiation doses as those calculated for man.

An estimate can be made for the ingestion dose to a terrestrial animal such as a duck, which is assumed to consume only aquatic vegetation growing in the water in the discharge region. The duck ingestion dose was calculated to be about 500 millirads per year, which represents an upper-limit estimate, because equilibrium was assumed to exist between the aquatic organisms and all radionuclides in water. A nonequilibrium condition for a radionuclide in an actual exposure situation would result in a smaller bioaccumulation and therefore in a smaller dose from internal exposure.

The literature relating to radiation effects on organisms is extensive, but very few studies have been conducted on the effects of continuous low-level exposure to radiation from ingested radionuclides on natural aquatic or terrestrial populations. The most recent and pertinent studies point out that, while the existence of extremely radiosensitive biota is possible and while increased radiosensitivity in organisms may result from environmental interactions, no biota have yet been discovered that show a sensitivity to radiation exposures as low as those anticipated in the area surrounding the Wolf Creek Generating Station. In the "BEIR" report,[18] it is stated in summary that evidence to date indicates that no other living organisms are very much more radiosensitive than man. Therefore, no detectable radiological impact is expected in the aquatic biota or terrestrial mammals as a result of the quantity of radionuclides to be released into the Neosho River and into the air by Wolf Creek Generating Station.

5.4.2 Impact on man

The NRC staff is currently reassessing assumptions and evaluating models for projected radioactive effluent releases and calculated doses in order to reflect the Commission's guidance in its opinion issued April 30, 1975, in the rulemaking proceeding RM-50-2.

The revised specific models for a detailed assessment of individual and population doses have not been completed. For the interim, it can be said that the individual doses associated with the radioactive releases of the Wolf Creek Station will be in accord with the requirements stated in Appendix I, 10 CFR Part 50. Thus, no final plant design will be approved which will result in individual doses in excess of the Appendix I requirements.

The staff has developed a procedure to quantitatively evaluate the maximum integrated doses that could be delivered to the U.S. population by radioactive emissions from the Wolf Creek Station. A description of the procedure for gaseous effluents is contained in Appendix E of this Statement. The intent of this estimate is to evaluate the radiological environmental impact of the facility by establishing an upper bound population dose associated with plant operation which is unlikely to be exceeded when the detailed review is performed for the subsequent hearing.

5.4.2.1 Liquid effluents

Expected radionuclide releases in the liquid effluent have been estimated for the Wolf Creek Station and are listed in Table 3.6. Doses to the population from these releases were calculated using dose procedures consistent with the recommendations of ICRP-II.[17]

The cumulative dose resulting from the consumption of fish harvested from the Neosho River was estimated. It was conservatively assumed that 100% of the population within 50 miles of the plant consumed 5 g of fish per day caught in the region of the river where the coolant water discharges were diluted by an additional factor of 86 over those dilutions in the immediate discharge region.

The exposed recreational population was estimated to represent 10% of the total population within a 50-mile radius, and each person was assumed to be exposed during 1 hr/year each of swimming and boating and 4 hr/year of shoreline activities in the plant vicinity.

The tritium released to the receiving water is assumed to enter the biosphere in the same manner as tritium released to the atmosphere. Thus, the tritium discussion in Appendix E applies to all tritium sources from the plant.

Table 5.11 includes the doses to the population due to the release of radionuclides in the liquid effluents.

Table 5.11. Annual integrated dose to U.S. population

Radionuclide group	Annual dose (man-rem)	
	Total	Thyroid
Noble gases	0.78	0.78
Radioiodine	0.12	49
Particulate	5.0	4.3
Tritium	1.1	1.1
Carbon-14	17	17
Total	24	72

5.4.2.2 Gaseous effluents

The NRC staff estimates of the probable gaseous releases listed in Table 3.7 were used to evaluate potential doses to the U.S. population. As discussed in Appendix E these gaseous effluents were considered in five categories (i.e., noble gases, radioiodines, particulates, carbon-14, and tritium). Krypton-85 was treated separately from the other noble gases because of its relatively long half-life (about 11 years).

The population can be exposed via the pathways discussed in Appendix E. External total body irradiation results from submersion in dispersed noble gases and from standing on surfaces containing deposited radioiodines and particulates. Internal total body and organ exposures result from inhalation of contaminated air or ingestion of contaminated foodstuffs. Three food pathways which involved consumption (meat, milk, and food crops) were evaluated.

Doses to the population were calculated by assuming uniform dispersal of the radionuclides. Direct exposure pathways to the population (e.g., noble gas submersion) were based upon a uniform population density (160 people/sq mile). Indirect food pathways were based on the assumption that meat, milk, and crop productivity of the land area east of the Mississippi River is capable of supporting the U.S. population.

Table 5.12 lists the population doses resulting from this analysis.

Table 5.12. Summary of annual doses to the U.S. population

Category	Population dose (man-rem/year)
Natural environmental radioactivity	21,000,000
Nuclear plant operation	
Plant work force	450
General Public	
Gaseous and liquid effluents (total body and thyroid)	97
Transportation of nuclear fuel and radioactive wastes	6

5.4.2.3 Evaluation of radiological impact

Using conservative assumptions, the staff has estimated an upper bound integrated exposure to the population of the U.S. due to operation of the Wolf Creek Station. Appendix I to 10 CFR Part 50 requires that individual doses be kept to a small fraction of the doses implied by 10 CFR Part 20.

The above statements can be placed in perspective by noting that individuals in the U.S. population each receive an average of about 100 millirem/year from natural background radiation. Thus, the annual population dose due to natural background to the U.S. population is about 21,000,000 man-rem.

Both the maximum individual doses and the upper bound population doses resulting from operation of the Wolf Creek Station are fractions of the doses individuals and the population receive from naturally occurring radiation.

5.4.2.4 Direct radiation

Radiation from the facility

The plant design includes specific shielding of the reactor, holdup tanks, filters, demineralizers, and other areas where radioactive materials may flow or be stored, primarily for the protection of plant personnel. Direct radiation from these sources is therefore not expected to be significant at the site boundary. Confirming measurements will be made as part of the applicant's environmental monitoring program after plant start-up. Low-level radioactivity storage containers outside the plant are estimated to contribute less than 0.01 millirem/year at the site boundary.

Transportation of radioactive material

The transportation of cold fuel to a reactor, of irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to burial grounds is within the scope of the NRC report entitled, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants." The environmental effects of such transportation are summarized in Table 5.13.

Occupational radiation exposure

Based on a review of the applicant's Preliminary Safety Analysis Report, the staff has determined that individual occupational doses can be maintained within the limits of 10 CFR Part 20. Radiation dose limits of 10 CFR Part 20 are based on a thorough consideration of the biological risk of exposure to ionizing radiation. Maintaining radiation doses of plant personnel within these limits ensures that the risk associated with radiation exposure is no greater than those risks normally accepted by workers in other present-day industries.[19] Using information compiled by the Commission[20] of past experience from operating nuclear reactor plants (with a range of exposures of 44 to 5134 man-rem/year), it is estimated that the average collective dose to all onsite personnel at large operating nuclear plants will be approximately 450 man-rem per year per unit. The total dose for this plant will be influenced by several factors for which definitive numerical values are not available. These factors are expected to lead to doses to onsite personnel lower than those estimated above. Improvements to the radioactive waste effluent treatment system to maintain offsite population doses as low as practicable may cause an increase in onsite personnel doses if all other factors remain unchanged. However, the applicant's implementation of Regulatory Guide 8.8 and other guidance provided through the staff radiation protection review process is expected to result in an overall reduction of total doses from those currently experienced. Because of the uncertainty in the factors modifying the above estimates, a value of 450 man-rems will be used for the occupational radiation exposure for the one-unit station.

5.4.2.5 Summary of annual radiation doses

The annual population doses (man-rem) resulting from the plant operation are presented in Table 5.12. As shown in this table, the operation of the Wolf Creek Station will contribute a small fraction of the population dose that persons living in the U.S. normally receive from natural background.

5.4.3 Environmental effects of the uranium fuel cycle

The environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials and management of low-level and high-level wastes are within the scope of the

AEC report entitled, "Environmental Survey of the Uranium Fuel Cycle." The contributions of such environmental effects are summarized in Table 5.14.

Table 5.13. Environmental impact of transportation of fuel and waste to and from one light-water-cooled nuclear power reactor[a]

Normal conditions of transport	
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr
Weight (governed by Federal or State restrictions)	73,000 lbs. per truck; 100 tons per cask per rail car.
Traffic density	
Truck	<1 per day
Rail	<3 per month

Exposed population	Estimated number of persons exposed	Range of doses to exposed individuals[b] (millirems per reactor year)	Cumulative dose to exposed population (man-rems per reactor year)[c]
Transportation workers	200	0.01 to 300	4
General public			
Onlookers	1,100	0.003 to 1.3	3
Along route	600,000	0.0001 to 0.06	

Accidents in transport	
Radiological effects	Small[d]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.

[a]Data supporting this table are given in the Commission's *Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants,* WASH-1238, December 1972, and Supp. I, NUREG 75/038, April 1975.

[b]The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5,000 millirems/year for individuals as a result of occupational exposure and should be limited to 500 millirems/year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirems/year.

[c]Man-rem is an expression for the summation of whole-body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirems) each, the total man-rem in each case would be 1 man-rem.

[d]Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.

5.5 NONRADIOLOGICAL EFFECTS ON ECOLOGICAL SYSTEMS

5.5.1 Terrestrial

5.5.1.1 Impacts of station operation

Because of the nature of the cooling system, the major direct ecological impacts of plant operation will occur on the aquatic environment of the area. The staff concludes that the operation of the Wolf Creek Generating Station will have only minor nonradiological impacts on the remaining terrestrial ecosystems of the local area.

Air pollutant data resulting from operation of the two emergency diesel engines and the oil-fired auxillary steam boiler are provided by the applicant (ER, p. 3.7-1). The staff estimates that if all of these were operating simultaneously, no effects would be noticeable at the site boundary even under stagnant meteorological conditions.

Table 5.14. Summary of environmental considerations for uranium fuel cycle

Normalized to model LWR annual fuel requirement

Natural resource use	Total	Maximum effect per annual fuel requirement of model 1,000-MWe LWR
Land (acres)		
Temporarily committed	63	
Undisturbed area	45	
Disturbed area	18	Equivalent to 90 MWe coal-fired power plant.
Permanently committed	4.6	
Overburden moved (millions of metric tons)	2.7	Equivalent to 90 MWe coal-fired power plant.
Water (millions of gallons)		
Discharged to air	156	≈2% model 1000 MWe LWR with cooling tower.
Discharged to water bodies	11,040	
Discharged to ground	123	
Total	11,319	<4% of model 1000 MWe LWR with once-through cooling.
Fossil fuel		
Electrical energy (thousands of MW-hour)	317	<5% of model 1000 MWe LWR output.
Equivalent coal (thousands of metric tons)	115	Equivalent to the consumption of a 45-MWe coal-fired power plant.
Natural gas (millions of scf)	92	<0.2% of model 1000-MWe energy output.
Effluents — chemical (metric tons)		
Gases (including entrainment)[a]		
SO_2	4,400	
NO_x[b]	1,177	Equivalent to emissions from 45-MWe coal-fired plant for a year.
Hydrocarbons	13.5	
CO	28.7	
Particulates	1,156	
Other gases		
F^-	0.72	Principally from UF_6 production enrichment and reprocessing. Concentration within range of state standards — below level that has effects on human health.
Liquids		
SO_4^-	10.3	From enrichment, fuel fabrication, and reprocessing steps. Components
NO_3^-	26.7	that constitute a potential for adverse environmental effect are present
Fluoride	12.9	in dilute concentrations and receive additional dilution by receiving
Ca^{2+}	5.4	bodies of water to levels below permissible standards. The constituents
Cl^-	8.6	that require dilution and the flow of dilution water are:
Na^+	16.9	NH_3 — 600 cfs.
NH_3	11.5	NO_3 — 20 cfs.
Fe	0.4	Fluoride — 70 cfs.
Tailings solutions (thousands of metric tons)	240	From mills only — no significant effluents to environment.
Solids	91,000	Principally from mills — no significant effluents to environment.
Effluents — radiological (curies)		
Gases (including entrainment)		
Rn-222	75	Principally from mills — maximum annual dose rate <4% of average
Ra-226	0.02	natural background within 5 miles of mill. Results in 0.06 man-rem
Th-230	0.02	per annual fuel requirement.
Uranium	0.032	Principally from fuel reprocessing plants — whole body dose is 6
Tritium (thousand)	16.7	man-rem per annual fuel requirements for population within 50-mile
Kr-85 (thousands)	350	radius. This is <0.007% of average natural background dose to this
I-129	0.0024	population. Release from Federal Waste Repository of 0.005
I-131	0.024	Ci/year has been included in fission products and transuranics total.
Fission products and transuranics	1.01	
Liquids		
Uranium and daughters	2.1	Principally from milling — included in tailings liquor and returned to ground — no effluents; therefore, no effect on environment.
Ra-226	0.0034	From UF_6 production — concentration 5% of 10 CFR 20 for total
Th-230	0.0015	processing of 27.5 model LWR annual fuel requirements.
Th-234	0.01	From fuel fabrication plants — concentration 10% of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Ru-106	0.15[c]	From reprocessing plants — maximum concentration 4% of 10 CFR
Tritium (thousands)	2.5	20 for total reprocessing of 26 annual fuel requirements for model LWR.
Solids (buried)		
Other than high level	601	All except 1 Ci comes from mills — included in tailings returned to ground — no significant effluent to the environment. 1 Ci from conversion and fuel fabrication is buried.
Effluents — thermal (billions of Btu's)	3,360	<7% of model 1000-MWe LWR.
Transportation (man-rem): exposure of workers and general public.	0.334	

[a]Estimated effluents based upon combustion of equivalent coal for power generation.

[b]1.2% from natural gas use and process.

[c]Cs-137 (0.075 Ci/AFR) and Sr-90 (0.004 Ci/AFR) are also emitted.

Source: Paragraph 51.20(e), 10 CFR 51.

Of the 10,500 acre site, approximately 5211 acres will not be altered by construction. Table 5.15 presents a summary of the acreage of land usage during the operational life of the plant. The applicant plans to the extent possible to continue in production approximately 4357 acres, which is 94% of the remaining agricultural land. Over 795 acres of the site will remain essentially undisturbed and some of this will revert to native vegetation through the process of succession as described in Sect. 2.7.

Table 5.15. Summary of land use acreage during operational life of plant which was not altered due to construction

Land unit	Exclusion area	Wildlife habitat	Agricultural acreage	Miscellaneous acreage	Post construction acreage (totals)
Cropland	41		1955		1996
Range	249		2402		2651
Miscellaneous					
Ponds		49			49
Roads				26	26
Gravelpits				30	30
Cemetery				3	3
Bluestem prairie	4	4			8
Woodlands	18	430			448
Totals	312	483	4357	59	5211

Noise levels associated with the operation of the plant are not expected to constitute a serious disturbance to wildlife. Sources of noise include the main power transformers (90 DBA at 6 ft), steam release valves, and diesel engines. The staff feels that resident wildlife species will become habituated to routine noises of operations.

5.5.1.2 Impacts of lake operation

The proposed cooling lake will create suitable habitat for wildlife belonging to the following ecological groups: generally ubiquitous species, farmland-wetland species, ubiquitous wetland species, lentic wetland species, pond-marsh species, and pond species. Of the 273 potential species for the site, 40% belong to one of these ecological groups. Of these, waterfowl can be expected to use the cooling lake in large numbers (Table 5.16). The extensive shallow littoral zone will serve as a waterfowl feeding area. Table 5.17 depicts depth-area data in acreage for different operating levels of the cooling lake. The lake is quite shallow, with 34% of lake surface composed of water 10 ft or less in depth. These shallow areas of the cooling lake should produce some suitable habitat for rooted aquatic macrophytes.

Typically the rooted aquatics form concentric zones within the littoral zone, one group replacing another as the depth of water changes. Approximately 404 acres of the cooling lake will have water 2 ft or less in depth. Some of these areas may support plants typical of the zone of emergent vegetation.

Approximately 605 acres of the cooling lake will have water from 2 to 5 ft in depth. Some of these areas will support plants typical of the zone of rooted plants with floating leaves. Plants typical of the zone of submergent vegetation will occupy the rest of the littoral area. Turbidity of water will be one of the factors determining the depth of the littoral zone.

Figure 5.8 depicts simulated fluctuations in cooling lake levels from 1952 to 1960 for a 100% plant factor and covers two distinctive climatic eras, a dry period and a normal period. Extensive mudflats will be developed during the dry period of plant operation. These mudflats will fall into three categories: (1) approximately 460 acres will be reinundated once a year for one to three months, (2) approximately 30 acres will not be reinundated for four years which is near the end of the drying cycle, and (3) approximately seven acres will not be reinundated for a period of five years. This is a conservative model and mudflat acreage probably will not be this great. During the normal period, lake level fluctuations are more frequent but less severe in magnitude. The mudflat area will be drastically reduced and will range from approximately 0 to 10 acres but will frequently be expanded to include 80 more acres of the littoral zone for a period not to exceed 30 days at a time. Also during this interim cycle, flooding above 1087 ft MSL will occur frequently but also will not exceed 30 days in duration per flood. Some of the flooding occurs during the growing season (Fig. 5.8).

Table 5.16. Average density of ducks using John Redmond Lake during 1973

Species	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Whistling swan		4										
Canada goose	2,050	4,720	440	6						2,025	1,320	690
White fronted goose		75	175	50						123	131	57
Blue–snow goose[a]	400	253	2,049	80					1	1,775	6,400	2,893
Mallard	18,150	10,620	15,425	958	16	12	10			3,355	20,250	13,880
Pintail	20	1,200	1,058	57					20	2,785	1,133	300
Gadwall	2	4	1,725	1,715						4,605	2,400	
American widgeon		13	1,475	1,267						418	3,200	
Shoveler		2	45	66						552	43	3
Blue wing–cinnamon teal[b]			60	400	8	5	15	46	108	730	50	
Green winged teal		5	39	10							173	60
Wood duck		2	2	9	4	4					2	
Redhead		135	824	1,400							33	
Canvasback		5	313	403						40	210	
Ring-necked duck		90	4,300	4,170								
Scaup		25	2,850	10,642							6,200	20
Common golden eye	65	15	6									
Bufflehead	13	3										650
Ruddy duck		4	30	15							5	
Common merganser	1,645	90	5									
Hooded merganser	23	7								3	30	4,927
Coot			581	1,083					130	9,743	1,300	30
Total	22,368	17,272	31,402	22,331	28	21	25	46	259	26,154	42,880	23,510
Number of species	10	21	21	17	4	4	3	2	5	14	19	13

[a]Due to problems in identification Blue goose and Snow goose species have been combined.

[b]Due to problems in identification Blue wing and Cinnamon teal species have been combined.

Source: ER, Table 5.7-1 and 5.7-2.

Table 5.17. Depth area data in surface acreage of the proposed Wolf Creek cooling lake[a]

Elevation, MSL (ft)	Acreage											
	Mud flat	Lake										
		0–2 ft depth	2–5 ft depth	5–10 ft depth	10–15 ft depth	15–20 ft depth	20–25 ft depth	25–30 ft depth	30–35 ft depth	35–40 ft depth	>40 ft depth	Total
1087	0	403.6	605.4	796.6	655	567.1	508.5	420.9	362.5	267.1	767.9	5354.6
1086	201.8	403.6	605.4	725.8	655	537.8	508.5	391.7	362.5	235.3	727.2	5152.8
1085	403.6	403.6	605.4	655.0	655.0	508.5	508.5	362.5	362.5	203.5	686.5	4951.0
1084	605.4	403.6	534.6	655.0	625.7	508.5	479.3	362.5	330.7	203.5	645.8	4749.2
1083	807.2	403.6	463.8	655.0	596.4	508.5	450.1	362.5	298.9	203.5	605.1	4547.4
1082	1009	403.6	393.0	655.0	567.1	508.5	391.7	362.5	235.3	203.5	564.4	4345.6
1081	1210.8	332.8	393.0	655.0	537.8	508.5	391.7	362.5	235.3	203.5	523.7	4143.8
1080	1412.6	262	393	655.0	508.5	508.5	362.5	362.5	203.5	203.5	483.0	3942

[a]Based on ER, Fig. 3.4-9.

Initially the mudflats will be occupied by two plant communities. In poorly drained areas, plants typical of wet marshy areas of John Redmond Reservoir will dominate (Table 5.18). The dry areas will be dominated by annual weeds (Table 5.19). These communities will occupy the greatest portion of the mudflats due to periodic inundation of these areas on a yearly basis. However, in other areas of the cooling lake which are not reinundated for 4 to 5 years, some advanced seral communities will replace the pioneer communities. Flood tolerant woody species will also invade these mudflats.

Annual reinundation will kill some of the woody species on mudflats. The age and species composition of woody plants surviving on mudflats areas during the drought years will reflect the

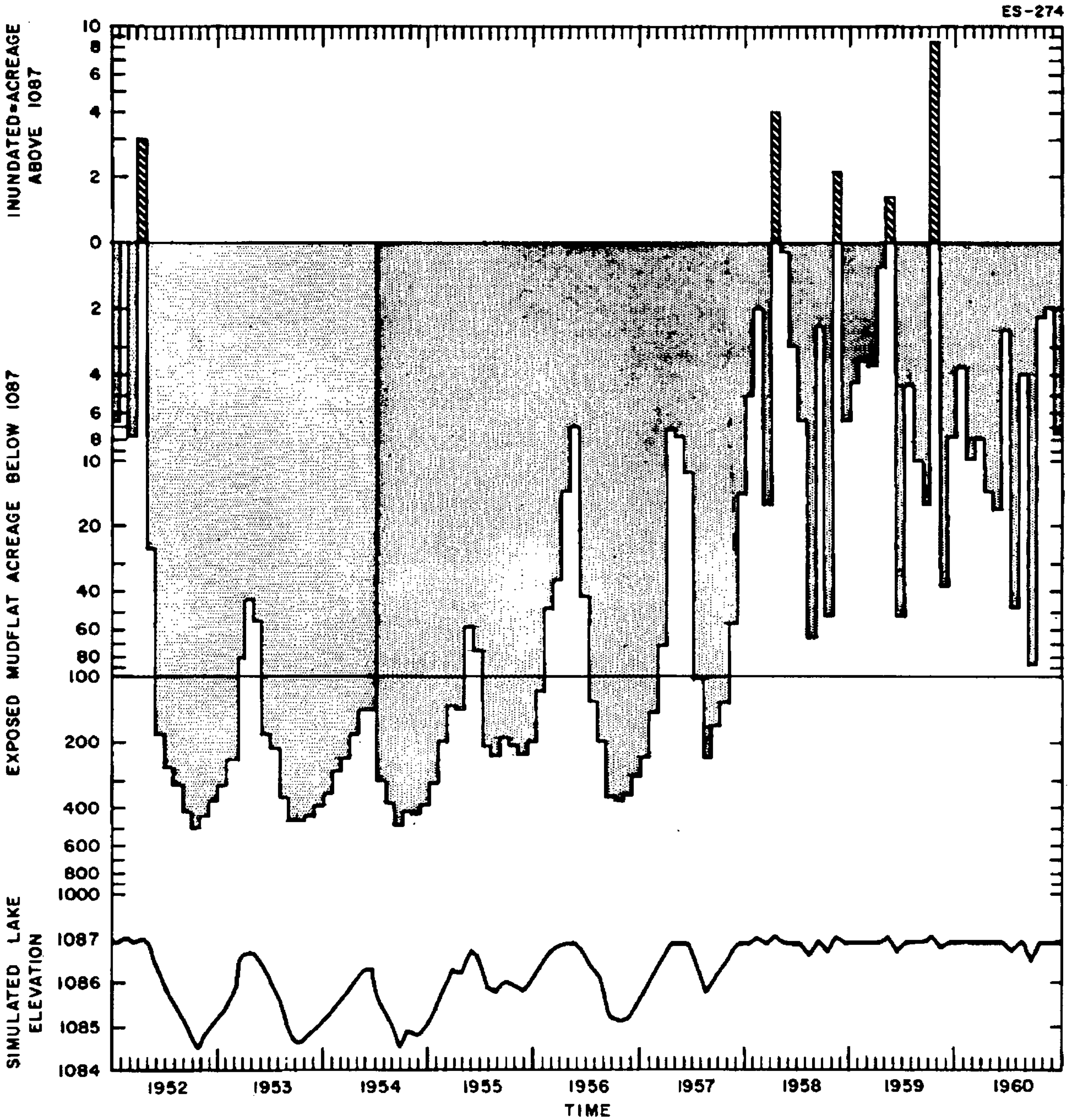

Fig. 5.8. Simulated fluctuations in cooling lake levels from 1952-1960 during a dry period and a normal period.

Table 5.18. Analysis of plants found at the moist base of the rocky embankment at the John Redmond Dam, Burlington, Kansas (July 1974)

Species	Common name	Occurrence[a]
Carex sp.	Sedge	A
Cyperus esculentus	Galingale	A
Sagitarria latifolia	Arrowhead	A
Salix nigra	Black willow	C
Typha latifolia	Cattail	C

[a]A – Abundant; frequently found, wide distribution.
C – Common; often found, scattered distribution.

Source: ER, Q 2.22.

Table 5.19. Analysis of vegetation on the flood control pool bench areas of John Redmond Reservoir between the elevations of 1036 and 1068 feet, Burlington, Kansas (July 1974)

Species	Common name	Occurrence[a]
Polygonum coccineum	Water smartweed	A
Polygonum pensylvanicum	Smartweed	A
Populus deltoides	Cottonwood	I
Salix nigra	Willow	C

[a]A – Abundant; frequently found, wide distribution.
C – Common; often found, scattered distribution.
I – Infrequent; seldom found, scattered distribution.

Source: ER, Q 2.2.1.

frequency and duration of reinundation. Flooding has caused death or visible damage to some tree species of the area.[22,23] The tree species and number of flood days are as follows:

Salix nigra, 78-209
Acer saccharinum, 90-168
Fraxnus pensylvanica, 70-158
Populus deltoides, 60-173
Gleditsia triacanthus, 53-173
Ulmus americana, 45-170
Platanus occidentalis, 44-199
Quercus rubra, 50-80
Prunus serotina, 1
Celtis occidentalis, 46-50
Morus ruba, 47
Carya ovata, 29-50
Asimina triloba, 21
Ostrya virginiana, 3

Only those species that can tolerate flooding in excess of 60 days will be able to survive on these mudflat areas.

The effect of flooding on woody species is also dependent on the season. Inundation during the dormant season has been shown to have little effect on the woody plants.[24-26] Thus 460 acres of mudflats may be occupied by many dead saplings varying in age from one to five years. Death of all woody vegetation on mudflats is assured when the climatic cycle changes from a dry cycle to a normal regime. Also, in the interim between dry cycles, flooding occurs above 1087 ft MSL during the growing season (Fig. 5.8) and thus will promote changes in species composition of plant communities on the shores of the cooling lake. These communities will be dominated by flood tolerant woody vegetation.

The existing herbaceous species which develop on the mudflats during the dry periods will be adversely affected by inundation.[24,27] During the dry cycle, reinundation of the mudflats occurs during the nongrowing season. Thus the annual herbaceous species occupying 460 acres of seasonal inundated mudflats produced by the dry cycle will not be significantly impacted. However, some of the herbaceous biomass produced during the previous summer will be added to detritus of the cooling lake during these reinundations. Some detritus and seeds will provide food for wildlife.

Lake level fluctuation will have greater impacts on the floating leaved and submerged hydrophytes than on the emergent hydrophytes. The major impact on the hydrophytes will occur during the dry cycle. As water levels drop, species will migrate toward deeper parts of the lake if suitable habitat is available. During the dry years evaporative losses of the cooling lake are expected to increase the total dissolved solids to approximately 1200 ppm (ER, pp. 3.6-2 and 5.4-1) and this will have a deleterious effect on some of the hydrophytic species.[28]

The staff estimates that the operation of the plant will prevent ice from forming on 41 to 81% of the lake during January of the coldest year. Furthermore, the average surface water temperature during winter months will be approximately 2F° higher than ambient. The applicant predicts that waterfowl may overwinter since warm water discharges will keep a minimum of 1490 surface acres open through the winter months (ER, Sect. 5.7). Ducks and geese will feed on available grains, particularly corn and soybeans that have been missed during harvesting. Thus, crop depredation by waterfowl could occur during years when harvesting of grains is delayed. Waterfowl usage of John Redmond Reservoir is given in Table 5.16.

5.5.1.3 Impacts of transmission line operations

The applicant has indicated that chemical treatment of rights-of-way will involve the use of Ded-weed Lu-33 Brush Kill and Tordon 10-K pellets. They will be selectively applied to selected woody plants for maintenance of transmission line rights-of-way at five to seven year intervals (ER, Sect. 5.6). Active ingredients of Ded-weed Lu-33 Brush Kill include:

2, 4-dichlorophenoxyacetic acid isoctyl ester	33.5%
(equivalent to 2, 4-dichlorophenoxyacetic acid)	(22.5%)
2.4, 5-trichlorophenoxyacetic acid isoctyl ester	31.9%
(equivalent to 2.4, 5-trichlorophenoxyacetic acid)	(22.2%)
Inert ingredients	34.6%
	100.0%

Active ingredients of Tordon 10-K pellets include:

4-amino-3, 5, 6-trichloropicolinic acid as the potassium salt	11.6%
(equivalent: 4-amino-3, 5, 6-trichloropicolinic acid)	(10.0%)
Inert ingredient	88.4%

Only tall tree species will be eliminated, leaving shrubs and grasses. Egler[29] demonstrated that shrubs form a more stable ground cover than grasses and require far less maintenance. In addition, shrubs provide a greater variety of food and cover for wildlife than grasses. The application rate of LU-33 will be 4 gal of LU-33 mixed with 96 gal of diesel fuel. The application rate of Tordon 10-K pellets will be 75 to 85 lbs/acre. The staff will require that the applicant adhere to selective basal application of herbicides, thereby prohibiting broadcast application from aircraft or ground rigs which might result in serious impacts upon nontarget areas.

Patrols of 115 V and 345 V lines by other utility companies[30] have shown no evidence of collisions with lines. Thus, when taken into consideration with other man-made obstacles that confront avian species, the hazards presented by high-voltage transmission lines are probably negligible.

5.5.1.4 Impacts of railroad and pipeline operation

Since the makeup water pipelines are buried, no impacts are anticipated.

Operation of about 10 miles of railroad spur will necessitate maintenance of the rights-of-way. The railroad spur crosses four streams where natural riparian vegetation occurs. The staff recommends that in rangeland areas the rights-of-way be maintained by acceptable methods that will promote the development of bluestem prairie. The staff further recommends that areas adjacent to streams where natural riparian vegetation must initially be cleared be maintained by periodic brush and sapling removal. Even selective application of herbicides should not be practiced due to the close proximity of the stream.

5.5.1.5 Impacts to offsite areas

Floodplain forests along Wolf Creek between the dam and the Neosho River will be subject to subtle changes in composition from elimination of the present flooding regime. There will be a gradual reduction in available soil nutrients and a change in average subsurface water level. The net effect will not be realized for many years. Floodplain tolerant species will eventually be replaced by upland forest species. Thus a further reduction of the existing dwindling northern floodplain forest habitat will occur. The impacts of habitat loss have been discussed in Sect. 4.3.

5.5.2 Aquatic

Operation of Wolf Creek Generating Station will affect three major aquatic ecosystems: (1) the Neosho River below John Redmond Dam, through reduced flows and blowdown from the cooling lake; (2) John Redmond Reservoir and the Neosho River (makeup source), through impingement and entrainment of organisms at the makeup structure; and (3) the proposed Wolf Creek cooling lake, through impingement and entrainment of organisms in the once-through cooling system, chemical effects, temperature changes, and water fluctuations.

5.5.2.1 Impacts of operation on aquatic biota in the Neosho River

Reduced flow

Makeup withdrawal from the John Redmond Reservoir could extend both duration and severity of naturally occurring drought conditions in the Neosho River and consequently pose serious problems for the aquatic biota, particularly fish populations. The 177 miles of the Neosho River stretching from John Redmond Dam to the State line is considered an important sport fishery[31] and is, in fact, heavily fished with annual estimates approaching 155,000 man-days.[32] Channel and flathead catfish, paddlefish, crappies, sunfishes, white bass, and walleye constitute the fisherman's primary objectives. Populations of the primitive paddlefish have been expanding in the Neosho in recent years, whereas the reverse has been usually observed in most rivers in which the fish is found.[32]

Before regulation of stream flow in the Neosho River, extremes of flow were not uncommon. At Burlington, 4.3 river miles below the dam, flow data for the years 1948-1963 show all months but April through July as having experienced minimum daily flows of zero cfs (ER, Tables 2.5-1a and 2.5-1b). Most instances of no flow, however, occurred during the severe drought of 1952-1956. Since regulation by John Redmond Dam began in 1964, the minimum daily flow has been 14 cfs (ER, Table Q5.9-2). Average annual flow for this period was 1467 cfs. It is not inconceivable that regulation possibly stresses riffle-dependent species as much as extreme low flows if higher flows than normal (which obliterate riffle areas) are maintained for extended periods of time.

Average annual makeup requirements are estimated by the applicant to be 46.6 cfs for one unit and 60.9 cfs for two units (ER, Table 3.3-1). During times of average or above average flow, a withdrawal of 46.6 cfs or even the maximum of 120 cfs is not expected to significantly alter the Neosho River ecosystem. However, during drought-induced low flows, the withdrawal of a minimum of 41 cfs would in effect greatly extend the duration and severity of low flow conditions, and thus stress fish populations and other elements of the aquatic communities of the Neosho River much more than would otherwise be the case. For example, should 56 cfs of water flow into John Redmond Reservoir following drought, withdrawal of 41 cfs makeup would leave only 15 cfs for maintenance of aquatic communities of the Neosho River for several miles downstream.

Reduction in river flow can pose serious implications for downstream biota. The severe drought of 1952-1956 seriously reduced the abundance of many fish species in the Neosho River, including the channel catfish.[33,34] During the above-mentioned drought, one pool of less than one acre in the then nonflowing Neosho River concentrated an estimated 40,000 fish of all kinds, including about 30,000 channel catfish, two to 14 in. long.[33] Many of these would have died from overcrowding, disease, reduced dissolved oxygen, and other stresses if the Kansas Fish and Game Commission had not removed them.

Once flow returns to normal, populations of some fish such as the channel catfish, flathead catfish, and drum recover rapidly; others, occupying more restricted habitats such as those of the Neosho madtom, stonecat, gravel chub, and slender-headed darter, respond much more slowly to the return of normal flows.[33] The former three species are of course highly adaptable to various habitats including standing pools and are thus at an advantage over, for example, obligate riffle inhabitants such as certain madtoms and darters. The long-term effects on the currently expanding paddlefish populations are unknown. Cross[34] attributes the decline and virtual disappearances of the rosyface shiner, Topeka shiner, bigeye chub, hornyhead chub, freckled madtom, sauger, and smallmouth bass from the upper and middle Neosho River at least in part to low flows. Other contributors to the decline of many fish species include, of course, increased turbidity and pollution. The river redhorse, blue sucker, and highfin carpsucker are described as depleted, largely for the same reasons.[35]

The Neosho madtom, which is endemic to the Neosho River basin and presently known only from the Cottonwood and Upper Neosho mainstreams, is in danger of extinction.[35-37] Food, growth, and reproduction requirements are met only in well-oxygenated, flowing waters with gravel-bottomed riffles. The staff believes that withdrawal of a minimum of 41 cfs makeup water during periods of low flow will, in effect, extend the duration and severity of low flow conditions for all fish populations downstream of John Redmond Dam. Some localized fish populations may be stressed beyond their ability to recover, resulting in an even more precarious status for endangered and depleted species such as the Neosho madtom, highfin carpsucker, river redhorse, and blue sucker.[36-38]

Blowdown, one unit

Due to the blowdown of hypolimnetic water from the bottom of the cooling lake, late spring and summer blowdown temperatures may be as much as 30F° below ambient according to staff calculations (Sect. 5.3.2 and Table 5.8). Supported by reduced oxygen levels, low temperatures may prevent summer inhabitation of lower Wolf Creek by most fish and many other aquatic organisms. Species composition will likely shift towards one dominated by aquatic organisms more tolerant of low temperatures and oxygen levels.

During winter, blowdown temperatures may on occasion exceed ambient temperatures by as much as 7.8F° as calculated by the staff for December 1971 (a blowdown temperature of 41.1°F against an ambient of 33.3°F). Typically, blowdown temperature will exceed ambient by 4 to 6F°. No discernible effects on biota of Wolf Creek are expected due to these small winter ΔT's other than a potential for a slight increase in productivity if sufficient nutrients are available.

As discussed in Sect. 5.3.2, blowdown with ΔT's of these magnitudes will require a small mixing zone in the Neosho River to reduce (winter) or raise (summer) blowdown temperatures to ambient river temperatures. Even organisms residing in the mixing zone should incur no adverse effects from the slight increase in wintertime temperatures. During summer, most fish and many other aquatic organisms will find the much colder water within the mixing zone undesirable. Fish should readily avoid the small plume, but many sessile organisms within the mixing zone will probably disappear or become greatly reduced in numbers.

In summary, the staff foresees no significant impact on the biota of the Neosho River due to blowdown temperatures; however, substantial reductions in production and a shift in species composition in Wolf Creek will likely occur. The applicant will be required to control the rate of blowdown in order that the State criteria for mixing zones and zones of passage are met for both positive and negative ΔT's.

Blowdown (40 cfs max) will raise TDS and sulfate ion concentrations in the Neosho River. The applicant will regulate blowdown to the extent that the Kansas State Board of Health standards for drinking water will not be exceeded in the Neosho River (500 ppm TDS and 250 ppm sulfate). The TDS and sulfate levels in the Neosho River should usually fall considerably short of these limits. In order to meet these standards, the applicant will be required to monitor TDS, sulfate levels, and flow in the Neosho River downstream of its confluence with Wolf Creek. The staff concludes that increased TDS and sulfate concentrations in the Neosho River due to plant operation will pose no threat to existing aquatic organisms.

Blowdown, two units

The operation of two units will moderately raise the lower-than-ambient temperatures calculated for one unit and consequently reduce the effects on aquatic biota experienced by Wolf Creek during late spring and summer. Staff calculations indicate a maximum ΔT of 23F° below ambient. Generally, ΔT's will range between 3 and 20F° below ambient during this period (see Table 5.9).

During winter, blowdown temperatures may exceed ambient by up to 14F°. Typically, winter blowdown ΔT's will range from 6 to 11F° above ambient (Table 5.9). In any case, the resulting temperatures at the point of discharge in the river will be considerably below those naturally experienced by aquatic biota during the summer. Organisms residing in or passing through the thermal plume should therefore experience no measurable adverse effects. If sufficient nutrients are available, an increase in productivity within the plume may occur which, along with the higher temperatures, may prove attractive to some fish during winter. Any fish for which such temperatures would be undesirable could readily avoid the small plume.

5.5.2.2 Impact of operation on aquatic biota in the John Redmond Reservoir

Makeup structure

The makeup facility is described in detail in Sect. 3 of this Statement. When the pool elevation in John Redmond Reservoir is below 1039 ft MSL, makeup will be limited to 41 cfs. Otherwise, water may be pumped from the reservoir at rates as high as 120 cfs (PSAR, Sect. 2.4.8.2). Water from John Redmond Reservoir will arrive at the traveling screens of the pumphouse immediately downstream of the dam via two routes: (1) through the dam spillway gates and (2) through the three existing pipes in the dam (one of 30-in. diam, two of 24-in. diam, and all approximately 440 ft in length).

The upstream mouth of the pipe is at an elevation of 1016.5 ft MSL. Trash bars around the upstream mouth of the pipe prevent entry by logs. The pipe has at least seven bends at angles from approximately 40° to 90°.

Immediately downstream, makeup water and any entrained organisms plunge from the pipe into a canal which leads past the traveling screens of the pumphouse and into the Neosho River. Approach velocities to the traveling screens will be quite low — less than 0.5 fps (Table 3.4). Studies at the Indian Point Nuclear Generating Plant on the Hudson River indicate significant reductions in impingement when intake velocities are reduced below 1 fps.[39]

During the cold winter months, fish will move into deeper water, thus increasing the probability of their entrainment in the dam makeup pipe, especially since visibility is virtually nonexistent at depth. Furthermore, swimming speeds of some fish drop drastically with decreased temperature, resulting in a greater likelihood of impingement as evidenced by the winter rise in impingement losses at Indian Point.[39,40] Studies at the Peach Bottom Power Plant reveal that young-of-the-year and juvenile white crappie and channel catfish are unable to consistently swim against approach velocities of 0.5 to 0.7 fps, especially during cold, winter temperatures.[40] Table 5.20 shows swimming speeds under various conditions of these species and others collected from John Redmond Reservoir.

Table 5.20. Swimming speeds of fish collected from John Redmond Reservoir

Name		Water temperature (°F)	Fish length (mm)	Fish observed (number)	Swimming speed (fps)	Source reference
Common	Scientific					
Channel catfish	*Ictalurus punctatus*	75	54	5	0.74	1
		80	57	1	1.74	2
		81	55	10	1.25	3
Bluegill	*Lepomis macrochirus*	65	43	1	1.23	2
		79	45	5	0.49	1
		86	49	5	0.41	1
White crappie	*Pomoxis annularis*	70	74	5	0.63	1
		84	60	5	0.38[a]	
Largemouth bass	*Micropterus salmoides*	85	50	2	1.28	2
Carp	*Cyprinus carpio*				1.2	4

[a] Results given in source reference 2 are very close to the values.

Sources:

1. L. R. King, *Swimming Speed of the Channel Catfish, White Crappie and Other Warm Water Fishes from Conowingo Reservoir,* Susquehanna River, Pa., Ichthyological Associates, Bulletin No. 4, 1969, pp. 1–74.
2. C. H. Hocutt, "Swimming Speed of the Channel Catfish and Other Warm Water Fishes of Conowingo Reservoir as Determined in the Beamish Respirometer," pp. 289–303 in *Conowingo Reservoir-Muddy Run Fish Studies,* Progress Report No. 2, 1969.
3. L. R. King, *Supplementary Results of Swimming Speed and Endurance Studies on White Perch as Determined by the Beamish Respirometer,* Ichthyological Associates, 1970.
4. R. Haley, "Maximum Swimming Speeds of Fishes," in *Inland Fisheries Management,* A. Calhoun, Ed., California Dept. Fish and Game, 1966.

For worst conditions (lowest canal water level and highest pumping rate of 120 cfs), the staff calculated the screen approach velocity to be 0.45 ft/sec and the velocity through the trash racks to be 0.54 fps (Table 3.4). Large healthy fish would easily overcome such velocities.

However, velocities through the 30-in. pipe in the dam will approach 8.4 fps. Few fish, large or small, approaching near the mouth of the pipe will be able to escape such a current. Passage through the pipe and into the plunge basin will probably result in stunned and disoriented fish due to pressure changes and collisions with the pipe's walls. Therefore, such fish may still suffer impingement on the traveling screens of the pumphouse despite very low intake velocities. All fish avoiding impingement will be carried into the Neosho River via the canal, where the more stunned fish will be particularly subject to predation. A few fish from the Neosho River may enter the canal on occasions; but if they are strong enough to swim up the canal, they should be strong enough to avoid impingement.

All fish and plankton entrained in the 30-in. makeup pipe will be lost from John Redmond Reservoir. All fish impinged on the pumphouse screens will be lost since there will be no provisions for returning fish surviving impingement to the reservoir or river. The staff will require the applicant to monitor impingement at the makeup intake screens upon initiation of intake operation (Sect. 6.1.3.2).

Since present plankton densities in John Redmond Reservoir maintain themselves in the presence of a 1337 cfs average annual discharge through and over the dam,[41] the staff feels that the diversion of an average 46.6 cfs of this discharge to the makeup line will have no increased impact on plankton densities in the cooling lake. Some entrainment of planktonic fish larvae or eggs may occur, including those of white bass, walleye, gizzard shad,[38] drum, and river carpsucker.

The magnitude of entrainment and impingement losses and their significance from the standpoint of the total fishery in the Neosho River cannot be definitively assessed due to insufficient data. However, on the basis of the small amount of water to be withdrawn (relative to the average discharge downstream), it would appear that no serious impacts will be felt by the Neosho River.

The total plankton biomass entrained in the makeup line, less that discharged from the cooling lake into the Neosho River via Wolf Creek, represents the total loss of plankton drift from the Neosho River. On the assumption that plankton densities in the average 20.2 cfs discharge to the Neosho River are comparable to densities in the 46.6 cfs withdrawal from John Redmond Reservoir, a net loss of only 26.4 cfs of plankton-laden water will be incurred by the Neosho River. The staff does not consider this a significant loss of plankton from the Neosho River ecosystem.

Drawdown

Simulated water surface fluctuations in John Redmond Reservoir indicate that conditions characteristic of the severe drought of the mid-1950s would reduce the surface elevation to as low as 1030.3 ft MSL (ER, Fig. 2.5-5a). This drawdown estimate factors in continuous withdrawal of 41 cfs for industrial purposes such as makeup for the WCGS cooling lake. Normal conservation pool level is 1039 ft MSL.

A drawdown of this magnitude will reduce the reservoir's area from nearly 10,000 acres to approximately 4300 acres. Capacity will drop from nearly 90,000 acre-ft to about 24,000 acre-ft.

Such drawdowns will temporarily discourage fishing and recreation, mainly because extensive mudflats will reduce access to the reservoir waters. Most people will probably find sightseeing and picnicking by the reservoir less desirable during periods of drawdown. The return to "normal" water levels probably will fully restore the recreational value of the reservoir.

Drawdowns generally stress rough and small-fish populations much more than those of the larger piscivorous fish. Through loss of cover and crowding, for example, rough fish and the smaller sunfish will sustain much greater losses from predation by larger fish such as largemouth bass. Smaller fish also become stranded on the exposed bottom more often than larger ones. The more favorable ratio of predators to foragers resulting from these selective stresses often means greater production of predators, including many game fish, upon return of normal water elevations. This phenomenon has been demonstrated in several lakes.[21]

5.5.2.3 Impact of operation on aquatic biota in the Wolf Creek cooling lake

Wolf Creek cooling lake will be subject to a number of impacts, some of which may tend to counteract one another. Synergistic interactions among numerous impacts, such as changes in TDS, temperature, dissolved oxygen, and entrainment losses, may elicit unexpectedly severe responses in a cooling lake ecosystem and cannot be predicted from available data. However, on the basis of surveys of other lakes and reservoirs, field and laboratory studies, and baseline data provided in the applicant's ER, the staff feels Wolf Creek cooling lake may prove to be as productive as John Redmond Reservoir, if not more so. If operational monitoring should prove otherwise, then cold shock, entrainment, impingement, and hydrogen sulfide would be prime suspects as causes of reduced productivity, particularly from the fisheries standpoint. If the applicant's prediction of four unscheduled shutdowns per winter proves correct, cold-shock-induced fish kills are likely to occur.

Discharge of heated water

Temperature has a strong influence on aquatic ecosystems. Physical parameters such as dissolved gases, viscosity, and specific gravity respond to changes in temperature and thus influence the biota of the ecosystem.[42] The organisms themselves possess upper and lower temperature tolerance limits and optimum growth, reproduction, and migration temperatures. Species composition often shifts dramatically with small but significant changes in temperature.

The circulating water system of WCGS will discharge water into the cooling lake at temperatures up to 28.8F° above intake temperature. The staff calculated monthly temperature distributions in the cooling lake for a 23-year period (1951-1973) and concluded from these that highest lake temperatures will normally occur in July. Staff calculations singled out conditions in July of 1969 as eliciting the highest lake temperatures during the 23-year study period. Under such conditions, the entire surface of the cooling lake would experience temperatures greater than 86.0°F, which compares with a predicted ambient water temperature of 85.6°F. The 114.5°F discharge would result in 6% of the lake surface (area of the discharge pond) being hotter than 103.7°F and 10% hotter than 92.6°F. About 25% and 50% of the lake surface would yield temperatures above 90.0 and 87.4°F, respectively. July of 1968, with a discharge temperature of 110.5°F, was judged a typical or "average" July of the study period. The entire surface area would exceed 82.0°F; 50% of the area would exceed 83.4°F; and 25% would exceed 86.2°F. Ten and 6% of the surface area would yield temperatures above 89.1 and 100.1°F, respectively.

Benthic invertebrates. Several studies indicate that a reduction in benthos species diversity and shifts in species composition can be expected in the area of thermal discharge.[43-45] A study of a heated Texas reservoir by Durrett[43] revealed winter increases and summer decreases in benthic faunal density and diversity.. Production peaks were shifted to later months for many species such as *Coelotanypus*, a chironomid midge.[43] Some chironomids and oligochaetes appear to be among the most heat tolerant of the benthos, if not actually favored by moderate heating.[43,45] The staff predicts similar changes in the benthos of the discharge pond and its outfall area in the main body of Wolf Creek cooling lake. These localized changes should not significantly alter benthic production for the cooling lake as a whole. However, an indirect effect of thermal loading probably will significantly reduce benthic production in summer. Thermal stratification will lead to a serious oxygen deficiency in the hypolimnion and will likely exclude most benthic macroinvertebrates from all substrates within the hypolimnion during summer. This may reduce fish carrying capacity.

Fish. Fishery development in the cooling lake prior to plant operation is discussed in Sect. 4. A survey of reservoirs in Texas indicates little or no significant differences in fish growth and production between unheated and heated reservoirs in that State.[46,47] One heated reservoir exhibited slightly lower species diversity than expected, presumably as a result of thermal loading.[48] Another study compared fish productivity in five heated reservoirs with that in 10 unheated reservoirs. Production in the heated reservoirs was reported at least as good as in the unheated reservoirs,[49] although supplemental stocking of bass is carried out in all but one of the reservoirs.[49] However, such comparisons on the basis of temperature alone are extremely tenuous since many variables other than temperature are important in determining the productivity of a lake. These variables include extent and duration of thermal stratification, age of reservoirs, water level fluctuations, shoreline development, surface area, storage ratio, depth, turbidity, TDS, and composition of dissolved solids. Reservoirs surveyed in the above study varied widely for most of these parameters and others.[50]

At least 19 species of fish collected at or near the plant site have been collected alive in Texas waters at temperatures ranging from 90.5 to 103.1°F (Table 5.21). Incipient lethal temperature thresholds (maximum temperature at which 50% of a population could survive for extended periods of time) for several species occurring in the site area are shown in Table 5.22. Most of Wolf Creek cooling lake surface water should be cooler than the above temperatures. Proffitt's study[45] of effects of thermal discharges into the White River (Indiana) revealed the presence of several species of fish expected to inhabit Wolf Creek cooling lake in the discharge canal at temperatures of 93°F or higher. These included gizzard shad, river carpsucker, carp, longear sunfish, freshwater drum, shortnose gar, buffalo, and channel catfish. However, poor catch results from waters hotter than 93°F indicated most fish prefer lower temperatures even though they may tolerate 93°F and higher.[45] An interesting exception was the congregation of tiny minnows in backwaters as hot as 99°F, possibly because of relative safety from larger predator fish. Proffitt found no adverse impact on the river fishes due to heated water discharge.[45]

Fish growth and reproduction are very sensitive to increased temperatures and may be enhanced or depressed, depending upon species, by the amount of temperature increase, and interaction of temperature with other environmental variables. Heated water discharge from a power plant on the Wabash River (Indiana) elicited greater reproduction in flathead and channel catfish.[51] A North Carolina cooling lake experienced overpopulation by four stunted sunfish species (*Lepomis*). Largemouth bass on the other hand grew relatively rapidly (10 in. in 2 years).[52] Heated waters in another cooling lake accelerated gonadal development and subsequent spawning of largemouth bass.[52] Other observed sublethal temperature effects on fish include loss of condition ("skinny fish")[53] and increased parasite infestations.[48]

Given the predicted worst case temperatures as described above, only 27% (70% for two units) of Wolf Creek cooling lake would have surface temperatures greater than 90°F. On the basis of studies such as those previously described, the staff believes this temperature will be adequately tolerated by most species of fish likely to inhabit the new cooling lake. In an average year, more than 90% of the cooling lake surface area would register temperatures less than 90°F during the hottest month. The discharge lagoon and a small area around the lagoon's outfall into the main lake will probably be devoid of fish during the hottest months since fish can actively seek cooler water. Spawning initiated mainly by temperature and/or photoperiod may occur weeks earlier in the spring. Some species likely will find the discharge lagoon and the littoral regions surrounding its outfall unsuitable for spawning and will thus suffer overall reduction in available spawning habitat in the cooling lake. This small reduction in spawning habitat for some species should not significantly affect total fisheries productivity, especially since other species may find the heated areas more suitable for spawning. Early spawning induced by above-normal temperatures could possibly subject developing fish larvae and fingerlings of some species to starvation if development were not accompanied by a corresponding growth of food organisms. The staff considers massive starvation of young fish unlikely.

Table 5.21. Temperatures above 32.5°C (90.5°F) at which fish species recognized near WCGS have been collected in streams and rivers in Texas

Species	Water temperatures at time of collection		Species	Water temperatures at time of collection	
	°C	°F		°C	°F
Shortnose gar	32.5	90.5	Yellow bullhead	33.0	91.4
	34.5	94.1		34.0–36.0	93.2–96.8
Red shiner	32.4–36	90.5–96.8		39.0	102.2
	37.5	99.5	Mosquito fish	32.5–37.5	90.5–99.5
	39.0	102.2		39.0–40.0	102.2–104.0
	39.5	103.1	Green sunfish	33.0–36.0	91.4–96.8
Carp	32.5	90.5		37.5	99.5
Fathead minnow	34.5	94.1		39.0	102.2
Bullhead minnow	33.5–34.5	92.3–94.1	Bluegill sunfish	32.5–33.5	90.5–92.3
	35.5–36.0	95.9–96.8		34.5–35.0	94.1–96.0
	37.5	99.5		36.0–36.5	96.8–97.7
	39.0	102.2		39.0	102.2
Mimic shiner	33.5–35.5	92.3–95.9	Longear sunfish	33.0–37.5	91.4–99.5
Smallmouth buffalo	34.5	94.1		39.0–39.5	102.2–103.1
River carpsucker	32.5	90.5	Orangespotted sunfish	33.5	92.3
	33.5–34.0	92.3–93.2		37.5	99.5
	37.5	99.5	White crappie	32.5	90.5
Channel catfish	30.0–33.5	91.4–92.3		39.0	102.2
	34.5–36.0	94.1–96.8	Freshwater drum	37.5	99.5
	39.0–39.4	102.2–103.1	Gizzard shad	33.5	92.3
Flathead catfish	33.5	92.3		34.5	94.1
	35.0	95.0		37.5	99.5
	36.0	96.8		39.0	102.2
Black bullhead	33.5	92.3			
	35.5	95.9			

Source: Fish collection records of Dr. Clark Hubbs, University of Texas, Austin, Texas. In: H. B. Sharp and J. C. Grubb, "Biological Investigations – Inland Waters," Sect. 4.0 in *Review of Surface Water Temperatures and Associated Biological Data as Related to Temperature Standards in Texas*, Radian Corporation, 1973.

Phytoplankton. Periphyton and phytoplankton communities often exhibit rather dramatic changes in species composition with changes in water temperature[54] as shown in Fig. 5.9. Generally, species diversity will decline at the expense of diatoms and green algae with increasing temperatures and TDS.[55,56] Diatom usually dominate the community at temperatures below 80°F while green algae tend to gain ascendancy when temperatures exceed 80 to 85°F. Should temperatures exceed 95°F, blue-greens will likely dominate the phytoplankton community if other requirements such as adequate nutrient levels are present. As noted earlier (Sect. 2.7), critical phosphate and nitrate concentrations for the development of nuisance algal blooms are as low as 0.01 mg/liter as phosphorus and 0.30 mg/liter as nitrogen, respectively.[57] The measurements of phosphates in John Redmond Reservoir (ER, Appendix 2.5A) ranged from four to 15 times this critical phosphate concentration (0.044-0.15 mg/liter as phosphorus) while nitrate measurements exceeded critical nitrate values by factors ranging from two to four (0.70 to 1.2 mg/liter as nitrogen). A summer study in 1968 yielded phosphate and nitrate means of 0.11 mg/liter as phosphorus and 0.30 mg/liter as nitrogen, respectively.[58] The staff expects these nutrient levels to be exceeded in the Wolf Creek cooling lake through evapoconcentration of nutrients in makeup water from John Redmond Reservoir.

Prophet[58] reported phytoplankton blooms in Council Grove Reservoir, 177 km above John Redmond Reservoir. The blue-green alga *Anabaena*, a nitrogen-fixer, dominated the bloom. In North Carolina, increasing temperatures in a cooling pond were accompanied by increasing thickness of blue-green algal mats (*Oscillatoria limnosa, O. tenius*).[52] Species of both of these genera in all likelihood will be represented in Wolf Creek cooling lake.

Table 5.22. Incipient lethal temperature threshold for fish species recognized in the vicinity of Wolf Creek Generating Station

Species	Stage/age	Acclimation temperature	Locality	Threshold °C	Temperature °F	Source
Gizzard shad	Juvenile	25	Ohio	34.0	93.2	Hart, 1952
		30	Ohio	36.0	96.8	Hart, 1952
		35	Ohio	36.5	97.7	Hart, 1952
		25	Tennessee	34.5	94.1	Hart, 1952
		30	Tennessee	36.0	96.8	Hart, 1952
		35	Tennessee	36.5	97.7	Hart, 1952
Mosquito fish	Adult	25	Tennessee	37.0	98.6	Hart, 1952
		30	Tennessee	37.0		Hart, 1952
		35	Tennessee	37.0		Hart, 1952
		15	Florida	35.5	95.9	Hart, 1952
		20	Florida	37.0	98.6	Hart, 1952
		30	Florida	37.0		Hart, 1952
		35	Florida	37.0		Hart, 1952
Channel catfish	Juvenile	26	Arkansas	36.6	97.9	Allen and Strawn, 1967
		30	Arkansas	37.8	100.0	Allen and Strawn, 1967
		34	Arkansas	38.0	100.4	Allen and Strawn, 1967
	Adult	15	Florida and Ohio	30.4	86.7	Hart, 1952
		20	Florida and Ohio	32.8	91.0	Hart, 1952
		25	Florida and Ohio	33.5	92.3	Hart, 1952
Bluegill sunfish	Adult	15	Florida	30.5	86.9	Hart, 1952
		20	Florida	32.0	89.6	Hart, 1952
		25	Florida	33.0	91.4	Hart, 1952
		30	Florida	33.8	92.8	Hart, 1952
Longear sunfish		25	Arkansas	35.6	96.1	Neill, Strawn, and Dunn, 1966
		30	Arkansas	36.8	98.2	Neill, Strawn, and Dunn, 1966
		35	Arkansas	37.5	99.5	Neill, Strawn, and Dunn, 1966
Largemouth bass	9–11 month	20	Florida	32	89.6	Hart, 1952
		25	Florida	33	91.4	Hart, 1952
		30	Florida	33.7	92.6	Hart, 1952
		20	Ohio	32.5	90.5	Hart, 1952
		25	Ohio	34.5	94.1	Hart, 1952
		30	Ohio	36.4	97.5	Hart, 1952
	Under yearling	30	Tennessee	36.4		Hart, 1952
		35	Tennessee	36.4		Hart, 1952
		22	Wisconsin	31.5	88.7	Hart, 1952
Bluntnose minnow	Adult	95	Ontario	26.0	78.8	Hart, 1947
		10	Ontario	28.3	82.9	Hart, 1947
		15	Ontario	20.6	69.1	Hart, 1947
		20	Ontario	31.7	89.1	Hart, 1947
		25	Ontario	33.3	91.8	Hart, 1947
Fathead minnow	Adult	10	Ontario	28.2	82.8	Hart, 1947
	Adult	20	Ontario	31.7	89.1	Hart, 1947
		30	Ontario	33.2		Hart, 1947

Sources:

K. O. Allen and K. Strawn, "Heat Tolerance of Channel Catfish," pp. 339–411 in *Proc. 21st Annu. Conf. S.E. Assoc. Game and Fish Comm.*, 1967.

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J. W. Hart, "Geographic Variations of Some Physiological and Morphological Characters in Certain Freshwater Fish," *Publ. Ontario Fish Lab.* LXXII, p. 79 (1952).

W. H. Neill, Jr., K. Strawn, and J. E. Dunn, "Heat Resistance Experiments with the Longear Sunfish, *Lepomis niegalotis* (Rafinesque)." *Ark. Acad. Sci. Proc.* 20: 39–49 (1966).

The growing season for algae will extend earlier into spring and later into fall as a result of warmer temperatures. Consequently, greater annual production of algae than would otherwise occur is a good possibility, although entrainment will tend to counteract this effect of increased temperature. The staff considers the development of green and blue-green algal blooms of densities sufficient to constitute a nuisance a high probability during summer in the 247 acre discharge pond and in up to 10 to 12% of the main cooling lake surface area. Blue-green algae are an inferior and sometimes poisonous source of food for many zooplankters and fish.[59]

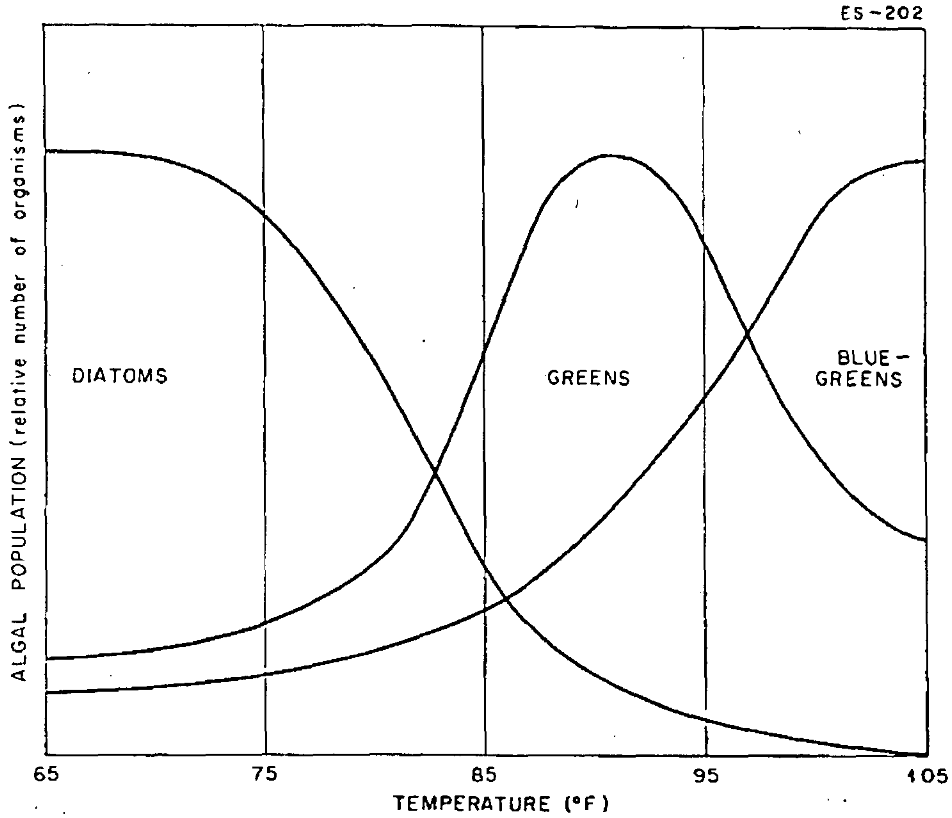

Fig. 5.9. Population changes among algal groups with change in temperature. Source: J. Cairns, Jr., "Effects of Increased Temperatures on Aquatic Organisms," Industr. Wastes 1(4): 150-152 (March-April 1966).

Zooplankton. The relatively few studies extant on zooplankton population responses to artificially increased temperature indicate a general tendency for populations to increase with temperature, short of lethal levels.[48,60] A study at the Paradise Power Plant on the Green River in Kentucky revealed zooplankton to be highly abundant in warm water up to 96.8°F.[60] A sampling station near a thermal discharge in a Texas reservoir reached temperatures as high as 107.6°F in August, yet annual zooplankton yields (particularly copepods and cladocerans) were greater here than at cooler stations.[48] However, lowest yields at this particular station occurred simultaneously with highest summer temperatures.[48] Information to make a firm judgment is insufficient, but the staff feels that zooplankton productivity in the cooling lake proper will at least equal, if not exceed, that in John Redmond Reservoir. However, subtle differences in species composition and diversity will likely develop once temperatures and TDS increase due to plant operation. Growing seasons will extend earlier into spring and later into fall. Zooplankton productivity will probably be depressed in the 247-acre discharge pond during the hottest summer months.

Effect of reactor shutdown on fish

In temperate waters, fish generally prefer temperatures warmer than ambient during the cooler winter months.[61] Thus, beginning with the autumn drop in ambient temperatures, the warmer water surrounding the discharge structure of a power plant will often attract relatively large numbers of fish.[61] In the event of a rapid reactor shutdown, those fish acclimated to the warmer water of the discharge plume will be subject to cold shock as temperatures in the plume rapidly approach ambient. This temperature drop will of course be greatly accelerated if forced circulation of ambient water continues after reactor shutdown.

An emergency shutdown of a 720 MW power plant on the Susquehanna River in February 1971 resulted in a significant fish kill when the water temperature in the discharge area dropped precipitously from 44°F to 36°F. More than 15,000 fish "of value" were estimated to have been killed.[62] The applicant estimates ten shutdowns per year at Wolf Creek, any one of which may last from a few hours to several months (ER, p. 5.1-11; Q5.7a). An average of four unscheduled shutdowns and one scheduled refueling shutdown is expected each winter (ER, p. 5.1-11). The applicant calculates the maximum rate of temperature drop at the plant discharge to be about 0.54°F/hr for the first day of shutdown (ER, Sect. 5.1.5).

The staff's thermal analysis (Sect. 5.3.2) predicts winter ΔT's up to 28.8 F° at 100% plant factor and 21.7 F° at 75% plant factor. The staff expects the average of five shutdowns per winter with temperature drops approaching 30 F° to stress those fish residing in the discharge area. An unknown number of fish will be lost due to cold shock. Such losses will be isolated to the cooling lake and will not impact Wolf Creek, the Neosho River, or the John Redmond Reservoir.

Fluctuating cooling lake levels

During drought, reductions in lake level will adversely affect benthic fauna and flora but recolonization following reinundation will likely be rapid.

Water quality

The applicant predicts maximum concentrations of TDS and sulfate ion in the cooling lake at approximately 1200 mg/liter and 787 mg/liter, respectively, during one-in-50-year drought conditions and operation of WCGS at 75% plant factor (ER, Table 3.6-3). Average TDS and sulfate concentrations are estimated by the applicant to be 700 mg/liter and 460 mg/liter, respectively.

The staff believes maximum TDS concentrations predicted for the cooling lake to be within the limits of tolerance for most aquatic organisms likely to inhabit the lake. Available data on tolerance of some of these organisms to TDS indicate they can tolerate TDS concentrations far in excess of 2000 mg/liter (Table 5.23). Furthermore, some evidence exists that high TDS concentrations, particularly those parts due to calcium and magnesium, reduce the toxicity of heavy metals and organic compounds to aquatic life through chelation.[63,64] On the other hand, much of the TDS will be composed of sulfate ions due to the addition of sulfuric acid to the cooling water in quantities sufficient to maintain a pH of 7.4 at the condensers. Sulfate concentrations as high as 700 mg/liter do not appear to be harmful to most organisms that have been examined.

Nutrients will enter the cooling lake from several sources: (1) nutrient release from flooded terrestrial vegetation, (2) evapoconcentration of makeup from John Redmond Reservoir, (3) duck excreta from ducks likely to be attracted to the warm water of the cooling lake during winter, and (4) agricultural runoff. Impact of nutrient enrichment on biota was discussed earlier.

Thermal stratification during the summer months will probably lead to anaerobic conditions in the hypolimnion due to oxidation of organic detritus and thus effectively remove a significant portion of the cooling lake from normal production. Anaerobic bacteria may then reduce sulfate ions, which will be plentiful, to hydrogen sulfide. Bacterial decomposition of organic material may also release hydrogen sulfide[65] which is toxic to many aquatic organisms, including fish and their eggs. The staff believes that such concentrations are not likely to occur.

Up to 15,000 gal of sanitary wastes will be discharged into the cooling lake per day (ER, Sect. 3.7). This corresponds to a flow of only 0.023 cfs. Before discharge, however, the wastes will have been given tertiary treatment in a sewage treatment plant (ER, Sect. 3.7), a process that should remove most solid material and nutrients. The applicant predicts a maximum BOD of 10 mg/liter and a maximum total residual chlorine concentration of 0.5 mg/liter. The staff anticipates no significant adverse impacts on the biota of Wolf Creek cooling lake or the Neosho River from this discharge.

The applicant plans to control biofouling of the condensers through three daily 30-min applications of chlorine at the circulating water screen house. Continuous monitoring during chlorination will be conducted at the condenser discharge to ensure that free chlorine residual concentration remains in the range of 0.1-0.5 mg/liter. This procedure will meet current applicable EPA standards [40 CFR Part 423.13, Limitation 423.13 (h) and (j)]. However, compliance with EPA Guidelines limits only the free available chlorine that can be discharged, not the combined residual chlorine (e.g., chloramines and chloro-organics), which is also toxic to aquatic life and may be discharged in amounts exceeding free available chlorine. Therefore, a criterion based solely on concentrations of free available chlorine fails to provide satisfactory safeguards for aquatic organisms near the discharge.

Table 5.23. Median toxicity thresholds for invertebrates and fishes in brine wastes at a 96-hr exposure

Each group is in order of decreasing tolerance

Species	Median toxicity threshold (ppm) for dissolved solids
Fish	
Mosquito fish	15,244
White crappie	12,566
Bluegill	11,330
Green sunfish	11,330
Channel catfish	11,124
Red shiner	10,506
Black bullhead	10,300
Largemouth bass	9,476
Fathead minnow	8,858
Benthic Organisms	
Cambarus (crayfish)	17,922
Dragonfly	14,832
Damselfly	14,832
Hexagenia (mayfly)	10,506
Tubificid worm	10,094
Hyalella azteca	7,828
Baetidae (mayfly)	7,146
Physa (snail)	6,386
Zooplankton	
Diaptomus clavipes	6,592
Daphnia pulex	3,708

Source: H. P. Clemens and W. H. Jones, "Toxicity of Brine Water from Oil Wells," *Trans. Amer. Fish. Soc.* 84: 97–109 (1954).

The applicant provided no estimates of total residual chlorine (free available plus combined) concentrations expected in the discharge stream, but does propose addition of chlorine up to a level of 3.5 ppm with a maximum free available chlorine in the discharge of 0.5 ppm. The remaining 3.0 ppm of chlorine must then be in the form of (1) toxic combined residual chlorine and/or (2) relatively nontoxic chlorides. Although the relative abundance of these chemical species is unknown, the staff assumes that total residual chlorine in the discharge may constitute a significant fraction of the total chlorine reaction products.

Within the time frame proposed for chlorination, the available evidence suggests that concentrations of total residual chlorine in excess of 0.1 mg/liter are not safe for many freshwater organisms.[66,67] Consequently, some mortality of fish and other organisms will likely occur within the discharge pond during or following proposed chlorination. Beyond the discharge pond, dilution, volatilization, and chlorine demand should reduce concentrations to below the level of detection.

The staff is unable to determine the concentration of combined residual chlorine based on the applicant's proposed chlorination limit and is therefore unable to determine the acceptability of impacts on the aquatic biota. The staff is of the opinion that, if the total residual chlorine concentrations were maintained at 0.1 ppm at the point of discharge, the impacts would be acceptable.

Several aspects of the expected water quality of Wolf Creek cooling lake were previously discussed in Sect. 4.

Entrainment

Entrainment of organisms of the cooling lake in the circulating water system of the steam plant will be a problem because of (1) a flow through the system of 1178 cfs of cooling water and 78 cfs of service water, and (2) a ΔT across the condenser as high as 30.0 F° (ER, p. 3.4-2).

Agents of mortality other than thermal shock include mechanical damage and chemical and pressure changes. Lacking definitive information to the contrary, the staff makes the conservative assumption that 100% of all organisms entrained in the circulating water system will die as the result of thermal shock and mechanical, chemical, and pressure effects. Maximum summertime temperature at discharge is predicted to be 114.5°F.

Intake and discharge temperatures will be much lower than in summer, but the ΔT values across the condenser will be at least as large, if not larger (maximum of 30.0°F according to staff calculations). Mechanical, pressure, and chemical stresses would remain essentially the same throughout the year.

Based on a total flow rate of 1259 cfs (1178 cfs of cooling water and 78 cfs of service water) and a cooling lake volume of 111,280 acre-ft, staff calculations yield an approximation of 44.6 days as the turnover time of the cooling lake (i.e., the time required to pump the entire volume of the lake through the circulating water system). Most plankters exhibit generation times shorter than 44.6 days (*Keratella*, 22 days),[68] and thus may be able to replenish their populations as fast as they are "grazed" by the circulating water system. Even so, some zooplankters exhibit relatively long resting periods of no reproduction and thus could be greatly reduced if entrainment mortality were high.

Since the cooling lake is not yet constructed, no estimates of planktonic populations are available. However, on the assumption that populations in Wolf Creek cooling lake will be comparable to those in John Redmond Reservoir, relative flow rates indicate that 20 to 30 times as many plankters will be lost to entrainment in Wolf Creek cooling lake as will be lost from John Redmond Reservoir. Since Wolf Creek cooling lake will be essentially a closed system, the nutrients bound up in the entrained organisms will not be lost, but will be available for utilization by decomposers, benthos, and plankton.

A few fish species expected to inhabit the cooling lake may produce planktonic eggs or larvae that will be subject to entrainment. These include white bass, walleye, gizzard shad,[38] and river carpsucker. Entrainment losses may significantly depress production of these species. White bass and walleye are valuable game fish and gizzard shad is an important forage fish.

Some fish will be entrained in the blowdown through the cooling lake dam (40 cfs max). The staff does not expect losses in the blowdown to significantly affect fish populations in the lake as a whole.

The staff expects some depression of productivity in Wolf Creek cooling lake due to entrainment losses, especially in the summer, but the extent of this depression cannot be predicted from the available data. Other factors such as increased temperatures in fall, winter, and spring may compensate for entrainment losses through extension of the growing season.

Impingement

Impingement of fish and aquatic herptiles will occur at the screens of the circulating water intake structure in the Wolf Creek cooling lake. Some impingement is also expected at the essential service water intake, but the volume of flow (33.5 cfs) is small when compared to that of the circulating water intake (1259 cfs including the service water flow); hence the discussion will be confined to the latter intake.

The traveling screens on the circulating water intake structure will operate intermittently and no provisions will be made for return of fish surviving impingement to the cooling lake. Screen mesh size will be 3/8 in. (ER, Q3.9). Approach velocities to the trash racks of the intake structure were calculated by the staff to be 0.49 fps at normal cooling lake elevation and 0.52 fps at the expected minimum elevation of 2.2 ft below normal (Table 3.1). The staff believes most healthy large fish will escape impingement at these velocities, but many young-of-the-year and juvenile fish and slow-swimming gizzard shad will suffer impingement or entrainment. The distribution of fish in the projected cooling lake is unknown, but fish will tend to accumulate in the intake pond due to relatively swift currents in canals leading from the main cooling lake into the intake pond (Table 3.3). This development is expected to greatly increase impingement and entrainment losses, particularly if spawning should occur there.

The staff expects impingement of fish on the screens of the circulating water intake structure, especially during periods of maximum drawdown. Until the magnitude of impingement losses under actual operating conditions is determined, the impact of impingement on some fish populations in Wolf Creek cooling lake must be considered potentially severe.

Whenever the cooling lake elevation falls below 1075.6 ft MSL, the applicant has committed to the adjustment of circulating water flow to maintain intake velocities at no more than 1.0 fps or to the monitoring of fish impingement. Should impingement losses prove damaging to the overall fishery of the lake, then possible mitigative measures include a fish return facility incorporating continuously revolving screens and low velocity screen-wash jets.

5.6 IMPACTS ON PEOPLE

5.6.1 Physical impacts

The site is sufficiently remote that the noise of operating machinery should not be audible to local residents. The air pollution resulting from occasional operation of the diesel engines on emergency equipment will not be significant. Sewage will be collected conventionally and handled in a package sewage treatment plant. During permanent operation of the plant, the sewage treatment unit will operate as an extended aeration system for the effluent that will also be given tertiary treatment, consisting of filtration and recirculation, then chlorinated and released into the cooling lake (ER, p. 3.7-1).

Transportation of the operating personnel is expected to have only a minor impact on traffic. The upgrading of roads for construction will be more than adequate for continued use during operation. The infrequent use of the railroad spur will have only minor effect on traffic on the few roads crossed by the spur. There will be continuing aesthetic impacts where the transmission lines are visible from roads and residential areas.

5.6.2 Population growth and operating personnel income

The applicant estimates that about 87 permanent personnel will staff WCGS. About 40% of these personnel are expected to settle within Coffey County; the remainder are expected to settle within a radius of 25 to 40 miles in the intermediate impact area (ER, p. 8.1-12). Using the Kansas statewide average of 2.96 persons per household, the increase in population in the immediate area will be about 228. The population increase in school age children is estimated to be approximately 93 in Coffey County and about 160 in the intermediate area.

The estimated annual total disposable income of the operating personnel is projected to be about $1.5 million in 1982 (ER, p. 8.1-18).

5.6.3 Impact on community services

The availability of housing in Coffey and surrounding counties is discussed in ER, Sect. 8.2.2.1.2. Sufficient housing is expected to be available for the operating force as the construction phase ends.

WCGS operator residences should not add significantly to the police and fire protection facility requirements in Coffey County.

The increase in school population generated by the operating forces is expected to be easily incorporated in the existing school systems.

The visitor's center planned by the applicant will provide additional educational opportunities for the area. Further benefits will accrue through cooperation with local colleges and universities in continuing studies of the environment, local archaeology, and nuclear sciences (ER, p. 8.1.24).

5.6.4 Impact on local institutions

The taxes to be paid by the applicant to the various cognizant public bodies are discussed in ER, Sect. 8.1.2.4.

The single 20-bed hospital in Burlington is crowded now; however, the additional load due to the small number of WCGS operating personnel can probably be accommodated.

5.6.5 Impact on recreational capacity of area

The applicant states that there are no plans to develop the cooling lake or any parts of the site for recreational use. However, there are many facilities for water-related sports, picnicking, and golf in the area and these will not be affected by the development of the site. Formation of the cooling lake and buffer zone will remove habitat area for some small animal species and some deer (ER, p. 8.2-18) and will inevitably affect hunting activities, especially over the short term. Compensatory adjustments are expected to be made over the long term.

The plant will be intermittently visible from local highways and farm roads. Creation of the cooling lake will provide scenic views which should be aesthetically pleasing. The applicant plans to minimize the visual impact of transmission lines and structures (ER, Sect. 8.2.2.5).

5.6.6 Impact of increased fogging and icing from the cooling lake

The total impact of the presence of the cooling lake regarding average temperature, relative humidity, and frequency of fogs is expected to be minimal. Fogs do occur over pond surfaces, particularly during cold weather periods when the difference between the pond surface and the ambient air temperature is the greatest and the difference between the actual and the saturation vapor pressure of the ambient air is the lowest.[69,70] When fog does occur, it generally does not extend over the land for more than 1000 ft; however, under extreme conditions the fog may extend a mile or more.

Meteorological data taken at Topeka and Wichita, Kansas, indicate that the frequency of heavy fog naturally occurs in this part of Kansas two or three days each month during December through February (ER, Table 2.6-3). The frequency is less during the rest of the year, being relatively low during the summer. The applicant has estimated that the largest changes in the frequency of the fog due to the construction and operation of the cooling lake will occur during the nighttime of the winter months (ER, p. 5.1-12a). At U.S. Highway 75, the maximum frequency of fogging is expected to increase from about 1% in November to about 5% in January. For the local roads about 1.5 miles north and east of the plant, the maximum frequency of fogging is expected to increase from about 2% in November to about 5% in January. No increase of fog in Burlington is expected.

When night temperatures drop below freezing, icing can occur around the cooling lake. All evidence indicates that rim ice (which is of a low-density, granular nature, and which is unlikely to cause weight damage), not glazed ice, tends to form around cooling lakes.[69,70] The applicant estimated that there would be a maximum of about 1% increase in the frequency of icing at U.S. Highway 75 during February (the month of highest increase) (ER, p. 5.1-12a and ER, Fig. 5.1-6). For the local roads about 1.5 miles north and east of the plant, the maximum icing frequency during February would be about 3%.

The staff concurs with the applicant's analyses of increased fogging and icing in the vicinity of the cooling lake and finds the impact acceptable.

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6. ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 PREOPERATIONAL PROGRAMS

6.1.1 Hydrological

The applicant has developed a preoperational water quality monitoring program (ER, Sects. 6.1.1 and 6.1.2). The program is rather extensive, measuring surface and groundwater characteristics at many points. The staff finds the applicant's preoperational monitoring program to be adequate.

6.1.2 Meteorological

The preoperational onsite meteorological program, initiated in May 1973, utilized a 300-ft tower, located about 2600-ft north-northeast of the main reactor complex. Wind speed and direction were measured at 32 ft, 116 ft, and 196 ft; vertical temperature gradient was measured between 32 ft and 116 ft, between 32 ft and 196 ft, and between 32 ft and 277 ft; ambient temperature and dewpoint temperature were measured at 32 ft; and precipitation and solar radiation were measured at 6 ft.

The applicant has submitted one full year (June 1, 1973 through May 31, 1974) of onsite joint frequency distribution of wind speed and direction at the 32-ft level by atmospheric stability (as defined by the vertical temperature gradient between 32 ft and 277 ft) in accordance with the recommendations of Regulatory Guide 1.23.[1] Data recovery was 95%. The staff has used these data to provide conservative and representative estimates of relative concentration (χ/Q) values for the site. A Gaussian diffusion model, described in Regulatory Guide 1.42,[2] with adjustments for building wake effects, was used to make estimates of relative concentrations at various distances and directions as specified in Sect. 5.

6.1.3 Ecological

6.1.3.1 Terrestrial

The applicant has obtained baseline data on terrestrial biota. These studies and subsequent preconstruction studies will be used as the basis to assess the effects of site preparation and construction. The baseline study was designed to establish quantitative and species composition of the terrestrial ecosystems of the site. Table 6.1 contains a summary of the preconstruction terrestrial monitoring program.

Several changes and additions are recommended in the preoperational terrestrial monitoring program:

(1) In the wildlife sampling program, sample for herps and small mammals in the wet marshy mudflats and the annual dominated mudflats of John Redmond Reservoir to provide a basis for predicting the kinds of animals that will probably inhabit the mudflat areas of the Wolf Creek cooling lake. Amphibians and reptiles should be censused by using seines, traps, trawls, etc., in aquatic environments, and nighttime road censuses should be taken for terrestrial forms in addition to stone and log rolling in herp habitat. The monthly waterfowl census of John Redmond Reservoir currently prepared by the U. S. Fish and Wildlife Service will be adequate data for predicting bird use of the Wolf Creek cooling lake and thus should be included in the monitoring data.

(2) In the preoperational vegetational sampling program, substitute wet marshy mudflats and annual dominated dry mudflats for pastures and mixed shrub pastures. Quantitative vegetational data from the mudflat areas of John Redmond Reservoir should be gathered at least once. Continued sampling of the wet marshy mudflat areas and annual dominated dry mudflat areas will provide a data base for predicting the fluctuation and kinds of plant communities that will inhabit the mudflat areas of the Wolf Creek cooling lake.

Table 6.1. Preconstruction terrestrial monitoring program

Item sampled	Methods	Data gathered	Sample station[a]	Sampling schedule: Baseline	Sampling schedule: Preoperational
Vegetation					
Lowland forest			1A		
Trees and saplings	Point quarter	Relative frequency, density, and dominance		Spring	Biyearly
Shrubs and seedlings	Line intercept	Relative frequency and dominance		Spring	Biyearly
Herbs	Quadrat			Spring and fall	Biyearly
Bluestem prairie			2		
Herbs	Quadrat	Relative frequency		Spring and fall	Biyearly
Open pasture			3		
Herbs	Quadrat	Relative frequency		Spring and fall	Biyearly
Mixed shrub-grass pasture			4		
Shrubs	Line intercept	Relative frequency and dominance		Spring	Biyearly
Herbs	Quadrat	Relative frequency		Spring and fall	Biyearly
Mammals					
Small	100 snap traps set in triplicate 25–30 ft intervals for 3 nights	Relative density	1A, 2, 3, and 4	Spring, fall, and winter	Annually
Medium					
Cottontail rabbits	Road census	Relative density	20 mile census route	Spring and summer	Annually
Squirrels	Time area counts	Relative density	1A, 5, 6 and 7	Winter	
Large					
Deer	Aerial census	Relative density	Proposed cooling lake basin	Spring	
Birds					
General	Strip census	Relative density	1A, 2, 3, and 4	Spring, summer, fall, and winter	Quarterly
	Road census	Relative density	20 mile census route	Spring, summer, fall, and winter	Quarterly
Special interest					
Birds					
Bobwhite	Road census	Relative density	20 mile census route	Spring and summer	Annually
Ring-necked pheasant	Road census	Relative density	20 mile census route		Annually
Mourning doves	Road census	Relative density	20 mile census route		Annually
Herps	Log rolling and stone turning	Species diversity relative density	1A, 2, 3, and 4	Annually	Annually
Terrestrial invertebrates	Blacklighting, pitfall traps, and sweep-netting	Relative density	1A, 2, 3, and 4	Summer	

[a]See ER, Fig. 6.1–6 for locations of sampling stations.

(3) The staff feels that replicate stands for each habitat would provide valuable additional information, but realizes that it is not practicable for this to be done because of the scarcity of appropriate stands in the area. Therefore, the recommendation for a minimum of three stands per system is dropped and monitoring in several different systems is recommended instead [see (2)]. Also, the staff feels that additional sampling in the open pastures and mixed shrub pastures is not necessary and preoperational sampling in these vegetation types can be eliminated. In addition, the staff suggests that sampling of trees, shrubs, saplings, and seedlings in the lowland forest be limited to once a year in the spring during the preoperational period, and the sampling of herbs be changed to twice in the spring and once in the early fall for the lowland forest and bluestem prairie.

(4) Establish stands below Wolf Creek cooling lake in examples of floodplain forest (silver maple-American elm) to monitor changes in density of seedling, sapling, and mature trees, shrubs, and herbs. Because the floodplain and lowland forest are essentially continuous vegetation gradients, with flood tolerant species dominating the banks of the stream and with oaks and hickories dominating the upper seldom flooded benches, several transects should be established perpendicular to the stream, thus, paralleling the environmental gradient in both the floodplain forest and the lowland forest. Gradient analysis techniques then should be used to document shifts in species composition resulting from changes in the environmental gradient along Wolf Creek due to construction of the Wolf Creek cooling lake.

(5) Use only live traps for trapping of small mammals.

(6) In taking vegetational data in the prairie, consider adding cover estimates or increasing quadrat size if only frequency data are to be gathered. "Frequency is not simply a character of the species, but a character of the species plus the sampling technique. Not unless frequency is determined with a sharpened rod is the effect of size of the observational unit removed."[3] Also, "the use of frequency as a single determination in analytic procedure has proven unsatisfactory."[4] Therefore, the staff suggests that cover estimates be taken in addition to

frequency estimates. Cover estimates can be accurately estimated on 0.1-m^2 quadrats. The size of the quadrats must be the same to compare frequency values for a species from different stands.[4] In sampling tall grass prairie ecosystems, most workers have used a quadrat that has an area of 1 m^2.[5-9] Therefore, because most of the literature on stable climax prairies reports use of a quadrat size of 1 m^2 and because sampling of the lowland forest (Stand 1A) of the site was accomplished using a circular 1-m^2 quadrat, increasing the size of the quadrat in future sampling seems justified.

6.1.3.2 Aquatic

The applicant's consultants (Industrial Bio-Test Laboratories) conducted baseline studies of the site area to enable identification of ecological changes due to future construction and operation of the generating station. Quarterly samplings for physical, chemical, and biological parameters were made at sampling stations in John Redmond Reservoir, the Neosho River, and Wolf Creek (Fig. 6.1). Table 6.2 outlines the sampling schedule, and Tables 6.3 and 6.4 list parameters measured and those to be measured in future monitoring, respectively. Methodology is described in detail in Sect. 6 of the ER.

The staff believes that certain deficiencies exist in the applicant's preoperational monitoring programs as already conducted and as scheduled for the future. These deficiencies and staff requirements for correcting them are identified in the following discussion.

Sampling intervals were too long. Several species of periphyton, phytoplankton, zooplankton, and benthic invertebrates are probably present in the site area but were not collected because they "bloomed" in the interim between sampling dates.

Fish larval densities and distributions are important biological parameters; none were reported by the applicant. Biweekly sampling of fish eggs and larvae from early April through June in the area of the makeup structure in the Neosho River and in the areas of the circulating water system intake and discharge structures will be required for future preoperational and operational monitoring. The applicant should conduct sampling of larvae during light and dark hours in order to obtain density and distribution data on as many different species as possible. Larvae should be quantified and identified to the lowest taxa possible.

In addition to correcting the deficiencies in the present monitoring program, the staff recommends that the following additions be made to the applicant's preoperational monitoring programs:

(1) Two additional fish collection stations should be added in the Neosho River; one of these should include shallow gravel bars near the Wolf Creek confluence. Careful sampling of shallow gravel bars may yield the Neosho madtom. One or two specimens should be preserved for positive identification and deposition in the University of Kansas Museum of Natural History and the rest returned to the river alive. The other station should be established as close to the makeup intake structure as practicable, with monthly sampling during spring and summer and bimonthly during the balance of the year.

(2) Catch per unit effort data should be supplied for all fish sampling.

(3) Turbidity, TSS, and rainfall must be measured under all weather conditions, including rain storms, for the remaining period of time prior to initiation of construction and during the entire period of construction. Both dissolved iron and total iron should be measured and recorded separately. Present measurements were apparently conducted for total iron only.

During the lake-filling phase, the applicant must monitor impingement on the makeup intake structure screens for at least one year. Two 12-hr screen counts must be conducted twice weekly during the spawning season and twice monthly during the rest of the year (one screen count for the period beginning at 8:00 AM and ending 8:00 PM; the other count for the period beginning at 8:00 PM and ending at 8:00 AM. Fish should be identified to species and categorized into size and weight ranges. Observations regarding spawning condition should be recorded. A detailed report on the results of the monitoring program must be submitted to the staff within three months of the completion of the program.

6.1.4 Radiological

The applicant has proposed an offsite preoperational monitoring program to provide background information for the operational radiological monitoring program.

A summary description of the applicant's preoperational program is presented in Tables 6.5 and 6.6. The description is not intended to be a complete technical specification of the program.

Monitoring and analytical techniques are likely to improve before the program is put into effect. More information is provided in the applicant's Environmental Report.

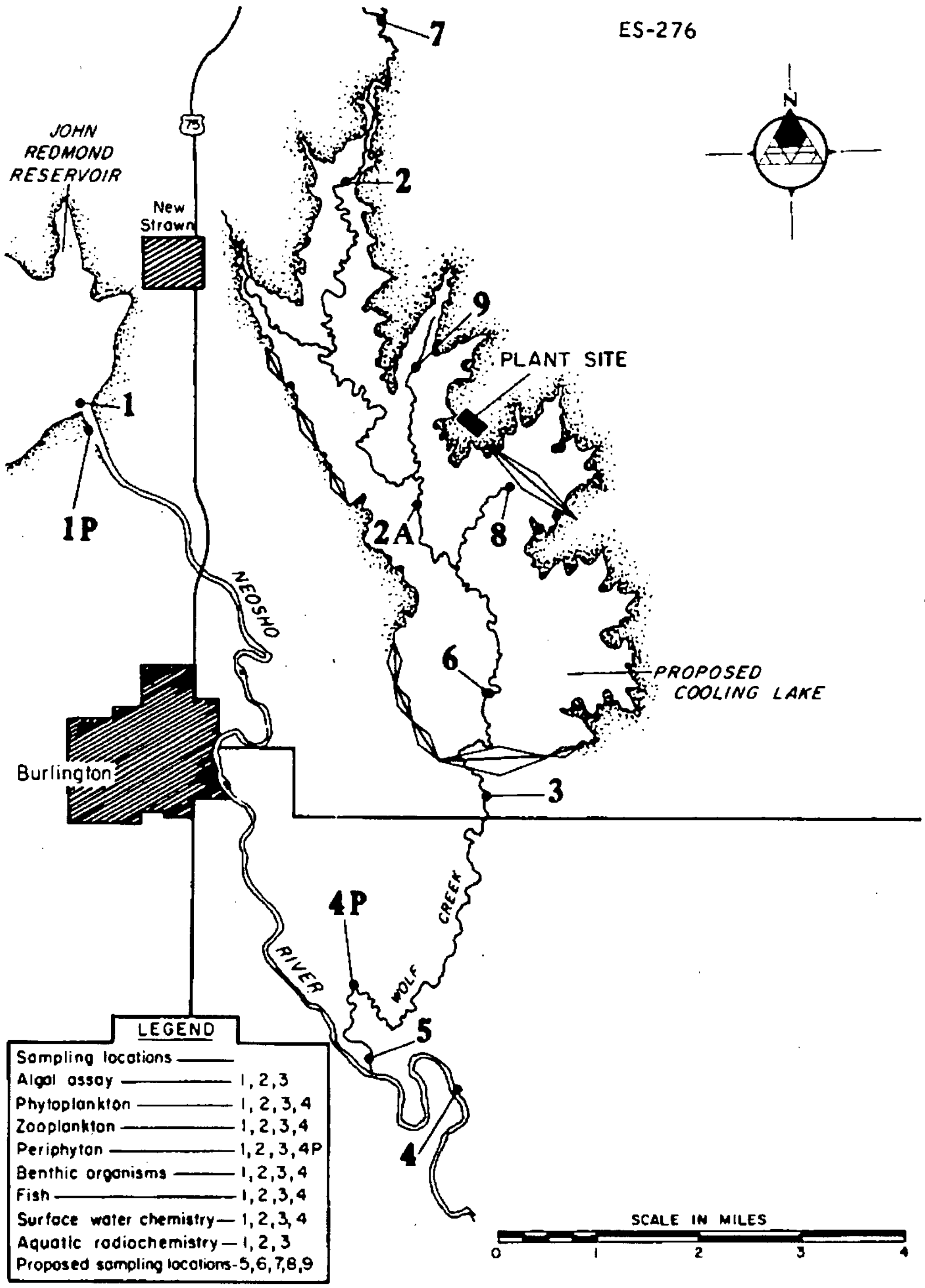

Fig. 6.1. Aquatic ecology and surface water chemistry sampling locations. Source: ER, Fig. 6.1-1.

Table 6.2. Sampling schedule for preconstruction, construction and lake filling monitoring phases of the Wolf Creek Generating Station, 1974 to operation

	Preconstruction				Construction				Lake filling			
	March	June	Sept.	Dec.	March	June	Sept.	Dec.	March	June	Sept.	Dec.
Water quality chemical	1–5[a,b]	1–5	1–5	1–5	1–9	1–9	1–9	1–9	1–9	1–9	1–9	1–9
Aquatic biology												
Phytoplankton[c]	1–5, 7	1–5, 7	1–5, 7	1–5, 7	1–7	1–7	1–7	1–7	1–9	1–9	1–9	1–9
Zooplankton[c]	1–5, 7	1–5, 7	1–5, 7	1–5, 7	1–7	1–7	1–7	1–7	1–9	1–9	1–9	1–9
Periphyton	1–5, 7	1–5, 7	1–5, 7	1–5, 7	1–7	1–7	1–7	1–7	1–9	1–9	1–9	1–9
Benthos	1–5, 7	1–5, 7	1–5, 7	1–5, 7	1–7	1–7	1–7	1–7	1–9	1–9	1–9	1–9
Fish	1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–4, 6	1–4, 6	1–4, 6	1–4, 6

[a]Numbers indicate sampling station designations.
[b]Dash indicates all stations between the numbers, inclusive.
[c]Phytoplankton and zooplankton will be sampled monthly at stations 2, 4, and 8 during the lake filling phase.

Source: ER, Table 6.1-1.

Table 6.3. Staff summary of parameters measured in applicant's baseline aquatic monitoring program

Chemical and physical parameters	
Air temperature	Relative humidity
Alkalinity	Sodium
Ammonia	Soluble orthophosphate
Biochemical oxygen demand	Soluble silica
Calcium	Specific conductance
Cesium	Strontium
Chemical oxygen demand	Sulfate
Chloride	Total chromium
Cloud cover	Total coliform bacteria
Copper	Total dissolved solids (TDS)
Current velocity	Total hardness
Fecal coliform bacteria	Total iron
Dissolved oxygen	Total manganese
Fecal streptococci bacteria	Total organic carbon
Hexane soluble materials	Total organic nitrogen
Lead	Total phosphorus
Magnesium	Total suspended solids (TSS)
Mercury	True color
Nitrate	Turbidity
Nitrite	Water temperature
Oxygen saturation	Wind direction
pH	Wind velocity
Potassium	Zinc
Biological parameters	
Benthos	Phytoplankton (and primary productivity)
Fish	
Periphyton	Zooplankton

Table 6.4. Staff summary of parameters to be measured in applicant's preconstruction aquatic monitoring program

Chemical and physical parameters	
Ammonia	Sulfate
Biochemical oxygen demand	Temperature
Chemical oxygen demand	Total alkalinity
Copper	Total dissolved solids
Current velocity	Total iron
Dissolved oxygen	Total manganese
Fecal coliform bacteria	Total organic carbon
Hexane soluble materials	Total organic nitrogen
Lead	Total phosphorus
Mercury	Total silica
Nitrate	Total suspended solids
Nitrite	True color
Oxygen saturation	Turbidity
pH	Weather conditions
Specific conductance	Zinc
Biological parameters	
Benthos	Phytoplankton (and primary productivity)
Fish	Zooplankton
Periphyton	

Table 6.5. Tentative scheme for the preoperational radiological monitoring program

Discharges to:	Sample medium	Number of sampling station	
		Indicator	Background
Atmosphere	Airborne particulates	7	1
	Airborne iodine	7	1
	Precipitation	1	1
	External radiation	7	4
	Soil	5	
	Grass	5	
	Vegetables	2	
	Livestock fodder	2	
	Milk	4	
Surface water	Water	5	1
	Sediment	3	1
	Aquatic organisms		
	Fish	4	1
	Plants	3	1
Groundwater	Wellwater	4	

Source: ER, Table 6.1-5.

Table 6.6. Sizes and sensitivities of environmental samples

Sample type	Sample size	Analysis	Sample sensitivity
External radiation	1 quarter	Read-out	10 millirem/period
Water	1 liter	Beta	0.2 pCi/ liter
	1 liter	Sr-90	0.5 pCi/liter
	0.25 liter	H-3	2 T U
	3.5 liters	Cs-137	3.5 pCi/liter
Soil, sediment	0.2 g	Beta	1.6 pCi/g
	5 g	Sr-90	0.1 pCi/g
	500 g	I-131	0.02 pCi/g
	500 g	Cs-137	0.03 pCi/g
Flesh and vegetation	0.2 g (ash)	Beta	1.6 pCi/g ash
	5 g (ash)	Sr-90	0.0013 pCi/g wet
Milk	1 liter	Beta	1.5 pCi/liter
	3.5 liters	I-131	3.1 pCi/liter
	1 liter	Sr-90	0.3 pCi/liter

Source: ER, Table 6.1-6.

6.2 OPERATIONAL PROGRAMS

6.2.1 Hydrological

The applicant plans to conduct an operational monitoring program similar to the preoperational program with modifications designed to assess any effect of station discharges on the local environment. The effluent radiological monitoring systems are designed to comply with 10 CFR Part 20 Standards for Protection Against Radiation, the as low as practicable limits of criterion 10 CFR Part 50 (Appendix I), and the Safety Analysis Report technical specifications limits (ER, p. 6.2-1). Total residual chlorine in the discharge from the circulating water or service water system to the Wolf Creek cooling lake will be monitored (ER, p. 6.2-3). The thermal effluent monitoring program will provide water temperature data at the inlet and outlet of the condenser and at a minimum of four cooling lake locations (ER, p. 6.2-3).

The monitoring program will also include the measurement of water flow rates and quality (TDS, sulfates, chlorides, and temperatures) upstream of the Wolf Creek-Neosho River confluence and in the Neosho River to assure compliance with the Kansas Department of Health and Environment Regulations 28-16-28, Water Quality Criteria for Interstate and Intrastate Waters of Kansas (Appendix F).

6.2.2 Meteorological

Staff evaluation of the operational program will be made when the application for an operating license is received.

6.2.3 Ecological

6.2.3.1 Terrestrial

Operational monitoring program for the terrestrial program will be similar in scope to the baseline monitoring program for the first two years of operation. After this the terrestrial ecology monitoring program will be conducted on a less frequent basis.

6.2.3.2 Aquatic

The applicant's operational aquatic monitoring program will be similar to the lake-filling phase of the preoperational monitoring programs (ER, p. 6.2-5). Changes in and additions to the program were discussed in Sect. 6.1.3.2. A more detailed staff evaluation of the operational program will be made when the application for an operating license is received.

6.2.4 Radiological

The applicant shall conduct a suitable operational radiological monitoring program based on the proposed preoperational radiological monitoring. The operational monitoring program will assist in verifying projected or anticipated environmental radioactivity concentrations and related public exposures.

Details of the radiological monitoring will be made final during the review at the operating license stage and will be described in detail in the environmental technical specifications for the operating license.

REFERENCES FOR SECTION 6

1. U.S. Atomic Energy Commission, Directorate of Regulatory Standards, *Onsite Meteorological Programs*, Regulatory Guide 1.23, Washington, D.C., 1972.

2. U.S. Atomic Energy Commission, Directorate of Regulatory Standards, *Interim Licensing Policy On As Low As Practicable for Gaseous Radioiodine Releases From Light-Water-Cooled Nuclear Power Reactors*, Regulatory Guide 1.42, Washington, D.C., 1973.

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7. ENVIRONMENTAL EFFECTS OF POSTULATED ACCIDENTS

7.1 POSTULATED ACCIDENTS INVOLVING RADIOACTIVE MATERIALS

A high degree of protection against the occurrence of postulated accidents in the Wolf Creek Generating Station is provided through correct design, manufacture, and operation and the quality assurance program used to establish the necessary high integrity of the reactor system, as will be considered in the Commission's Safety Evaluation. Deviations that may occur are handled by protective systems to place and hold the plant in a safe condition. Notwithstanding this, the conservative postulate is made that serious accidents might occur, even though they may be extremely unlikely; and engineered safety features are installed to mitigate the consequences of those postulated events that are judged credible.

The probability of occurrence of accidents and the spectrum of their consequences to be considered from an environmental effects standpoint have been analyzed using best estimates of probabilities and realistic fission product release and transport assumptions. For site evaluation in the Commission's safety review, extremely conservative assumptions are used for the purpose of comparing calculated doses resulting from a hypothetical release of fission products from the fuel against the 10 CFR Part 100 siting guidelines. Realistically computed doses that would be received by the population and environment from the accidents which are postulated would be significantly less than those to be presented in the Safety Evaluation.

The Commission issued guidance to applicants on September 1, 1971 requiring the consideration of a spectrum of accidents with assumptions as realistic as the state of knowledge permits. The applicant's response was contained in the "Wolf Creek Environmental Report" of May 1974.

The applicant's report has been evaluated, using the standard accident assumptions and guidance issued as a proposed amendment to Appendix D of 10 CFR Part 50 by the Commission on December 1, 1971. Nine classes of postulated accidents and occurrences ranging in severity from trivial to very serious were identified by the Commission. In general, accidents in the high potential consequence end of the spectrum have a low occurrence rate and those on the low potential consequence end have a higher occurrence rate. The examples selected by the applicant for these cases are shown in Table 7.1. The examples selected are reasonably homogeneous in terms of probability within each class.

Table 7.1. Classification of postulated accidents and occurrences

Class	NRC Description	Applicant's examples
1	Trivial incidents	Evaluated as routine releases.
2	Small releases outside containment	Evaluated as routine releases.
3	Radioactive waste system failure	Partial and total releases of waste gas storage tank contents, release of liquid waste storage tank contents.
4	Fission products to primary system (BWR)	Not applicable
5	Fission products to primary and secondary systems	Off-design transients that induce fuel failures above those expected, steam generator tube rupture.
6	Refueling accident	Fuel bundle drop, heavy object drop onto fuel in-core.
7	Spent fuel handling accident	Fuel assembly drop in fuel storage pool, heavy object drop onto fuel rack, fuel cask drop.
8	Accident initiation events considered in design-basis evaluation in the Safety Analysis Report	Small and large primary system pipe break, rod ejection accident, small and large steam line breaks.
9	Hypothetical sequence of failures more severe than Class 8	Not considered.

Commission estimates of the dose that might be received by an assumed individual standing at the site boundary in the downwind direction, using the assumptions in the proposed Annex to Appendix D, are presented in Table 7.2. Estimates of the integrated exposure that might be delivered to the population within 50 miles of the site are also presented in Table 7.2. The man-rem estimate was based on the projected population within 50 miles of the site for the year 2020.

Table 7.2. Summary of radiological consequences of postulated accidents[a]

Class	Event	Estimated fraction of 10 CFR Part 20 limit at site boundary[b]	Estimated dose to population in 50 mile radius, man-rem
1.0	Trivial incidents	c	c
2.0	Small releases outside containment	c	c
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	0.024	0.4
3.2	Release of waste gas storage tank contents	0.095	1.6
3.3	Release of liquid waste storage contents	0.003	<0.1
4.0	Fission products to primary system (BWR)	N.A.	N.A.
5.0	Fission products to primary and secondary systems (PWR)		
5.1	Fuel cladding defects and steam generator leaks	c	c
5.2	Off-design transients that induce fuel failure above those expected and steam generator leak	<0.001	<0.1
5.3	Steam generator tube rupture	0.032	0.5
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.005	<0.1
6.2	Heavy object drop onto fuel in core	0.087	1.5
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel rack	0.003	<0.1
7.2	Heavy object drop onto fuel rack	0.013	0.2
7.3	Fuel cask drop	0.096	1.6
8.0	Accident initiation events considered in design basis evaluation in the SAR		
8.1	Loss-of-coolant accidents		
	Small break	0.055	1.7
	Large break	0.57	5.5
8.1(a)	Break in instrument line from primary system that penetrates the containment	N.A.	N.A.
8.2(a)	Rod ejection accident (PWR)	0.051	5.5
8.2(b)	Rod drop accident (BWR)	N.A.	N.A.
8.3(a)	Steamline breaks (PWR's outside containment)		
	Small break	<0.001	<0.1
	Large break	<0.001	<0.1
8.3(b)	Steamline break (BWR)	N.A.	N.A.

[a]The doses calculated as consequences of the postulated accidents are based on airborne transport of radioactive materials resulting in both a direct and an inhalation dose. Our evaluation of the accident doses assumes that the applicant's environmental monitoring program and appropriate additional monitoring (which could be initiated subsequent to a liquid release incident detected by in-plant monitoring) would detect the presence of radioactivity in the environment in a timely manner such that remedial action could be taken if necessary to limit exposure from other potential pathways to man.

[b]Represents the calculated fraction of a whole body dose of 500 millirem or the equivalent dose to an organ.

[c]These releases are expected to be in accord with Appendix I for routine effluents (i.e., 5 millirem per year to the whole body from either gaseous or liquid effluents).

To rigorously establish a realistic annual risk, the calculated doses in Table 7.2 would have to be multiplied by estimated probabilities. The events in Classes 1 and 2 represent occurrences which are anticipated during plant operations; and the consequences, which are very small, are considered within the framework of routine effluents from the plant. Except for a limited amount of fuel failures and some steam generator leakage, the events in Classes 3 through 5 are not anticipated during plant operation; but events of this type could occur sometime during the 40-year plant lifetime. Accidents in Classes 6 and 7 and small accidents in Class 8 are of similar or lower probability than accidents in Classes 3 through 5 but are still possible. The probability of occurrence of large Class 8 accidents is very small. Therefore, when the consequences indicated in Table 7.2 are weighted by probabilities, the environmental risk is very low. The postulated occurrences in Class 9 involve sequences of successive failures more severe than those required to be considered in the design bases of protection systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrence is judged so small that their environmental risk is extremely low. Defense in depth (multiple physical barriers), quality assurance for design, manufacture and operation, continued surveillance and testing, and conservative design are all applied to provide and maintain a high degree of assurance that potential accidents in this class are, and will remain, sufficiently small in probability that the environmental risk is extremely low.

The NRC is currently performing a study to assess these risks more quantitatively. The initial results of these efforts were made available for comment in draft form on August 20, 1974.[1] This study is called the Reactor Safety Study and is an effort to develop realistic data on the probabilities and sequences of accidents in water cooled power reactors in order to improve the quantification of available knowledge related to nuclear reactor accidents probabilities. The Commission organized a special group of about 50 specialists under the direction of Professor Norman Rasmussen of MIT to conduct the study. The scope of the study has been discussed with EPA and described in correspondence with EPA which has been placed in the NRC Public Document Room (letter, Doub to Dominick, dated June 5, 1973).

As with all new information developed that might have an effect on the health and safety of the public, the results of these studies will be made public and will be assessed on a timely basis within the regulatory process on generic or specific bases as may be warranted.

Table 7.2 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the site boundary which are less than those that would result from a year's exposure to the maximum permissible concentrations (MPC) of 10 CFR Part 20. The table also shows the estimated integrated exposure of the population within 50 miles of the plant from each postulated accident. Any of these integrated exposures would be much smaller than those from naturally occurring radioactivity. When considered with the probability of occurrence, the annual potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. The staff concludes from the results of the realistic analysis that the environmental risks due to postulated radiological accidents are exceedingly small and need not be considered further.

7.2 TRANSPORTATION ACCIDENTS

The transportation of cold fuel to the plant, of irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to burial grounds is within the scope of an AEC report entitled, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," December 1972. The environmental risks of accidents in transportation are summarized in Table 7.3.

Table 7.3. Environmental risks of accidents in transport of fuel and waste to and from a typical light-water-cooled nuclear power reactor[a]

	Environmental risk
Radiological effects	Small[b]
Common (nonradiological) causes	1 fatal injury in 100 years; 1 nonfatal injury in 10 years; $475 property damage per year

[a]Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," dated December 1972 and Supp. I, NUREG 75/038, April 1975

[b]Footnote d, Table 5.11.

8. NEED FOR POWER GENERATING CAPACITY

8.1 DESCRIPTION OF THE POWER SYSTEM

8.1.1 Applicant's service area

The Kansas Gas and Electric Company (KG&E) and Kansas City Power and Light Company (KCPL) will jointly operate the WCGS and equally share the output. The service area is shown in Fig. 8.1.

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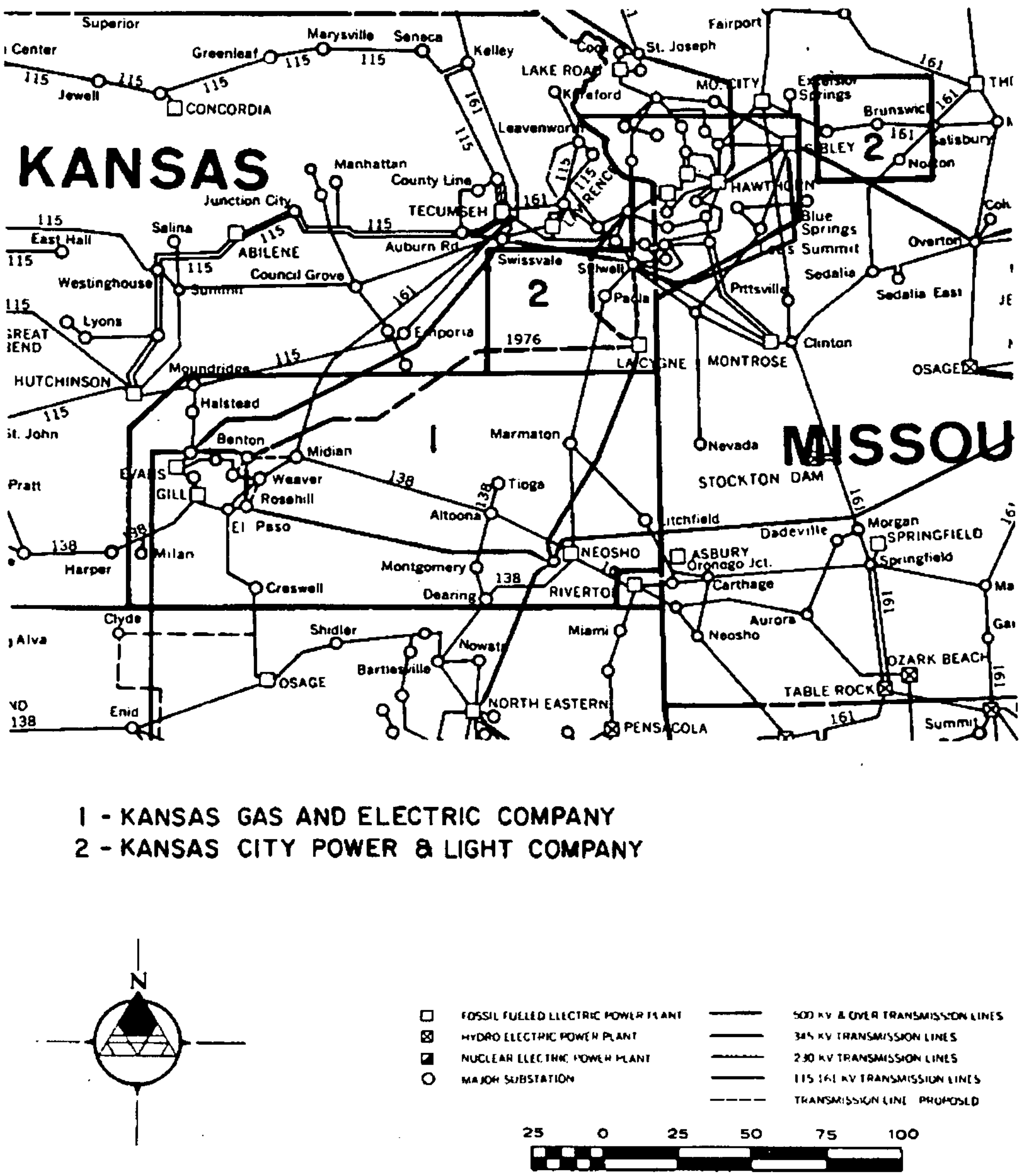

Fig. 8.1. KG&E and KCPL service area map. Source: ER, Fig. 9.2-1.

The KG&E currently serves a population of almost 600,000 in south central and southeast Kansas in a 25-county area of about 8000 sq miles. The major KG&E load center is Wichita, which historically has demanded approximately one half of the output. KCPL serves a population of about one million in a 5700 sq mile area including the Kansas City metropolitan area which comprises the bulk of the load (ER, p. 1.1-2).

8.1.2 Regional relationships

The joint owners of WCGS are members and/or individual participants in several pools and associations as shown in Table 8.1.

Table 8.1. Associations in which Kansas Gas and Electric Company (KG&E) and Kansas City Power and Light Company (KCPL) are members or individual participants

	KG&E	KCPL
Southwest Power Pool (SWPP)	X	X
South Central Electric Companies	X	
Missouri-Kansas Pool (MOKAN)	X	X
Companies-Associated – Southwestern Power Administration (SPA)	X	X
Kansas City-Twin Cities		X

The commitments vary to a large extent with the particular pool. For the Missouri-Kansas Pool (MOKAN) as an example, the coordinating arrangements cover reserve sharing, standby service, construction and operation of 345-kV interconnection facilities, economy energy transactions, system planning, maintenance scheduling, and spinning reserve supply (ER, Table 1.1-1). Other pools and associations coordinate purchase and sales of hydroelectric peaking power [Companies-Associated – Southwestern Power Administration (SPA)], construction of interconnection facilities (MOKAN, Kansas City-Twin Cities), and reserve sharing (MOKAN).

8.1.2.1 Reliability council

The Southwest Power Pool (SWPP) is one of the coordinating groups of the National Electric Reliability Council (NERC). The SWPP is a coordinating and planning group, not an operating pool. The boundaries of SWPP are shown in Fig. 8.2. The activities accomplished by SWPP are: (1) coordinated load projections are made, including present and future power requirements and capabilities of participants; (2) coordinated system reserve analyses are prepared annually; (3) system stability studies are sponsored; (4) reports covering all segments of the industry are prepared, showing joint participation and the staggering of generating facilities; and (5) load duration and power energy curves are prepared, including a monthly operating report showing actual load shapes.

The SWPP will also (1) develop inter-regional reliability arrangements; (2) exchange information with respect to planning and operational matters relating to bulk power supply; (3) review regional and inter-regional activities on reliability; (4) provide independent reviews of inter-regional matters; and (5) provide information, where appropriate, to the Federal Power Commission and to other federal agencies with respect to matters considered by the Council.[1]

The SWPP does not have consolidated generating planning responsibilities. Under the membership agreements, each utility is responsible for meeting its own load.

8.2 POWER REQUIREMENTS

8.2.1 Energy consumption

Wichita and Kansas City are the principal load centers in the applicant's service area (Fig. 8.1).

ES-278

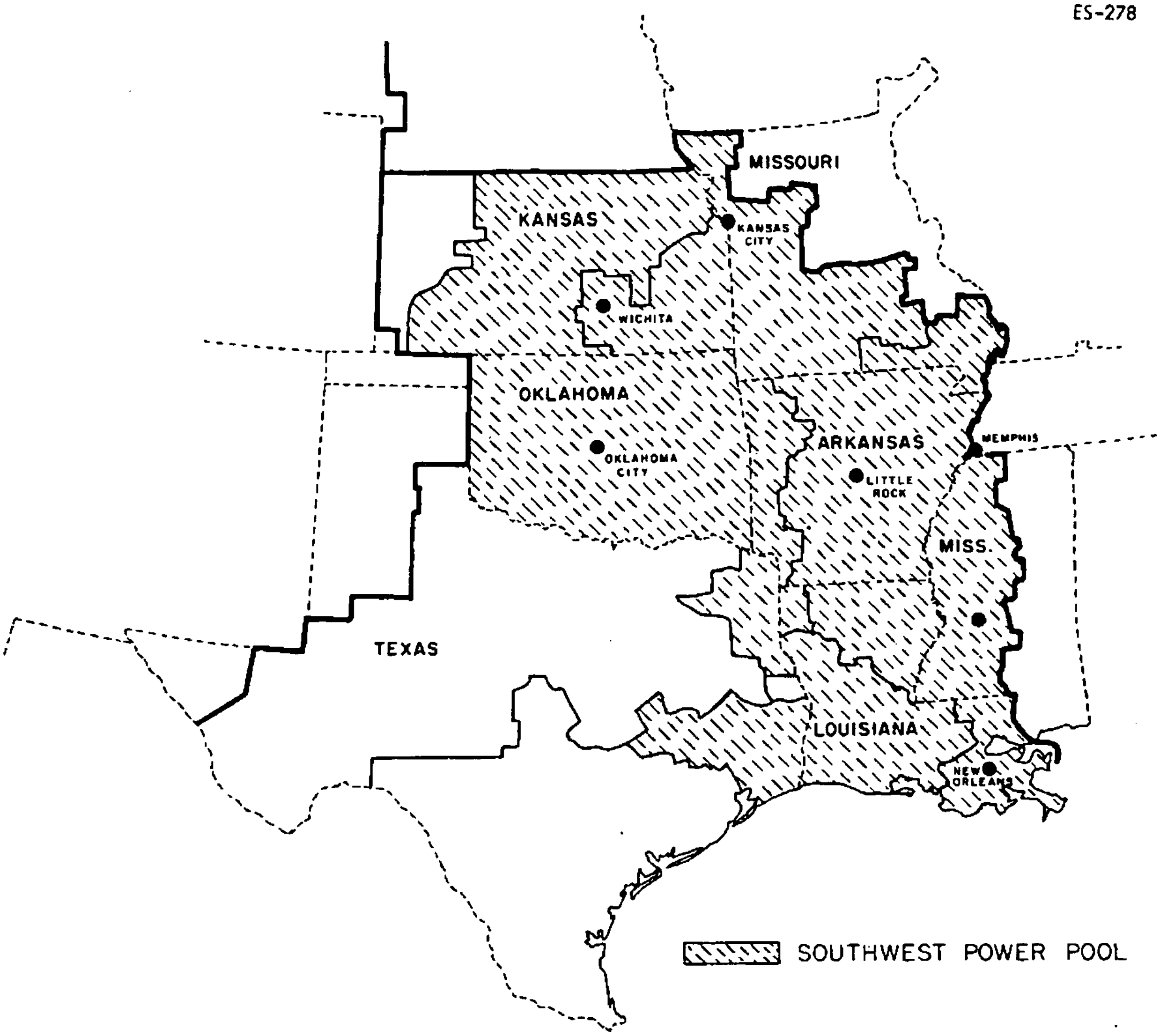

Fig. 8.2. Boundaries of Southwest Power Pool. Source: Federal Power Commission, *The 1970 National Power Survey, Part III*, U.S. Government Printing Office, Washington, D.C., February 1969.

The KG&E and KCPL together have experienced an average compound growth rate in energy production of 6.0% per year since 1963 based on an historic growth rate of 5.6% for KG&E and 6.4% for KCPL. The size and growth rates for the two utilities are similar. For this reason combined statistics are used in various portions of this statement. Table 8.2 shows the total annual energy requirements in the combined system, the year-to-year change, and projections for the years through 1984.

The KCPL only has a single contract providing for interruption of service. That load is about 5 MW and the contract is with the Union Carbide Corporation. Efforts to arrange other such contracts have apparently been unsuccessful (ER, Sect. 1.1.13).

Distribution of sales by customer class for 1973 and projected to 1984 is shown in Table 8.3.

8.2.2 Peak-load demand

The applicant's load experience (1963-1974) and projected loads (through 1984) are shown in Table 8.4. KG&E and KCPL have a combined average annual compound growth rate of 6.3% and a projected average compound growth rate (1974-1984) of 5.7%.

Table 8.2. Combined KG&E and KCPL annual energy at plant (actual and projected)

Year	Annual energy (million kWhr)	Increase (million kWhr)	Increase (%)	Annual load factor (%)
		Actual		
1963	7,138	–	–	52.1
1964	7,528	390	5.5	49.7
1965	7,917	389	5.2	51.2
1966	8,575	658	8.3	48.3
1967	8,947	372	4.3	50.2
1968	9,698	751	8.4	50.2
1969	10,344	646	6.7	49.1
1970	11,072	728	7.0	49.1
1971	11,459	387	3.5	49.3
1972	12,332	873	7.6	49.9
1973	13,114	782	6.3	50.6
1974	13,625	511	3.9	48.1
		Projected		
1975	14,214	589	4.3	48.4
1976	15,211	997	7.0	49.1
1977	16,604	1393	9.2	50.7
1978	17,652	1048	6.3	50.6
1979	18,636	984	5.6	50.7
1980	19,672	1036	5.6	50.5
1981	21,058	1386	7.0	50.9
1982	22,235	1177	5.6	50.9
1983	23,492	1257	5.7	50.9
1984	24,812	1320	5.6	50.7

Table 8.3. Distribution of sales by customer class for 1973 and projected to 1984[a]

	Residential		Commercial		Industrial		Other	
	(GWhr)	(%)	(GWhr)	(%)	(GWhr)	(%)	(GWhr)	(%)
KG&E	1421	25.8	1088	19.8	2045	37.1	951	17.3
	(2637)	(24.8)	(1771)	(16.7)	(4029)	(37.9)	(2191)	(20.6)
KCPL	2113	29.8	2678	37.8	1986	28.0	311	4.4
	(3767)	(30.5)	(4778)	(38.7)	(3258)	(26.4)	(537)	(4.4)

[a]Numbers in parentheses are projections to 1984.

Source: ER, Tables 1.1-3a, 1.1-3b.

Table 8.5 includes the value of the firm purchases or sales of power at the time of the annual peak demand for the years 1963 to 1974 and projections through 1984. Figures are also given for SWPP as a whole.

Annual firm net purchase (or sales) of energy are given in Table 8.6. Traditionally both KG&E and KCPL have sold more during the winter months than they have purchased during the summer. In the future, KG&E estimates that purchases will exceed sales for its system.

8.2.3 Impact of energy conservation and substitution on need for power

Recent energy shortages have focused the nation's attention on the importance of energy conservation as well as on measures to increase the supply of alternative energy sources. The need to conserve energy and to promote substitution of other energy sources for oil and gas have been recommended by the report to the President on *The Nation's Energy Future* as major efforts in regaining national energy self-sufficiency by 1980.[2] In the following sections, the staff considers conservation of energy as related to the need for the electricity to be produced by the Wolf Creek Generating Station.

Table 8.4. KG&E and KCPL capacity, peak-hour demand, and reserves

Year	Capacity (MW)		Peak-hour demand (MW)		Combined system capacity (MW)	Combined peak-hour demand including firm purchases and sales (MW)	Combined reserve (%)
	KG&E	KCPL	KG&E	KCPL			
				Actual			
1963	764	984	713	882	1748	1594	9.6
1964	764	1163	713	1041	1927	1754	9.9
1965	849	1202	746	1065	2051	1811	13.3
1966	814	1216	789	1174	2030	1963	3.4
1967	1005	1387	864	1176	2392	2040	17.2
1968	1074	1346	888	1146	2420	2034	19.0
1969	1021	1594	908	1409	2615	2317	12.9
1970	1201	1734	977	1502	2935	2479	18.4
1971	1203	1852	1019	1570	3055	2589	18.0
1972	1203	1961	1069	1661	3164	2730	15.9
1973	1536	2222	1102	1780	3758	2882	30.4
1974	1414	2372	1225	1907	3786	3132	20.9
				Projected			
1975	1554	2384	1310	1958	3938	3268	20.5
1976	1604	2486	1400	2030	4090	3430	19.2
1977	1762	2634	1520	2120	4396	3640	20.8
1978	2047	2585	1645	2240	4632	3885	19.2
1979	2047	2590	1750	2350	4637	4100	13.1
1980	2153	2927	1855	2480	5080	4335	17.2
1981	2153	2927	2000	2620	5080	4620	10.0
1982	2794	3387	2125	2760	6181	4885	26.5
1983	2794	3387	2260	2910	6181	5170	19.6
1984	2930	3387	2405	3070	6287	5475	14.8

8.2.3.1 Recent experience

Implementation of energy conservation measures by households, business, and government has already contributed to the lack of growth in the consumption of electricity nationally since the third quarter of 1973. Consumption of electricity in the applicant's service area has been less than the forecasted consumption by an average of 5% during the period October 1973 to June 1974. Monthly peak-load demand has deviated from forecast by an average of 3.4% during the same period. Milder than anticipated weather accounts for 2% of the deviation and 1.4% is attributed to energy conservation. The interpretation of the significance of such limited data on energy conservation impacts on the forecasted need for power in the applicant's general service area over the next six to ten years is highly uncertain. Much will depend, of course, on the future decisions of consumers and governmental agencies in responding to the energy crisis and potential developments in energy supply and demand factors which might ease the energy crisis or cause it to worsen. However, as time progresses, historical information of these kinds and the actual data on power demand impacts in the applicant's general service area will provide a more significant basis for demand projections.

8.2.3.2 Promotional advertisement and conservation information services

In the past, electric utilities have attempted, through advertising, to accelerate the demand for electricity in their service areas. Generally, the major thrust of advertising was to promote demand during off-peak periods, thereby covering expensive peaking capacity with expanded lower cost base-load capacity. Notably electric space heating, air conditioning, and water heating have been promoted to offset the higher seasonal peaking demands and thus to level loads.

The applicant began phasing out promotional advertising in 1973 (ER, Sect. 1) and by direct mail and mass media advertising disseminated information designed to promote efficient residential usage of electricity. On the other hand, promotional advertising by manufacturers of electrical appliances and equipment has not been eliminated. These manufacturers spent an estimated $450 million in promotional advertising in 1972.[3]

Table 8.5. Firm net purchase (or sales) of power at time of the annual peak demand (MW)

Year	KG&E[a]	KCPL[a]	Southwest Power Pool[b] Purchases (sales) outside area		
			Purchases	(Sales)	Net
			Actual		
1963	41	116	42	(200)	(158)
1964	21	26	199	(235)	(36)
1965	88	43	714	(271)	443
1966	120	114	967	(255)	712
1967	(139)	216	1227	(180)	1047
1968	(75)	210	2004	(433)	1571
1969	(51)	(108)	1996	(1100)	896
1970	87	27	1734	(725)	1009
1971	71	97	1608	(1258)	350
1972	119	203	1650	(1188)	462
1973	110	(160)	1796	(478)	1318
1974	65	299			
		Future projected[c]			
1975	140[d]	118[e]			
1976	140	118			
1977	133[f]	99[g]			
1978	132	95[h]			
1979	132	0			
1980	132	0			
1981	132	0			
1982	132	0			
1983	132	0			
1984	132	0			

[a]KG&E and KCPL net purchases are not combined meaningfully because annual peak demands were not concurrent.

[b]SWPP was reorganized in 1969. Purchases and sales figures revised to represent transactions outside the area now represented by SWPP membership. Data for 1974 will be furnished after it is available from SWPP.

[c]Information for future projections for the Southwest Power Pool will be furnished when it becomes available.

[d]100 MW diversity interchange and 40 MW purchase of hydropeaking capacity from the Southwestern Power Administration through KCPL.

[e]Net from 194 MW purchase from the Southwestern Power Administration.

[f]100 MW diversity interchange and 33 MW net purchase in 1977 and 32 MW net purchase 1978 and thereafter.

[g]Net from 162 MW purchase from the Southwestern Power Administration.

[h]Net from 155 MW purchase from the Southwestern Power Administration.

Source: ER, Table 1.1-4.

The applicant is currently developing a program to promote conservation of electricity; for example, radio and television advertising has been directed to specific energy-conservation suggestions, and brochures dealing with air-conditioning and other appliance efficiency measures and proper home insulation have been mailed to residential customers.

Considering the combined impact of the program discussed above, the staff believes that there is no conclusive evidence the programs will have a significant impact on projected demand.

Table 8.6. Annual gigawatt-hours firm net purchase (or sales) of energy

Year	KG&E	KCPL	Year	KG&E	KCPL
	Actual[a]			Future projected	
1963	(395)	(329)			
1964	(351)	(468)	1975		
1965	(303)	(592)	1976		
1966	(310)	(484)	1977		
1967	(762)	(96)	1978	No firm transactions projected	
1968	(913)	(844)	1979		
1969	(1,626)	(199)	1980		
1970	(1,422)	(613)	1981		
1971	(1,074)	(636)	1982		
1972	(650)	(270)	1983		
1973	(507)	(149)	1984		
1974	(102)	331			

[a]The source of the "actual" numbers is FPC Form 12, Schedule 14. The transactions shown on Schedule 14 are not necessarily "firm" transactions.

Source: ER, Table 1.1-5.

8.2.3.3 Change in utility rate structure

The Federal Power Commission regulates the rates for interstate wholesale electric energy,[4] while the State Corporation Commission of Kansas regulates the rates utilities charge the ultimate consumer in the applicant's service area.

Historically, utility rate structures were designed to encourage consumption of electricity by using the declining block rates, which reflected the declining average cost of furnishing additional kilowatt hours of electrical energy to each customer. In the past the economic logic for declining block rates was never seriously disputed. Today, however, under conditions of increasingly scarce fuel resources, declining block rates (lowering the price of each additional kilowatt hour), may tend to encourage unnecessary use of electricity by individual consumers and also encourage individual consumers to use more and more electricity at the expense of other energy sources.

The most commonly mentioned alternatives to declining block rates to dampen demand for electricity are increasing block rates, peak-load pricing, and flat rates.

Table 8.7 presents some statistics on the average cost of electricity to consumers and the average energy (kilowatt-hours) used per customer from 1964 through 1971. Statistics such as these indicate that across the United States even though the price of electricity has increased during the last few years, the demand is still increasing. The question that statistics such as these do not answer is at what point will the costs of residential and commercial electricity cause the consumer to significantly decrease his demand. However, with sufficient economic incentive, total demand could be reduced or at least its rate of growth reduced.

Since the demand for electricity is also sensitive to such other factors as Gross National Product, the local economy, the substitution of electricity for more scarce fuels, population growth, and local temperature variations, there are questions of how long it would take a rate change to have a detectable effect considering these other variables.

8.2.3.4 Load-shedding, load staggering, and interruptible load contracts to reduce peak demand

Load shedding is an emergency measure to prevent system collapse when peak demand placed upon the system is greater than the system is capable of providing. This measure is usually not taken until all other measures are exhausted. The Federal Power Commission's report on the major load shedding that occurred during the northeast power failure of November 9 and 10, 1965, indicates that reliability of service of the electrical distribution systems should be given more emphasis, even at the expense of additional costs.[5] This report identified several areas that are highly impacted by loss of power, such as elevators, traffic lights, prisons, and communication facilities. Serious impacts on areas such as these result in load shedding as a temporary method to overcome a shortage of generating capacity during an emergency.

Table 8.7. Statistics on cost and consumption of electricity (1964–1971)

Year	Residential	Commercial	Industrial
	Average cost to consumers (cents per kilowatt-hour)		
1971	2.32	2.20	1.10
1970	2.22	2.08	1.02
1969	2.21	2.06	0.98
1968	2.25	2.07	0.97
1967	2.31	2.11	0.98
1966	2.34	2.13	0.98
1965	2.39	2.18	1.00
1964	2.45	2.26	1.02
	Average kilowatt-hours per customer (thousands)		
1971	7.039	42.598	1735.482
1970	6.700	40.480	1695.087
1969	6.248	37.607	1666.019
1968	5.706	35.009	1578.366
1967	5.220	32.234	1481.496
1966	4.931	30.238	1445.802
1965	3.618	28.093	1289.949
1964	4.377	25.450	1217.878

Source: Federal Power Commission, Statistics of Privately Owned Electric Utilities in the United States, 1971, FPCS 226, U.S. Government Printing Office, Washington, D.C., October 1972.

Load staggering has also been considered by the staff as a possible conservation measure. Basically this alternative involves shifting the work hours of industrial or commercial firms to avoid diurnal or weekday peaks. However, the staff considers the interference with customer and worker preferences as well as productivity to be of significant impact to make such proposals of questionable feasibility.

For interruptible load contracts to be effective in system planning, the load reduction must be large enough to be effective in system stability planning. Thus, this type of contract is primarily related to industrial customers. At the present time 0.76% of KCPL's industrial customers are under interruptible service contracts with lower incentive rates. These contracts are equal to 5 MW of capacity and have been included in the applicant's power forecasts. The acceptability of interruptible load contracts to industrial customers depends upon balancing the potential economic loss resulting from unannounced interruptions against the saving resulting from the reduced price of electricity. If the frequency or duration of interruptions increases as a result of insufficient installed capacity, the customer will convert to a normal industrial load contract. Even if the applicant has 1200 MWe of interruptible load, it is speculative to project that customers would continue this contractual relationship if faced with frequent and long periods with no electrical service.

The above measures do little to solve the energy shortage and cannot be considered as viable alternatives for required additional capacity.

8.2.3.5 Factors affecting the efficient utilization of electrical energy

During the past two years, much of industry, the Federal government, and many State and local governments have made the promotion of energy conservation a priority program. The Department of Commerce has developed a departmentwide effort to: (1) encourage business firms to conserve energy in the operation of their own processes and building; (2) encourage the manufacture and marketing of more energy-efficient products; and (3) encourage businessmen to disseminate information on energy conservation. The National Bureau of Standards has been given a leading role in promoting the development and implementation of energy saving standards. Programs include: voluntary labeling of household appliances; research, development, and education relative to energy conservation in building practices; efficient use of energy in industrial processes; and improved energy efficiency in environmental control processes. While considerable efficiencies in electricity usage have already been gained and while further efficiencies will be realized, any present estimates of the magnitude of electricity savings to be realized over a period of time must be treated as tentative and subject to continual reassessment.

The need for generating capacity is based on annual peak-load demand and not on the volume of consumption over the year. Any conservation measures that reduce consumption but not peak demand will have little or no impact on the need for capacity. The applicant's most recent forecasts for total sales and annual peak-load demand indicate that total sales are expected to grow at a rate 0.5% per year greater than peak demand. The growth in peak demand will continue to be strongly influenced by installation of air conditioning in an increasing percentage of residences and commercial and industrial buildings. Service area projections by the applicant indicate air-conditioning installations will grow 10% between 1974 and 1983.

Considerable efficiency can be achieved in space conditioning by improved insulation and by the use of building materials with better insulation properties as well as by using equipment that transfers or stores excess heat or cold. For example, the seven-story Federal Office Building to be built in Manchester, New Hampshire, illustrates the potential for energy conservation in future commercial buildings using existing technology.[6] For this particular building, energy savings are anticipated to be a minimum of 20 to 25% over a conventionally designed building in the same location. Heat savings alone are expected to be 44% because of better insulated walls, less window area, use of efficient heating and heat storage equipment, and the use of solar collectors on the roof.

In 1971, FHA established new insulation standards to reduce average residential heating losses by one-third. Studies have shown the possibility of gaining even greater reductions in heat loss through improved insulation at costs that are economical over a period of years.[7] Improved insulation conserves not only in winter but also reduces the air conditioning burden in the summer.

Lighting, which accounts for about 24% of all electricity sold nationally, is another area where savings are being realized. Many experts believe recommended lighting levels in typical commercial buildings are excessive.[8] Calculations show that adequate illumination in commercial buildings can be achieved at 50% of current levels through various design and operational changes.[8] Another study indicated that if all households in 1970 had changed to fluorescent from incandescent lighting, the residential use of electricity for lighting would have been reduced approximately 2.5%.[9] However, since the majority of residential lighting occurs in off-peak hours, the reduction on peak demand would be less than one percent.

The potential for greater energy efficiency in household appliances is well recognized. The National Bureau of Standards is working with an Industrial Task Force from the Association of Home Appliance Manufacturers in a voluntary labeling program that would provide consumers with energy consumption and efficiency values for each appliance and educate them as to how to use this information. Room air conditioners are the first to be labeled. The next two categories of house appliances that are to be labeled are refrigerators and refrigerator/freezers and hot water heaters.

Energy efficiency labeling of appliances is important because it will allow the consumer to select the most energy-efficient appliance. A recent study[10] has estimated that an improvement in average efficiency from six to 10 Btu/Whr could hypothetically save electric utilities almost 58,000 MW in 1980. The more efficient air conditioners require a combination of increased heat exchanger size and higher efficiency compressors resulting in higher initial cost. The consumer must be convinced of the advantages for him in the long run of purchasing the more expensive machine. Today, however, there is a high degree of uncertainty in predicting to what extent consumers will actually purchase these more expensive appliances. In addition, selection of central air conditioning by developers and many home owners has historically been based on minimizing front end costs consistent with meeting local building codes.

Considerable opportunity for electricity conservation exists in industry in addition to lighting and air-conditioning efficiency already mentioned. Electric motors should be turned off when not in use and motors should be carefully sized according to the work they are to perform. Small savings can be realized by de-energizing transformers whenever possible. Fuel requirements for vacuum furnaces can be reduced by 75% if local direct combustion low quality heat is employed rather than high quality electrical resistance heating.[11]

It is possible that some of the above examples of potential energy saving will be realized in the future, but in other instances there will be a substantial shortfall in achieving theoretical potentials due to economic, political, and technological performance considerations. As historical experience accumulates, a better forecast of the extent to which savings for these kinds of conservation measures will be possible. In addition, the staff is aware that the National Institute of Occupational Safety and Health has recommended a heat stress standard to the Occupational Safety and Health Administration which, if adopted, would require a significant number of employers to air-condition their plants.[12] This possible requirement, coupled with other energy demands, makes any significant reduction in the future peak demand for electricity due to this conservation of energy measure speculative at this time.

8.2.3.6 Consumer substitution of electricity for scarce fuels

While conservation measures are rather quickly adopted in a "crisis" situation, the consumer's substitution of electrical energy for fuels such as oil or gas takes several years to result in a substantial upward impact on the need for power. The staff expects that substitution of electricity for scarce energy sources will likely accelerate in the applicant's service area because of the uncertainty of oil and gas supplies. For example, the applicant anticipates an increased use of electricity (replacing propane which is becoming scarce and expensive) for the irrigation of fields and for the drying and handling of grain. Also in the applicant's service area 5% of living units were electrically heated in 1974 and a projected 16.5% will be electrically heated by 1983. The advent of electric automobiles or other new uses of electricity cannot be discounted but are not now quantified in projecting the need for power since the use of such items is speculative. The staff concludes that substitution effects will to some degree offset savings from other conservation-of-energy techniques.

A second kind of substitution relatively important in considering the applicant's need to add the proposed nuclear plant to the system is the desirability of adding nuclear capacity as soon as possible to reduce fuel consumed by gas- or oil-fired units now forming a significant part of the applicant's system. This, in turn, will increase the availability of these material resources for other uses for which there is no available substitute.

8.3 POWER SUPPLY

8.3.1 System capability

Table 8.8 shows the projected net generating capability for KG&E and KCPL during the peak-load periods for 1974-1983. The table also shows the percent reserve over peak-hour load. Planned additions to the system, retirements, and reratings are shown in Table 1.1-7a and 1.1-7b of the ER along with the principal generating stations of both utilities. At present KG&E is heavily dependent on natural gas as a fuel. More than 1180 MW of their total capacity of 1564 MW are generated by natural gas. Approximately 913 MW of this natural gas capacity are utilized for base and intermediate load operations. As a result of the diminishing gas supply and a failure to procure long-term gas commitments KG&E plans to convert the 913 MW to peaking operations as soon as coal fired units and WCGS can take over the load. KG&E has projected that its available natural gas supply will be reduced from 62.4×10^{12} ft^3 in 1975 to 25.1×10^{12} ft^3 in 1983 (ER, p. 9.2-5). The reduction in supply would leave only a sufficient amount of natural gas to supply the systems peaking capacity by the year 1982. Table 8.9 summarizes the changes since 1969 and those projected as a function of energy source. Table 8.10 summarizes the system capabilities in terms of fuels for both utilities as of June 1, 1983.

8.3.2 Regional capability

The basic philosophy requires that each utility meet its own load. Nevertheless, there are opportunities for interchange within the power pools, e.g., MOKAN and SWPP (limited by the small seasonal diversity). There is also a seasonal exchange with the TVA which provides 100 MW of capability to KG&E during the summer and returns an equal amount to TVA during the winter (ER, Sect. 1.1.1-4). Also, KG&E and KCPL purchase hydroelectric peaking capacity from the Southwestern Power Administration. The entire Southwest Power Pool normally has a history of net purchases during the period of the summer peak-hour loads (ER, Sect. 1.1.1.4). Both KG&E and KCPL are summer peaking utilities and load projections indicate that they will remain in this status (ER, Table 1.1-6a).

8.4 RESERVE REQUIREMENT

The Federal Power Commission considers limits of 15% to 25% margin of reserve capability over peak demand acceptable.[13] The *1970 National Power Survey* states that, although general policies would require attained reserves in the 15% to 20% range, these planned reserve percentages may become smaller due to unforeseen circumstances. To minimize the consequences of errors in load forecasting and in lead-time estimating which are inherent in any long-range study, the advisory committee for the *1970 National Power Survey* considers it a wise step to establish future targets as progressively higher limits than those resulting from short-range planning. As a contingency against unforeseen construction delays or errors in estimations,[14] future reserve allowances are normally increased by 5% to 10% of the anticipated peaks.

Table 8.8. Applicant's net generating capability during peak load periods, 1975–1984 (projected)

Year	Total system peak responsibility (MW)	Accredited generating capacity[a,b] (MW)	Reserve (MW)	Reserve (% of peak responsibility)
		KG&E projected		
1975	1310	1554	244	18.6
1976	1400	1604	204	14.6
1977	1520	1762	242	15.9
1978	1645	2047	402	24.4
1979	1750	2047	297	17.0
1980	1855	2153	298	16.1
1981	2000	2153	153	7.7
1982	2125	2794	669	31.5
1983	2260	2794	534	23.6
1984	2405	2930	525	21.8
1985	2555	2930	375	14.7
		KCPL projected		
1975	1958	2384	426	21.8
1976	2030	2486	456	22.5
1977	2120	2634	514	24.2
1978	2240	2585	345	15.4
1979	2350	2590	240	10.2
1980	2480	2927	447	18.0
1981	2620	2927	307	11.7
1982	2760	3387	627	22.7
1983	2910	3387	477	16.4
1984	3070	3357	287	9.3

Source: ER, Table 1.1-8a, 1.1-8b.

Table 8.9. Changes in system capability as a function of energy source

Net additions and retirements (MW)

	Gas	Coal	Oil	Hydro	Nuclear	Year
KG&E			+2.8			1969
		+412				1973
		+315				1977
		+136				1978
		+136				1980
		+136			+575	1982
		+136				1984
KCPL		+519.5				1969
			+100.9			1972
		+412				1973
						1974
	−10.6	−12.5	+116	−30		1975
		−14	+116			1976
		+90	−19	−19		1977
		−45		−4		1978
			+100	−95		1979
	−60	+397				1980
		−15			+575	1982
		−30				1984

Source: ER, Table 1.1-7.

Table 8.10. Projected systems capabilities in terms of fuels for KG&E and KCPL, June 1, 1984

	Gas	Coal	Oil	Hydro	Nuclear
			(MW)		
KG&E	1101.7	1318.5	2.8	150.0[a]	575.0
KCPL	68.7	2365.5	413.9		575.0

[a]Purchased from KCPL and from diversity interchange.

Source: ER, Table 1.1-7.

Power pools to which the applicants belong require that the individual members maintain 15% of their forecasted peak-hour demand as a reserve margin (ER, p. 1-1.3). Both KCPL and KG&E have adopted the 15% margin requirement since 1973. Figure 8.3 shows the combined past and future loads and capabilities of KG&E and KCPL, assuming WCGS is completed on schedule. The plots show that without added capacity in 1982 the KG&E and KCPL will not be able to maintain minimum reserve requirements although they should be barely able to meet the projected demand in that year. With the addition of WCGS the reserve margins will be approximately 26 and 20% for the combined utilities in 1982 and 1983, respectively. In Fig. 8.3 staff projections of future demand are also shown. The lower projection is based on an independent study by Tyrrell[15] utilizing a variable elasticity model of electricity demand. From Tyrrell's analysis, the average compound growth rate in electric energy was determined for the State of Kansas for the years 1970-1985. This determination was constructed from the total requirements of the residential, commercial, and industrial sectors. Since the population served by the two utilities represents about 70% of the State's population, the staff concluded that Tyrrell's state projections would reasonably apply to the applicant's service area. First, however, energy growth must be converted to peak load growth. Normally peak load growth rates are greater than energy usage growth rates. This was found to be true historically for the WCGS applicants (see Sect. 8.2.1 and 8.2.2) and the ratio of the historical peak load growth rate to energy load growth could be determined. It was assumed to be applicable to the coming decade as it was to the preceding even though the actual growth rates differed. Therefore, the rate of growth of electrical energy usage determined from Tyrrell's analysis was adjusted upward in accordance with the above factor. The upper projection is based upon a modification of demand projections from "Project Independence" for the nation as a whole.[16] Identification of differences in projected growth of major economic variables, such as population and total personal income, on a national scale with respect to those variables pertaining to a service area, allows one to draw conclusions about the anticipated rate of growth in electricity demand in that locality. Since the applicant's growth rate was equal to the mean national growth rate for the period of 1962-1970 and since the total personal income (TPI) ratio was 1.0 for this period, the TPI ratio for the period 1970-1980 was weighted heavily in determining the projected growth. The ratios of three other factors (population, per capita income, and total employment) were averaged and this average combined with the TPI ratio to determine a regionalizing ratio. The regionalizing ratio was multiplied by the projected mean national growth rate to find the projected growth rate for the region in question. Appropriate information about the service area can be found in the OBERS projections.[17]

It is noted that the applicant's projection falls within the range of the staff's projections and is indeed closer to the lower staff estimate and is judged to be quite reasonable. If the higher growth rate pertains, the applicant would be unable to meet demands in 1981, much less maintain a satisfactory reserve. On the other hand, if the lower growth rate is realized, a one-year delay could possibly be supported but with a less than satisfactory reserve. Figure 8.4 shows the actual and projected reserve margins for KCPL and KG&E.

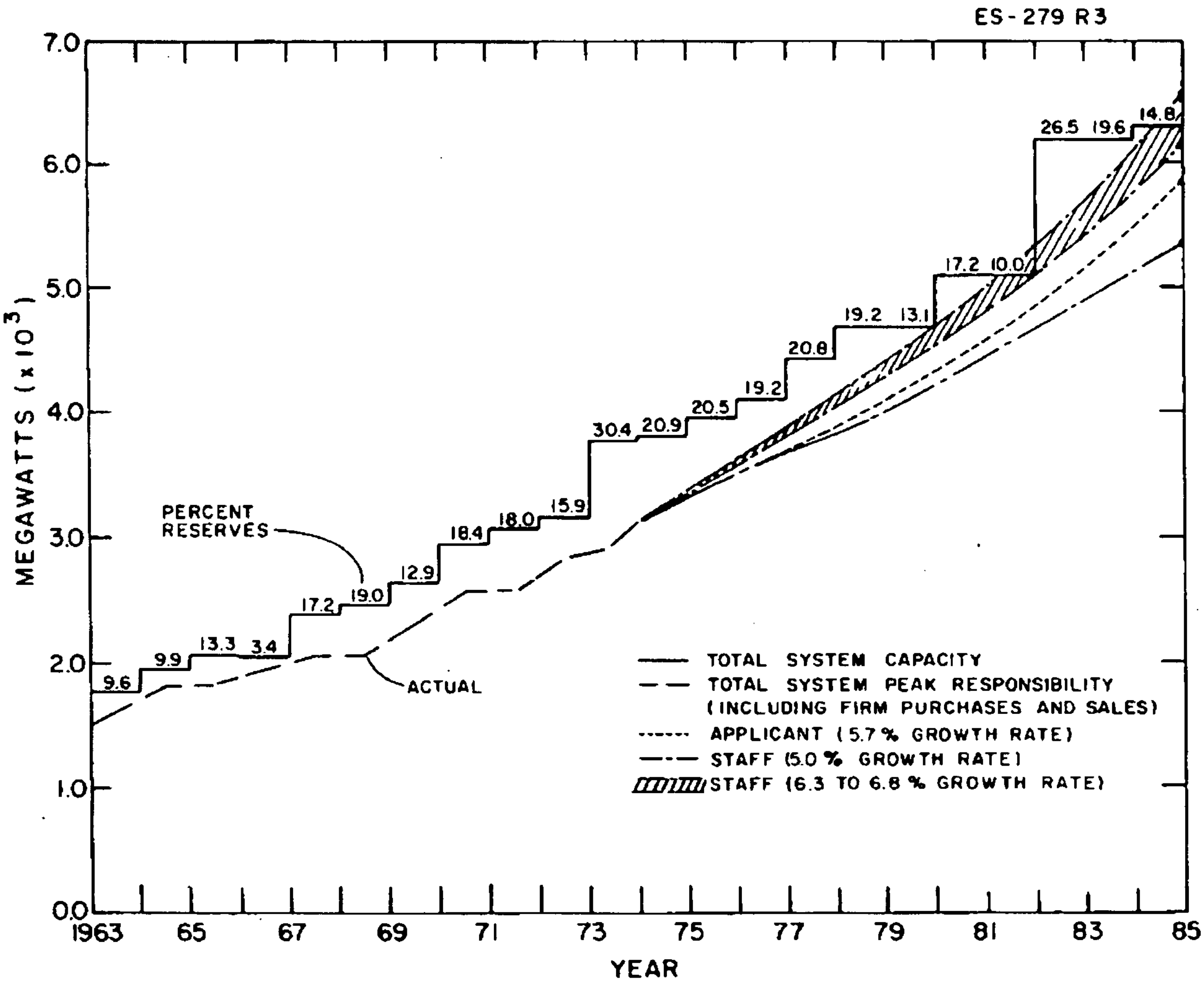

Fig. 8.3. Combined KG&E and KCPL peak load and capacity data (actual – 1963-1974; Projected – 1974-1984). Source: ER, Tables 1.1-8a and 1.1-8b.

8.5 CONCLUSION

The reserve margin with the nuclear plant added on the proposed date of 1982 will be 31.5% for KG&E and 22.7% for KCPL. The staff notes that KG&E will have a reserve margin somewhat larger than is recommended in 1982, but this is due to the large incremental increase represented by the addition of the single nuclear unit. Because of the uncertainty in forecasting the course of the energy crisis and its resolution through conservation and substitution measures, it is recommended that the plant not be delayed beyond 1982. Even if conservation of energy measures are effective in reducing the demand for electricity in the 1980s, adding nuclear capacity to reduce the amount of fuel consumed by gas- or oil-fired units is desirable to increase the availability of this resource for which there are no available substitutes. Note that KG&E is at present heavily dependent upon the use of natural gas as a fuel. In view of the very uncertain but diminishing supply of natural gas, the utility must reduce its dependence upon this fuel. Based on the foregoing, the staff concludes that the additional capacity of the proposed nuclear plant is warranted.

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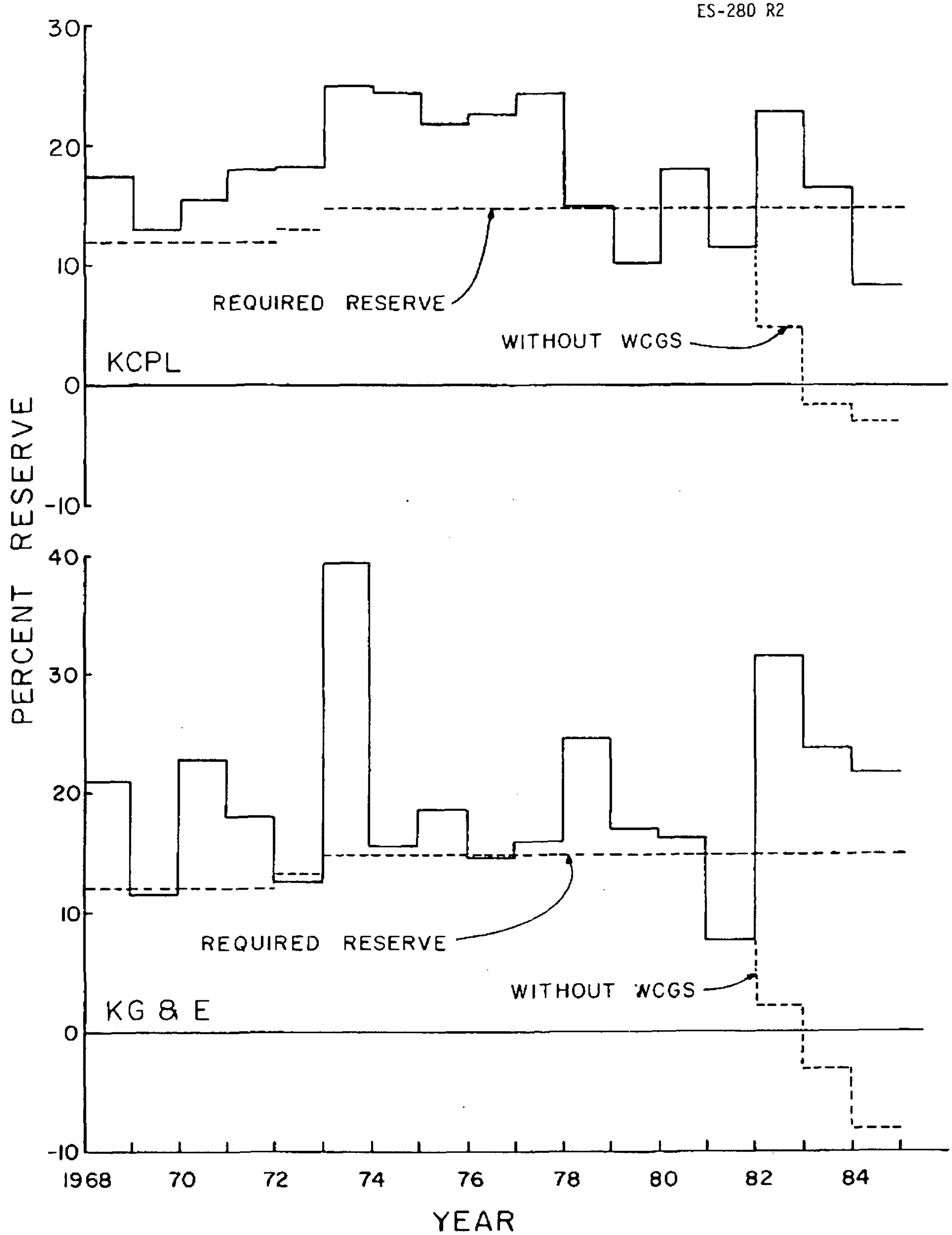

Fig. 8.4. Actual and projected reserve margins for KCPL and KG&E.

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9. BENEFIT-COST ANALYSIS OF ALTERNATIVES

Section 8 established the applicant's need for approximately 1150 MWe of additional generating capacity in 1981-1982. This section will examine possible energy sources to generate the electricity, potential sites for the facility, and alternative cooling systems.

9.1 ALTERNATIVE ENERGY SOURCES AND SITES

9.1.1 Alternatives not requiring creation of new generating capacity

9.1.1.1 Purchased power or diversity exchange

While KG&E and KCPL belong to several pools, they are individually responsible for planning and furnishing their own bulk power supply. Nevertheless, some power is purchased each year, but power sufficient to equal 1150 MW or that necessary to maintain the required 15% reserves cannot be purchased reliably or effected through a diversity interchange. The staff concludes that the purchase or exchange of power is not a viable alternative.

9.1.1.2 Reactivating or upgrading an older plant

The applicant does not have deactivated units of sufficient size to achieve 1150 MWe. Upgrading of existing units is not considered by the staff to be practical. This would require higher pressure or higher capacity boilers, additional or redesigned turbines and condensers, and added capacity to dissipate waste heat. The staff concludes that this is not a viable alternative.

9.1.1.3 Operating peaking units as base load

Peaking units are designed for intermittent operation to supplement base loads during peak demand periods and not for extended operation. Hence the staff concludes that conversion of existing peaking units is not a viable alternative.

9.1.1.4 Conclusion

The staff concludes that no alternative offers a better solution to the need for power than the construction of new generating capacity.

9.1.2 Alternatives requiring creation of new generating capacity

9.1.2.1 Alternative energy sources and sites

The selection of a feasible power source as an alternative to the Wolf Creek Generating Station requires that a broad range of criteria be satisfied. These criteria for selection are adapted from *The Nation's Energy Future*[1] where they were used in establishing Federal research and development priorities and are listed in Table 9.1. For this particular application, an alternative is considered to be feasible, providing it fulfills every one of the criteria and, in addition, has a timing that is rated "near". The latter means that the alternative power source is available for the near term, 1974-1985. This overlaps 1982, the year Wolf Creek Generating Station is expected to begin operation. The alternatives listed in Table 9.1 were chosen from comprehensive references.[1-5]

Of all the alternatives investigated by the staff only coal is a feasible alternative and is ranked at the same level as nuclear power. Oil and gas are ranked second because of the uncertainty of the adequacy of the reserves of these resources. At the present time the applicant, as well as the country as a whole, is experiencing difficulty in obtaining adequate long-range supplies of oil and gas. In spite of the fact that additional supplies may become available in the 1980s from the Trans-Alaskan Pipeline, the Outer Continental Shelf, and

Table 9.1. Selection of feasible power sources for alternatives to the Wolf Creek Generating Station

Type of power	Criteria for selection														
	Adequacy of scientific base	Probability of future technological success	Feasible absorbable investment	Public and government consensus that project is acceptable	Expected price/cost of production	Environmental acceptability	No substantial need for government role	Adequacy of resource reserves	Labor available	Hardware developed	Private capital available	National security	Total	Timing (near, mid, long)[a]	Feasible alternatives
1. Nuclear – WCGS	x	x	x	x	x	x	x	x	x	x	x	x	12	N	1
2. Coal – conventional	x	x	x	x	x	x	x	x	x	x	x	x	12	N	1
3. Oil	x	x	x	x	x	x	x		x	x	x		10	N	2
4. Gas	x	x	x	x	x	x	x		x	x	x		10	N	2
5. Hydroelectric	x	x	x	x	x	x	x		x	x	x	x	11	N	
6. Shale oil	x	x	x	x	x	x	x				x	x	9	M	
7. Geothermal	x	x		x	x	x	x	x				x	8	M	
8. Nuclear – LMFBR	x	x	x	x	x	x		x				x	8	M	
9. Fuel from wastes	x	x		x	x	x			x			x	7	M	
10. Fuel cells	x	x		x		x		x				x	6	M	
11. Wind	x	x		x		x		x				x	6	M	
12. Coal – binary cycle				x		x		x				x	4	M	
13. Coal – MHD				x		x		x				x	4	M	
14. Solar				x		x		x				x	4	L	
15. Fusion				x		x		x				x	4	L	
16. Ocean thermocline				x		x							2	L	

[a]Timing: Near (N):1974–1985, Mid (M):1985–2000, Long (L):2000+.

imports, as well as from on-land sources which could result from secondary recovery of oil on a massive scale and deregulation of natural gas, quantities of these supplies are very uncertain. In addition, an overall public interest point of view to retain oil and gas for premium uses, such as petrochemicals, transportation, space heating, and uses for which there are few, if any, alternatives is more desirable.

The remaining sources are not feasible for a variety of reasons. For example, hydroelectric sources are not possible because of the lack of water potential in the area to be serviced. The most important reason for dismissing the others as not feasible is the important criterion of timing. In addition, geothermal sources are ruled out because there are no suitable sources in the area.[6]

The coal alternative

A conventional coal-fired power plant is the only serious alternative to the Wolf Creek Generating Station since all of the criteria for selection are fulfilled in a broad sense. In order to determine which of the two is more socially desirable, each criterion must be examined and compared. The staff's view is that the only differences arise from two criteria: expected price cost of production and environmental acceptability. Before considering these two points specifically, the coal option shall be considered more generally. At the beginning of the 20th century, coal accounted for 90% of the energy in the United States. However, in recent decades, coal has lost some of its important markets and is now used mainly in generating electricity and in making steel and other manufactured goods. It is the most abundant fossil fuel, accounting for 73% of the total recoverable fuels in the nation. By contrast, oil and natural gas account for 9% and oil shale about 17%.[7] A supply of economically recoverable coal is expected to be available beyond the year 2000 to meet future domestic power demand.

Rail lines would be an economical method of delivering coal to the Wolf Creek Generating Station (ER, Sect. 2.2.2.6.3). Logistics and transportation of coal are much more costly than for gas, oil, or nuclear fuel regardless of the geographic supply area. An 1150-MWe station operating at 85% capacity would consume annually about 4,123,000 tons of 8700-Btu/lb coal. If 100-car unit trains were used and each car had a capacity of 100 tons, about 413 train deliveries would be required annually. The 1982 cost would be about $\$1.60/10^6$ Btu (ER, Table 9.2-1).

Coal-fired stations require about 60 acres for each 1000 MW of capacity, including coal storage areas. Additionally, an estimated 35 acres would be required for ash storage and coal handling equipment. A smoke stack several hundred feet tall would be required. These facilities make coal-fired stations aesthetically less desirable than nuclear stations. To meet Federal and state clean air standards coal-fired steam generators must use coal containing a maximum of 0.6% sulfur or be equipped with effluent gas cleaning facilities to remove sulfur oxide. Note that of the 0 to 3% range in sulfur content coal, only about 16% has 0.7% or less sulfur. The use of eastern low sulfur coal (1% or less) for power generation will be limited in the future because that coal is in high demand by the metallurgical industry. Of the total of about 300 million reserve tons in these eastern states only 44% has 1 to 3% sulfur content. The mere existence of a coal reserve, however, is not sufficient basis for its consideration as an economic fuel alternative.[8] Coal from these states having characteristics required to satisfy current environmental standards would probably not be available in the required quantities.

The necessary fuel handling and pollution abatement equipment for high-sulfur coal could add considerable cost to the capital investment of the station. As an example, the additional investment cost for an SO_2 removal system for a 1000-MW station burning 3.0% sulfur coal, including initial investment and capitalized operating cost and capacity penalty, ranges from \$40 to \$55 per kWe in 1971 dollars depending upon the type of process.[9]

Coal having a low-sulfur content (approximately 0.6% or less) and other characteristics required to satisfy current environmental emission standards is available in the western portion of the United States (primarily in Montana and Wyoming) in the quantities necessary to meet the requirements of an 1150-MWe station (ER, Sect. 9.2.1.1.5).

The delivered price for the needed quality of coal from Wyoming is about $\$1.60/10^6$ Btu (ER, Table 9.2-1). The Environmental Protection Agency's standard for SO_2 emission resulting from the combustion of solid fuel is 1.2 lb of SO_2 per million Btu.[9] These two western fuels are well within the SO_2 requirements. Electrostatic precipitators would probably be required to limit particulate emissions.

Present coal-fired stations convert thermal energy into electricity more efficiently than nuclear stations and the capital cost of a coal-fired plant is about 70% of that of a comparable-sized nuclear station. However, the long-term costs of energy from a nuclear station are less because of the much lower fuel and operating costs. The staff has estimated the present value (1982) generating cost for a coal-fired power plant using Wyoming coal and has compared it with WCGS. The results are illustrated as a function of capacity factor in Table 9.2.

The assumptions used in obtaining these results are listed in Table 9.3. For comparison, the applicant's estimate for the WCGS is also given. The staff concludes that for capacity factors in the range of 50 to 90% nuclear power is more economical than a conventional coal-fired plant using Wyoming coal. (Note that both plants would be expected to operate in the range of 60 to 80% capacity factor.) This conclusion is consistent with two separate independent estimates. One estimate was for Comanche Peak Steam Electric Station near Dallas, Texas[10] and the other was for Allens Creek Nuclear Generating Station near Houston, Texas.[11] For both cases, the basic assumptions were close enough to those used in Table 9.3 that in the staff's view the conclusions would be similar. The staff has examined the overall environmental impact of a coal-fired plant compared to a nuclear plant sited at Wolf Creek as described in a number of reviews,[8,10,12-14] and concludes that although a coal-fired plant is a reasonable alternative to the proposed WCGS, it is a less favorable alternative because of higher fuel costs, pollution abatement costs, and greater adverse impacts, aesthetically.

On balancing expected cost of production with environmental acceptability, the staff concludes that WCGS is the more favorable alternative from both economic and environmental considerations.

9.1.2.2 Alternative sites

The load centers for the areas serviced by the two utilities are shown in Fig. 8.1. Wichita has historically claimed about one half of KG&E's output, while metropolitan Kansas City represents the load center for KCPL.

Table 9.2 Economic comparison of energy alternatives, 1982

	Nuclear				Fossil (coal)			
Capital cost	803×10^6 dollars				586×10^6 dollars			
Capacity factor (%)	50	60	70	80	50	60	70	80
Operation and maintenance cost (mills per kWhr)	1.72	1.49	1.30	1.15	1.72	1.49	1.30	1.15
Fuel costs (mills per kWhr)	7.0	7.0	7.0	7.0	16.0	16.0	16.0	16.0
Generating costs (million dollars)	1217	1286	1355	1422	1427	1582	1736	1890
30-year-levelized generating costs (mills/kWhr)	25.6	22.6	20.4	18.7	30.1	27.8	26.1	24.9
Differential 30-year levelized generating cost (mills/kWhr)	Base	Base	Base	Base	+4.5	+5.2	+5.7	+6.2

Table 9.3. Assumptions and data used to estimate the present value (1982) generating cost for the Wolf Creek Generating Station and a Wyoming coal-fired power plant alternative

Assumptions and data	Nuclear			Coal	
	Staff		Applicant		
Capital costs (million dollars)	766[a]	803[a]	888[b]	559[a]	586[a]
Operation and maintenance cost (mills per kWhr)	1.15[c]	1.15	1.13[b]	1.15[c,d]	1.15
Fuel costs (mills per kWhr)	5.6[d]	7[a]	5.7[e]	16.0[e]	16.0
Discount rate (%)	10	10	10	10	10
Plant life (years)	30	30	30	30	30
Capacity factor (%)	80	80	80	80	80
Generating costs (million dollars)	1279	1422	1407	1862	1890
30-year-levelized generating costs (mills/kWhr)	16.8	18.7	18.5	23.1	24.9

[a]Estimated from CONCEPT CODE, see Appendix D. More recent staff estimates indicate capital costs of 803 million dollars and 586 million dollars for nuclear and coal, respectively, and 7 mills per kWhr for nuclear fuel in 1982.

[b]ER, Sect. 8.2.

[c]Staff estimate. Operation and maintenance costs for coal assume no SO_x removal systems.

[d]U.S. Atomic Energy Commission, *The Nuclear Industry 1974*, WASH 1174-74 Government Printing Office, Washington, D. C. 1974.

[e]ER, Table 9.2-1.

Preliminary site screening

Certain potential site areas were eliminated because of population densities. The large metropolitan areas of Kansas City, Wichita, Topeka, Lawrence, Leavenworth, Manhattan, and Hutchinson are centers of over 25,000 population. Similarly, sites on the Missouri River were eliminated as being too far from the main load centers. Evaluation of regional water resources sufficient to sustain power plants of the size envisioned led to the delineation of the following sub-regions within the primary siting region (Fig. 9.1): (1) Lower Arkansas River Basin, (2) Little Arkansas River Basin, (3) Walnut River Basin, (4) Marais des Cygnes River Basin, (5) Verdigris River Basin, and (6) Neosho River Basin.

Judgments concerning water flow and quality and other parameters are derived from investigations performed by consultants[15-18] to the applicant.

Lower Arkansas River Basin

Three potential sites were identified in this area (ER, p. 9.2-31). Each of them is dependent upon the water supply from the proposed Corbin Reservoir which, however, is not expected to be completed before late 1982. In addition, the average annual runoff is small and has a high total dissolved solids content (ER, p. 9.2-32). Finally, these sites are too close to heavily populated areas, for example, Wichita. The staff concludes that use of sites in this region would result in greater environmental costs than in the proposed region.

Little Arkansas River Basin

This area is situated fairly close to the Wichita metropolitan area as shown in Fig. 9.1. Investigations indicate that the principal stream has inadequate flow and poor quality (ER, p. 9.2-32). The staff concurs that this area is unsuitable for the plant and should not be given further consideration.

Walnut River Basin

Five possible sites were identified in this sub-region (ER, p. 9.2-33). The most important, the Douglas site, would be dependent upon a future U.S. Corps of Engineers flood-control project which would not be operable in time for WCGS. The other four potential sites: Leon site, Rock Creek site, Silver Creek site, and Grouse Creek site were all found to be inadequate to support even one 1150-MWe generating unit because each site received water from an insufficient drainage area. In the case of the Rock Creek site, makeup water from the proposed Douglas Reservoir would be required. The staff concludes that sites within this region would not be adequate to support a nuclear generating station such as the proposed WCGS in the necessary time period.

Marais des Cygnes River Basin

The major stream, the Marais des Cygnes River, flows easterly into the State of Missouri. Two sites are identified near two existing reservoirs, both of which were built by the Corps of Engineers for flood control and water supply. The streams feeding the two completed reservoirs have inadequate flow and one reservoir is within 15 miles of a densely populated area. Consequently the sites within this region are judged undesirable.

Verdigris River Basin

The Verdigris River flows in a southerly direction into Oklahoma and contains two flood control reservoirs. Each of the four potential sites identified by the applicant (ER, p. 9.2-34,-35) possesses a water supply inadequate to support a single 1150-MWe power station. Hence the sites in this sub-region were eliminated from consideration.

Neosho River Basin

The Neosho River is a major stream and carries the largest total annual discharge in the southeastern section of the State (ER, p. 9.2-36). The applicant states that the vicinity of John Redmond Reservoir is the most favorable for siting because the reservoir is the only one capable of storing sufficient water to carry the proposed generating station through potential drought periods. The staff agrees with this finding and further concurs that the Neosho River Basin, and in particular the John Redmond Reservoir area, is the most suitable for the location of a nuclear generating station.

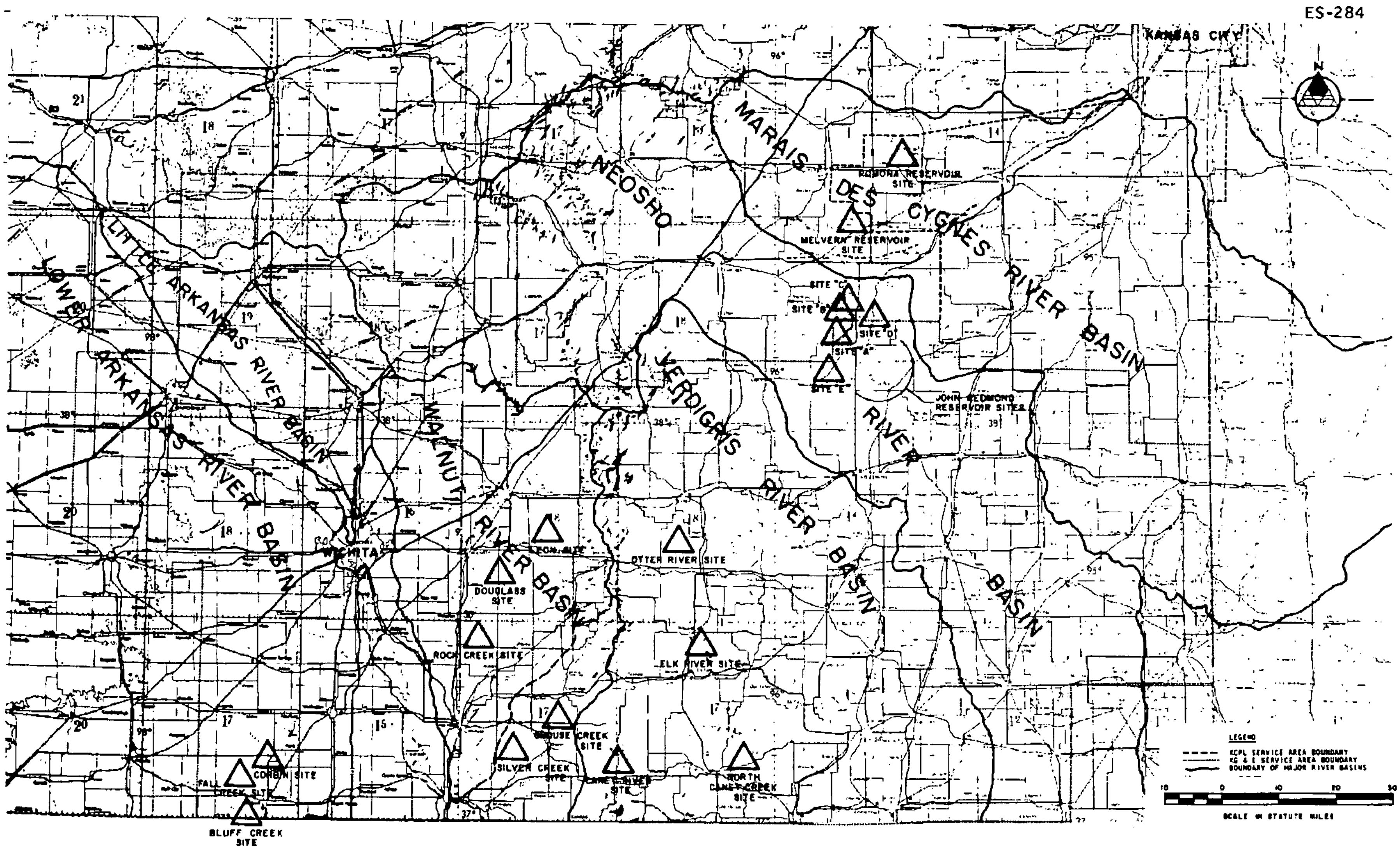

Fig. 9.1. Primary candidate siting region. Source: ER, Fig. 9.2-5.

Consideration of alternate sites near the John Redmond Reservoir

Five potential sites (labeled A through E in Fig. 9.1) were initially identified in the John Redmond Reservoir area. The characteristics of these sites are very similar, for example, land use and geological and meteorological conditions. Transmission line considerations are also similar although the distances vary somewhat according to the site.

In comparing these five sites the following additional characteristics were evaluated in order to reach a decision with respect to suitability: costs, effect on water quality, and potential for future expansion. The latter was given consideration because, other things being equal, a site should be selected that permits future expansion if the need arises.

Sites A and B would require the use of cooling towers with makeup water taken from John Redmond Reservoir. These sites would not be capable of future expansion and hence appear to be less desirable than Sites C, D, E.

The latter three sites require the formation of cooling lakes by the impoundment of natural drainage areas: Site C would impound two small unnamed drainage areas; Site D would impound the Wolf Creek drainage area; and Site E would impound the North Big Creek drainage area. Sites C and D would be able to meet all required water quality standards while Site E would not be able to do so (ER, Table 9.3-1). Hence Site E can be ruled out as a viable alternative.

In terms of water usage Site D is preferable since it could provide a larger cooling surface area to volume ratio than is possible for Site C (ER, Table 9.3-1).

Finally, preliminary cost figures indicate that both Sites C and E would be more expensive than Site D (ER, Table 9.3-1).

The staff is left to consider the relative merits of Sites A, B, and D. Since Sites A and B would not be capable of future expansion and since there are no overriding advantages of Sites A and B, the staff concludes that Site D is the most desirable of the sites near John Redmond Reservoir.

The applicant has provided a detailed analysis of the alternative sites (ER, Sect. 9.2.1.4.5). Table 9.4, based on ER, Table 9.3-1, is a summary of the applicant's findings in its analysis of John Redmond Sites C, D, and E.

9.1.3 Conclusions

The staff concurs in the selection of the proposed site at Wolf Creek and concludes that no other site will offer significant advantages over the chosen site.

9.2 STATION DESIGN ALTERNATIVES

9.2.1 Alternate cooling systems

The staff considered the use of other methods of dissipating waste heat. A review of potential water supplies by the staff indicated that the only water available in sufficient quantity for circulating water purposes is from John Redmond Reservoir. Seven potential alternatives to the proposed cooling lake heat dissipation systems were considered: (1) once-through cooling, (2) smaller cooling lake, (3) dry cooling towers, (4) mechanical-draft wet (evaporative) towers, (5) natural-draft (evaporative) towers, (6) wet-dry cooling towers, and (7) spray pond.

9.2.1.1 Once-through cooling

Once-through cooling requires a body of water with sufficient volume to support a continuous flow through the condensers and back into the water body without any perceptible increase in water temperature at the circulating water intake. A reliable source to provide 1293 cfs for such a system is not available; therefore, the staff concludes that this alternative is not viable.

Table 9.4. Comparison of sites C, D, and E in the John Redmond Reservoir area[a]

Siting parameter	Site C	Site D	Site E
Geology and seismology	No unusual problems	No unusual problems	No unusual problems
Access to roads and rail transportation	Four and one-half miles of highway will be needed to connect with U.S. highway 75. Eight and one-half miles of track will be needed to connect with the Atchison, Topeka, and Santa Fe Railroad.	Two and one-half miles of highway will be needed to connect with U.S. highway 75. Eleven miles of track will be needed to connect with the Missouri Pacific Railroad.	Six miles of highway will be needed to connect with U.S. highway 75. Six miles of track will be needed to connect with the Atchison, Topeka, and Santa Fe Railroad.
Population density	Nearest town is Ottumwa, three miles south of the site. Low population zone extends nine miles south of the site to Burlington.	Nearest town is New Strawn, three miles west of the site. Low population zone extends 3.5 miles SW of the site to Burlington.	Nearest town is Gridely, 3.5 miles south of the site. Low population zone extends seven miles east of the site to Burlington.
Cooling lake potential[b]	Cooling lake formed by impoundment in two small drainages. Volume, ~162,000 acre-ft[c] Surface area, ~5000 acres[c] Average consumptive water use, 30,000 acre-ft Blowdown discharge to John Redmond Reservoir. Water quality standards would be met.	Cooling lake formed by impoundments in Wolf Creek drainage. Volume, 110,000 acre-ft Surface area, 5,090 acres Average consumptive yearly water use, 27,500 acre-ft Blowdown discharge to Neosho River. Water quality standards would be met.	Cooling lake formed by impoundments in North Big Creek drainage. Volume, ~124,000 acre-ft[c] Surface area, ~7000 acres[c] Average consumptive water use, 27,600 acre-ft Blowdown discharge to Big North Creek. Water quality standards would not be met.
Land required[d]	~9200 acres	10,500 acres	~13,000 acres
Cost of transmission hookup	$24,400,000	$25,900,000	$26,200,000
Agricultural land use	Agricultural productivities of land at all three sites are similar.		
Recreational conflicts	Site C is in close proximity to John Redmond Reservoir.	Site D would not conflict with recreational use of the reservoir.	Site E would not conflict with recreational use of the reservoir.
Estimated construction costs	$121,600,000	$95,000,000	$99,300,000

[a]Based on information contained in reports prepared by Ebasco Services, Inc., (see Sources below). The applicant concedes that various figures may fluctuate due to inflation, changes in assumed construction requirements, design changes, and other engineering factors. However, each alternative is assumed to be affected similarly by the changes that have occurred.

[b]Based on current water requirements, the surface area of the cooling lake for Site D has been expanded to 5090 acres. Sites C and E would also require larger cooling lakes.

[c]Staff estimates.

[d]Based on current land requirements, the area for Site D has been expanded to 10,500 acres. Sites C and E would also require larger site areas.

Sources:

Ebasco Services, Inc., 1968, Nuclear site selection study, *for* Kansas Gas and Electric Company.

Ebasco Services, Inc., 1968, Supplement to January 1968 nuclear site selection study, for Kansas Gas and Electric Company.

Ebasco Services, Inc., undated, Nuclear site selection study, reevaluation of John Redmond Site, *for* Kansas Gas and Electric Company.

Ebasco Services, Inc., 1973, Nuclear site selection study, John Redmond Site and alternatives, *for* Kansas Gas and Electric Company.

9.2.1.2 Smaller cooling lake

Thermal considerations

A smaller cooling lake (ER, Appendix 10.1A) could be used to dissipate the heat from the warmed circulating water. This lake would have essentially the same general layout (Fig. 9.2) and area-capacity curves as the proposed cooling lake but would operate at a lower water surface elevation. The normal operating level for the smaller lake would be 1069 ft MSL and the lowest anticipated elevation would be 1067.5 ft MSL (ER pp. 10.1A-1 and 10.1A-5). The volumes and surface areas of the smaller lake are:

	Elevation (ft, MSL)	Volume (Acre-ft)	Surface area (Acres)
Probable minimum operating level	1067.5	40,000	2350
Normal operating level	1069	43,600	2500

The smaller lake would have a surface area of 2500 acres compared to 5090 acres for the proposed lake. This implies lower evaporation losses as shown in Table 9.4. Average evaporation losses from the smaller cooling lake would be 32.3 cfs or 23,400 acre-ft/year using 1949 to 1964 hydrological-meteorological data. The staff reviewed the values in Table 9.5, and they appear to be reasonable. Comparing the evaporation losses in Table 9.5 with those in Table 5.2, the average losses for the smaller lake would be 17.1 cfs or 12,400 acre-ft/year less than for the proposed lake.

The calculated average seasonal water budget for the smaller lake for the same period is shown in Table 9.6. About two-thirds of the water for the lake would be pumped from the John Redmond Reservoir and the remainder would be provided by rainfall and runoff from Wolf Creek. About 60% of the total water entering the lake would be lost by evaporation.

Surface temperature distributions in the smaller cooling lake are shown in Table 9.7. The staff reviewed these values predicted by the applicant and found them to be reasonable. Comparing these temperatures with those for the larger lake (Table 5.4), it can be seen that the temperatures of the circulating water entering the plant would be slightly higher for the smaller lake, about 0.7 to 3.0 F° higher in the summer and 4.1 to 5.0 F° higher in the winter.

The temperature differences between the blowdown and the Neosho River would be about the same as those for the proposed lake with two operating units, as discussed in Sect. 5.3.2. Table 5.9 indicates that the differences in the winter will be greater than the limits permitted by the Water Quality Criteria for Interstate and Intrastate Waters of Kansas. Therefore, mixing zones in the river will be required. The analysis in Sect. 5.3.2 shows that the sizes of these mixing zones will be within the Water Quality Criteria guidelines, providing that the Neosho River flow rates exceed minimum values as determined by the blowdown flow rates and temperature differences.

Economic considerations

The staff has performed an analysis to determine the economic viability of constructing a smaller cooling lake subject to its eventual expansion when additional generating capacity is required by the applicant. To create the additional capacity, the applicant has proposed constructing an oversized lake which would allow siting a second nuclear unit or other plant expansion at Wolf Creek in 1987 without incurring the costs associated with expanding the lake. The applicant justifies the large lake on the basis that it would cost only 9.6 million dollars (mid-1974 dollars) more to construct, whereas it would cost 41.0 million dollars to expand in 1982 (ER, p. 10.1A-5).

The future needs of Kansas Gas and Electric Company have been projected through 1990 showing their requirements for an additional 475 MWe in 1987 and another 475 MWe in 1990 (ER, Table 1.8a).

In order to evaluate the applicant's proposal, a present-worth calculation was performed for both the small and large lakes using the first year of commercial operation (April 1982) as the base date. The calculations were done in two parts: (1) The preoperational costs associated with each lake were escalated at a yearly rate of 8% and accumulated through the first quarter of 1982. This consisted of the costs for water and maintenance of the lake plus the lost agricultural production for each year. Total agricultural production of each alternative was assumed to be lost

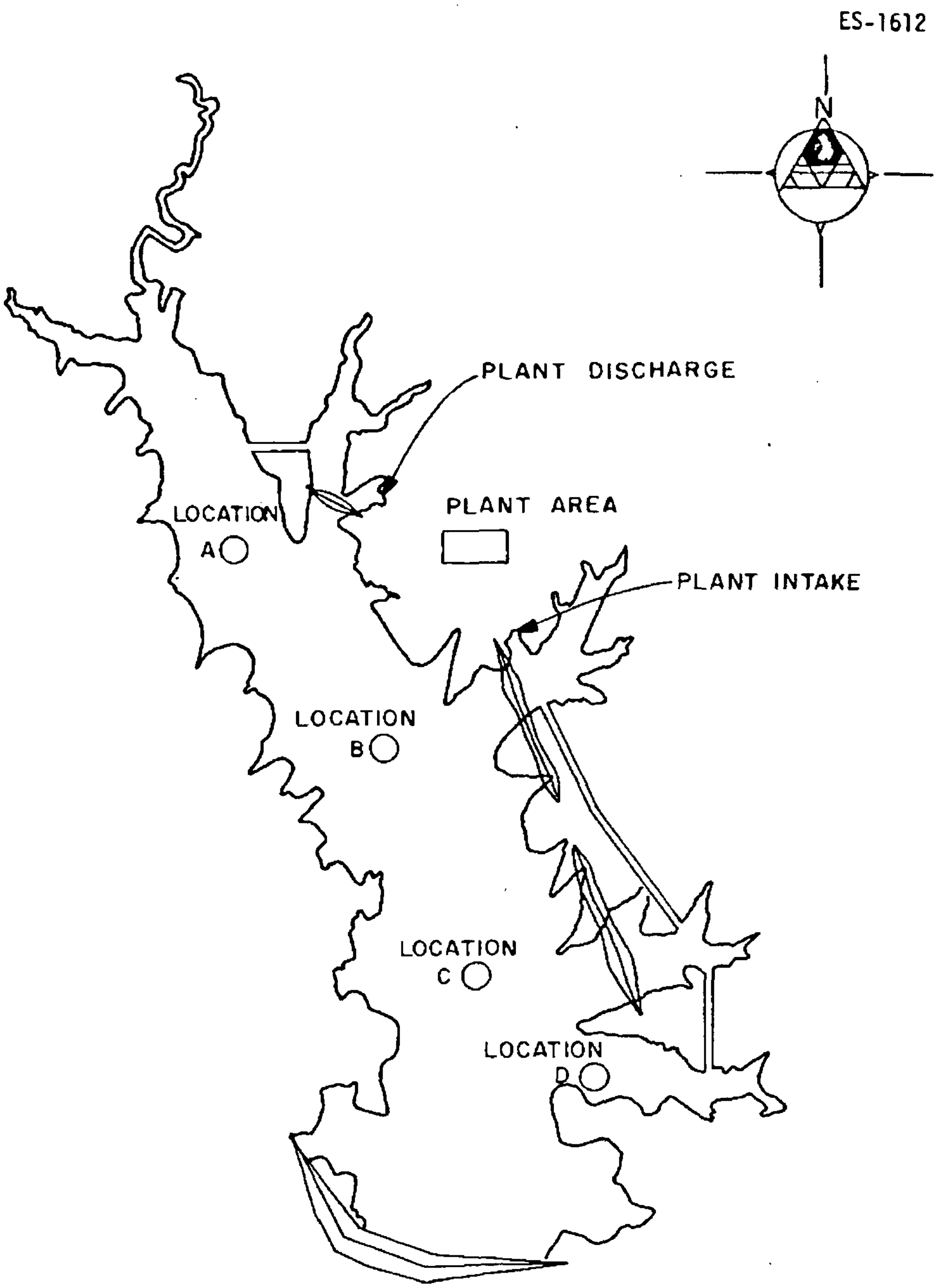

Fig. 9.2. Location of points on smaller cooling lake as referenced in Table 9.6. Source: ER, Fig. 10.11-7.

Table 9.5. Average monthly evaporation rates (cfs) for the smaller cooling lake at a 62.5% plant factor for October through May and a 100% plant factor for June through September

	Natural	Forced	Total
January	5.6	8.4	14.0
February	5.4	8.0	13.4
March	9.2	9.4	18.6
April	14.4	9.8	24.2
May	19.6	11.0	30.6
June	25.3	21.0	46.3
July	29.1	23.3	52.4
August	30.4	26.7	57.1
September	26.3	26.0	52.3
October	19.0	17.6	36.6
November	12.3	12.9	25.2
December	6.6	10.1	16.7
Average	16.9	15.4	32.3

Source: ER, Table 10.1A-5.

Table 9.6. Average seasonal water budget (cfs) for the smaller cooling lake at 62.5% plant factor for October through May and a 100% plant factor for June through September

	Makeup from John Redmond Reservoir	Rainfall and Wolf Creek runoff	Evaporation	Blowdown and spillage	Seepage
Winter	31.8	7.2	14.7	19.1	3.5
Spring	26.2	22.4	24.5	18.4	3.5
Summer	49.4	26.3	51.9	24.3	3.5
Fall	47.3	15.3	38.0	20.7	3.5
Average	38.7	17.8	32.3	20.6	3.5

Source: ER, Table 10.1A-1.

Table 9.7. Smaller cooling lake temperatures (°F) at 100% plant factor and cooling lake surface at 1069 ft MSL

Location[a]	Plant discharge	A	B	C	D	Plant intake
1 Percentile[b]						
Winter	82.1	67.9	63.7	57.5	55.1	53.9
Spring	111.0	93.5	89.7	84.7	83.3	83.0
Summer	117.0	99.7	95.5	90.7	90.0	89.9
Fall	105.9	90.2	86.2	80.5	78.5	77.6
50 Percentile[b]						
Winter	72.8	59.6	56.6	49.2	46.5	45.3
Spring	95.0	78.2	73.8	69.0	67.4	66.8
Summer	109.0	91.9	88.2	83.5	82.1	81.6
Fall	87.7	72.7	68.9	63.3	61.2	60.2

[a]See Fig. 9.3.
[b]ER, Table 10.1A-4.

for this and for the post-construction cost projections inasmuch as the applicant had provided no definite plans for the agriculture utilization of available portions of the property. (2) For the operational years, 1982 and following, the annual costs for lake maintenance, water, lost agricultural production, and the annual cost of the investment were determined and totaled, assuming the plant is operated at an 80% capacity factor. Table 9.8 shows the preoperational costs and the operational costs that vary with lake size.

The present-worth value to 1982 was calculated for the sum of the annual costs (Table 9.8) for each succeeding year after 1982. The 1982 annual costs (0.75 year) were added to the preoperational costs to determine the expenses through 1982. Then each succeeding year's 1982 present-worth costs were added to the sum for 1982 for each case. A summary of the staff's calculations carried through the 30-year life of the plant is presented in Table 9.9.

Table 9.8. Cost estimates (lake size dependent) preoperational (Jan. 1977 to Apr. 1982) and operational costs (1982 and following years)

Dates	Lake size	Lake maintenance	Lost agriculture	Water costs	Investment costs	Total
		Preoperational costs ($ X 10^6)				
Jan. 1977 to Apr. 1982	Small lake	0.494	4.93	2.48	–	7.90
	Large lake	0.659	8.48	2.48	–	11.62
		Operational costs ($ X 10^6)				
Apr. 1982 through Dec. 1982	Small lake	0.104	1.210	0.318	19.3	20.93
	Large lake	0.139	1.499	0.483	19.7	21.82
1983 and following	Small lake	0.139	1.610	0.425	25.7	27.87
	Large lake	0.185	1.999	0.644	26.2	29.03

Table 9.9. Yearly accumulated cost differences (in $ X 10^6) for the two lakes for the 30-year life of the plant

	1982	1983	1987	1990	1995	2000	2005	2012
			Small lake					
Annual Cost	20.93	27.87	27.87	27.87	27.87	27.87	27.87	27.87
1982 present-worth of annual costs	20.93	25.34	17.30	13.00	8.07	5.01	3.11	1.60
1982 present-worth of annual costs and preoperational costs	28.83	54.17	134.48	177.51	226.80	257.40	276.40	291.55
			Large lake					
Annual costs	21.82	29.03	29.03	29.03	29.03	29.03	29.03	29.03
1982 present-worth of annual costs	21.82	26.39	18.02	13.54	8.41	5.22	3.24	1.66
1982 present-worth of annual costs and preoperational costs	33.44	59.83	143.48	188.31	239.65	271.52	291.31	397.09
Savings from initially constructing large lake	18.67	17.62	14.28	12.48	10.43	9.16	8.37	7.74
Accumulated difference (in 1982 dollars)	4.61	5.66	9.00	10.80	12.85	14.12	14.91	15.54

From the applicant's figures (ER, Appendix 10.1A), the 1982 present-worth costs of expanding the small lake were calculated, and a comparison of the present-worth differences in costs between the two lakes with the present-worth cost of expanding the smaller lake was possible. The staff's estimates of the 1982 present-worth of the capital costs of the plant and lake (Appendix Table D.2) shows a greater cost of 16 million dollars for the large lake. If the cost difference is subtracted from the 1982 present-worth of the expansion cost ($39.28 million), the actual cost of expansion in 1982 becomes 23.3 million dollars. Subtracting the yearly accumulated difference for cost of operation (Table 9.9) from the actual expansion cost shows the saving in that year as a result of initially constructing the large lake.

The savings in 1987, if expansion is on schedule, will be 14.28 million dollars (1982 dollars). In fact, expansion occurring anytime throughout the 30-year life of the plant or later would result in a minimum savings of approximately five million dollars. It was found that the accumulated difference (Table 9.9) never equalled the present-worth cost of expanding the lake. Thus, on this basis, if the need for expansion develops within the 30-year life of the first unit, it would be economically advantageous to construct the large lake now.

Social considerations

The staff acknowledges that social costs may be severe in particular cases. However, without an in-depth analysis of the conditions that pertain in this case, an evaluation of these costs is not possible. Even with such an analysis, the staff believes the social costs would not exceed the 14.3 million dollar savings in 1987 if expansion is on schedule.

Conclusion

On the basis of the above analysis, the staff concludes that the smaller lake is a viable alternate cooling method. In considering the thermal, biological, social, and economic impacts, the staff finds them to be acceptable and consistent with those presented through this document for the proposed cooling lake. However, based on the applicant's need for future generating capacity and increased costs incurred by expanding a smaller lake to accomodate more capacity, the staff finds the large lake to be the preferable cooling method. Based on the analysis of the projected demands in the applicant's service area as set forth in Sect. 8 of this document, the staff has concluded that a future need for generating capacity as projected by the applicant is reasonable to assume.

9.2.1.3 Dry cooling towers

The use of dry cooling towers was considered for the Wolf Creek Generating Station. This type of cooling device removes heat from the circulating water through radiation and convection to air being circulated past the heat-exchanger tubes. Because of the poor heat-transfer properties of air, tubes are generally finned to increase the heat-transfer area. Theoretically, the lowest temperature that a dry cooling system can achieve is the dry-bulb temperature of the air. The dry-bulb temperature is never lower than the wet-bulb temperature, which is theoretically the lowest temperature that a wet cooling tower can achieve. As a result, dry cooling towers are a less-efficient cooling system, which leads to increased cost and size of the cooling equipment. Turbine back pressures will be increased, as will the range of back pressures over which the turbines must operate. This will result in a reduced station capability for a given size reactor.

Dry tower systems are of three different types:

(1) Smaller units (up to 300 MW) can be built in which steam is ducted from the turbine to the heat exchanger for direct steam condensing. Very large ducts, operating under substantial vacuum and distributing steam over a large heat-exchanger area, make this system impractical for large nuclear facilities.[19]

(2) Direct-contact systems can be built in which the cooling water and steam mix in a direct contact condenser. This system requires a significant increase in water treatment and storage costs, since the entire cooling system uses steam-generator-quality water.[19]

(3) Depending on turbine design, conventional surface condensers (but larger) or multi-pressure (zoned) surface condensers can also be used, with the dry tower replacing the wet tower in a system similar to existing wet tower systems. These systems do not require steam-generator quality water. At this time, this is probably the most practical system to consider for large power plants.[20]

The advantage of a dry cooling tower system is its ability to operate without the consumption of large quantities of cooling water. In theory this allows power plant siting without consideration of water availability, and eliminates thermal/chemical pollution of the aquasphere. In practice, some amount of water will always be required, so that power plant siting cannot be completely independent of water availability. From an environmental and cost-benefit standpoint, dry cooling towers can permit optimum siting with respect to environmental, safety, and load distribution criteria without primary dependence on a supply of cooling water. When considered as a direct alternative to wet cooling towers, the advantages of dry cooling towers include elimination of drift problems, fogging water consumption, and blowdown disposal.

The principal disadvantage of dry cooling towers is economic. For a given reactor size, plant capacity can be expected to decrease by about 5 to 15% depending on ambient temperatures and assuming an optimized turbine design.[20] Bus-bar energy costs are expected to be in the order of 20% more than a once-through system, and 15% more than a wet cooling tower system, assuming 1980 operation. Dry cooling towers now being used for European and African fossil plants are limited to plants in the 200-MW or smaller category; the use of dry towers to meet the much larger cooling requirements of 1000-MW-size nuclear stations requires new turbine designs to achieve optimum efficiencies at the higher back pressure and range required of this system.[21]

Mechanical-draft dry cooling towers can be constructed as a series of interconnected modules (a "single" tower), or as separate modules or groups of modules. Selection of tower layout will be controlled by plant layout, terrain, piping requirements, etc. The total land area required will be larger than that required by equivalent wet cooling towers; however, there should be no recirculation problem with dry cooling towers, so that total plant areas required for cooling towers may not be too dissimilar for wet and dry towers.[19] Total area and number of modules will also be influenced by the type of module selected. For a single-fan design, assuming a 60-ft-diam fan and a module area of about 9200 ft^2, the staff estimates that about 40 to 50 modules would be required for a 1000 MWe unit. Thus a total area of about 10 acres per unit would be used, which probably represents a minimum area design. Additional area will be required for maintenance access, piping runs, clearance, condensate storage tanks, etc.

After weighing the overall advantages and disadvantages of dry cooling towers and particularly when comparing the economic penalty associated with their use with the acceptable environmental impact of the proposed cooling lake, the staff has concluded that dry cooling towers are not a practical alternative for the Wolf Creek Generating Station.

9.2.1.4 Mechanical-draft wet cooling towers

One viable alternative for dissipating heat from the warmed circulating water is mechanical-draft wet cooling towers. This heat dissipation system, like the cooling lake, would be a closed system, but would use much less land. The applicant (ER, Table 10.1-2) estimated that each of the two mechanical-draft wet cooling towers would occupy an area 580 by 71 ft. Addition of auxiliary equipment for these towers could double this area.

The staff estimated the consumptive water use of such a system for a typical year (1968) using the following assumptions: (1) the plant factor is 62.5% during October through May and 100% during June through September, (2) the towers are designed for ambient air temperatures of 99°F dry-bulb and 79°F wet-bulb and approach temperature of 16 F°, (3) the ratio of the water to the dry air flow rates is 1.5, and (4) drift losses are 0.03%. These estimates are shown in Table 9.10. The total evaporative water losses from the Wolf Creek cooling lake heat dissipation system for the same year and same plant factors are included in this table for comparison. The total water evaporated by the cooling tower is much less than that by the cooling lake, 14,000 acre-ft per year (19.4 cfs) compared to 31,950 acre-ft per year (44.1 cfs). However, the land area that will be covered by the cooling lake is losing water by evapotranspiration at the staff-estimated rate of 18.5 cfs. Subtracting this from the 44.1 cfs cooling lake evaporation loss results in the effective loss of water to the downstream Neosho River of 25.6 cfs.

Blowdown is necessary from both cooling towers and cooling lakes to limit TDS buildup resulting from evaporation and chemical additions (Sect. 3.6).

If the cooling tower blowdown water is discharged into Wolf Creek and the Neosho River, the applicant calculated that during the period-of-record drought the cooling tower concentration factor will have to be limited to 2.4 for a two-unit station operating at a 75% plant factor to meet Kansas State water quality standards.[22,23] The staff reviewed the assumptions for these calculations and found them to be reasonable. Higher concentration factors could be used for a one-unit station and during nondrought periods.

Table 9.10. Staff estimates of consumptive water use for mechanical draft, wet cooling towers and for Wolf Creek cooling lake for a typical year (1968); 62.5% plant factor for October through May and 100% plant factor for June through September

Month	Consumptive water use (acre-ft)			
	Cooling towers			Cooling lake
	Induced evaporation	Drift	Total	
January	788	23	811	868
February	745	21	766	839
March	933	23	956	1,561
April	944	22	966	2,410
May	1,004	23	1,027	2,967
June	1,723	22	1,745	4,214
July	1,789	23	1,812	4,603
August	1,775	23	1,798	4,415
September	1,667	22	1,689	4,060
October	989	23	1,012	2,866
November	847	22	869	1,812
December	805	23	828	1,338
Total	14,009	270	14,279	31,953

However, using the conservative assumption that the concentration factors would be 2.4 for operation of one unit during 1968, the staff estimated that the rate of blowdown would be 13.4 cfs. During a drought year, such as 1954, the makeup-water required for such a cooling tower would be 34 cfs, which is below the 41 cfs available.

Although one unit with a cooling tower can be supported at the Wolf Creek site, the applicant states that the site is being developed for two units (ER p. 9.2-25). Cooling towers for two units would require about 68 cfs makeup water during a drought year, which is close to the applicant's prediction of 70.6 cfs.[23] The minimum 41 cfs makeup water from John Redmond Reservoir (Sect. 3.3) would not be sufficient and additional water storage would be required to operate the station through the period-of-record drought. The applicant calculated that a storage pond the size of Wolf Creek cooling lake would not be large enough to provide the required water during the entire period-of-record drought (ER, p. 10.1-4). A storage pond the same size as the cooling lake would have the same natural evaporative loss. Evaporative losses from cooling towers would be greater than the induced evaporative loss from the cooling lake. Thus, the combined losses from cooling towers and associated storage pond would be greater than the total losses from a cooling lake.

In addition to the minimum of 41 cfs available for industrial use at John Redmond Reservoir, another minimum of 32 cfs is available at this reservoir for maintaining water quality in the Neosho River downstream of John Redmond Dam. It can be argued that this water could be combined with the 41 cfs of industrial water to provide 73 cfs of makeup water for the cooling towers and then use the cooling tower blowdown water to maintain water quality in the Neosho River. This method is not viable, however, because the sulfate concentration in the cooling tower blowdown water would exceed the State water quality standards.[22] The staff knows of no economical way to remove sulfate from water. In addition, the Neosho River bed between John Redmond Dam and the Wolf Creek confluence probably would be dry during droughts if this method were used.

Since wet cooling towers add water to the air, there is concern about additional fogging and drift deposition associated with these towers. Staff calculations of additional fogging and drift deposition using the Oak Ridge Fog and Drift Program[24] are shown in Table 9.11.

In addition, the station would produce less net electrical power with cooling towers than with a cooling lake since the cooling tower system has a higher turbine back pressure and requires more electrical energy to operate. In consideration of the above factors, particularly that the site ultimately will be developed as a two-unit station and the net power output from the station will be less with the towers, the staff concludes that a cooling lake would be the better choice for the waste heat dissipation system at WCGS.

Table 9.11. Staff estimates of additional fog and drift deposition from wet forced-draft cooling towers for a typical year (0.03% drift fraction)

Location	Additional fog (hr/year)	Drift (g/m^2/year)
U.S. highway 75 (2.75 mile W)	6	0.6
Local road (1.5 mile N)	7	1.8
Local road (1.5 mile E)	14	1.5

9.2.1.5 Natural-draft wet cooling towers

The volume of air flow and the cooling efficiency of natural-draft towers depend on the temperature-dependent density difference between air in the shell and ambient air. Natural-draft towers are not generally considered suitable for hot dry climates where the difference obtainable between inside and outside air densities would be too small to achieve the minimum required air flow and rate of evaporative cooling of the circulating water. Inherently, these conditions tend to reduce the cooling efficiency of a natural-draft cooling tower during the hotter, drier months of the year. Proper designs to accommodate these factors at WCGS make natural-draft cooling towers more expensive than mechanical draft. Since natural-draft towers would have essentially the same water consumption and higher turbine back pressure as mechanical-draft towers, the staff concludes this alternative is not preferred for WCGS.

9.2.1.6 Wet-dry cooling towers

One way to reduce the station water requirements and maintain reasonable turbine back pressures (5 in. Hg) is using wet-dry cooling towers. These towers consist of two parts: (1) one in which the circulating water is passed through a fin-and-tube heat exchanger where the water is cooled by sensible heat transfer to the air flowing around the outer surfaces of the heat exchanger tubes; and (2) one in which the circulating water drops through the air where it is cooled by evaporative and sensible heat transfer to the air. The warmer circulating water usually passes through the heat-exchanger portion before it comes into direct contact with the air.

The amount of heat dissipated in the heat exchanger tubing relative to that dissipated by direct contact heat transfer can be controlled by design features and/or operation mode.[25] The applicant did an extensive study of wet-dry cooling towers for a two-unit station[23] (ER, Sect. 10.1). Results of these studies, summarized in Table 9.12, show that the water and storage lake requirements do decrease as the ratio of the dry-to-wet air inlet face increases. A storage lake would not be necessary for makeup water for the last case in Table 9.12, but was included because of the need for a reliable ultimate heat sink.

The equivalent capital required to build and operate wet-dry cooling towers increases with the dry-to-wet air inlet face ratio. This cost includes the penalty for the additional condenser backpressure, pumping power, additional fuel cost, and maintenance and water costs, in addition to the initial capital. The cost of wet-dry towers is large and would result in a considerable increase in the cost of energy generated by the WCGS.

After weighing the overall advantages and disadvantages of wet-dry-cooling towers, and particularly when comparing the economic penalty and limited experience associated with their use, the staff concludes that a cooling lake would be the better choice for a heat dissipation system at WCGS.

9.2.1.7 Spray pond

Use of a spray pond, which is much smaller in surface area than a cooling lake, is another possibility for dissipating the station waste heat. The operating characteristics of the circulating water system and the cooling water requirements for a station using spray nozzles would be about the same as those for a station using mechanical-draft wet cooling towers. Experience with spray ponds is limited.[26]

Table 9.12. Comparison of the wet and the wet-dry cooling towers for two-unit operation at 75% plant factor

Type of cooling tower	Average rate of water consumption (cfs)		Air temperature below which all cooling is in dry section (°F)[c]	Storage lake size (acres)[d]	Equivalent capital cost above cooling lake ($10^6)[e]
	Average year[a]	Drought year[b]			
Wet	58.0	70.6	–	5960	26.1
Wet-dry					
D/W = 1.65[f]	44.8	42.3	8	3800	66.1
D/W = 2.45[f]	25.2	26	38	1800	83.6

[a]Sargent and Lundy Engineers, *Cooling Systems Evaluation, Wolf Creek Generating Station – Units 1 and 2,* Report SL-3060 prepared for Kansas Gas and Electric Company and Kansas City Power and Light Company, Revision of June 21, 1974 (Table 23).

[b]Sargent and Lundy Engineers, *Cooling Systems Evaluation, Wolf Creek Generating Station – Units 1 and 2,* Report SL-3060 prepared for Kansas Gas and Electric Company and Kansas City Power and Light Company, Revision of June 21, 1974 (Tables 15–18).

[c]ER, p. 10.1-3 and 10.1-4.

[d]ER, p. 10.1-5.

[e]ER, Table 10.2-2.

[f]D/W is the ratio of dry-to-wet air inlet face area.

The spray pond cooling system is based on pumping water through nozzles to produce a coarse spray rising to a height of about 20 ft. Heat is dissipated as the spray rises and falls back into the pond. The pond itself acts largely as a collecting basin. Most of the spray and mist will fall back within 200 ft of the spray nozzle,[27] and the staff feels that this would be within the pond area. Drift beyond 600 ft from the spray nozzle will be very small.[27] Fogging due to a spray pond would be less than that from mechanical-draft wet cooling towers.

Since makeup water requirements for spray ponds would be about the same as those for mechanical-draft wet cooling towers, there would be sufficient makeup water available from John Redmond Reservoir to operate a spray pond heat dissipation system for a one-unit station. However, a storage lake of at least the size of the proposed Wolf Creek cooling lake would be required for a two-unit station.

Considering these and other factors for the spray ponds, the staff concludes that the cooling lake would be the better choice for WCGS.

9.2.2 Intake structure and canals

The system as now proposed by the applicant for a single unit (Sects. 3.4.2 and 3.4.3) results in water velocities which are at acceptable levels through the canals and through the trash racks and traveling screens of the circulating water intake structure. However, unless significant structural changes accompany the anticipated addition of a second unit, water velocities at these critical points will be excessive. With two units, velocities should not exceed 1.0 fps when the cooling lake is at its probable minimum operating level of 1075.6 ft MSL.

For the makeup water intake structure, the staff evaluated the applicant's design (ER, Sect. 3.4.3) and alternatives (ER, Sect. 10.2.3). The staff concludes that the applicant's choice is acceptable and that the alternative structure offers no significant improvement.

9.2.3 Discharge structures

The staff evaluated the applicant's structures for both circulating water and makeup water and concluded that alternative structures would offer no significant improvement.

9.2.4 Transmission lines

The applicant considered two alternate routes for the Wolf Creek to Rose Hill transmission line, three for the Wolf Creek to LaCygne-Craig Substation, and for the Wolf Creek to Athens-Burlington tap. These routes are described in detail by the applicant (ER, Sect. 10.9). The staff generally concurs on the routes chosen by the applicant. The existing LaCygne-Benton line passes through a one-mile stretch of the proposed cooling lake. An alternate route which passes around the northern perimeter of the cooling lake is planned for the following reasons: (1) from the aesthetic standpoint, the visual impact of the existing line would be substantial since the lines and towers would be visible for long distances, and (2) the existing transmission lines may present a hazard to waterfowl using the cooling lake (Sect. 5.5.1.3). Recent Department of Interior criteria[28] for transmission lines specifically state, "Avoid open exposure of water----utilized by migrating waterflow." The staff concurs with the proposed routes.

9.2.5. Railroad spur

The staff is not aware of any alternate routes that would be preferable to the selected route.

9.3 ALTERNATIVES TO NORMAL TRANSPORTATION PROCEDURES

Alternatives such as special routing of shipments, providing escorts in separate vehicles, adding shielding to the containers, and constructing a fuel recovery and fabrication plant on the site rather than shipping fuel to and from the station have been examined by the staff for the general case. The environmental impact of transportation under normal or postulated accident conditions is not considered sufficient to justify the additional effort required to implement any of these alternatives.

REFERENCES FOR SECTION 9

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10. CONCLUSIONS

10.1 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

10.1.1 Abiotic effects

10.1.1.1 Land

The construction of any large power station causes considerable disturbance to and modification of the land. The Wolf Creek Generating Station will include a total of 10,500 acres of which approximately 5300 acres will be occupied by the power plant, the dam, dikes, cooling lake, and related facilities. Except for rail and road access routes and transmission line rights-of-way, the remainder of the acreage within the site will be largely undisturbed by the construction and operation of the facility. In addition to the 10,500 acres, WCGS will require approximately 3140 acres for various external rights-of-way connecting the site. The land area directly occupied by the plant, the dam and the cooling lake, and related facilities will result in the elimination of some riparian vegetation and woodland important for wildlife habitat, but such displacement as this will not involve an irreversible or irretrievable elimination of local biological resources in the immediate area.

10.1.1.2 Water

The construction and operation of WCGS will have only a slight impact on the availability of potable water and water for agricultural uses in the area around the site. Damming the flow of Wolf Creek will have little economic impact beyond that related to the displacement of agricultural land.

The applicant has estimated that an average of about 34,000 acre-ft of water per year will be diverted from John Redmond Reservoir to the cooling lake to make up for losses. There will be no return flow to John Redmond Reservoir.

Recreational accessibility and water quality below John Redmond Dam will be affected by construction of the makeup water intake structure. Releases from the cooling lake, when mixed with the Neosho River flow, must meet water quality standards set by Federal and State agencies.

Filling and operation of the cooling lake will raise the groundwater in the shallow, weathered bedrock aquifer to coincide with the level of the lake at its perimeter. Groundwater TDS levels will increase in the immediate vicinity of the cooling lake. However, this should not affect groundwater users outside the site boundary.

10.1.1.3 Air

The construction of the station will cause some smoke and dust within a few miles of the construction areas. The applicant is committed to meeting all applicable regulations for dust and smoke during construction. Therefore, the staff concludes that there will be no serious adverse impact on the air quality during station construction.

10.1.2 Biotic effects

10.1.2.1 Lake level fluctuation effects

Extensive mudflats will develop during dry climatic periods. These mudflats will be dominated by annuals. Woody vegetation that invades these areas will be killed when the areas are reinundated, leaving as much as 500 acres distributed around the perimeter of the lake inhabitated by dead shrubs and trees of various ages.

10.1.2.2 Increased turbidity due to construction

Temporary increases in turbidity during construction will destroy some aquatic organisms, but restriction of turbidity to those concentration limits recommended in Sect. 4.3.2 should confine these losses to acceptable levels (i.e., levels at which populations can yet recover when the stress is removed).

10.1.2.3 Thermal effects

Exposure of entrained organisms to thermal shock and of fish to shutdown-induced cold shock may depress productivity in Wolf Creek cooling lake below that which would occur under natural conditions. On the other hand, due to warmer lake temperatures the longer growing season may tend to compensate for these losses.

Elevated cooling lake temperatures will probably induce shifts in species composition. Undesirable blue-green algae are expected to achieve nuisance level densities during summer.

The staff expects no adverse thermal effects in the Neosho River due to operation of WCGS.

10.1.2.4 Chemical effects

The addition of sulfuric acid to cooling water will result in sulfate ion concentrations as high as 787 mg/liter in the cooling lake. Although concentrations will be high, the staff expects no direct adverse effects on aquatic organisms. However, the combination of high sulfate concentrations and anaerobic conditions in the hypolimnion during summer will probably lead to hydrogen sulfide production. Thus the hypolimnion will not be available to most of the biota inhabiting the cooling lake during summer. Furthermore, the fall overturn will mix hydrogen sulfide throughout the water column where it may come into contact with fish and plankton in lethal concentrations. The increase in TDS in the cooling lake (maximum of 1200 mg/liter) will not adversely affect most organisms. Evapoconcentration of nutrients will encourage productivity, including nuisance algal blooms. Blowdown to the Neosho River will not raise TDS in the river enough to harm the aquatic biota.

10.1.2.5 Mechanical effects

An unknown number of fish will suffer impingement on the screens of the makeup intake structure below John Redmond Reservoir. Impingement and entrainment losses at the makeup intake are not likely to significantly reduce fish populations in John Redmond Reservoir or in the Neosho River, but monitoring of impingement will be required to verify this tentative assessment.

Fish will also be impinged on the circulating water intake structure in the cooling lake. The staff believes impingement and entrainment losses at the circulating water intake structure may reduce some fish populations in the cooling lake.

10.1.2.6 Effects of reduced flow in the Neosho River

During drought, the withdrawal of makeup water from John Redmond Reservoir will in effect extend the duration and severity of low flow conditions in the Neosho River downstream of the dam. Extreme low flows may stress some aquatic populations beyond their ability to recover, including populations of the endangered Neosho madtom.

10.2 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The purpose of this section is to set forth the relationship between the proposed use of man's environment implicit in the proposed construction and operation of the generating station (as permitted under the terms of the proposed construction permit) and the actions that could be taken to maintain and enhance the long-term productivity.

10.2.1 Enhancement of productivity

The construction of WCGS will have potentially beneficial effects on the economy of Kansas. The capacity of WCGS represents 18.6% of the total projected system dependable capacity of KG&E and KCPL in 1982, the scheduled date for the plant to be in operation. At the present time these two companies serve a combined total of about 1,600,000 people over a 13,700-sq-mile area of Kansas and Missouri.

10.2.2 Adverse effects on productivity

10.2.2.1 Impact on land use

The Wolf Creek Generating Station will preempt 10,500 acres of land in Coffey County, Kansas. Present uses of the land on the site are predominantly agricultural. Soybeans, the highest value food crop, were grown on 1625 acres of the proposed plant site in 1973. Sorghum, corn, and wheat were grown on a total of 1657 acres, and 5519 acres were devoted to hay and pasture. The remainder of the land on the site (1699 acres) was left to woodland and other miscellaneous uses.

The staff's analysis of the impact of preemption of the site for a nuclear plant is devoted in greatest detail to the impacts on the food crop production, since this is the most significant use of the region. Hay and pasture are of lesser importance; however, the unimproved rangeland of the site may support about 850 head of beef cattle and about 1000 hogs (ER, Table 2.2-6), the estimated value of which is probably less than $200,000.

There is considerable public concern that the preemption of productive land for nonfarm uses will have a detrimental effect on the long-term capability of the United States for food and fiber production. This fear is enhanced by current economic difficulties of farmers and high prices for foods at the retail level. Historical data on land-use allocation in the United States,[1] however, show that at the national level the amount of land devoted to various productive categories has been remarkably constant for more than the last half century and that no trend exists in the country towards significant reduction of available productive land. Department of Agriculture projections[2] (Fig. 10.1) show that the stability of land allocation is expected to persist through the year 2000 in most sections of the country. Figure 10.1 shows that for the central plains region of the country, which includes Kansas, only minor changes in land-use allocation are expected to occur by the turn of the century.

The proportionally small amount of land in nonfarm uses, however, is vital to the welfare of the nation. This land is devoted to cities, highways, airports, wildlife refuges, parks, and other essential urban-industrial-cultural needs. Most of the population of the United States now lives in areas included in the category of nonagricultural land. This may cause a distortion of perspective on the part of some observers since they are witness to the seemingly endless expansion of urban-industrial development in and near the cities. This expansion annually accounts for about one million acres of productive land at the national level, and it often has locally important consequences. However, the United States has somewhat more than one billion acres of land available for productive purposes either as cropland or pasture, and the proportional impact of preemption for urban-industrial-cultural purposes is not expected to create a general disruption of land-use allocation at the national level in the foreseeable future.

Historical United States production data for sorghum, corn, wheat, and soybeans are given in Table 10.1. Yield increases have been obtained through research that has led to improved fertilization, improved crop varieties, and improved pest, weed, and disease control. As a result of these factors, annual United States production of corn, for example, has more than doubled in the last two decades.

Land devoted to sorghum and soybeans has been on an increasing trend during the past 20 years. This factor combined with improved cultural practice that has led to increasing yields per acre has resulted in roughly a fourfold increase in the total annual production of these crops since 1951. Similarly, dramatic increases in yield and production have been made for most other major crops grown in the United States during this period.[3]

Comparison of Fig. 10.1 with the data of Table 10.1 permits a perspective on crop production of the United States. While land available to agricultural crop production is expected to change by only a small fraction, yields and the total production of corn, soybeans, and sorghum have increased by factors of 2 to 4 in recent history. Yield increases due to improved cultural practices have more than compensated for small proportions of land preempted for urban-industrial purposes in the past. The potential for this to continue in the future is substantial since most major crops grown in the United States have considerable margin for still further increases in average yield. Table 10.2 shows average and top yields for some major crops grown in the United States.[2] Whether or not any of this yield potential will be realized in the future is not certain. The uncertainty arises not from consideration of land availability but from uncertainty of the future availability of technological inputs required for crop production. If farmers are unable to obtain machinery, fertilizers, pesticides, and fuels in adequate quantity due to energy shortages, they may be unable to realize even part of the remaining biological potential for increased yields. Indeed future yields could actually diminish. Historically, yield increases due to technological inputs have more than compensated for marginal diversions of productive land.

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LAND THAT MEETS THE CENSUS OF AGRICULTURE DEFINITION OF A FARM: ANY PLACE UNDER 10 ACRES IF ESTIMATED SALES OF AGRICULTURAL PRODUCTS EXCEED $250 A YEAR, OR ANY PLACE OVER 10 ACRES IF SALES EXCEED $50. PASTURES AND OTHER LAND INCLUDES FARMSTEADS, ROADS, AND WASTELAND ON THE FARM. LAND IN FARMS IS THE PREDOMINANT LAND USE IN THE 48 CONTIGUOUS STATES, OCCUPYING SLIGHTLY OVER 1 BILLION ACRES IN 1969 - MORE THAN 65 PERCENT OF TOTAL LAND AREA.

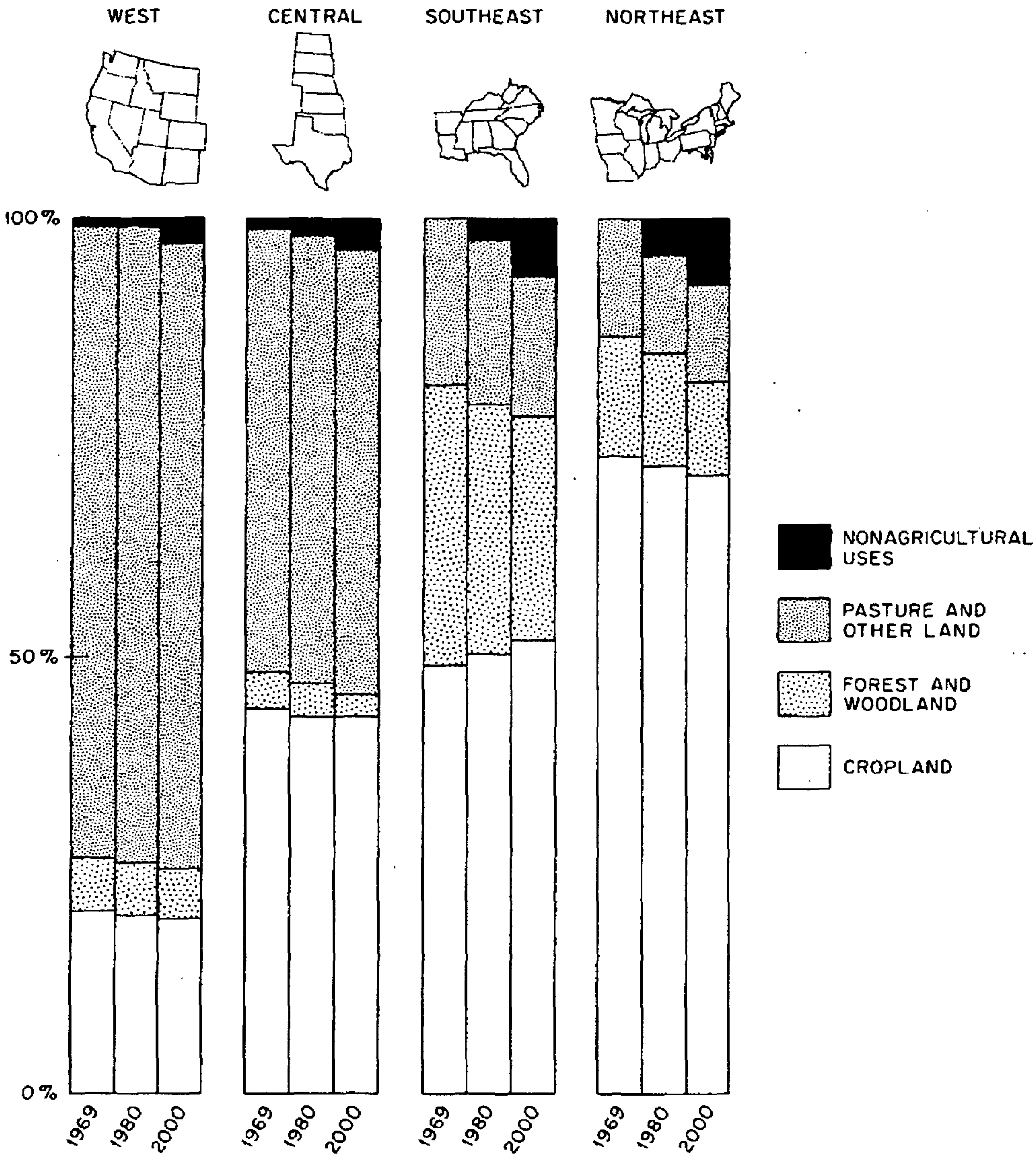

Fig. 10.1. Today's farmland -- How it may be used by the year 2000. Source: U.S. Department of Agriculture, *Our Nation's Land and Water Resources*, Economic Research Service, ERS-530, 1973.

Table 10.1. U.S. production of some crops impacted by WCGS

	1951–1955 (av)	1956–1960 (av)	1961–1965 (av)	1969	1970	1971	1972	1973	1974
Soybeans									
Acres, 10^3	15,709	22,351	29,694	41,337	42,249	42,701	45,698	56,416	52,410
Yield, bu/acre	20.0	23.2	24.2	27.4	26.7	27.5	27.8	27.8	25.1
Production, 10^6 bu	313	520	719	1,133	1,127	1,176	1,271	1,567	1,316
Sorghum									
Acres, 10^3	8,955	15,284	12,131	13,437	13,568	16,301	13,368	15,440	13,583
Yield, bu/acre	18.7	32.4	45.0	54.3	50.4	53.7	60.7	58.8	47.5
Production, 10^6 bu	170	506	548	673	730	876	822	937	645
Corn									
Acres, 10^3	70,082	67,001	56,658	54,598	57,224	64,047	57,289	61,894	65,194
Yield, bu/acre	40.2	51.2	66.3	83.9	71.6	88.1	96.9	91.2	71.3
Production, 10^6 bu	2,814	3,442	3,758	4,583	4,099	5,641	5,553	5,647	4,651
Wheat									
Acres, 10^3	60,497	50,032	48,017	47,146	43,564	47,674	47,301	53,869	65,459
Yield, bu/acre	17.9	23.4	25.3	30.6	31.0	33.9	32.7	31.7	27.4
Production 10^6 bu	1,077	1,178	1,214	1,443	1,352	1,618	1,545	1,705	1,793

Source: U.S. Department of Agriculture Statistical Reporting Service, *Crop Production, 1974 Annual Summary*, CrPrZ-1(75), 1975. (Some data is taken from earlier issues of the same publication).

Table 10.2. Average, top, and record crop yields in the USA, bu/acre

Crop	1973 Av	Top	Record
Corn	94	230	306
Wheat	32	135	216
Soybeans	28	80	110
Sorghum	63	200	320

Source: S. H. Wittwer, "Maximum Production Capacity of Food Crops," *Bioscience* 24: 216–224 (1974).

The staff does not believe that productive land can be preempted for the indefinite future, however, nor does it believe that yields will increase indefinitely. The day will probably come when the costs of technological input will no longer be repaid in the value of added food output. In that case yields per acre will no longer increase, and the only option for increasing total production will be to increase the acreage under cultivation with full technological input. At that point it would be necessary to carefully review all diversions of productive land if demand for food required continued increases in total production. Comprehensive land-use policy at both state and national levels could be required to strike an appropriate balance between agricultural and urban-industrial uses of land.

The exact future allocation of energy from the WCGS is not known, but additional increments of available energy should have a positive effect on production of technological inputs to agriculture. Only an energy rich society can sustain the high yield required to meet current and future demands for food both for domestic consumption and export. Therefore, the construction of an energy producing facility does not necessarily constitute an adverse impact on agricultural production even though proportionally small amounts of productive land are preempted.

The relative impact of the facility on production at the national, State, and county levels is shown in Table 10.3. The data show that there would be no detectable change in the annual crop production at the State or national levels. Variation caused by the facility is within the normal year-to-year variation in production and is probably within the error of estimates for these crops.

At the county level, however, the facility will cause a 3.3% reduction in wheat income, a 3.4% reduction in corn income, a 3.2% reduction in income from soybeans, and 0.3% reduction in income from sorghum. The estimated reduction in income from all these crops amounts to $0.43 million

Table 10.3. Food crop acreage, yield production, and value of the WCGS site relative to U.S., Kansas, and county totals

	U.S.[a]	Kansas[a]	Coffey[b] County	WCGS[c]	Project impact on county income from crop (%)	Project impact on state income from crop (%)
Soybeans						
Acres, 10^3	52,410	1,030	51.5	1.625		
Yield, bu/acre	25.1	20.0	21.0	21.0		
Production, 10^6 bu	1,316	20.6	1.081	0.00341		
Value, $\$10^6$	9,251[d]	145	7.6	0.240	3.2	0.16
Sorghum						
Acres, 10^3	13,583	3,320	20.9	0.591		
Yield, bu/acre	47.5	40.0	67.0	67.0		
Production, 10^6 bu	645	133	1.40	0.0040	0.3	0.003
Value, $\$10^6$	1,925[d]	397	4.2	0.012		
Corn						
Acres, 10^3	65,194	1,730	10.8	0.363		
Yield, bu/acre	71.3	76.0	75.0	75.0		
Production, 10^6 bu	4,651	131,480	0.81	0.0272		
Value, $\$10^6$	15,209[d]	430	2.6	0.089	3.4	0.021
Wheat						
Acres, 10^3	65,459	11,600	21.4	0.703		
Yield, bu/acre	27.4	27.5	28.1	28.1		
Production, 10^6 bu	1,793	319	0.601	0.0197		
Value, $\$10^6$	8,337[d]	1,483	2.8	0.092	3.3	0.006
Total of four crops, $\$10^6$	34,722	2,455	17.2	0.433	2.5	0.018

[a] U.S. Department of Agriculture, Statistical Reporting Service, *Crop Production*, CrPr2-2(9-74), Sept. 11, 1974.
[b] Kansas State Board of Agriculture, 73–74, *Farm Facts Bulletin*, (1973 or 1974 figures when available).
[c] ER, Table 2.1-1.
[d] Based on Dec. 1974 prices, average U.S.

as compared to a total county income of $17.2 million paid to farmers for these crops. Therefore, immediate short-term adverse local effects are expected due to the construction of the WCGS on some individuals whose livelihood is related to this industry.

The normal expected lifetime of the WCGS is approximately 40 years. If, at the end of that time, the food situation in the United States required that the property be reclaimed for agricultural production, it would be technically feasible to do so. Thus, construction of the cooling lake is not expected to have an irreversible effect on the soils involved due to flooding. Whether the lake is actually reclaimed or not will depend on the economic feasibility for doing so at the time of decommissioning of the plant.

The staff concludes from the foregoing analysis that (1) the United States is not running short of productive land and is not likely to in the foreseeable future; (2) preemption of the land for the WCGS will have no detectable effect on United States or State production totals for corn, soybeans, wheat, or sorghum during the life of the plant; (3) technological inputs to agriculture are more important than marginal availability of land for sustained high-crop production, and an energy-producing facility contributes to the manufacture of technological inputs to agriculture; (4) the land of the site, including the lake, could be reclaimed for agriculture upon decommissioning, if needed; and (5) adverse economic impact on the agricultural industry at the county or local level could occur.

In view of the foregoing, the staff concludes that the use of 10,500 acres of land in Coffey County, Kansas, for the purpose of construction and operation of the WCGS is justified and that no long-term adverse impacts on the agricultural industry will occur.

10.2.2.2 Impact on water use

Damming the flow of Wolf Creek will have little economic impact beyond that related to the displacement of agricultural land. An average of about 34,000 acre-ft of water per year will be diverted from John Redmond Reservoir to the cooling lake to make up for losses, but this is not considered a significant impact on present or future uses of the reservoir. Releases from the cooling lake, when mixed with the Neosho River flow, will be within State and Federal water quality standards.

10.2.3 Decommissioning

No specific plan for the decommissioning of the Wolf Creek Generating Station has been developed. This is consistent with the Commission's current regulations which contemplate detailed consideration of decommissioning near the end of a reactor's useful life. The licensee initiates such consideration by preparing a proposed decommissioning plan which is submitted to the NRC for review. The licensee will be required to comply with Commission regulations then in effect and decommissioning of the facility may not commence without authorization from the NRC.

To date, experience with decommissioning of civilian nuclear power reactors is limited to six facilities which have been shut down or dismantled: Hallam Nuclear Power Facility, Carolina Virginia Tube Reactor (CVTR), Boiling Nuclear Superheater (BONUS) Power Station, Pathfinder Reactor, Piqua Reactor, and the Elk River Reactor.

There are several alternatives that can be and have been used in the decommissioning of reactors: (1) Remove the fuel (possibly followed by decontamination procedures); seal and cap the pipes; and establish an exclusion area around the facility. The Piqua decommissioning operation was typical of this approach. (2) In addition to the steps outlined in (1), remove the superstructure and encase in concrete all radioactive portions that remain above ground. The Hallam decommissioning operation was of this type. (3) Remove the fuel, all superstructure, the reactor vessel, and all contaminated equipment and facilities, and finally fill all cavities with clean rubble topped with earth to grade level. This last procedure is being applied in decommissioning the Elk River Reactor. Alternative decommissioning procedures (1) and (2) would require long-term surveillance of the reactor site. After a final check to assure that all reactor-produced radioactivity has been removed, alternative (3) would not require any subsequent surveillance. Possible effects of erosion or flooding will be included in these considerations.

Estimated costs of decommissioning at the lowest level are about $1 million plus an annual maintenance charge in the order of $100,000.[3] Estimates vary from case to case, a large variation arising from differing assumptions as to level of restoration. For example, complete restoration, including regrading, has been estimated to cost $70 million. At present land values, consideration of an economic balance alone likely would not justify a high level of restoration. However, planning required of the applicant at this stage will ensure that variety of choice for restoration is maintained until the end of useful plant life.

The degree of dismantlement would be determined by an economic and environmental study involving the value of the land and scrap value versus the complete demolition and removal of the complex. In any event, the operation will be controlled by rules and regulations that are in effect at the time to protect the health and safety of the public.

10.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

10.3.1 Introduction

Irreversible commitments generally concern changes set in motion by the proposed action which at some later time could not be altered so as to restore the present order of environmental resources. Irretrievable commitments are generally the use or consumption of resources that are neither renewable nor recoverable for subsequent utilization.

Commitments inherent in environmental impacts are identified in this section, while the main discussions of the impacts are in Sects. 4 and 5. Also, commitments that involve local long-term effects on productivity are discussed in Sect. 10.2.

10.3.2 Commitments considered

The types of resources of concern in this case can be identified as (1) material resources (materials of construction, renewable resource material consumed in operation, and depletable resources consumed) and (2) nonmaterial resources, including a range of beneficial uses of the environment.

Resources that generally may be irreversibly committed by the operation are (1) biological species destroyed in the vicinity, (2) construction materials that cannot be recovered and recycled with present technology, (3) materials that are rendered radioactive but cannot be decontaminated, (4) materials consumed or reduced to unrecoverable forms of waste, including uranium-235 and -238 consumed, (5) the atmosphere and water bodies used for disposal of heat and certain waste effluents, to the extent that other beneficial uses are curtailed, and (6) land areas rendered unfit for other uses.

10.3.3 Biotic resources

10.3.3.1 Terrestrial

Approximately 200 acres will be covered with structures and 5090 acres will be covered with water by the cooling lake. This acreage represents a habitat loss for 25 wildlife species restricted to woodland and seven species restricted to native prairies. In addition, the fairly mature bluestem prairie of the site is currently inhabitated by two species of wildlife that are rare in the upper and middle Neosho River basin: plains harvest mouse (*Reithrodontomys montanus*) and badger (*Taxidea taxus*). The floristic diversity of the bluestem prairie is higher than other plant communities of the area with approximately 52% of the species (20) restricted to bluestem prairies.

10.3.3.2 Aquatic

Construction of WCGS will:

(1) change approximately 15 miles of intermittent stream habitat into still water habitat; i.e. the cooling lake will cover approximately 55% of the length of Wolf Creek and cause species composition to shift drastically;

(2) during cooling lake filling, impose drought conditions on the seven miles of Wolf Creek below the dam (about 20% of Wolf Creek's length); and

(3) destroy less than 1.5 acres of benthic habitat in the Neosho River below John Redmond Dam (through construction of makeup facilities).

Furthermore, a distinct possibility exists that reduced flows in the Neosho River due to makeup withdrawal may stress some fish populations beyond their ability to recover, as described in Sect. 5.5.2.

10.3.4 Material resources

Materials of construction are almost entirely of the depletable category of resources. Concrete and steel constitute the bulk of these materials, but there are numerous other mineral resources incorporated in the physical station. No commitments have been made on whether these materials will be recycled when their present use terminates.

Some materials are of such value that economics clearly promote recycling. Station operation will contaminate only a portion of the equipment to such a degree that radioactive decontamination would be needed in order to reclaim and recycle the constituents. Some parts of the station will become radioactive by neutron activation. Radiation shielding around each reactor and other components inside the dry-well portion of each containment structure constitutes the major materials in this category for which separation of the activation products from the base materials is not feasible. Components that come in contact with reactor coolant or with radioactive wastes will sustain varying degrees of surface contamination, some of which could be removed if recycling is desired. The quantities of materials that could not be decontaminated for unlimited recycling probably represent very small fractions of the resources available in kind and in broad use in industry.

Construction materials are generally expected to remain in use for the full life of the station, in contrast to fuel and other replaceable components discussed later. There will be a long period of time before terminal disposition must be decided. At that time quantities of materials in the categories of precious metals, strategic and critical materials, or resources having small natural reserves must be considered individually, and plans to recover and recycle as much of these valuable depletable resources as is practicable will depend upon need.

10.3.5 Replaceable components and consumable materials

Uranium is the principal natural resource material irretrievably consumed in station operation. Other materials consumed, for practical purposes, are fuel-cladding materials, reactor control elements, other replaceable reactor core components, chemicals used in processes such as water treatment and ion exchanger regeneration, ion exchange resins, and minor quantities of materials used in maintenance and operation.

Between 5000 and 7000 metric tons of contained natural uranium in the form of U_3O_8 must be produced to feed the unit for 30 years (operating at a 75% plant factor). The assured U.S. reserves of natural uranium, recoverable at a cost of $8 or less per pound of U_3O_8, are 200,000 metric tons of uranium.[4] A greater reserve exists if more expensively mined ore is considered.

In view of the quantities of materials in natural reserves, resources, and stock piles, and the quantities produced yearly, the expenditure of such material is justified by the benefits of the electrical energy produced.

10.3.6 Land resources

Approximately 5300 acres of land would be completely committed to the construction and operation of this power station for the 30-year life of the plant. The staff does not expect this land to be returned to present uses after decommissioning of the station. The likely use is the continuation of use as a cooling system or the development of an independent recreation area.

This document does not address recreational uses in the Wolf Creek cooling lake. However, the staff believes that the recreational potential associated with the lake is equal to or greater than that of the John Redmond Reservoir. For the reasons stated in Sects. 4.3.2.2 and 5.5.2.1 and in other parts of this document, the cooling lake should be biologically more productive than the John Redmond Reservoir. The staff realizes the lake will experience elevated temperatures and elevated TDS concentrations during drought periods; however, this should not significantly reduce productivity in the lake. If drought conditions persist, reduced productivity is expected and will occur in the John Redmond Reservoir as well as in the Wolf Creek cooling lake and the Neosho River for an undetermined distance downstream.

10.4 COST-BENEFIT BALANCE

10.4.1 Benefit description of the proposed plant

The benefits are summarized in Table 10.4 and discussed below.

Table 10.4. Benefits from the proposed facility

Direct benefits	
Expected average annual generation, GWhr	8000
Capacity, MW	1150
Expected average annual amount of steam sold from the station, Btu (X 10^6)	0
Expected average annual delivery of other beneficial products	0
Indirect benefits	
Taxes (annual state and local, 1982)	$7.31 million
Research	see text
Regional product	0
Employment (annual operating payroll, 1982)	$2.30 million
Education	see text
Others (flood control)	see text

10.4.1.1 Expected average annual generation

When the station is operated at 1150 MWe with an annual capacity factor of 75%, the result will be the generation of 7555 GWhr of energy. This benefit will be available to the approximately 1.6 million inhabitants of the 13,700 sq miles of service area. In addition this will be provided at a cost equal to or below that of alternative generation sources and without the substantial quantities of emission products normally released to the air by a fossil-fueled generating station.

10.4.1.2 Expected distribution of electrical energy

Estimates of the distribution of energy by user class in 1982 are given in Table 10.5.

Table 10.5. Estimates of distribution of energy by user class by 1982

	Residential		Industrial		Commercial		Other		Total
	GWhr	(%)	GWhr	(%)	GWhr	(%)	GWhr	(%)	GWhr
KG&E	2488	24.6	3905	38.6	1663	16.4	2061	20.4	10,117
KCPL	3353	30.5	2899	26.4	4252	38.7	478	4.4	10,982
Combined	5841	27.7	6804	32.2	5915	28.0	2539	12.0	21,099

Source: ER, Table 1.1-3.

10.4.1.3 Other products

The applicants do not plan to sell steam or other products from the facility.

10.4.1.4 Taxes

The generating station will provide tax benefits primarily to Coffey County and its school districts. The applicant estimated that the annual taxes based upon the plant valuation in 1981-82 will be somewhat more than $5.7 million compared to the $1.6 million presently collected by Coffey County on behalf of the State, county, and school districts (ER, p. 8.1-21). In addition, about $200,000 in taxes will be paid in 1982 to the counties affected by transmission line rights-of-way (ER, 8.1-21).

10.4.1.5 Research and education

The applicant's preconstruction and continuing environmental investigations and monitoring programs are considered by the staff to be valuable. Data already collected have been useful to earth science students. Data generated by the monitoring program concerning surface waters, groundwater, flora, fauna, meteorology, and radiology will be available to interested individuals. Relationships with local universities and colleges will prove to be mutually beneficial, especially to students of the earth and physical sciences. Archaeological investigations performed by Wichita State University have already provided new information on the prehistory of Kansas. Sites showing promise will be further excavated, tested, and studied. In addition, a visitors' center is to be constructed which will provide educational benefits to the general public and regional school populations.

10.4.1.6 Employment

During the peak construction year, 1979, the construction work force will number nearly 1800 and the estimated payroll for that year will be $58.9 million (ER, Table 8.1-6). The operating force is expected to be about 87 permanent employees with an annual payroll of $2.30 million during the year in which WCGS is expected to become operational.

10.4.1.7 Other benefits

The holding capacity of the cooling lake will provide some relief from local flooding of Wolf Creek and also some erosion control of the stream. In addition, the creation of the cooling lake will provide aesthetically pleasing scenic views to the general public.

10.4.2 Cost description of the proposed facility

10.4.2.1 Power generation costs

The staff estimated the cost of the generating station in 1982 to be $803 million. The annual operating, maintenance, and fuel costs in 1983, the projected first full year of operation, is estimated to be $66 million, assuming an average capacity factor of 80%. Assuming a 30-year life and a discount factor of 10%, the present worth (in 1982 dollars) of the generating cost would be $1422 million. The annualized generating cost in 1982 would be $151 million, assuming an average capacity factor of 80%. The staff estimates that the costs of decommissioning and those required to meet Appendix I guidelines would not add significantly to the total generating costs.

10.4.2.2 Social costs other than community service costs

Social impacts were discussed in Sects. 4.4 and 5.6. Coffey County will experience the greatest effects. Although some of these cannot be quantified, the staff judges that any dollar costs will be more than offset by the tax revenues generated by the power plant on behalf of the county.

10.4.2.3 Community service costs

The increased community service costs were discussed in Sects. 4.4 and 5.6. Coffey County will again experience the greatest impacts associated with the construction and operation of the power plant. This county and the towns of Burlington and New Strawn probably will have to provide increased public services. In most instances (e.g. education, housing, water, and sewage facilities), the existing services and planned improvements can accommodate the impacts of the construction and operating phases. However, the medical facilities of the immediate area will be overcrowded, especially during the construction period. In general, however, the costs associated with additional facilities and services will be more than accounted for by increased revenues.

10.4.2.4 Environmental costs

The environmental costs have been discussed in previous sections. One of the most significant costs is the loss of approximately 10,500 acres of land, including about 5090 acres to be inundated to form the cooling lake. All of the flooded portion and part of the remaining land will be lost to agricultural production. About 5% of the total woodland of Coffey County will be inundated by the proposed cooling lake for the WCGS (ER, Table 8.2-4). About 25 households and 52 persons will have to be moved as a result of construction (ER, p. 8.2-14b).

There are no sites designated as national historic sites within the WCGS boundaries.

If a single 1150-MWe plant operating at 75% plant factor is assumed, about 36,000 acre-ft/year of water will evaporate from the cooling lake. Of this, approximately 34,000 acre-ft/year will be supplied from John Redmond Reservoir.

In order to limit salt buildup in the cooling lake, periodic discharge of part of the water by blowdown and replacement by makeup from the John Redmond Reservoir will be necessary. Blowdown will increase TDS in the Neosho River. This is not expected to have serious adverse effects on the Neosho River aquatic organisms.

During construction of the plant, activities will produce some smoke, dust, and noise that will create a nuisance within about a mile of the construction site. The air quality will not be significantly degraded during operation of the plant.

The contribution environmental effects associated with the uranium fuel cycle are sufficiently small as not to affect significantly the conclusion of the cost-benefit balance.

10.4.3 Summary of cost-benefit balance

The staff concludes that the primary benefit of increased availability of electrical energy outweighs the environmental and economic costs of the station. The staff further concludes that the indirect benefits of increased employment and increased tax revenues outweigh the social costs resulting from construction and operation of WCGS.

As indicated in Sect. 9, the staff believes that there would be no reduction in overall costs by the use of an alternate site, the use of an alternate generating system, or any combination of these. The staff concludes that a nuclear station using the Wolf Creek impoundment for cooling is a system with a benefit-to-cost ratio at least as high as that of any alternative system, including that of a nuclear station using mechanical-draft wet cooling towers.

In the staff's opinion, the benefits of increased availability of electrical energy and improved system reliability in the applicant's service area outweighs the economic and environmental costs caused by the station when it is operated in accordance with the conditions listed in the Summary and Conclusions.

REFERENCES FOR SECTION 10

1. *Major Uses of Land in the United States,* U.S. Department of Agriculture, Agricultural Economic Report No. 247, 1969.

2. S. H. Wittwer, "Maximum Production Capacity of Food Crops," *Bioscience* 24: 216-224 (1974).

3. *Atomic Energy Clearing House,* 17(6): 42 (Feb. 8, 1971); 17(18): 7 (May 3, 1971); and 16(35): 12 (Aug. 31, 1970).

4. Energy Research and Development Administration Weekly Announcement No. T5-35 for week ending March 26, 1975.

11. DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL STATEMENT

Pursuant to 10 CFR Part 51, the Draft Environmental Statement for the Wolf Creek Generating Station was transmitted, with a request for comments, to:

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army, Corps of Engineers
Department of Commerce
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
Energy Research and Development Administration
Environmental Protection Agency
Federal Power Commission
State of Kansas
Chairman, Coffey County Commission

In addition, the NRC requested comments on the Draft Environmental Statement from interested persons by a notice published in the *Federal Register* on July 7, 1975. In response to the requests referred to above, comments were received from:

Advisory Council on Historic Preservation (ACHP)
Department of Agriculture (AGR)
Department of the Army, Corps of Engineers (ARM)
Department of Commerce (COM)
Department of Health, Education, and Welfare (HEW)
Department of Housing and Urban Development (HUD)
Department of the Interior (INT)
Energy Research and Development Administration (ERDA)
Environmental Protection Agency (EPA)
State of Kansas (KAN)
Kansas Gas and Electric Company (KGE)
State of Missouri
American Nuclear Society/Missouri-Kansas Section
Institute for Environmental Studies (IES)

The comments are reproduced in this Statement as Appendix A, which is reserved solely for them. The staff's consideration of the comments received and its disposition of the issues involved are reflected in part by revised text in the pertinent sections of this Final Environmental Statement and in part by the following discussion. The comments are referenced by use of the abbreviations indicated above; also, the pages in Appendix A on which copies of the comments appear are indicated.

11.1 CONSTRUCTION IMPACTS

11.1.1 Construction of dams and dikes

(INT A-45)

Clearing for construction and site development constitutes an unavoidable disturbance of the immediate environs. Table 4.1 presents a summary of the changes in acreage of land classification units and natural plant association as a result of construction on the site. Of the 10,500 acres examined by the applicant, approximately 50% of the habitat will be altered, with 48% due to Wolf Creek cooling lake, 1% due to the station construction, and 1% due to dam construction. Since the area covered by the dams and dikes is a small percentage of the entire acreage to be covered by the cooling lake, the impact of their construction will be minimal when compared to the construction and filling of the lake. According to present plans, the fill material for the earthwork will come from the region which will become the lake bottom. The remaining 50% of the site (5211 acres) will not be altered by construction. Of this, 4647 acres are used for agricultural purposes, 108 acres for miscellaneous purposes, and 456 acres are in natural plant communities. The applicant plans, to the extent possible, to continue agricultural land outside the cooling lake and the exclusion area in production (ER, Sect. 8.2.2.3). This may account for as much as 30% of the acquired land (3150 acres).

11.1.2 Impacts on recreation

(INT A-48)

Within a 5-mile radius of the plant site there are at least 18 recreational facilities (ER, Sect. 2.2.1.9, Table 2.2-5). These include a fair ground and two parks, a national wildlife refuge, the John Redmond Reservoir, a campground, and two country clubs (one projected). The activities available include fishing, camping, boating, picnicking, tennis, swimming, and golf. These facilities are capable of catering to about 25,000 visitors in a peak day. Within approximately 50 miles of the site are 13 state parks and four reservoirs or lakes, besides the John Redmond Reservoir, which had a total visitation in 1972 of over three million. The facility below the dam at John Redmond which will be temporarily disturbed during construction of the makeup water line consists of about six picnic tables and does not constitute a serious loss. The staff's opinion remains that, because of the large capacity of the facilities and the relatively small numbers of additional potential users, recreation facilities will not be seriously impacted by the construction force and their families during the period of plant construction.

11.1.3 Access roads and railroad spur

(KAN A-8, EPA A-56)

The plant area will be served by two main access roads. The southern one will join an east-west road that intersects Highway 75 in the center of Burlington. Another road will join Highway 75 approximately 1 to 2 miles north of New Strawn. For further details, see ER, Sect. 8.2.2.2.

From a 1972 survey by the State Highway Commission, it was determined that the Average Annual Daily Traffic (AADT) volume at the southern limits of Burlington was 2750. At the nearest point of Highway 75 to the plant the AADT ranged from 1700 to 3000 automobiles and 340 to 600 trucks. At the New Strawn intersection, the 1972 AADT was 2250. The traffic volume may increase to 5000 or so with the project, with peak traffic at shift changes. More detailed information with respect to the nearby Federal Aid Secondary (FAS) roads may be found in the ER, p. 2.2-18 and p. 8.2-14a.

The proposed railroad spur (p. A-31 or ER, Fig. 3.4-2) is planned to leave the main Missouri Pacific Railroad line at a point NE of Aliceville just north of FAS 1472. The spur will proceed westerly then NNW to a point approximately 1 mile east of the site. In so doing, it will make one major crossing (i.e., FAS 10 at about one-half mile west of the intersection with FAS 149), and two minor crossings (FAS 149 and FAS 1136). There will also be nine rural road crossings, for a total of 12 road crossings. Estimates are that during the peak construction period from mid-1977 to mid-1980 about six to seven short trains per week will make the trip.

With respect to the plant, all the major and heaviest components will be brought into the plant site by rail. The remainder will be brought by truck.

11.2 AQUATIC ECOLOGICAL IMPACTS

11.2.1 Neosho River

(KAN A-4)

The Neosho River (Neosho and Labette Counties) is believed to be the only Kansas river to yield highfin carpsuckers since 1940.[1] At one time, this fish was known from Coffey County. Because the fish still likely exist in the Neosho River and previously existed in Coffey County, the possibility that the stretch of river near the site is inhabited by this fish cannot be rejected.

(ARM A-16)

Although TDS and sulfate concentrations in the Neosho River will increase somewhat (FES, Sect. 5.5.2.1), the applicant must regulate blowdown to the extent that the State standards of 500 ppm TDS and 250 ppm sulfate are not exceeded. These concentrations are far below those known to harm aquatic organisms (FES, Table 5.23).

(INT A-47, EPA A-55)

Given the meteorological conditions existing from 1951 through 1959, which includes the one-in-50-year frequency drought, Table 5.1 presents estimated monthly flows immediately downstream of John Redmond Reservoir with and without the presence of the Wolf Creek Generating Station. On a monthly basis, the greatest reduction in flow due to plant operation occurs in September 1955, when a release calculated to average 314 cfs without the influence of the plant drops to only 15 cfs with plant operation, a 95% reduction. The worst case, averaged over six months, is represented by the months November 1952 through April 1953. During this period, the flows without and with the presence of the proposed plant would average 76.6 cfs and 15 cfs, respectively, an 80.4% reduction in average flow in the latter case. Defining the severe drought of the mid-1950s as stretching from July 1952 through March 1957, the mean flows without and with the presence of the plant would average 73.4 cfs and 38.6 cfs, respectively. Thus, during a repeat of the historical drought of nearly 5 years, operation of WCGS could be expected to reduce releases (flows) to the Neosho River by an average of about 47.5% of the releases expected without WCGS operation. The above flows represent releases through John Redmond Dam. Contributions from tributaries and groundwater should supplement these releases by an undetermined amount further downstream. (See Table 5.1 and further discussion of downstream effects in Sect. 5.5.2.1.)

(EPA A-55)

Regarding the relatively high concentration of some materials suggestive of poor water quality in Wolf Creek, operation of WCGS will not increase the total quantity of these materials flowing through the Neosho River. Some of these materials may be concentrated within the cooling lake by a factor of two or three times through evaporation; however, upon mixing in the Neosho River, these concentrations should return to preoperational levels. For at least one parameter (turbidity), there should be an improvement because the cooling lake will serve as a large sediment trap.

Although ammonia levels in Wolf Creek as reported by the applicant are fairly high (up to 0.11 mg/liter in Wolf Creek and 0.17 mg/liter in John Redmond Reservoir), the toxic un-ionized form (NH_4OH) will comprise only a small fraction of these concentrations. For example, the ratio of ammonium ion to un-ionized ammonium hydroxide is about 300:1 at pH 7.0 and 30:1 at pH 8.0,[2] the pH range so far observed in Wolf Creek. Therefore, the concentration of un-ionized ammonium hydroxide in Wolf Creek would be expected to range from 0.000033 mg/liter to 0.0037 mg/liter, considerably below the 0.02 mg/liter maximum recommended by the Joint Committee on Water Quality Criteria of the National Academy of Sciences and National Academy of Engineering.[3] Even if un-ionized ammonium hydroxide were to be concentrated in the cooling lake by a factor of three, concentrations would probably still fall below the above recommended level, particularly because pH in the cooling lake will likely be lower than that in Wolf Creek due to the use of sulfuric acid as an antiscalant and the generally more acid conditions existing in the hypolimnetic waters where ammonia species are most likely to occur.

Concentrations of hexane soluble materials (principally oils and grease) in Wolf Creek were well below EPA low-volume effluent limitations (40 CFR Part 423.13). These materials should not be concentrated in the cooling lake to any extent. No baseline data on organophosphates and other pesticides were provided by the applicant.

(INT A-48)

Flows in the Neosho cannot be described as normal due to abnormal releases by John Redmond Dam. The staff used the words "normal flows" to mean flows representative of pre-drought conditions.

While the Neosho madtom and other riffle-dependent species may have been stressed by abnormally high flows as well as seriously reduced low flows, the Neosho madtom is still represented by several populations in the Neosho River downstream from John Redmond Reservoir.

11.2.2 Wolf Creek

(KAN A-10)

During periods of drought, the water suggested for continuous blowdown to Wolf Creek will find better use, in the staff's opinion, in maintenance of flow in the stretch of the Neosho River between the makeup station and the mouth of Wolf Creek. As an intermittent stream, Wolf Creek naturally ceases to flow during drought.

(INT A-48)

Wolf Creek will continue to flow through the site up to 40 months after commencement of construction activities.

11.2.3 Operational monitoring

(KGE A-28)

The results of almost any fish-sampling method can be at least semi-quantitatively described in terms of catch-per-unit-effort. For example, the number of net-feet fished, the exact amount of time fished, the length of seine hauls, and the length of stream (in the case of Wolf Creek) electro-shocked can be presented with each catch.

(KGE A-28)

Although the staff disagrees with the applicant's position that creel censuses are of "questionable value," the staff concurs that the benefits probably would not justify the cost to the applicant.

(KAN A-3, HEW A-14)

The operational monitoring program will include the measurement of water flow rates and quality (TDS, sulfates, chlorides, and temperatures) upstream of the Wolf Creek-Neosho River confluence and in the Neosho River to assure compliance with the Kansas Department of Health and Environment Regulations 28-16-28, Water Quality Criteria for Interstate and Intrastate Waters of Kansas (Appendix F). However, since the proposed action is the issuance of a construction permit, the staff will discuss the details of the operational monitoring program when the application for an operating license is received.

11.3 TERRESTRIAL ECOLOGICAL IMPACTS

11.3.1 Avian impacts

(INT A-47)

The proposed electrical distribution facilities appear to be planned so as to minimize the accidental electrocution of large raptors. The towers which are planned for the rerouting of the existing 69-kV line should not result in losses of large birds due to electrocution. Since the towers that are to be erected for transmission lines will be taller than existing distribution lines, large birds will not likely perch on them when higher perches are available. Therefore, the possibility of loss from electrocution on existing distribution lines is minimal.

11.3.2 Fish and wildlife management plan

(INT A-47, A-48)

The Kansas Forestry, Fish, and Game Commission is preparing a plan for mitigating wildlife losses due to construction and operation of the proposed plant. This plan will follow the guidelines set up by the Joint Federal-State-Private Conservation Organization Committee in *Ecological Planning and Evaluation Procedures.*[4]

Although not yet finalized, it is the understanding of the staff that the wildlife mitigation plan currently being developed will recommend expansion of the bluestem prairie on the site to improve wildlife habitat.

11.3.3 Air quality

(EPA A-56)

Gaseous emissions for one month resulting from operation of the two emergency diesel engines and the oil-fired auxiliary steam boiler are provided by the applicant (ER, p. 3.7-1). Table 11.1 gives the concentrations at the nearest boundary under the worst stability conditions and the applicable standards for each pollutant released by the diesel engines. All pollutants are below the standards in the worst stability case except hydrocarbons (HC). Assuming a ground level emission, HC would exceed the 3-hr standard during the three worst stability conditions, generally

Table 11.1. Concentrations of gaseous emissions from the diesel engines at the nearest site boundary under the worst stability conditions and under applicable Federal standards

Pollutant	Concentration during Pasquill type F stability conditions[a]	Federal standard[b]
NO_x	28 $\mu g/m^3$, yearly average	100 $\mu g/m^3$, annual average
SO_x	52 $\mu g/m^3$, 24-hr average	365 $\mu g/m^3$, 24-hr average
CO	2.078 mg/m^3, 1-hr average	40 mg/m^3, 1-hr average
HC	2078 $\mu g/m^3$, 3-hr average (10.39 $\mu g/m^3$, 3-hr average during Pasquill Type A stability conditions)	160 $\mu g/m^3$, 3-hr average

[a]W. F. Hilsmeier and F. A. Gifford, Jr. *Graphs for Estimating Atmospheric Dispersion,* Report ORO-545, 1962.

[b]Environmental Protection Agency, "National Primary and Secondary Ambient Air Quality Standards," *Federal Regist.,* 36(84): 8186–8201 (1971).

during the night, but not during the three best conditions. Therefore, if the engines are tested during the day, emissions will not normally exceed the HC standard. The emissions from the auxiliary steam boiler will comply with or be less than the following requirements:

Particulates	-	0.1 $lb/10^6$ Btu
NO_x	-	0.3 $lb/10^6$ Btu
Visible emission	-	20% opacity .

Since these emissions will be only occasional, the staff feels that the impact at the site boundary will not be significant.

11.4 WATER QUALITY CRITERIA AND CONSUMPTION

11.4.1 Lime softening

(KAN A-3)

Figure 3.2 is correct. Water will be lime-softened as a prior treatment of that water used as makeup for the steam cycle and other miscellaneous uses.

11.4.2 Cooling lake

(KAN A-3)

The portion of the lake where the plant discharge will be received has been considered in the staff's thermal analysis in Sect. 5.3.2.

11.4.3 Stream flow

(KAN A-3)

Updating the period of record shown in Table 2.3 would not alter the staff conclusions.

The minimum flows recorded are not inconsistent; however, they are based on different periods.

11.4.4 Water availability

(KAN A-42)

The main thrust of the hydrologic analysis given in ER, Sect. 2.5.1.3 is to determine the extent of drawdown in John Redmond Reservoir due to water being diverted to the Wolf Creek Generating Station from the reservoir. This analysis indicated that the low water level in John Redmond Reservoir during the period-of-record drought would have been 1030.3 ft MSL, which is equivalent to 12,700 acre-ft of water remaining in the reservoir storage space. Daily flow-analysis would result in less water being released from the reservoir than that predicted by the monthly flow analysis. This implies that the applicant's analysis in the ER is conservative since the reservoir drawdown would be less with lower water releases.

In their response to comments, the applicant stated that the daily flows at Chanute, Kansas, for the 1951-1960 period had been examined. These flows were extrapolated from the daily flows measured at Strawn and Iola during that period. Careful examination of these data by the applicant indicates that while the nature of the fluctuation in the reservoir water level would be somewhat different during this period, there would have been little difference in the minimum drawdown level.

(INT A-46)

The Kansas Water Resources Board, independently of the applicant, determined that the John Redmond Reservoir is capable of yielding 41 cfs during a 2% drought. In the applicant's analysis (ER, p. 2.5-4b through 2.5-4j) the natural evaporation rates of John Redmond Reservoir were assumed to be the same as those measured at the Fall River Dam, Kansas. This appears to be a reasonable assumption to the staff. At the present time, John Redmond Reservoir is operated at a conservation level of 1039 ft MSL in the summer and 1036 ft MSL during the rest of the year. However, it is the staff's understanding that the reservoir will be operated at a conservation level of 1039 ft MSL during the entire year, once water is being diverted from the reservoir to Wolf Creek Generating Station. The estimated monthly inflows to the three reservoirs considered in the applicant's analysis are those given in the U.S. Army Corps of Engineers Regulation Manual for those three reservoirs.[5]

11.4.5 Down-stream effects of plant operation

(EPA A-55)

Prior water rights holders have first priority to water flowing by natural means in the Neosho River. When there is no natural flow in the river, water can be released from John Redmond Reservoir for the purpose of quality maintenance. Once water has been released, it is considered natural flow and may be used by communities to fulfill their water requirements.

The average annual water usage downstream to Chanute, Kansas, is approximately 5 cfs. The Kansas Water Resources Board has calculated the 2% chance drought yield of the John Redmond Reservoir to be 73 cfs. The yield capability after makeup of 41 cfs for plant operations would be 32 cfs. Table 5.1 shows the flow rates in the Neosho River with and without WCGS. It can be seen that during the six months period of zero flow (September 1956-February 1957) the plant had no impact on downstream water availability. The staff concludes that there will be sufficient water in the John Redmond Reservoir to maintain plant operation and downstream users through the 2% chance drought.

11.4.6 Makeup water

(EPA A-55)

Water will be released from John Redmond Reservoir through the pipes within the dam only when there is insufficient water passing over the dam spillway which has a crest at 1033 ft MSL. For the 1951-1960 time period, which includes the period-of-record drought, Fig. 5.2 shows that the reservoir elevation would have been below this elevation about 5% of the time.

(EPA A-56)

The staff considers the added cost and associated impacts involved in taking makeup water directly from the John Redmond Reservoir to be in excess of the benefits which might be realized.

11.4.7 Groundwater

(INT A-45)

The applicant's preoperational monitoring program is described in ER, Sects. 6.1.1 and 6.1.2. Groundwater levels were obtained by the applicant by installing piezometers in the site vicinity and by observing groundwater levels during the local well inventory. Water samples for groundwater chemical analyses were collected from 10 wells in the site vicinity. The locations of these wells are shown in ER, Fig. 6.1-3 and the water quality data are presented in ER, Appendix 2.5A. Staff evaluation of the operational monitoring program for groundwater will be made when the application for an operating license is received. At that time, the program will be evaluated, in part, on the probable direction of groundwater movement, considering the effects of the cooling lake on the groundwater environment.

(EPA A-55)

The applicant considered the effects of the cooling lake on groundwater in ER, Sect. 5.1.7. Due to construction of the cooling lake, groundwater levels are expected to rise in the bedrock units a maximum of about 1.5 ft within 1 mile of the cooling lake boundary after 50 years. For the weathered bedrock units (most private wells in the vicinity tap these units), the maximum rise in groundwater levels is estimated to be 2.0 ft within 1000 ft of the cooling lake boundary after 50 years. The staff has concluded that these analyses are conservative.

Effects on groundwater quality were also estimated by the applicant in ER, Sect. 5.1.7. With two units operating at 100/62.5% load factor during a postulated 5-year drought, the maximum TDS concentration in the cooling lake is expected to be about 1700 mg/liter. During nondrought years, TDS concentrations will be maintained at 900 mg/liter. Groundwater in the site vicinity currently is of rather poor quality and exceeds U.S. PHS drinking water standards in many cases for TDS, sulfates, and nitrates as N. The applicant's analyses indicated that TDS concentrations in the groundwater, due to recharge from the cooling lake, could be increased from an average of 1340 mg/liter to a maximum of about 2240 mg/liter. The staff has concluded that these analyses are conservative.

One of the chemical processes that takes place as water seeps out of the cooling lake would be ion exchange with both bottom sediment and soil particles. This process would remove some radionuclides from the lake water before it enters the groundwater. Therefore, for a given concentration in the cooling lake, the concentration in the seepage would be less. Concentrations in the cooling lake have been estimated by the staff in Sect. 5.4.2.2. These concentrations would meet 10 CFR Part 50 Appendix I guidelines and, therefore, concentrations in the seepage would also meet Appendix I guidelines.

11.5 RADIOLOGICAL IMPACTS AND ASSESSMENTS

11.5.1 Dose assessment

(EPA A-52, KAN A-41)

EPA commented that it appears that Wolf Creek "will not be able to meet the liquid dose criteria of the design objectives of Appendix I to 10 CFR 50. Furthermore, it appears the calculated potential doses from liquid effluents, as indicated in the Draft Environmental Statement and in the Environmental Report, have not taken into account the buildup of radioactivity in the Wolf Creek cooling lake."

The applicant, in the Environmental Report, did not consider buildup in the cooling lake. However, Amendment 4 to the Environmental Report, which was received after the DES was issued, does consider this. In the staff's analysis, this effect was considered in a very conservative fashion. It was assumed that the only dilution of the liquid effluent entering Wolf Creek was that due to the long-term average flow of water out of the cooling lake, with no credit for the large initial dilution by the condenser cooling water. The latter flow is 75 times that which was assumed for dilution, which is a far greater factor than is required to account for buildup of the long-lived activity in the cooling lake. The only other assumption made in the liquid dilution model was that the average travel time from the reactor to the discharge from the lake is 25 days, which is half the time required for all the water in the lake to pass through the reactor once.

As explained above, a conservative model was used to evaluate doses due to liquid effluents. Since staff calculated doses are within the applicable Appendix I design objectives of 3 millirems to the whole body and 10 millirems to any organ, there appears to be no problem in meeting the design objectives.

11.5.2 Fuel cycle and waste management impacts

(EPA A-56)

The environmental effects of the uranium fuel cycle were the subject of recent rulemaking (39 FR 14888). 10 CFR Part 51 reads in part:

" 20.(e) In the Environmental Report required by paragraph (a) for light-water-cooled nuclear power reactors, the contribution of the environmental effects of uranium mining and milling, the production of uranium hexafluoride isotopic enrichment, fuel fabrication reprocessing of irradiated fuel, transportation of radioactive materials, and management of low level wastes and high level wastes related to uranium fuel cycle activities to the environmental costs of licensing the nuclear power reactor shall be as set forth in the following table [S-3 of the Commission's *Environmental Survey of the Uranium Fuel Cycle*]. No further discussion of such environmental effects shall be required."

A similar requirement extends to the Commission's draft and final environmental statement (10 CFR Parts 51.23 and 51.26).

11.5.3 Radiological monitoring

(ERDA A-44)

Details of the radiological monitoring will be made final during the review at the operating license stage and will be described in detail in the environmental technical specifications for the operating license.

11.6 ALTERNATIVES

11.6.1 Fossil fuel alternatives

(EPA A-57)

The economic comparison of the 1150-MWe nuclear plant and the alternative 1150-MWe coal-fired plant are presented using the same dollar base. The bottom two lines in Tables D.2 and D.3 are the plant capital cost at the time of commercial operation which is identified in Table D.1 as April 1982 and is applicable to both plants. The costs were calculated by adding the escalation during construction to the funds (Table D.1) that must have been made available at the start of the project. Since a coal-fired plant requires a shorter construction period, the base total costs are for a later year than those for the nuclear plant.

11.7 MISCELLANEOUS

11.7.1 Sludge disposal

(KAN A-41)

The amount of sludge produced by the package waste treatment plant and the proposed lime softening of the makeup demineralizer system will be minimal. The lime sludge which is produced will be used for fill material or recycled by the process of recalcination. The sludge produced by the waste treatment plant will be disposed of in a manner consistent with State and local regulations.

11.7.2 Commitment of resources

(INT A-46)

The applicant will acquire all mineral rights with the property, both within the exclusion area and within the property boundaries in general. No drilling or other such activities will be permitted. The staff concludes that such endeavors have safety related implications which cannot be ignored. For example, even if oil were demonstrated to exist beneath the site, it probably could not be extracted during the years of plant operation because of possible subsidence. In any event, the present state of affairs does not represent an irreversible and irretrievable commitment of resources because, after the useful life of the plant, exploration and extraction could be carried out, if desired.

11.7.3 Decommissioning

(EPA A-57)

In Sect. 10.2.3 of the DES, a possible upper limit of $70 million (1972 dollars) was estimated to completely restore a particular site. If the same value is applicable to the Wolf Creek site, then the present value (1982) total generating costs of the nuclear plant would increase to about $1310 million, assuming 6% per annum inflation rate to 1982, a 5% inflation rate to 2012, and a 10% discount rate. Thus the 30-year levelized generation costs would be 17.2 mills/kWhr. Even neglecting tear-down costs for a coal-fired plant, the conclusion still stands that a nuclear plant at Wolf Creek possesses an economic advantage over a comparable coal-fired plant.

11.7.4 Meteorology

(ERDA A-44)

The meteorological data used in the staff's analysis can be found in Sect. 2.3 of the applicant's PSAR.

11.7.5 Emergency plan

Emergency planning for accidents is discussed in the Nuclear Regulatory Commission's Safety Evaluation Report.

11.7.6 Social impacts

(HEW A-14)

In purchasing land, the applicant considered the value of the land and the relocation expense and normally allowed the seller to remove crops and material. This led, over a three-year purchase period, to an average price of $532/acre. Local authorities confirmed that land comparable to that purchased for the generating station was valued at between $270 and $400 per acre. Thus, it appears that a fair market price was paid for the land. However, the staff recognizes that there are components of the costs for relocation for which there may be no possibility of compensation.

11.7.7 Archaeological surveys

(ACHP A-2, INT A-49)

Excavation and testing of the archaeological sites have been completed. The recovered materials are being studied, and a report is being prepared by Arthur H. Rohn and C. Martin Stein of the Wichita State University Archaeology Laboratory. Under the guidelines of 10 CFR 800.4(a)2, the staff, in consultation with State Archeologist Thomas A. Witty and with Arthur H. Rohn, concludes that the property does not meet the criterion for eligibility for inclusion in the National Register.

11.8 LOCATION OF PRINCIPAL CHANGES IN THE STATEMENT IN RESPONSE TO COMMENTS

Topic commented upon	Agency commenting	Section where topic is addressed
Baffle dikes and channel locations	KGE A-18	2.2
Circulating water intake structure	KGE A-18	2.3
Channel velocities	KGE A-19	3.4.3
Blowdown	KAN A-3, KGE A-20, KGE A-24, KAN A-41	3.4.3, 5.3.2, 5.3.3
Makeup water	KGE A-19, KGE A-20, KGE A-24, EPA A-56	3.4.3, 5.5.2.2
Chlorination	KGE A-20	3.6.1, 5.5.2.3
Siltation controls	AGR A-4, KGE A-20, KGE A-23, KAN A-41, EPA A-55	4.3.2.1, 4.5.2
Reduced flow in Wolf Creek	INT A-47, INT A-48	4.3.1.3
Wildlife mitigation	INT A-48	4.5.2
Water rights	AGR A-4, KAN A-42	5.2.1
Water availability	ARM A-6, ARM A-16, INT A-46	5.2.1
Radiological assessment	COM A-16	5.4
Downstream effects of plant operations	KGE A-24, KAN A-41, INT A-47, EPA A-55	5.5.2.1
Sport fishery in the Neosho River	INT A-47	5.5.2.1
Preoperational monitoring	KGE A-24, KGE A-27, EPA A-56	5.5.2.3, 6.1.3.1
Cooling lake effect on the atmosphere	COM A-15	5.6.6
Operational monitoring	KGE A-28, EPA A-56	6.1.3.2
Dry cooling towers	ERDA A-44	9.2.1.3
Alternate transmission line routing	KGE A-29, INT A-48	9.2.4
Air quality	EPA A-56	10.1.1.3
Fossil fuel alternative	IES A-14	Appendix D, Table D.4
State of Kansas stream standards	ERDA A-44	Appendix F

REFERENCES FOR SECTION 11

1. F. B. Cross, *Handbook of Fishes of Kansas,* University of Kansas Museum of Natural History, Lawrence, 1967.

2. G. E. Hutchinson, *A Treatise on Limnology,* Vol. I, John Wiley and Sons, Inc., New York, 1957.

3. Committee on Water Quality Criteria, *Water Quality Criteria, 1972,* National Academy of Sciences—National Academy of Engineering, 1972.

4. Joint Federal-State-Private Conservation Organization Committee, *Ecological Planning and Evaluation Procedures,* Washington, D.C., January 1974.

5. U.S. Army Corps of Engineers, *Reservoir Regulation Manual for Council Grove, Marion, and John Redmond Reservoirs, Upper Grand (Neosho) River, Kansas,* Tulsa, Oklahoma District, June 1969.

Appendix A

COMMENTS ON DRAFT ENVIRONMENTAL STATEMENT

BY AGENCIES AND INTERESTED PARTIES

Advisory Council
On Historic Preservation
1522 K Street N.W. Suite 430
Washington D.C. 20005

RECEIVED
JUL 18 1975

July 15, 1975

Mr. Gordon K. Dicker, Chief
Environmental Projects Branch 2
Division of Reactor Licensing
Nuclear Regulatory Commission
Washington, D. C. 20555

STN 50-482

Dear Mr. Dicker:

This is in response to your request of July 3, 1975 for comments on the draft environmental statement (DES) related to the construction of the Wolf Creek Generating Station, Kansas. Pursuant to its responsibilities under Section 102(2)(C) of the National Environmental Policy Act of 1969, the Advisory Council has determined that the DES appears adequate concerning compliance with Section 106 of the National Historic Preservation Act of 1966.

However, with respect to compliance with Executive Order 11593, "Protection and Enhancement of the Cultural Environment" of May 13, 1971, the Council notes that the proposed undertaking will affect at least five (5) archeological sites which possess "the potential for scientific knowledge," (DES page 2-6) thus possibly meeting the criteria for inclusion in the National Register of Historic Places.

Because these properties appear to meet the criteria for inclusion in the National Register, they are entitled to the protection afforded them by the Executive Order 11593. Therefore, pursuant to Section 800.4(a)(2) of the "Procedures for the Protection of Historic and Cultural Properties" (36 C.F.R. Part 800), which sets forth the steps for compliance with the Executive Order 11593, the Council requests that the Nuclear Regulatory Commission (NRC) request in writing an opinion from the Secretary of the Interior respecting these properties eligibility for inclusion in the National Register and inform us of the findings. The NRC is reminded that should the Secretary of the Interior determine the properties are eligible for inclusion in the National Register, it must afford the Council an opportunity to comment on the undertaking's affect upon the cultural resources in accordance with the procedures prior to proceeding with the project.

7645

The Council is an independent unit of the Executive Branch of the Federal Government charged by the Act of October 15, 1966 to advise the President and Congress in the field of Historic Preservation.

Until the requirements of the Executive Order 11593 and the procedures are met, the Council considers the DES to be incomplete in its treatment of archeological, historical, architectural and cultural resources. To remedy this deficiency, the Council will provide substantive comments on the undertaking's effect upon the cultural resources through the compliance process outlined in the procedures. Please contact Brit Allan Storey of the Council staff at P. O. Box 25085, Denver, Colorado 80225, telephone number (303) 234-4946, to assist you in completion of this process as expeditiously as possible to avoid any unnecessary delays in the implementation of the project.

Sincerely yours,

Michael H. Bureau
for
Louis S. Wall
Assistant Director, Office of
Review and Compliance

THE STATE OF KANSAS

WATER RESOURCES BOARD

4th Floor, Mills Building
109 W. 9th Street
Telephone (913) 296-3185
TOPEKA, KANSAS 66612

July 18, 1975

Mr. D. C. Scaletti
NRC Environmental Project Manager
Division of Reactor Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Scaletti:

The Water Resources Board has reviewed the U.S. Nuclear Regulatory Commission draft environmental statement related to the construction of the Wolf Creek generating station, your docket number STN50-482. The following comments on your report are submitted for your review prior to final publication of the draft environmental statement. Comments are broken into two areas; the first deals with specific comments, and the second deals with general and editorial suggestions.

Specific comments

Comment 1. The environmental statement indicates blow down from the cooling lake will be discharged into Wolf Creek and thence into the Neosho River. The Water Resources Board has been informed that a decision relative to the point of discharge for blow down water has not been finalized pending the outcome of discussions with the state pollution control authorities and the Environmental Protection Agency. If blow down is discharged to Wolf Creek at an average rate of 3.5 cfs and up to a maximum of 40 cfs, please advise as to the change in depth of water along Wolf Creek and whether or not such flows will prevent low water crossing or prohibit domestic animal access to the stream. Please advise on the frequency of blow down in excess of 3.5 cfs as noted on page 5-23.

An operational monitoring program is discussed on pages 6-7, however, discussion does not specify the type of monitoring which will be required along Wolf Creek. Please advise on your recommendation for measuring the quality and quantity of blow down water.

Comment 2. Table 1.1 indicated the permits or approval required for construction and operation of the Wolf Creek generating station. Your attention is called to several errors in the table. Under the heading "Agency", the Kansas Water Resources Board, on August 16, 1973, stated the cooling lake was not inconsistent with the Kansas State Water Plan. However, a permit for the construction of the dam will have to be secured from the Division of Water Resources, State Board of Agriculture. A contract for water from the state owned water supply storage in John Redmond Reservoir will be required and must be obtained from the Kansas Water Resources Board. A water right will also have to be secured from the Division of Water Resources, State Board of Agriculture, to impound water from Wolf Creek.

Comment 3. On page 2-10, there are a number of errors in the numerical values sited for John Redmond, Council Grove, and Marion reservoirs. Data in the environmental statement for John Redmond and Council Grove reservoirs are based upon the lakes without full water supply storage. The Kansas Water Resources Board has signed an agreement with the U.S. Government to purchase the storage in both John Redmond and Council Grove reservoirs. The top of the conservation pool, in the case of John Redmond Reservoir, is 1039 msl. Thus, the last sentence of paragraph 1 would read, "The allocation of flood control and conservation storage is 562,500 acre-feet and 82,100 acre-feet, respectively." In the second paragraph, under John Redmond Reservoir, the maximum pool elevation attained was elevation 1066.8 msl on October 17, 1973. In the case of Council Grove Reservoir, a similar situation exists. The third sentence in the paragraph should read, "The allocation of flood control and conservation storage is 63,700 acre-feet and 50,600 acre-feet, respectively." The last sentence should read, ". . . the maximum pool elevation was 1283.7 msl. . ." In the case of Marion Reservoir, maximum pool elevation was 1056.6 msl on October 14, 1973.

Comment 4. On page 2-11, the period of record should be updated from 1965. Maximum discharge for the Neosho River at Americus is 10,900 cfs recorded on June 27, 1969. There are several inconsistencies in the definition of minimum flows, a careful review is suggested.

Comment 5. On page 3-2, figure 3.2 indicates a lime softening system in the diversion line from John Redmond Reservoir. We understand the lime softening process has been deleted. Does this mean 1.34 cfs not needed for the lime softening process will be used for lake make up?

Comment 6. Page 2-2, figure 2.2 shows the existence of an impounded lake created by baffle dike "B". Have environmental or thermal studies been made on this impoundment?

8025

Mr. D. C. Scaletti
Page 3
July 18, 1975

Editorial comments

On page ii, reference is made to types of rare or endangered fish populations. Your attention is called to a recent publication by Frank B. Cross and Joseph P. Collins, University of Kansas, entitled Fishes in Kansas. Their report does not show the existence of high-fin carp suckers in the area of the stream feeding into the reservoir.

On page 5-2, paragraph 5.2.1, in the third paragraph, sixth line, the word should be "quantity" and not "quality".

The opportunity to review the draft environmental statement on the Wolf Creek generating station is appreciated; and if we can further clarify any of the questions, feel free to contact us.

Sincerely,

Keith S. Krause

Keith S. Krause
Executive Director

KSK:dk

cc: Mr. M. Miller
Kansas Gas and Electric Co.

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, D.C. 20250

July 31, 1975

Mr. Gordon K. Dicker, Chief
Environmental Projects Branch 2
Division of Reactor Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Dicker:

The Draft Environmental Statement related to construction of the proposed Wolf Creek Generating Station appears acceptable from an agricultural standpoint. The statement gives due consideration to the impacts of the facility on agricultural production, water use, and water quality.

Temporary but significant changes in the suspended sediment levels of both Wolf Creek and Neosho River waters are expected during the construction of the facility. This situation will be aggravated, as pointed out in the environmental statement, by the high probability of heavy rains occurring over the site. The commitments made by the applicant and the additional precautions recommended by the staff of the U.S. Nuclear Regulatory Commission are designed to keep water turbidity to an acceptable level and appear adequate. During periods of low flow some consideration might be given to a release of water from John Redmond Reservoir over and above that required to maintain water quality in the Neosho River at Chanute.

The withdrawal of makeup water from the John Redmond Reservoir, estimated to average 34,000 acre-ft. per year, is expected to extend the duration and severity of low flow conditions in the Neosho River downstream of the dam. The effect of this reduced flow on aquatic life in the river has been considered. Some consideration of its effect on water users downstream of the John Redmond Dam seems desirable.

Sincerely,

H. L. Barrows
Deputy Assistant Administrator

8340

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Box 600, Salina, Kansas 67401

August 4, 1975

Mr. Gordon K. Dicker, Chief
Environmental Projects Branch 2
Division of Reactor Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Dicker:

The Draft Environmental Statement related to the construction of the Wolf Creek Generating Station (Docket No. STN 50-482) addressed to the Soil Conservation Service has been reviewed.

We note that there will be a change in land use on 3,282 acres of cultivated land, 5,519 acres of hay and pasture land, and 1,699 acres of woodland and miscellaneous land. This is a total of 10,500 acres. Approximately 5,300 acres will be occupied by the power plant, dam, cooling lake, and related facilities. The remaining acres would be planted or remain in permanent vegetative cover.

We note also that measures have been considered to adequately protect the soils from erosion during and after construction.

The Soil Conservation Service has provided the Kansas Gas and Electric Engineering Firm in Chicago and their headquarters in Wichita with our standards and specifications for applicable soil and water conservation practices. We understand that KG&E will soon be a Coffey County Conservation District cooperator. This will provide us the opportunity to give assistance on a continuing basis as may be desired.

We suggest that the agricultural production losses should be listed in the Summary and Conclusions Section of this statement.

This project has minimal adverse impacts on the resources within our agency's expertise or jurisdiction.

We appreciate the opportunity to review and comment on this draft statement.

Sincerely,

Robert K. Griffin
Robert K. Griffin
State Conservationist

cc:
Dr. Fowden G. Maxwell, Coordinator of Environmental Activities,
Office of the Secretary, USDA, Washington, D. C.
R. M. Davis, Administrator, SCS, Washington, D. C.
Council on Environmental Quality - 5 copies

8556

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
POST OFFICE BOX 61
TULSA, OKLAHOMA 74102

SWTED-PE

6 August 1975

Director
Division of Reactor Licensing
Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Washington, DC 20555

RECEIVED 8-13-75 U.S. NUCLEAR REGULATORY COMMISSION MAIL SECTION

Dear Sir:

We have reviewed the draft environmental statement related to the construction of the Wolf Creek Generating Station located near John Redmond Reservoir. We feel that the draft statement adequately addresses the effects on the environment and on the operation of John Redmond Dam and Reservoir; however there is one point that needs to be cleared up.

John Redmond Reservoir was authorized for the purposes of flood control, water supply, water quality, recreation, and fish and wildlife. The Corps is presently negotiating a contract with KWRB for all water supply storage in John Redmond, providing them the right to direct all withdrawals and releases and sales to others. The EIS states a need for 26.45 MGD from John Redmond, although the John Redmond General Design Memorandum gives the estimated yield as 24.5 MGD for a deficiency of 1.95 MGD. The report is not clear on alternative sources and the impacts of the effects of other near-term and future supplies.

We appreciate the opportunity to review this draft statement.

Sincerely yours,

WELDON M. GAMEL
Chief, Engineering Division

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

8594

Christopher S. Bond
Governor

State of Missouri
OFFICE OF ADMINISTRATION
Jefferson City 65101

J. Neil Nielsen
Commissioner

Mark L. Edelman
Deputy Commissioner

August 7, 1975

RECEIVED 8-13-75 U.S. NUCLEAR REGULATORY COMMISSION MAIL SECTION

U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, D.C. 20202

Dear Sir:

Subject: Draft Environmental Statement related to construction of Wolf Creek Generating Station, Docket No. STN 50-482 OA 75070037

The Division of State Planning, as the designated State Clearinghouse, has coordinated a review of the above referred draft environmental impact statement with various concerned or affected state agencies pursuant to Section 102(2)(c) of the National Environmental Policy Act.

None of the state agencies involved in the review had comments or recommendations to offer at this time.

We appreciate the opportunity to review the statement and anticipate receiving the final environmental impact statement when prepared.

Sincerely

Terry L. Rehma
A-95 Coordinator

STATE OF KANSAS

Department of Administration

DIVISION OF PLANNING AND RESEARCH

Topeka, Kansas 66612

August 8, 1975

AUG 14

U.S. Nuclear Regulatory Commission
Division of Reactor Licensing
Washington, D.C. 20555

Re: Kansas Gas and Electric Company
Wolf Creek Draft Environmental
Statement, Docket No. STN 50-482
Clearinghouse Number 2137-24.998 (ES)

Sirs:

The referenced project has been processed by the Division of State Planning and Research under its clearinghouse responsibilities described in Circular A-95.

There are no objections to the proposed project, however, we are enclosing comments made by the following state agencies:

Office of Comprehensive Health Planning
State Highway Commission
Water Resources Board
State Corporation Commission
State Conservation Commission

Sincerely,

Walter H Plosila

Dr. Walter H. Plosila
Acting Director
Division of State Planning and Research

WHP:rb

enc.

9578

State Clearinghouse
State of Kansas

REQUEST FOR ACTION ON PROPOSAL (UNDER OFFICE OF MANAGEMENT AND BUDGET CIRCULAR A-95)

Agency Name John D. McNeal - State Highway Commission	
Clearinghouse Number 2137-24.998(ES)	Applicant's Name Nuclear Regulatory Commission
Expected Filing Date	Project Title Environmental Statement of Wolf Creek Generating Station
RETURN NO LATER THAN July 28, 1975	Return to Division of the Budget, Department of Administration, 1st Floor, Statehouse, Topeka, Kansas 66612

The enclosed proposal has been submitted to the Division of the Budget under its clearinghouse responsibilities described in Office of Management and Budget Circular A-95. Your review of this proposal as it affects the interest of the state will be appreciated. Your appropriate comments concerning the proposal should be submitted to the Division of the Budget no later than the date specified above.

Comments filed on a proposal may include: (1) the extent to which the project is consistent with or contributes to the fulfillment of comprehensive planning within the state; (2) how the proposal relates to state objectives; and (3) the effect of the proposal on your agency's activities.

X No Objections

X* Request for Additional Information (discuss below)

___ Objections (discuss below)

___ Request for a Conference

COMMENTS:

* Although we have no objection to the project, there are several points of direct concern to the Highway Commission. We believe that these points should be addressed in the final environmental statement and should appreciate being advised of any action taken on the points raised prior to filing of the final statement. Please see attached memorandum for details.

John D. McNeal
State Highway Engineer
Signature

July 15, 1975

DRAFT ENVIRONMENTAL STATEMENT COMMENTS
BY THE KANSAS HIGHWAY COMMISSION
CONCERNING THE WOLF CREEK GENERATING STATION

Clearinghouse Number: 2137-24.998(ES)

US-75
Coffey County

Section 3.9.2 Access road on page 3-19 reads as follows:

The principal connection between U.S. Highway 75 and the plant site will have to be improved to accommodate an increased volume of heavily laden trucks. Widening of this connection may be necessary to speed the flow of traffic. The road does not cross any known historical or archaeological sites.

Comments:

1. What is the increased volume of traffic that will be generated by the proposed project, such as the Average Annual Daily Traffic (AADT) which should include the percent of cars and trucks? The AADT should be furnished for the year the project is completed and what it is expected to be 20 years hence.

2. We were unable to find the proposed typical section for the access road or what type of intersection or interchange is proposed at its junction with U.S. 75.

3. We were unable to locate a map or explanation of where the access road is located or where the junction with U.S. 75 would be.

Section 4.1.4 Access road and railroad spur on page 4-2 reads as follows:

Since the plant area itself is very close to a major highway, the access road will be short and its impact insignificant. A new railroad spur will be constructed from the Missouri Pacific Railroad northwest to the plant site. The total area disturbed by the spur will be approximately 150 acres.

Comment: Since the location of the access road is not shown or the type of connection to U.S. 75, we are unable to determine if the impact is significant or not. The safety aspects of the junction with U.S. 75 is of prime importance.

Section 4.4.3 Impact on community services, fourth paragraph, reads as follows:

Traffic will increase several fold on local roads. Thus, road maintenance and construction will cause a major impact on county resources (ER, p. 8.2-13).

Comment: We note that no comments were made in regard to relocation of the Federal-Aid Secondary Route (FAS-10).

General Comments:

The Environmental Statement should address the impact of the proposed facility on all affected roads in the general area. Such as: US-75 Highway, Federal-Aid Secondary Routes, (FAS-10), (FAS-153), (FAS-149), (FAS-1135), and all local roads

A map showing the location of the generating station, highway, Federal-Aid Secondary Routes, railroad spur and main access road should be included.

The Environmental Statement should include a statement that all relocated Federal-Aid Secondary Routes and that portion of Federal-Aid Secondary route (FAS-153) to be used as the main plant access road, will be upgraded to applicable geometric design standards for highway and Federal-Aid Secondary routes in Kansas.

Where will the railroad spur cross existing highways, Federal-Aid Secondary routes and local roads? What is the number of trains per day and speed? What is the proposed minimum sight distance at each crossing?

How will existing traffic be handled during construction of those items involved with roads?

How the Reactor will be transported to the site, if highways are involved, is of prime importance to the Highway Commission.

Permits will be required from the Highway Commission for any installation or construction that takes place within the limits of any highway right-of-way. This may include such things as:

1. Transmission Lines
2. Access road junctions with any highway.
3. Railroad crossings.
4. Makeup water line.

We have no objections to the proposed project but reserve the right to review and approve those items that would be involved with highway right-of-way when detailed plans are available.

John D. McNeal

John D. McNeal, P.E.
State Highway Engineer

cc: Division Engineer

State Clearinghouse
State of Kansas

REQUEST FOR ACTION ON PROPOSAL (UNDER OFFICE OF MANAGEMENT AND BUDGET CIRCULAR A-95)

Agency Name Dale Saffels - State Corporation Commission	
Clearinghouse Number 2137-24.908(ES)	Applicant's Name Nuclear Regulatory Commission
Expected Filing Date	Project Title Environmental Statement of Wolf Creek Generating Station
RETURN NO LATER THAN July 28, 1975	Return to Division of the Budget, Department of Administration, 1st Floor, Statehouse, Topeka, Kansas 66612

The enclosed proposal has been submitted to the Division of the Budget under its clearinghouse responsibilities described in Office of Management and Budget Circular A-95. Your review of this proposal as it affects the interest of the state will be appreciated. Your appropriate comments concerning the proposal should be submitted to the Division of the Budget no later than the date specified above.

Comments filed on a proposal may include: (1) the extent to which the project is consistent with or contributes to the fulfillment of comprehensive planning within the state; (2) how the proposal relates to state objectives; and (3) the effect of the proposal on your agency's activities.

X No Objections

___ Objections (discuss below)

___ Request for Additional Information (discuss below)

___ Request for a Conference

COMMENTS:

There is a strong possibility of build-up of salt deposits in Wolf Creek which can be corrected by a slight modification of design and/or operating techniques. Please see accompanying letter.

Paul B. Adams
for Dale E. Saffels, Chairman

State of Kansas

State Corporation Commission

Fourth Floor, State Office Bldg.
TOPEKA, KANSAS 66612

July 23, 1975

Division of the Budget
Department of Administration
1st Floor, Statehouse
Topeka, Kansas 66612

Gentlemen:

Pursuant to your communication under Clearinghouse Number 2137-24.998 (ES), staff offers the following comments and recommendations for your consideration.

The Draft Environmental Statement for Wolf Creek Generating Station (WCGS) states that 34,000 acre-feet of water per year will be diverted from John Redmond Reservoir to the cooling lake to make up for evaporation and blowdown losses. For a single 1150 MWe plant, operating at 75% plant factor, approximately 36,000 acre-feet of water per year will evaporate from the cooling lake. The draft report states that TDS (Total Dissolved Solids) in the cooling lake will be kept below 1200 mg/liter (1200 parts per million) by periodic blowdowns of the cooling lake into Wolf Creek. The addition of sulphuric acid will result in sulfate ions as high as 787 mg/liter in the cooling lake.

The plan specifies monitoring of the coolinglake and Neosho River to maintain environmental standards but there are apparently no such provisions for the seven miles of Wolf Creek below the dam.

Inasmuch as the draft report specifically states that blowdowns from the cooling lake will be periodic, it follows that during periods of drought pools may be formed in Wolf Creek which will permit salt build-up by evaporation. Staff finds no mention of a continuous blowdown or additional flow system to protect Wolf Creek.

Anticipated life of WCGS is 40 years which includes a drought of 5 years duration.

It is suggested that one of the following procedures should be added to the proposed system.

1. Additional water should be pumped from John Redmond Reservoir to the cooling lake to allow continuous blowdown and dilution of the water in Wolf Creek.

2. Additional and separate flushing of Wolf Creek could be accomplished by running a water line from the Neosho River at a point just below Burlington to Wolf Creek at a point just below the dam complete with pumping facilities, as indicated in the accompanying drawing. A small, continuous stream here would provide fresh water dilution, reduce the fish kill, and recycle back to the Neosho River.

   This would be especially beneficial to Wolf Creek during the 24 to 65 months when it is predicted there would be no flow below the dam from the cooling lake while the lake is being filled and when a fish kill is predicted because of stationary pools in Wolf Creek.

I extend my best regards.

Very truly yours,

for — Dale E. Saffels
Chairman

DES:pm
Enc.

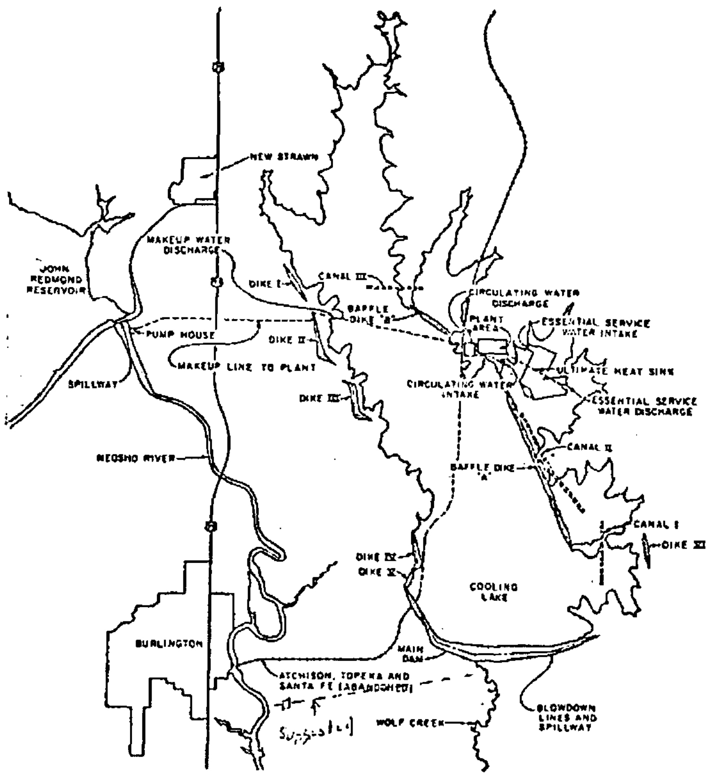

Fig. 2.2. Location of site within Coffey County, Kansas. Source: ER, Figs. 2.1-2 and 3.4-2.

The proposed plant site is to lie within an area of 10,500 acres of land. At present there are no roadway or railway networks within the immediate vicinity of the proposed plant, and according to the applicant, there is no commercial water traffic on the nearby John Redmond Reservoir or the Neosho River. The present site land use is shown in Fig. 2.4. According to present plans, construction of the cooling lake will inundate approximately 5090 acres of land, and approximately 200 additional acres will be affected by construction of the plant, the dam and related facilities.

State Clearinghouse
State of Kansas

REQUEST FOR ACTION ON PROPOSAL (UNDER OFFICE OF MANAGEMENT AND BUDGET CIRCULAR A-95)

Agency Name Raymond Solee - Office of Comprehensive Health Planning	
Clearinghouse Number 2137-24.998(ES)	Applicant's Name Nuclear Regulatory Commission
Expected Filing Date	Project Title Environmental Statement of Wolf Creek Generating Station
RETURN NO LATER THAN July 28, 1975	Return to Division of the Budget, Department of Administration, 1st Floor, Statehouse, Topeka, Kansas 66612

The enclosed proposal has been submitted to the Division of the Budget under its clearinghouse responsibilities described in Office of Management and Budget Circular A-95. Your review of this proposal as it affects the interest of the state will be appreciated. Your appropriate comments concerning the proposal should be submitted to the Division of the Budget no later than the date specified above.

Comments filed on a proposal may include: (1) the extent to which the project is consistent with or contributes to the fulfillment of comprehensive planning within the state; (2) how the proposal relates to state objectives; and (3) the effect of the proposal on your agency's activities.

____ No Objections

____ Objections (discuss below)

____ Request for Additional Information (discuss below)

____ Request for a Conference

COMMENTS:

Our review indicates that all water quality standards will be met and that there will be no significant impact on the water resources of the area, within the legal allocation of water. Normal operation of the facility when compared to background radiation indicates that environmental impact will be minimal.

Raymond R. Solee, Director
Signature

State Clearinghouse
State of Kansas

REQUEST FOR ACTION ON PROPOSAL (UNDER OFFICE OF MANAGEMENT AND BUDGET CIRCULAR A-95)

Agency Name C. F. Bredahl - State Conservation Commission	
Clearinghouse Number 2137-24.??6(ES)	Applicant's Name Nuclear Regulatory Commission
Expected Filing Date	Project Title Environmental Statement of Wolf Creek Generating Station
RETURN NO LATER THAN July 28, 1975	Return to Division of the Budget, Department of Administration, 1st Floor, Statehouse, Topeka, Kansas 66612

The enclosed proposal has been submitted to the Division of the Budget under its clearinghouse responsibilities described in Office of Management and Budget Circular A-95. Your review of this proposal as it affects the interest of the state will be appreciated. Your appropriate comments concerning the proposal should be submitted to the Division of the Budget no later than the date specified above.

Comments filed on a proposal may include: (1) the extent to which the project is consistent with or contributes to the fulfillment of comprehensive planning within the state; (2) how the proposal relates to state objectives; and (3) the effect of the proposal on your agency's activities.

____No Objections

____Objections (discuss below)

____Request for Additional Information (discuss below)

____Request for a Conference

COMMENTS:

Conservationists in general are concerned with the removal of the 12,000 acres of land from productive uses and those in the Coffey County area are somewhat skeptical of having a nuclear power plant for a neighbor. We, however, have no objections or comments with respect to the information included in the environmental statement.

C. F. Bredahl

State Clearinghouse
State of Kansas

REQUEST FOR ACTION ON PROPOSAL (UNDER OFFICE OF MANAGEMENT AND BUDGET CIRCULAR A-95)

Agency Name Keith S. Krause - Water Resources Board	
Clearinghouse Number 2137-24.998(ES)	Applicant's Name Nuclear Regulatory Commission
Expected Filing Date	Project Title Environmental Statement of Wolf Creek Generating Station
RETURN NO LATER THAN July 28, 1975	Return to Division of the Budget, Department of Administration, 1st Floor, Statehouse, Topeka, Kansas 66612

The enclosed proposal has been submitted to the Division of the Budget under its clearinghouse responsibilities described in Office of Management and Budget Circular A-95. Your review of this proposal as it affects the interest of the state will be appreciated. Your appropriate comments concerning the proposal should be submitted to the Division of the Budget no later than the date specified above.

Comments filed on a proposal may include: (1) the extent to which the project is consistent with or contributes to the fulfillment of comprehensive planning within the state; (2) how the proposal relates to state objectives; and (3) the effect of the proposal on your agency's activities.

____No Objections

____Objections (discuss below)

____Request for Additional Information (discuss below)

____Request for a Conference

COMMENTS:

Comment 1. The environmental statement indicates blow down from the cooling lake will be discharged into Wolf Creek and thence into the Neosho River. The Water Resources Board has been informed that a decision relative to the point of discharge for blow down water has not been finalized pending the outcome of discussions with the state pollution control authorities and the Environmental Protection Agency. If blow down is discharged to Wolf Creek at an average rate of 3.5 cfs and up to a maximum of 40 cfs, please advise as to the change in depth of water along Wolf Creek and whether or not such flows will prevent low water crossing or prohibit domestic animal access to the stream. Please advise on the frequency of blow down in excess of 3.5 cfs as noted on page 5-23.

An operational monitoring program is discussed on pages 6-7, however, discussion does not specify the type of monitoring which will be required along Wolf Creek. Please advise on recommendation for measuring the quality and quantity of blow down water.

Comment 2. Table 1.1 indicated the permits or approval required for construction and operation of the Wolf Creek generating station. Attention is called to several errors in the table. Under the heading "Agency", the Kansas Water Resources Board, on August 16, 1973, stated the cooling lake was not inconsistent with the Kansas State Water Plan. However, a permit for the construction of the dam will have to be secured from the Division of Water Resources, State Board of Agriculture. A contract for water from the state owned water supply storage in John Redmond Reservoir will be required and

(Continued on attached sheet.)

Keith S. Krause

must be obtained from the Kansas Water Resources Board. A water right will also have to be secured from the Division of Water Resources, State Board of Agriculture, to impound water from Wolf Creek.

Comment 3. On page 2-10, there are a number of errors in the numerical values sited for John Redmond, Council Grove, and Marion reservoirs. Data in the environmental statement for John Redmond and Council Grove reservoirs are based upon the lakes without full water supply storage. The Kansas Water Resources Board has signed an agreement with the U.S. Government to purchase the storage in both John Redmond and Council Grove reservoirs. The top of the conservation pool, in the case of John Redmond Reservoir is 1039 msl. Thus, the last sentence of paragraph 1 would read, "The allocation of flood control and conservation storage is 562,500 acre-feet and 82,100 acre-feet, respectively." In the second paragraph, under John Redmond Reservoir, the maximum pool elevation attained was elevation 1066.8 msl on October 17, 1973. In the case of Council Grove Reservoir, a similar situation exists. The third sentence in the paragraph should read, "The allocation of flood control and conservation storage is 63,700 acre-feet and 50,600 acre-feet, respectively." The last sentence should read, ". . . the maximum pool elevation was 1283.7 msl. . ." In the case of Marion Reservoir, maximum pool elevation was 1056.6 msl on October 14, 1973.

Comment 4. On page 2-11, the period of record should be updated from 1965. Maximum discharge for the Neosho River at Americus is 10,900 cfs recorded on June 27, 1969. There are several inconsistencies in the definition of minimum flows, a careful review is suggested.

Comment 5. On page 3-2, figure 3.2 indicates a lime softening system in the diversion line from John Redmond Reservoir. We understand the lime softening process has been deleted. Does this mean 1.34 cfs not needed for the lime softening process will be used for lake make up?

Comment 6. Page 2-2, figure 2.2 shows the existence of an impounded lake created by baffle dike "B". Have environmental or thermal studies been made on this impoundment?

Editorial comments

On page ii, reference is made to types of rare or endangered fish populations. Your attention is called to a recent publication by Frank B. Cross and Joseph P. Collins, University of Kansas, entitled Fishes in Kansas. Their report does not show the existence of high-fin carp suckers in the area of the stream feeding into the reservoir.

On page 5-2, paragraph 5.2.1, in the third paragraph, sixth line, the word should be "quantity" and not "quality".

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
KANSAS CITY AREA OFFICE
TWO GATEWAY CENTER, 4TH. AND STATE
KANSAS CITY, KANSAS 66101

REGION VII
Room 300 Federal Office Building
911 Walnut Street
Kansas City, Missouri 64106

August 6, 1975

IN REPLY REFER TO:
7.1P:LL

Mr. Gordon K. Dicker
Chief, Evironmental Projects Branch 2
Division of Reactor Licensing
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Dicker:

Subject: Comments on Draft Environmental Statement
Wolf-Creek Generating Station Unit I
Coffey County, Kansas

This letter is in response to your request for comments in accordance with Section 102(2)(c), Public Law 91-190, regarding the subject Draft Environmental Statement. Please be advised that this office has reviewed the subject matter and found no apparent significant environmental impact on any HUD projects within its jurisdiction.

Sincerely,

Lance Long
Environmental Officer

IES

INSTITUTE FOR ENVIRONMENTAL STUDIES

University of Wisconsin--Madison

540 WARF Building
610 Walnut Street
Madison, WI 53706

9-15-75

30 July 1975

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

Subject: Wolf Creek Generating Station Draft Environmental Statement -- Docket No. STN 50-482

Dear Mr. Scaletti:

There appears to be an error in the table (Table 4, Appendix D) that presents the basis for the SO_2 - removal equipment cost estimate. With coal having 5 percent sulfur and 10,000 BTU per pound, the minimum abatement level is 88 percent, not 76 percent, to meet the EPA emission standard of 1.2 pounds of SO_2 per million BTU. If the sulfur content of the coal were only 2.5 percent, the minimum abatement level to meet the EPA standard would be 76 percent. The annual mass flows at the bottom of the table are based on 5 percent sulfur content and would also have to be adjusted if 2.5 percent sulfur content is the desired basis.

Very truly yours,

William A. Buehring
Research Assistant
Energy Systems and Policy Research Group

8717

Recycled

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

AUG 15 1975

STN- 50-482

Mr. Gordon K. Dicker
Chief, Environmental Projects
Branch 2
Division of Reactor Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Dicker:

We have reviewed the draft Environmental Impact Statement concerning the Wolf Creek Generating Station Unit #1. On the basis of our review, we offer the following comments:

1. We recommend that the final statement address the displacement of the 25 households that will be removed due to construction of this proposed station. Will these displaced persons be adequately compensated?

2. Also, we recommend that a complete description of the final specifications of the environmental sampling program be described in the final impact statement, as well as in the provisions of the operating license.

3. It appears that there are no unacceptable impacts on community services, i.e., schools and hospitals. As noted in the draft document the local school districts are planning expansions that would more than adequately handle the anticipated influx of both transient and permanent employees.

4. We agree that a feasibility study should be undertaken by the applicant to explore the possible benefits associated with recreational use of the proposed cooling lake.

5. The calculated doses to populations and quantities of radioactivity to be released from this plant are well within the "as low as practicable"

8873

guidelines of the NRC. Similarly, the calculated doses resulting from design basis accidents would be acceptable from a public health standpoint based on the probability of their very infrequent occurrence.

Thank you for the opportunity to review the draft statement.

Sincerely,

Paul Cromwell
Acting Director
Office of Environmental Affairs

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230

STN-50-482

8-21-75

August 14, 1975

Mr. Gordon K. Dicker, Chief
Environmental Projects Branch 2
Division of Reactor Licensing
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Dicker:

The draft environmental impact statement for "Wolf Creek Generating Station Unit 1," which accompanied your letter of July 3, 1975, has been received by the Department of Commerce for review and comment.

The statement has been reviewed and the following comments are offered for your consideration.

This statement gives no indication of effects that the Wolf Creek Cooling Lake might induce on the atmosphere. The water budget and thermal analysis supplied suggests that the gross effect might be comparable to that of a natural lake approximating the whole site area in size. This would be comparable to the existing John Redmond Reservoir. We are not aware of any particular effects from that reservoir.

However, the study shows (page 9-16) that the alternative of a wet forced-draft cooling tower would increase fog incidence to ranges of at least 2-3/4 miles, and affect U.S. Highway 75. Evaporation from the cooling lake will be over twice that from a cooling tower. A large part of it must emanate from about 1 square mile of especially warm lake water within 2 miles of the western site boundary, abutting U.S. Highway 75 and the community of New Strawn. Possible off-site effects of the cooling lake should be evaluated, particularly in that vicinity.

8735

According to Table 3.7, 75 percent of the total release of noble gases to the atmosphere is by way of the gaseous waste processing system. There is no information given on the length and frequency of these releases. Since, during normal operations the gases are stored in a system of six decay tanks for 90 days, we might postulate 24 releases per year if one tank at a time was filling for 15 days and then held for the remainder of the 90 days. If these 24 releases were each over a short period such as a few hours, it is inappropriate to use an average annual dilution rate (chi/Q) such as was done in Table 5.9 to compute annual radioactive doses to individuals from gaseous effluents.

A line of leveling survey monuments are located along the abandoned Atchison, Topeka and Santa Fe Railroad, which crosses the area of the proposed cooling lake. There may also be geodetic control survey monuments in the proposed transmission line routes. If there is any planned activity which will disturb or destroy these monuments, the National Ocean Survey (NOS) requires not less than 90 days' notification in advance of such activity in order to plan for their relocation. NOS recommends that funding for the project includes the cost of any relocation required for these monuments.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving six copies of the final statement.

Sincerely,

Sidney R Galler

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
POST OFFICE BOX 61
TULSA, OKLAHOMA 74102

STN-50-482

SWTED-PE

19 August 1975

Director
Division of Reactor Licensing
Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Washington, DC 20555

Dear Sir:

Our letter of 6 August 1975 containing comments concerning the draft environmental statement for the Wolf Creek Generating Station should be supplemented with the following comments:

a. On page 3-3 the minimum make-up water rate taken from John Redmond Réservoir is 41 c.f.s. Corps yield studies indicate 38 c.f.s. as the yield capability of John Redmond for water supply. The higher yield figure appears to be due to the fact that in the Sargent and Lundy study, inflows were not adjusted for upstream reservoirs. On page 9 of Sargent and Lundy's report entitled "Cooling Systems Evaluation Wolf Creek Generating Station Units 1 and 2" dated December 10, 1973, the statement is made that flows were not adjusted for the decreased drainage area due to Marion and Council Grove. The drainage area reduction was erroneously stated at 8%. This drainage area reduction is 15% for Marion and Council Grove and with Cedar Point added, it would amount to 19%. These reductions are considered significant and should be considered in the analysis.

b. On page 5-23 the statement is made that no thermal stress will be placed on the biota at Wolf Creek or the Neosho River. However, TDS and sulfate concentrations are expected to increase in the Neosho River downstream at Wolf Creek. On page 10-1 the statement is made that releases from the cooling lake, when mixed with the Neosho River flow must meet water quality standards. It is not clear from the report, whether reliance is made upon water quality releases from John Redmond to comply with these water quality standards. If the water quality releases are required by the project design, then consideration must be given to timing the releases to coincide with releases made to maintain water quality downstream.

Sincerely yours,

for Donald R. Henderson
WELDON M. GAMEL
Chief, Engineering Division

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

9048

KANSAS GAS AND ELECTRIC COMPANY

THE ELECTRIC COMPANY

E. S. HALL
SENIOR VICE PRESIDENT

August 25, 1975

Mr. Bernard C. Rusche, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Docket No. STN 50-482
Comments on Wolf Creek
Draft Environmental
Statement

Dear Sir:

Kansas Gas and Electric Company is transmitting herewith forty (40) copies of Kansas Gas and Electric Company's comments on the Draft Environmental Statement issued in July 1975 for the Wolf Creek Generating Station. These comments include recent design progress which will be included in Revision 4 to the Wolf Creek Generating Station Environmental Report.

Very respectfully,

E S Hall

ESH:bb

201 N. Market — Wichita, Kansas — Mail Address: P. O. Box 208 / Wichita, Kansas 67201 — Telephone: Area Code (316) 264-1111

SERVICE LIST

Samuel J. Jensch, Esq.
Chief Administrative Law Judge
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Mr. Lester Kornblith, Jr.
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. George C. Anderson
Dept. of Oceanography, Univ. of Washington
Seattle, Washington 98195

Gerald Charnoff, Esq.
Shaw, Pittman, Potts & Trowbridge
910 17th Street, N.W.
Washington, D.C. 20006

Alan S. Rosenthal, Chairman
Atomic Safety and Licensing
Appeal Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

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William H. Griffin, Esq.
Assistant Attorney General
State Capitol Building
Topeka, Kansas 66612

Mr. Charles Rich, Chairman
Coffey County Commission
Coffey County Courthouse
Burlington, Kansas 66839

CERTIFICATE OF SERVICE

A copy of the within instrument was mailed, postage prepaid, on this 25th day of August, 19 75, to each of the above and foregoing persons.

E S Hall

OATH OF AFFIRMATION

STATE OF KANSAS)
) SS:
COUNTY OF SEDGWICK)

I, E.S. Hall, of lawful age, being duly sworn upon oath, do depose, state and affirm that I am Senior Vice President of Kansas Gas and Electric Company, Wichita, Kansas, that I have signed the foregoing letter of transmittal, know the contents thereof, and that all statements contained therein are true.

KANSAS GAS AND ELECTRIC COMPANY

ATTEST:

W.B. Walker, Secretary

By (E.S. Hall)
Senior Vice President

STATE OF KANSAS)
) SS:
COUNTY OF SEDGWICK)

BE IT REMEMBERED that on this 25th day of August, 1975, before me, Virginia Collins, a Notary, personally appeared E.S. Hall, Senior Vice President of Kansas Gas and Electric Company, Wichita, Kansas, who is personally known to me and who executed the foregoing instrument, and he duly acknowledged the execution of the same for and on behalf of and as the act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my seal the date and year above written.

VIRGINIA COLLINS NOTARY PUBLIC SEDGWICK CO. KANS.

Virginia Collins
Virginia Collins, Notary

My commission expires on September 25, 1977.

Enclosure 1

Kansas Gas and Electric Company

Comments on Wolf Creek Draft

Environmental Statement

Page	Section, Table or Figure	Comment
i	3-c	Revised ER Page 4.1-3 will state that the total trackage will be approximately 14 miles. The offsite track ending at the north of the plant site is approximately 10.2 miles. The right of way needed outside the plant boundary is about 144 acres. The average right-of-way width is 125 feet. DES Pages 3-19, 4-2, 4-4, and 5-22 should also be corrected. Correct makeup water line length is 2 miles.
i	3-e	The total flow of circulating and service water for one unit will be 1256 (1178 + 78) cfs.
2-2	Figure 2.2	Revised ER Figure 3.4-2 is attached showing revised baffle dike and channel locations.
2-3	Figure 2.3	Revised ER Figure 3.1-2 is attached showing a slight relocation of the circulating water intake structure.
2-6	2.2.3.1 Par 2	To maintain the river quality, the effluent released will be within water quality standards after mixing.

Page	Section, Table or Figure	Comment
2-12 and 2-14	Figure 2.7 and Figure 2.8	Figures 2.5-15 and 2.5-16 as found in Revision 3 to the ER are the correct version.
3-3	3.4.2 Par 1	The 33.5 cfs for essential service water is not used during normal operation but only during shutdown. The last line should include "through the essential service water discharge structure . . ."
3-5	Par 4	Each of the two 33.5 cfs pumps provide essential service water which discharges to the ultimate heat sink through separate 42 inch pipes.
3-5	3.4.3 Par 1	Line 4 should read, "The main dam will have a service spillway with an ogee crest of 1088 ft MSL" and should add, "An auxiliary (emergency) spillway will be provided about 1500 ft east of the service spillway and will have a crest elevation of 1090.5 feet MSL". Line 5 should read, "Within the lake two baffle dikes having crests at 1094 ft MSL and two canals having inverts at 1070 ft MSL will be built to prevent short circuiting." (See revised ER Figures 3.4-2, 3.4-2a, and 3.4-2b, attached).
3-5	Table 3.2	For the Wolf Creek cooling lake at the probable maximum flood level at the plant site elevation, volume, and surface area are 1095.2 ft, 157,900 acre ft, and 6360 acres, respectively.

Page	Section, Table, or Figure	Comment
3-6	Par 1	The volumetric water rate in the canals should be 1256 (1178 + 78) cfs. The water velocity in the cooling lake canals (Table 3.3) will not significantly change because of the new channel location and design (see revised ER Figure 3.4-2, attached). The bottom surface of the canals will be 215 ft wide and the slope of the canal sides will be 1 ft vertical per 3 ft horizontal. Water velocities in cooling lake canals can be revised in Table 3.3 to show that for one unit these velocities are 0.97, 0.33, and 0.28 ft/sec and for two units these are 1.94, 0.66 and 0.56 ft/sec for lake levels of 1075.6, 1084.8 and 1087.0 ft MSL respectively.
3-6	Par 2	The makeup water will be pumped through a 54 inch diameter pipe. The invert of this canal at the intake structure will be 995 ft MSL (see revised ER Figures 10.2-6, 10.2-7, and 10.2-8 attached).
3-6	Par 3	Water from a 30 inch pipe is fed into the canal only when reservoir level is below spillway crest. Also, water will be fed into the canal through two (2) existing 24 inch pipes whenever these have capacity in excess of their low flow discharges.

Page	Section, Table, or Figure	Comment
3-7	Par 2	Revised ER Figure 10.2-6, attached, shows makeup water canal elevation 995 ft MSL, and revised ER Figure 10.2-8, attached, (makeup water screen house) shows normal water elevation at 1007' 6" and low water level at 1003' 6". Preliminary calculations show that velocities listed in Table 3.4 will not be significantly different at these elevations. The maximum water velocity through the trash rack would be approximately 0.50 ft/sec. Revised ER Figures 10.2-7 and 10.2-6, attached, show 3-40 cfs makeup water pumps in the makeup water intake structure. Line 7 should read, "During the standard project flood it could be as high as 1028.5 ft MSL".
3-7	Par 3	Revised ER Figure 3.4-5a is attached showing two 400-gpm pumps located in the well of this discharge structure for the purpose of providing potable water and makeup water "to the demineralizing system".
3-7	Par 4	In addition to the cooling lake dam spillways, a low level outlet will be provided on the west abutment of the dam. The blowdown pipe will be combined with the low level outlet works. The center line of the blowdown pipe upstream of the dam will be at elevation 1035 ft MSL (see revised ER Figure 3.4-2b, attached).

Page	Section, Table, or Figure	Comment
3-17 and 5-31	3.6.1 Par 3	Chlorination will be used for circulating and service water systems. Provisions for a mechanical tube cleaning system is not provided. Chlorine concentration in the discharge to the cooling lake should be limited to 0.2 mg/l (average) and 0.5 mg/l (maximum) free chlorine residuals to be consistent with U S EPA effluent limitations.
3-17	3.7	ER Page 3.7-1 (Revision 3) states that a package waste treatment plant suitable for 2000 workers will be installed on the site. This system will handle 30,000 gal/day for the 8 hour workday.
3-17 and 3-19	3.8 Par 2 Table 3.10	References to La Cygne-Benton Hill transmission line should be La Cygne-Benton line.
3-19 and 4-2	3.9.3 4.1.5	The 8 inch water line carrying potable water and makeup demineralizer feedwater will pass under the lake from the makeup discharge structure.
4-9 and 4-17	4.3.2.1 Par 6 4.5.2 Item 1	Section 4.5.2 Staff Evaluation Item 1 indicates that the main dam should be constructed prior to commence of upstream construction so that an impoundment will be created that would serve as a settling basin for the rainfall runoff from subsequent upstream construction activity. The construction and use of the main dam as described is not feasible for the following reasons: 1) The schedule calls for the construction of the main dam to start 10 months after work in the plant site area starts.

Page	Section, Table or Figure	Comment

Due to the complex interrelationships among construction activities a change of this nature is not possible without substantial cost in terms of both time and money. When the main dam construction starts, the construction of the baffle dikes, channels, and dams 1 through 6 must start at about the same time because of the large quantities of earthwork involved in the material for building the dams and dikes comes from the lake bottom.

A preliminary analysis shows that the runoff due to a 10-year frequency flood from the Wolf Creek drainage area if stored by the main dam, would inundate the lake area up to an elevation of about 1,043 ft MSL. For a 2-year frequency flood, this would be an elevation of about 1,039 ft MSL. Even though a low level outlet is provided in the main dam, it would not be sufficient to prevent rapid inundation resulting from the above floods. The design of the outlet is based on a Corps of Engineers procedure for draining lakes. By using this low level drain, it would take several days to partially drain the pool of water at elevation 1,043 ft.

Page	Section, Table or Figure	Comment

Because of the elevation of the low level outlet works, it would not entirely drain this pool and there still would be a pool of about 20 ft deep at the main dam. After the area was drained to the level of the low level outlet, the surrounding ground in the borrow areas would be saturated and the material could not be used until it had dried out sufficiently. Thus, when it rained, even with a flood of only 2-years frequency, there would be a significant stoppage of work and delay of construction.

2) The start of construction for the main dam cannot be moved up a significant amount because the detail engineering is just starting for the lake work.

3) Since it will take about 2½ years to completely build the main dam, it is physically impossible to have the dam built in time to serve as a sedimentation basin.

The construction of the main dam must be such that flow through the dam to Wolf Creek must be maintained until the main dam is almost completed. If closure is made earlier in construction of the main dam, the lake will start to fill

Page	Section, Table or Figure	Comment
		up and flood the borrow areas for the main dam, baffle dikes, and dams 1 through 6. This flooding would necessitate obtaining borrow from areas outside the lake and probably outside the site property line. Also, by making dam closure early, there is a serious danger of overtopping the main dam with a flood, thus creating flooding danger to the public downstream and great economic and schedule impact on the applicant. In Section 4.1.2 of the Environmental Report, the applicant did commit to taking measures for rainfall runoff that are necessary for compliance with all applicable requirements imposed pursuant to the Federal Water Pollution Control Act Amendments of 1972. With respect to this commitment, after initial grading, the entire plant site area approximately 140 acres with the exception of the power block excavation and small peripheral area will normally either be planted to vegetation or other suitable groundcover thereby removing these areas from the coverage of the effluent limitations. The runoff from the power block excavation and its periphery will be directed to a settling basin (described below), and the effluent from the settling basin will comply with applicable limitations.

Page	Section, Table or Figure	Comment
		The settling pond that will be provided for the power block excavation area will be designed and operated as follows: a) Rainfall on the power block excavation area will be directed to the collection system for drainage into the sediment pond. b) The pond will be designed to have the recommended overflow rate (O.F.R.) for silty suspended solids of 150 GPD/FT^2 and to handle the runoff resulting from a 10 year 24 hour rainfall event. c) The pond shall be designed to pass a storm of 50 years frequency and 24 hour duration without causing damage to dike and nearby structures. Other plant site areas will be subject to the following erosion control procedures: a) Construction laydown, storage areas will be covered with gravel. Parking areas will be covered with gravel or paved, and all other disturbed areas will be seeded. b) Grading slopes will be kept at a minimum with a maximum slope of 2 percent and an average of 1 percent.

Page	Section, Table or Figure	Comment
		c) In general, runoff, will be controlled and conveyed to storm sewers. Ditches' slopes will be kept at a minimum to prevent ditch erosion. d) Provisions for safe discharge of runoff, such as riprap protection at outlets of storm sewers and culverts, will be done. In summary, the applicant feels that the above settling pond and control procedures are adequate to control rainfall runoff pursuant to the Federal Water Pollution Control Act Amendments of 1972. The staff, in proposing a requirement on runoff discharge to Wolf Creek during construction, cites a recommendation by the National Academy of Science-National Academy of Engineering Committee on Water Quality Criteria. That requirement should take into consideration the ambient conditions at the site. The applicant has performed measurements on Wolf Creek quarterly since 1973. These measurements have found that the TSS levels in Wolf Creek vary from 19 to 370 mg/l. The average of these quarterly samples in 1974 was 113 mg/l. It is important to note that even the value of 370 mg/l occurring in June 1974 was more than 36 hours after a heavy rainfall. Also, Table 2.5A-2 of the Wolf Creek Environmental Report has TSS data for Wolf

Page	Section, Table or Figure	Comment
		Creek with values as high as 132 mg/l. Other streams in the area also have high TSS levels. One instance of this is the average of monthly measurements of TSS in the Neosho River downstream of the site for 5 months of 1975 which was 170 mg/l. These values which represent conditions prior to construction indicate that an 80 mg/l limit may not be an appropriate requirement for this site.
4-12	4.3.2.4	During construction a total of 30,000 gal/day of sanitary wastes for the 8-hour workday will be discharged into Wolf Creek, which is 0.05 cfs.
4-13	4.4.3 Par 4	The reference to ER Page 8.2-13 is incorrect. ER Section 8.2.2.2, Increased Traffic, concludes that the traffic situation can be easily handled with no unusual financial burden.
4-15	4.4.4 Par 1	The total valuation of WCGS-1 is estimated to be approximately $1030 million (ER Page 8.1-20)
4-17	4.5.1 Item 2.b	It is not necessary for all debris from construction activities to be removed from the site, if it can be disposed of or utilized onsite in a manner in compliance with local and state regulations.
4-18	4.5.2 Item 3	Used oil will be collected in containers for reuse which may include pickup by oil reclaimers.
4-18	4.5.2 Item 4	Metal scrap material will be collected for pickup by scrap material handlers, not necessarily local.

Page	Section, Table or Figure	Comment
5-6	Par 5	The revised low level outlet works (Revised ER Figure 3.4-2b, attached) will not change the staff evaluation since blowdown from the cooling lake is still withdrawn from the lower cooler layers of the lake.
5-8	Par 1	The first line should read, "Most of the time the temperature differences will be less than the $5^{\circ}F$ limit at the boundary of a reasonable mixing zone permitted in Neosho River by the Water Quality Criteria for Interstate and Intrastate Waters of Kansas.
5-23	Par 6	Line 9 should read, "Temperatures of this magnitude will require a small mixing zone in the Neosho River which will be in compliance with all applicable Kansas Water (thermal) Quality Criteria, to reduce the blowdown to ambient river temperatures.
5-24	5.5.2.2 Par 1	The statement regarding water withdrawal through John Redmond Reservoir Dam should also list a third route through two 24-inch diameter existing pipes in the dam used whenever their capacity is in excess of the low flow releases.
5-24	5.5.2.2 Par 3	Delete "plunge basin from which" from Line 2 and add "which" between "canal" and "leads".

Page	Section, Table or Figure	Comment
5-30	Par 6	ER Table 3.6-3 shows a value of 460 mg/l sulfate concentration during normal conditions.
5-33	Par 2	There is no need for a general monitoring of the circulating water intake structure for fish impingement as the structure is designed for an intake velocity of 1.0 foot per second at a cooling lake elevation of 1075.6 feet MSL (see ER, Page 3.4-2; DES, Page 3-3). At lake surface elevations below this low water level, the circulating water flow rate would be adjusted to maintain a 1.0 foot per second intake velocity or fish impingement would be monitored. With higher lake elevations, of course, the intake velocity is much lower, and monitoring for fish impingement is not necessary.
6-1	6.1.3.1 Item 1	The additional habitats suggested for study should not be necessary. Ponds occurring in the site area are generally for livestock watering purposes, and do not represent wildlife habitat to any significant extent. Those below pool level will be inundated and replaced with a larger aquatic ecosystem; those above pool level will remain and the habitat will improve in quality as a result of implementation of a mitigation plan. Ponds were indirectly sampled in that a number of them are located along the 20-mile wildlife survey route, and species

Page	Section, Table or Figure	Comment
		noted using these ponds were recorded. Marshes do not occur within the proposed site: any such areas which occur as a result of lake construction will be additional habitat for marshland species, and the impact will be positive for those species. Wolf Creek passes through one study area presently being used for monitoring (floodplain woods). A mammal grid is situated within 50 feet of the bank of Wolf Creek, and avifauna transects follow the stream. Therefore, it is not necessary to sample the creek specifically as a "habitat". The Neosho River is a completely different habitat from the intermittent Wolf Creek. The applicant fails to see how wildlife studies of the Neosho River can assist in the "assessment of site preparation and construction effects". In addition, personnel of the U S Fish and Wildlife Service annually publish lists of wildlife observations within the Flint Hills National Wildlife Refuge (located on John Redmond Reservoir). It is unnecessary to duplicate surveys that are currently being conducted by the U S Fish and Wildlife Service.
6-1	6.1.3.1 Item 2	Concerning vegetational sampling, no new habitat types appear necessary or practical to study. Three northern floodplain forests have been sampled, although access is currently available to only one. No typical,

Page	Section, Table or Figure	Comment
		homogeneous oak-hickory forest exists within 20 miles of the proposed facilities and, therefore, no measurable effect of the facilities is expected on this community type. No marshes exist in the vicinity of the site. The mudflat areas of John Redmond Reservoir were qualitatively examined in 1974.
6.1	6.1.3.1 Item 3	Increasing the number of replicate stands for each community sampled is possible in some cases, and impractical or unnecessary in others. The greatest problems are access, lack of available natural communities to sample, lack of communities with sufficient homogeneity to sample, and significantly high additional costs. Additional replicas would probably demonstrate stand variation, variation in sampling techniques, and effects of grazing. If replicas were increased to three and the recommended six habitat types were added, 30 communities would be sampled. The present monitoring study utilizes six sampling periods per year. Thus, from an economic point of view, the recommended sampling program changes seem excessive. As floodplain forests will probably be environmentally stressed more than other ecosystems, additional samplings could be scientifically valuable, but gaining access to floodplain communities is a major problem.

Page	Section, Table or Figure	Comment
		The value of sampling bluestem prairie is questionable because no significant changes attributable to the proposed facility are expected in this community type.
		The value of sampling additional mixed shrub pasture and open pasture is low. Natural stresses and man-induced stresses, such as grazing pressure, will be more important in affecting these communities than impact of the new facility.
		As stated above, oak-hickory forests and marshes do not exist in the immediate vicinity of the site.
6-1	6.1.3.1 Item 4	The recommendation for sampling floodplain forests below the Wolf Creek lake is valid.
6-1	6.1.3.1 Item 5	Live-trapping of small mammals was begun during the first year of monitoring studies in 1974.
6-2	6.1.3.1	Frequency data collection should be continued rather than taking cover information. Attempts at ascertaining both density and cover values for herbaceous species are impractical due to variation of habit or growth forms among grasses and forbs. Cover values for the two habits are not directly comparable. The presence of "bunch grasses" in the prairie communities near Wolf Creek tends to amplify

Page	Section, Table or Figure	Comment
		this problem, making comparisons between grasses invalid.
		Cover estimates are inherently much more subjective than frequency measurements, causing a decrease in sampling precision. Relative frequencies give the most feasible and adequate means of determining relative importance of species in herbaceous communities.
		The staff recommendation for 1.0 m^2, rather than 0.1 m^2, quadrat-plot size for measuring frequency in herbaceous communities has no apparent value. 0.1 m^2 plots yield maximum data for that habitat type. Optimum quadrat size can be continuously debated, but in general, the usage of more samples of smaller size tends to better differentiate the relative importance of species. An infinitely small quadrat gives a measure of density, whereas an infinitely large quadrat gives simply a presence list. Quality is assured through the use of species-area curves, regardless of quadrat size. Furthermore, it does not appear practical or scientifically sound to change the plot size in the course of a monitoring study because the system presently in use is adequate and a change in plot size would make direct comparisons of monitoring and baseline data impossible.

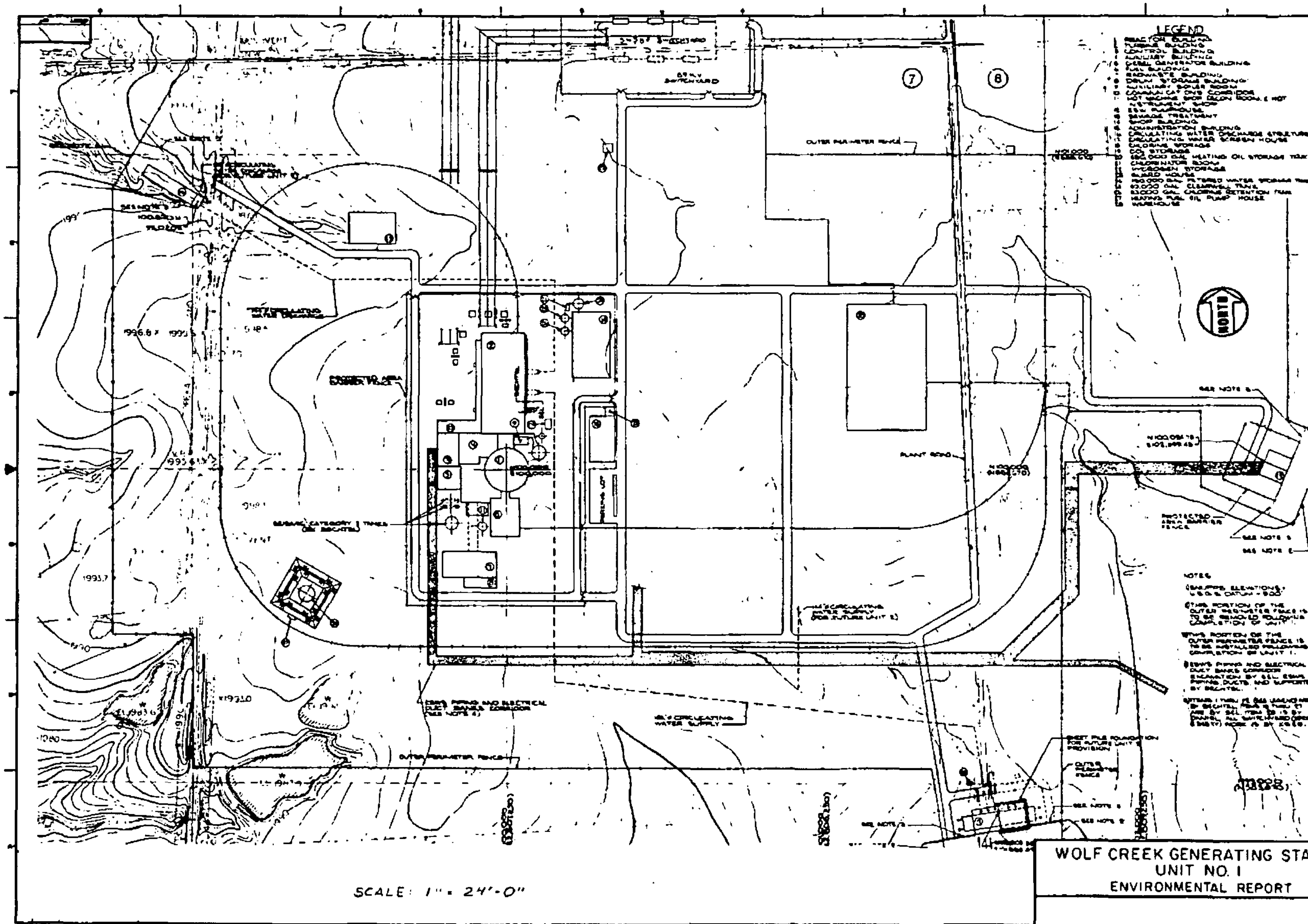
Page	Section, Table or Figure	Comment
6-2	6.1.3.1 Item 7	The increased quantity of aquatic habitat resulting from the proposed lake will greatly increase amphibian and turtle populations, and improved range and prairie conditions resulting from mitigation will provide better habitat for terrestrial prairie species. If additional herptile data is necessary, pitfall traps placed at the ends of wire mesh drift fences can be used to trap small terrestrial species, and aquatic environments may be sampled by hoop nets. An evening wildlife survey route is presently operated and this can be driven at night as well to survey nocturnal herptiles.
6-2	6.1.3.2 Par 3	Phytoplankton and zooplankton communities will be sampled monthly during the lake filling stage. This will be the time when most changes occur in these communities. However, it is our opinion that monthly sampling of other biological and chemical parameters will not yield a significant increase in data over that already collected during the preconstruction monitoring program and that quarterly sampling is adequate. We fail to see the value or rationale in collecting monthly data for zooplankton, periphyton, phytoplankton, primary productivity, benthos, fish and various chemical parameters in Wolf Creek, when it is an intermittent stream that has rapid and drastic changes in streamflow

Page	Section, Table or Figure	Comment
		which produces dynamic but often very short-term ecological changes. The baseline and preconstruction monitoring data (collected quarterly) has shown that the biota is typical for this type of stream. The ecological conditions which now exist in the portion of Wolf Creek that is to be inundated will be drastically altered after inundation and the present or existing community is not expected to play a major role in the establishment of the new community in Wolf Creek cooling lake. Present construction plans call for the building of the makeup water intake structure along the Neosho River below the John Redmond Reservoir dam. Therefore, construction activities will not affect John Redmond Reservoir proper. The Applicant cannot see the value in monthly sampling in this reservoir when it will not be directly affected. In addition, baseline data has been collected quarterly since the spring of 1972 and this data is very comparable to data collected by other investigators who have worked in the reservoir. Neosho River can be very difficult and dangerous to sample under high water conditions. There presently is very limited access to the river and no access in the immediate vicinity of the Wolf Creek confluence. We prefer sampling not more than every other month at two locations in the Neosho River (one above and one below the Wolf Creek confluence).

Page	Section, Table or Figure	Comment
		Construction activities along Wolf Creek are not expected to produce affects in the Neosho River. If the Neosho River is affected it will be minimal and short-term, and these effects could be monitored with a short-term intensive and specific study.
6-5	Par 1	The makeup water intake will be located in the Neosho River below John Redmond Reservoir. Therefore, the sampling should be conducted in the Neosho River at the proposed location and not in the John Redmond Reservoir. Quarterly sampling was begun at this location in 1975 and fish eggs and larvae were sampled for during the 1st & 2nd quarters. Sampling on a weekly basis is impracticable for the duration of the preoperational and operational programs. Fish eggs and larvae should only be sampled from April 15th through the month of June, since this is the spawning season. Sampling every other week would produce sufficient data, because changes in fish egg and larvae densities are not rapid and spawning for any given fish species will occur over a period of several days or weeks. The NRC staff also recommended fish egg and larvae sampling at different depths. This is not possible in the shallow Neosho River but will be practical in the cooling lake after it is filled.

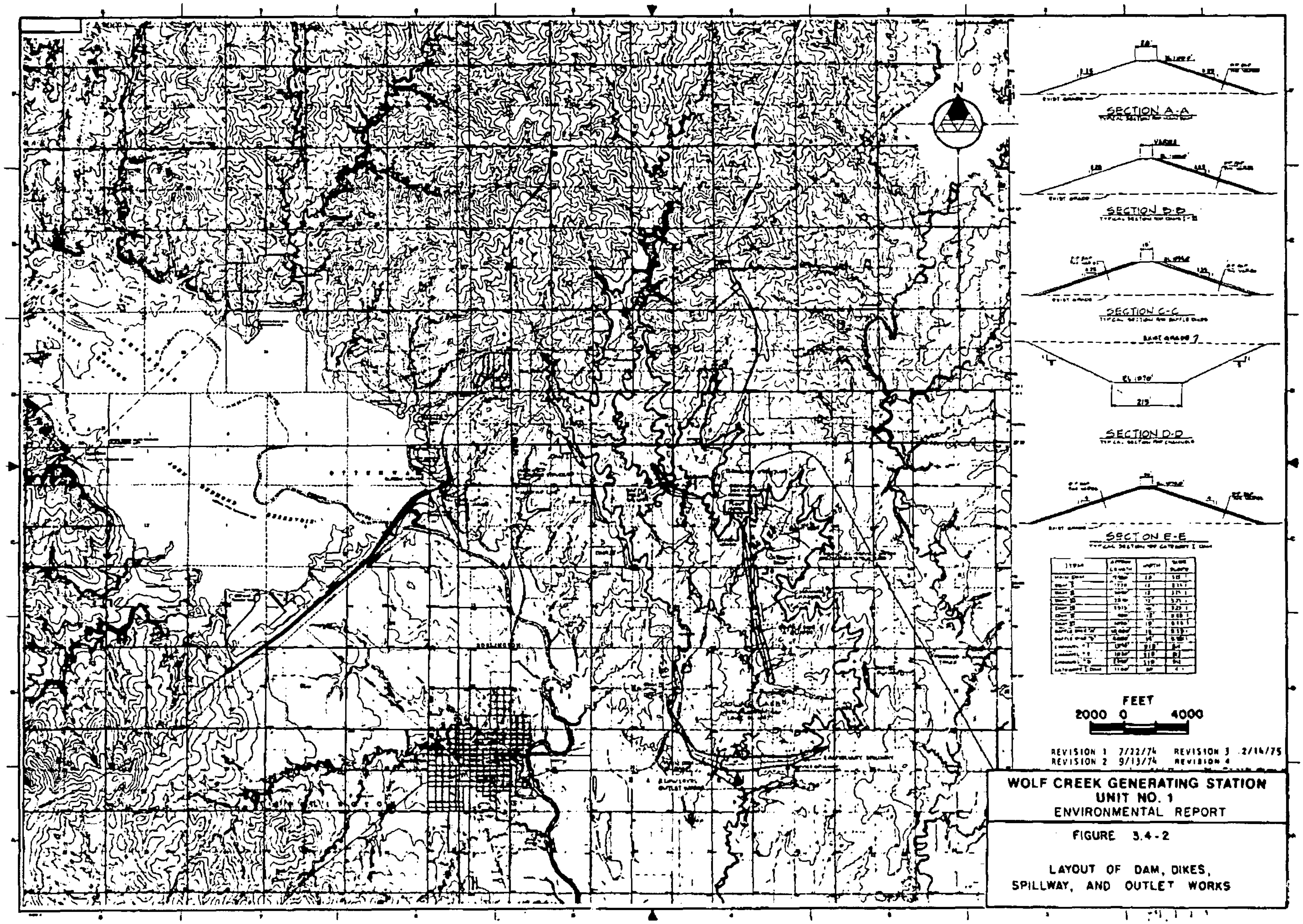
Page	Section, Table or Figure	Comment
6-5	Par 2 Item 2	Catch per unit effort data is not relevant for the kinds of fishing devices currently being used, i.e., screening, hoop netting, and shocking.
6-5	Par 2 Item 3	Creel censuses of sport fishermen would best be done by a governmental agency. Such a program is excessively costly and of questionable value.
6-5	Par 2 Item 4	Such a program has been initiated although the time period of one year prior to construction is not a valid requirement.
8-5	Table 8.4	The column labeled, "Peak-hour demand" actually reflects "System Responsibility" (see ER Tables 1.1-8a, b).
9-12	Par 1	The development costs for 5000-acre and 2500-acre cooling lakes are slightly affected due to the baffle dike and channel relocation (see revised ER Figure 3.4-2, attached) and additional engineering work. To construct the 5000 acre lake now costs 9.6 million dollars (mid-1974 dollars) more than a 2500 acre lake, whereas it would cost 41.0 million dollars to expand in 1983. These changes do not have a significant affect on the staff evaluation.
9-18	9.2.2 Par 1	An intake structure similar to the one provided for Unit 1 will be provided for Unit 2 with the same design criteria of 1.0 ft/sec intake velocity at the low water elevation 1075.6 ft MSL.

Page	Section, Table or Figure	Comment
		The Unit 1 intake velocity would be unaffected at a given lake level. Water velocity in the canals at elevation 1075.6 ft MSL will be higher than 1 ft/sec for a 2 unit plant, however, these canal water velocities will occur during the assumed drought and are not as critical as intake velocities at the circulating water intake structure for fish impingement. Considerations such as scouring and siltation are the important criteria in the design of the canals.
9-18	9.2.4	The proposed routing of the La Cygne-Benton and Wolf Creek-Rose Hill lines are as shown on ER Figure 3.9-2, Revision 3. This routing was revised to: a) Avoid double circuit construction of the connections to Wichita and thus improve reliability of service to the Wichita area. b) Avoid engineering problems and associated construction costs inherent in previous design which are ultimately passed on to the customer.



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT

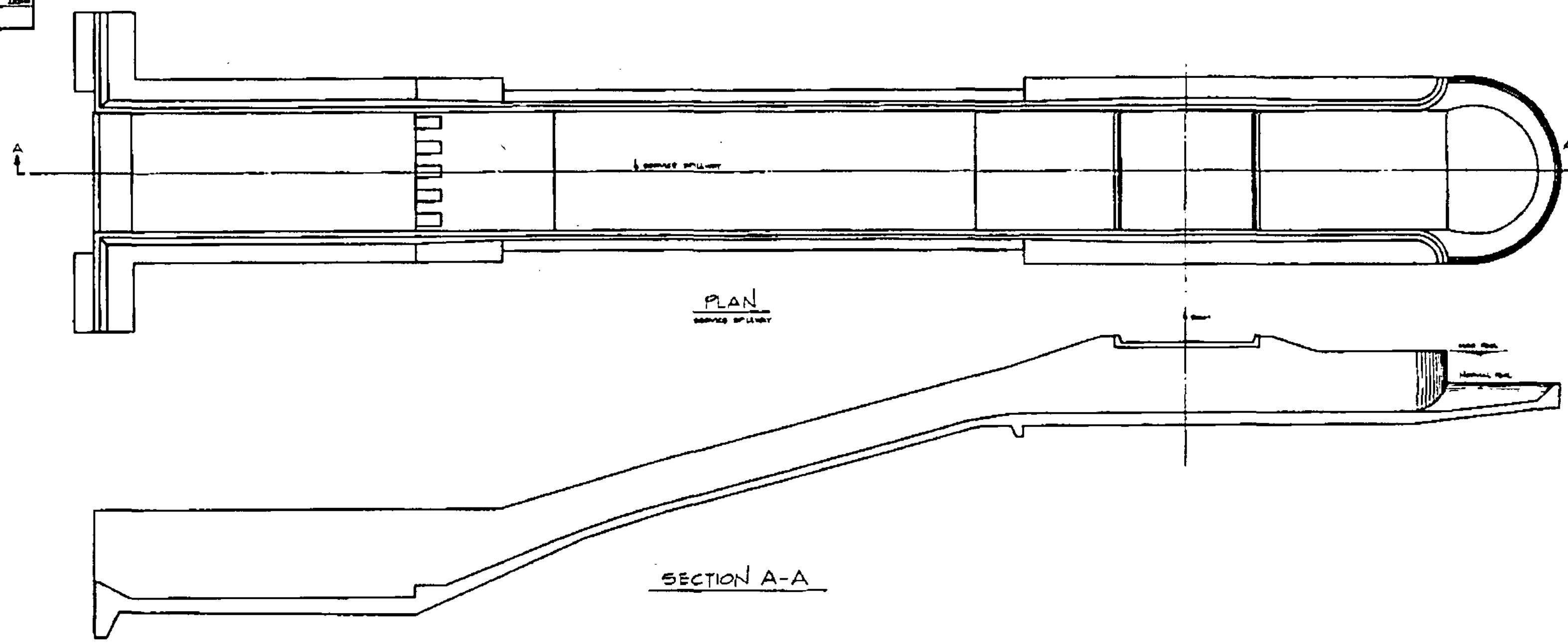
FIGURE 3.1-2
ARRANGEMENT AND LOCATION
OF PLANT STRUCTURES



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT

FIGURE 3.4-2

LAYOUT OF DAM, DIKES, SPILLWAY, AND OUTLET WORKS

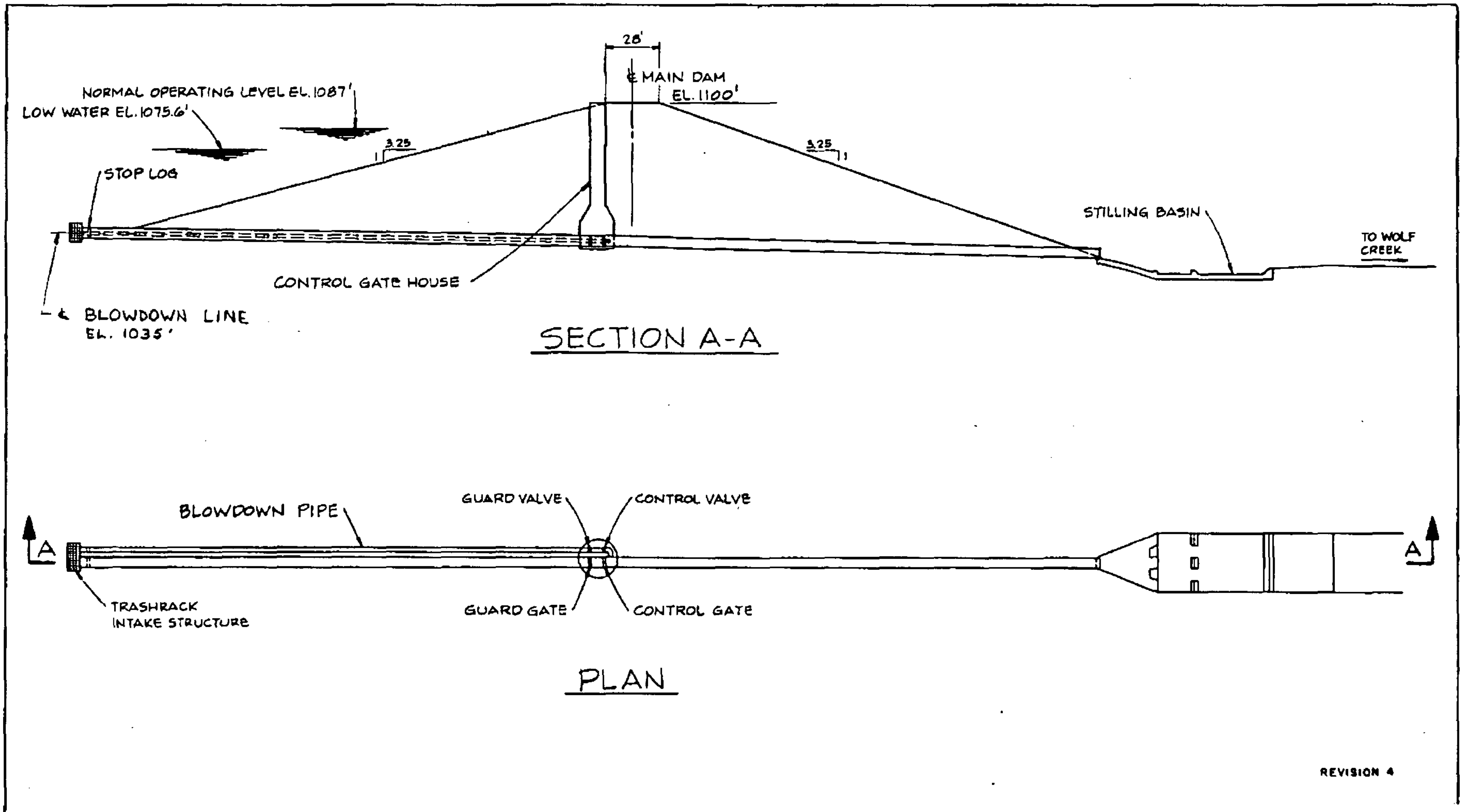


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT

FIGURE 3.4-2a

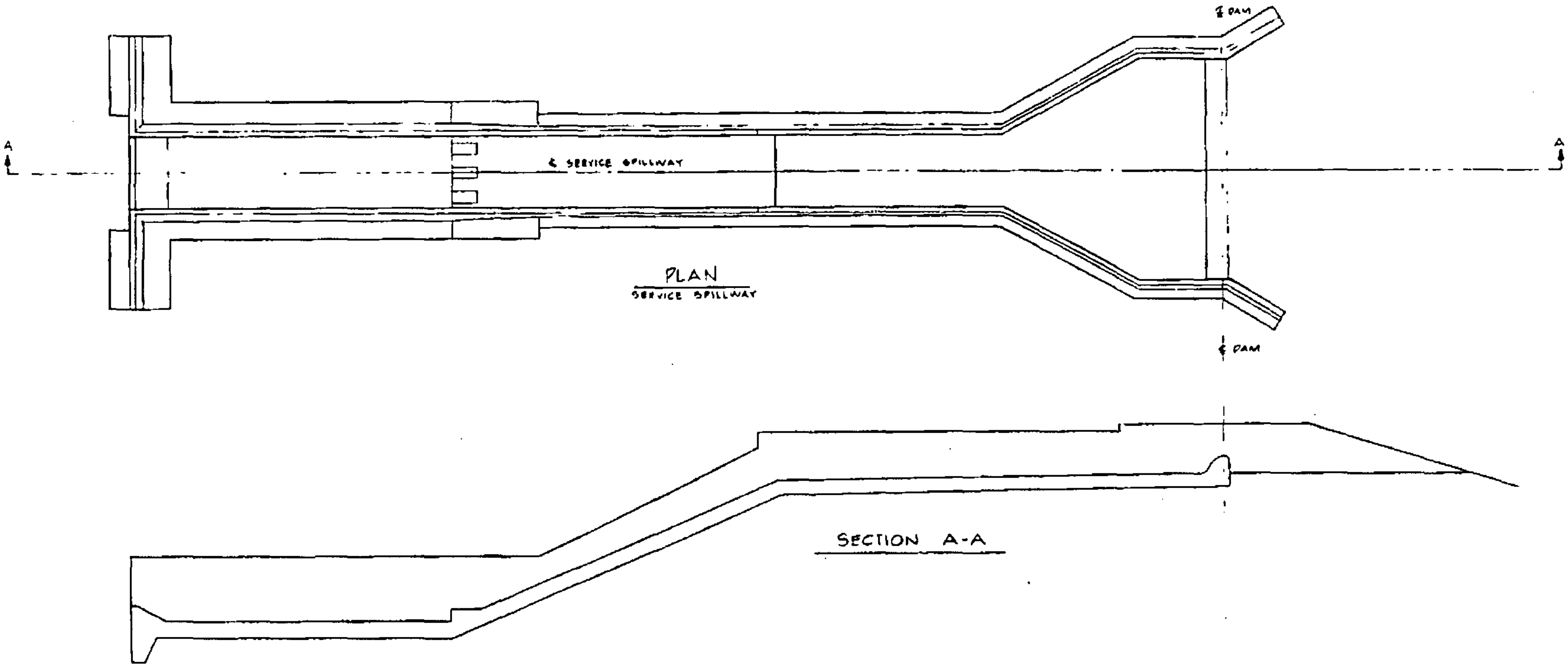
SERVICE SPILLWAY

7/22/74 REVISION 1
REVISION 4



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT

FIGURE 3.4-2b
OUTLET AND BLOWDOWN
STRUCTURES



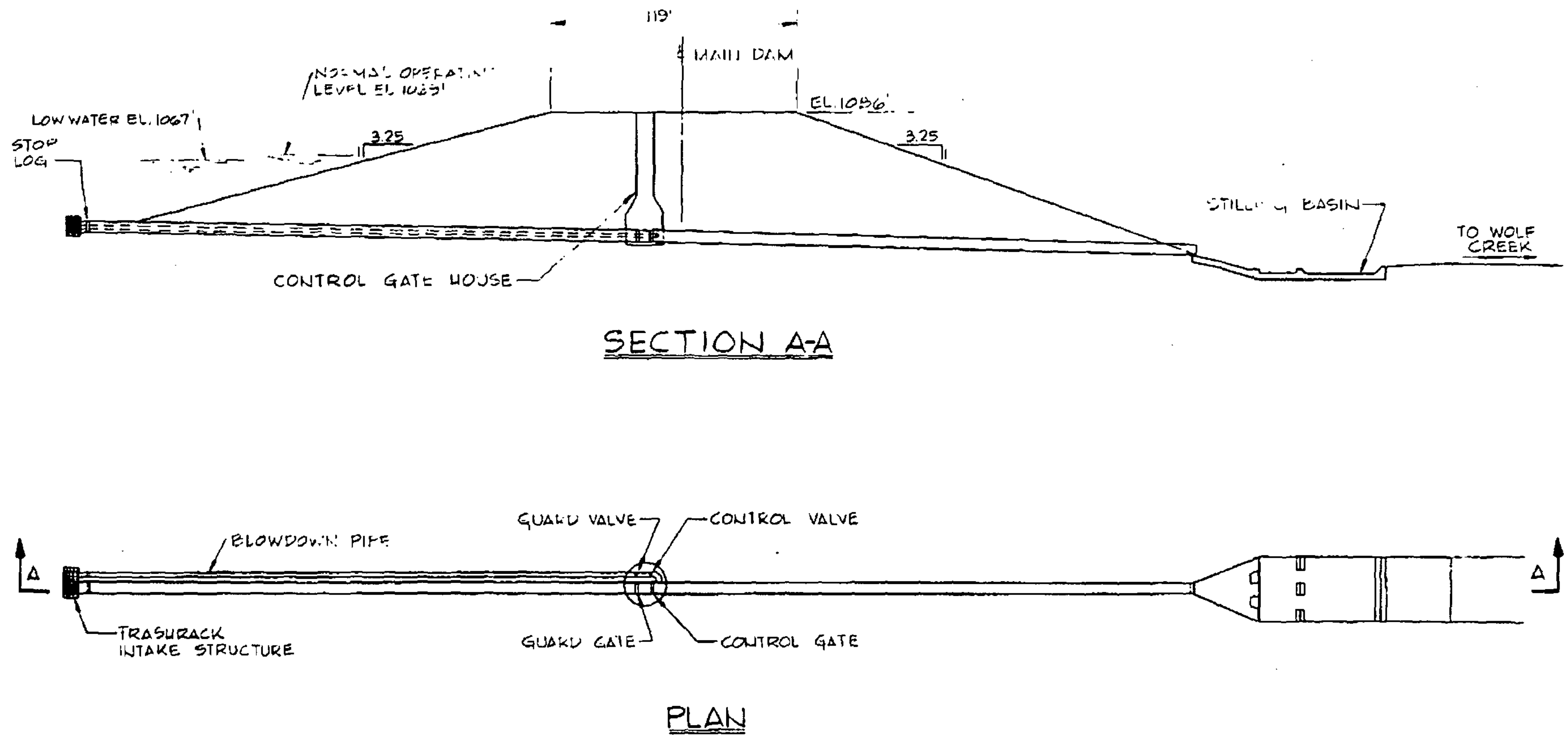
REVISION 4

REVISION 3 2/14/75

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT

FIGURE 10.1A-6

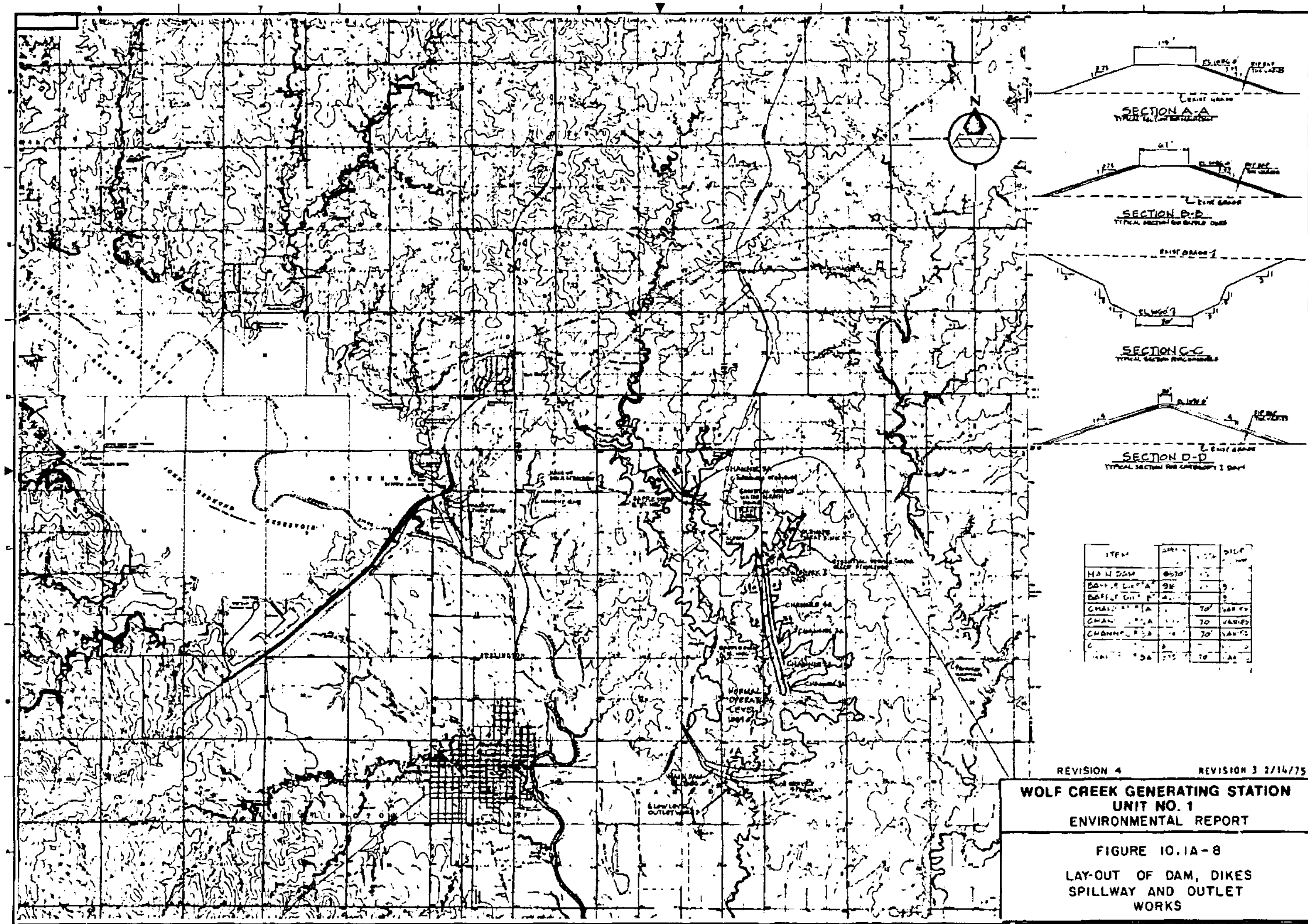
SERVICE SPILLWAY



REVISION 4

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT

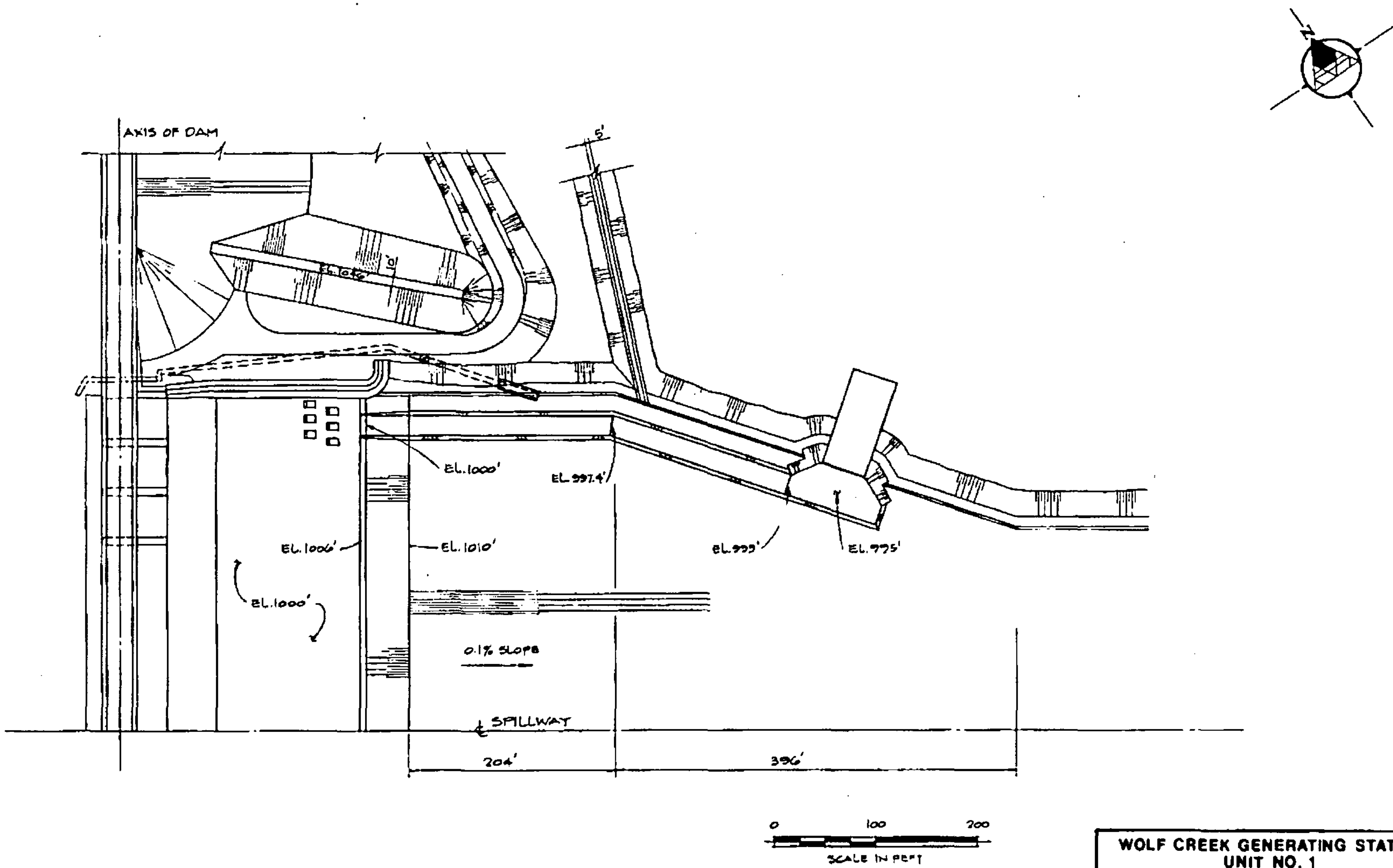
FIGURE 10.1A-6A
OUTLET AND BLOWDOWN STRUCTURES



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT

FIGURE 10.1A-8

LAY-OUT OF DAM, DIKES SPILLWAY AND OUTLET WORKS

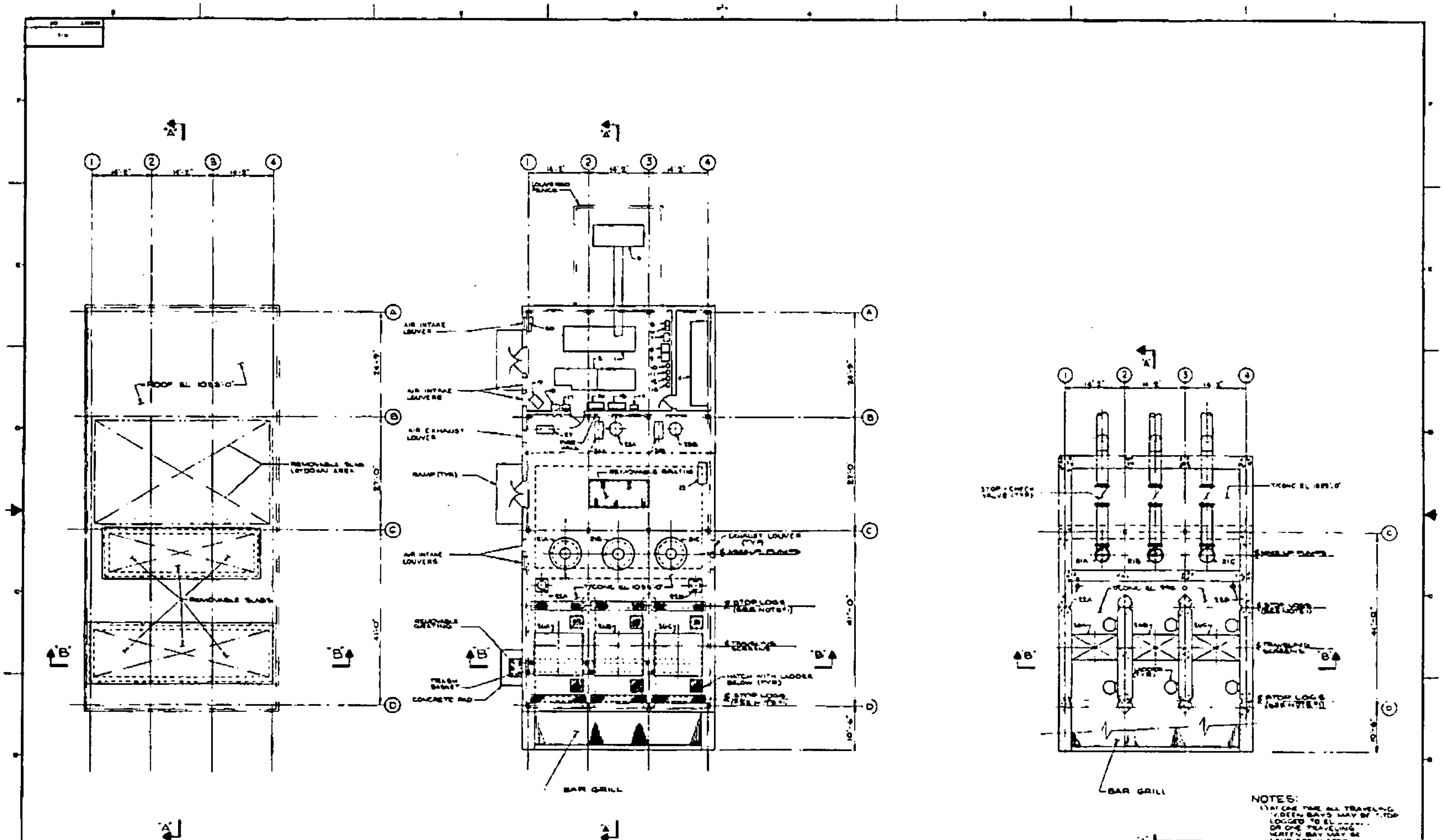


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT

FIGURE 10.2-6

MAKE-UP CHANNEL AT
JOHN REDMOND RESERVOIR

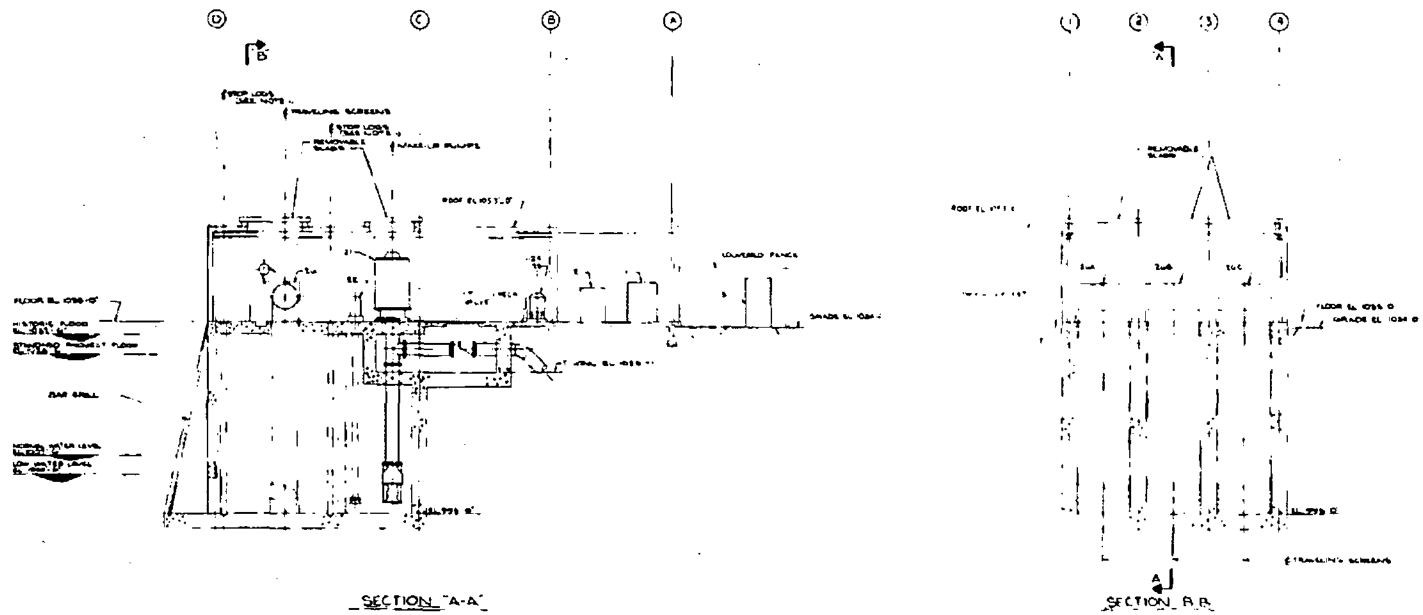
REVISION 4 9/13/74 REVISION 2



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT

FIGURE 10.2-7
CONVENTIONAL MAKEUP SCREENHOUSE
ON DISCHARGE CHANNEL
PLAN VIEW

REVISION 4



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT

FIGURE 10.2-8
CONVENTIONAL MAKEUP SCREENHOUSE
ON DISCHARGE CHANNEL-SECTIONS

REVISION 4

STATE OF KANSAS

OFFICE OF THE GOVERNOR
State Capitol
Topeka

ROBERT F. BENNETT
Governor

August 25, 1975

Mr. Gordon K. Dicker, Chief
Environmental Projects Branch
Division of Reactor Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Dicker:

Review has been made of the Draft Environmental Statement prepared by your office relating to Construction of the Wolf Creek Generating Station. Environmental aspects of the project have been studied by the Kansas Department of Health and Environment, the comments of which are included herein.

State agencies of Kansas have been working with the Kansas Gas and Electric Company and its project consultants for approximately the past eight years in the formulation of the Wolf Creek project. It is the opinion of the Department of Health and Environment that major environmental aspects have been developed in a sound manner; and that, through arbitration with the company, all state statutory environmental requirements can be satisfied. The risks associated with accidental radiation exposure from the site appear to be adequately analyzed in the draft Environmental Statement, and we concur that the radiation hazards are minimal. When compared to the natural background radiation for the site, the release of radioactive materials from normal plant operation will be insignificant.

The primary environmental concern associated with plant operation will be blowdown releases from the cooling lake, in terms of maintenance of chemical and thermal water quality standards for protection of beneficial water uses in the Neosho River. The

applicant is proposing a variable blowdown release rate, correlated to streamflow of the Neosho River, to maintain water quality standards below the discharge point. This requirement, supported by a monitoring program, will be stipulated as a condition of the National Pollutant Discharge Elimination System permit to be issued for the station by the Division of Environment, in order to assure the protection of downstream water uses. In addition to monitoring done by the applicant, the Division of Environment is operating monitoring programs which will track environmental conditions in the vicinity of the project throughout the life of the facility.

The alternatives to construction of the Wolf Creek Generating Station, including the timing of project commencement, have been investigated and presented by the Kansas Gas and Electric Company, and appear to be adequately reviewed in the draft Environmental Statement. The major alternatives for other energy systems, sites, and heat dissipation methods are currently less palatable from the standpoint of overall impact on the environment.

With regard to the specific content of the draft Environmental Statement, the following comments are raised for your consideration:

1. Several errors appear in Section 4.5.1, paragraph 2.a. which lists applicant commitments to state water quality requirements:

   a. The standards shown are stream standards rather than effluent standards as stated in the opening remarks;

   b. These standards apply to the Neosho River, a Class B water, but not to Wolf Creek, which is unclassified under the state water quality regulations;

   c. The standard shown for Bacteria is a Class A water standard and does not apply to the Neosho River. The applicable Class B water standard reads as follows:

   "The fecal coliform content shall not exceed 2,000 per 100 ml sample;"

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Mr. Gordon K. Dicker
August 25, 1975
Page 3

d. The limits shown for clorine, five day BOD, and suspended solids are not state standards and should not be identified as such.

2. With regard to thermal effects of cooling lake discharge to the Neosho River, as discussed in section 5.5.2.1., section 10.1.2.3, and elsewhere, we concur that a one-unit operation will have no significant effect on the river; however, we feel that the predicted effects of a two-unit operation will require more detailed evaluation and may require a different operational plan for blowdown releases in order to satisfy thermal requirements in the Neosho River.

3. We concur with the recommendations for erosion control during plant construction, as discussed in section 4.3.2. and elsewhere, except that we question the practicality of an 80 mg/l suspended solids limit when quality records of the Neosho River in the area indicate median suspended solids values ranging between 86 and 484 mg/l.

4. Mention in several locations including section 5.5.2.3. of the likelihood of hydrogen sulfide production in the lake is acknowledged as a theoretical possibility, but our experience with similar Kansas lakes indicates that this possibility is of no practical environmental significance.

5. We are interested in reviewing your evaluation of radiation exposure comparison to the 10 CFR 50 Appendix I ALAP values, since it appears that the value for the whole body exposure to liquids from all pathways may be exceeded.

6. No mention is made in the draft Environmental Statement of the disposal of sludges produced on site, both from the package activated sludge plant and from the proposed lime softening of reservoir make-up water. While neither is expected to create a significant environmental problem, we feel that the final disposition of these materials should be determined.

7. Our overall environmental evaluation of the Wolf Creek Generating Station agrees with your summary conclusion for the issuance of a construction permit for the facility.

Mr. Gordon K. Dicker
August 25, 1975
Page 4

Requests for additional information or clarification of the above comments may be made to this office. We appreciate the opportunity to review the draft document.

Very sincerely,

Robert F. Bennett
Governor of Kansas

RFB:pc

MISSOURI – KANSAS SECTION / AMERICAN NUCLEAR SOCIETY

PUBLIC INFORMATION COMMITTEE
BOX 8405
KANSAS CITY, MISSOURI 64114

STN-50-482

August 22, 1975

Director
Division of Reactor Licensing
Office of Nuclear Reactor Regulations
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Sir:

We have recently reviewed the Draft Environmental Statement for the Wolf Creek Generating Station, Docket No. STN 50-482. One of the criticisms raised by local residents involved the large amount of land needed for the generating facility. Our studies have shown that nuclear power represents the most effective land utilization alternative compared to any other future energy source. An average size fossil unit will require approximately twice as much land as an equivalent nuclear unit. Solar and wind power alternatives will require nearly 12 and 21 times more land respectively than an equivalent nuclear unit.

Since the majority of the land in Coffey County is used for agricultural purposes, we feel that in the consideration of other alternative energy sources, the additional loss of economically productive land should be considered in the cost-benefit analysis. We also support the use of the cooling lake as a recreational area provided such use can be shown to be feasible. These considerations will impact on a state-wide land-use policy which has not but must be considered in the near future.

Very truly yours,

Thomas C. Roberts

Thomas C. Roberts,
Chairman

TCR:dlw

9140

THE STATE OF KANSAS

WATER RESOURCES BOARD

4th Floor, Mills Building
109 W. 9th Street
Telephone (913) 296-3185
TOPEKA, KANSAS 66612

August 25, 1975

9-3-75

Mr. D. C. Scaletti
NRC Environmental Project Manager
Division of Reactor Licensing
Office of Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Scaletti:

This letter is to supplement my comments of July 18, 1975, relative to the construction of the Wolf Creek Generating Station, NRC docket number STN 50-482.

The Environmental Statement 5.2.1 on page 5-1 refers to certain hydrologic studies contained in the Environmental Report. On page 2.5-4c of that report, in discussing minimum releases for water quality required at Chanute, the estimated flow was based on the inflows into John Redmond Reservoir. The report points out whenever these local flows at Chanute were more than the required water quality no releases were assumed. I am of the opinion that the applicant should examine the quantity of releases for water quality purposes based upon historic downstream flows. I recognize that during the period 1951-1960 stream gaging stations were located only at Iola and Parsons. However, based on these streamflow records the estimate of water quality releases can be calculated. I would also urge the applicant to examine the quantity of releases not only from monthly average flows but also visually estimate the daily quantity of release. For example, in September 1954, the average daily flow at Strawn was 0.7 cfs, whereas, the flow at Parsons was 209 cfs. However, for 29 days the average flow at Parsons was 0.1 cfs and on the 30th day the flow was 6270 cfs. We have examined the series of months for 1954 and find a greater quantity of water would be released examining only monthly averages compared to daily flows. We are also in variance with values cited by the applicant in Table 2.5-3s.

Reservoir operating experience for water quality purposes in the last 10 years indicates releases were made to meet the quantity requirements as stated in the Environmental Report. I am sure the State of Kansas and responsible federal agencies will in the next drought schedule water quality releases to maintain water quality requirements and not make releases based upon a given quantity as

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Mr. D. C. Scaletti
Page 2
August 25, 1975

stated in the Environmental Report. It would be my opinion that the required quantity of releases based upon quality need should be less than making a release to meet a quantity criteria.

I feel the applicant has made a valuable contribution by pointing out that inflows below John Redmond should be used to meet water quality requirements at Chanute. The quantity released may indicate the availability of storage to meet municipal needs along the Neosho River. However, we feel careful examination of historic flows below John Redmond should be made by the applicant.

Sincerely,

Keith S. Krause
Keith S. Krause
Executive Director

KSK:dk

cc: District Engineer, Tulsa Corps of Engineers
Mr. Jerry Svore
Environmental Protection Agency
Kansas City, Missouri
Mr. Mike Miller
Kansas Gas and Electric Company
Wichita, Kansas

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

SEP 8 1975

RECEIVED SEP 10 1975

STN-50-482

Mr. Gordon K. Dicker, Chief
Environmental Projects Branch 2
Division of Reactor Licensing
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Dicker:

This is in response to your transmittal of July 3, 1975, inviting the U.S. Energy Research and Development Administration (ERDA) to review and comment on the Commission's Draft Environmental Statement (NUREG 75/063) related to the Construction of Wolf Creek Generating Station (Docket No. STN 50-482).

The Statement is generally well organized and presented in a comprehensive format. There is no known conflict or interaction with current or proposed ERDA programs within the area of the proposed action. Our review indicates that the description of the environment and the evaluation of likely environmental impacts of the proposed actions have been treated quite well.

The treatment of dry cooling towers in this Statement is more extensive than presented in certain other recent Commission Statements (Alan R. Barton Plant, Section 9.3.1.7, page 9-5, and Perkins Nuclear Station, Section 9.2.1.1, page 9-2) that we reviewed. Specifically, the Perkins Statement contains only a brief summary on dry cooling towers but provides no quantitative information and makes no references to the findings of others. It is our view that the treatment of dry cooling towers in this Statement is appropriate and suggest that it be used in all Commission Draft and Final Statements.

We have enclosed additional staff comments which we feel would be helpful to you in the preparation of the Final Statement.

Sincerely,

W. H. Pennington
W. H. Pennington
Office of the Assistant Administrator
for Environment and Safety

Enclosure:
ERDA Staff Comments

cc: CEQ (5)

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

ERDA STAFF COMMENTS ON THE
NRC DRAFT ENVIRONMENTAL STATEMENT FOR THE
WOLF CREEK GENERATING STATION

1. Although the document discusses resulting impacts, more specific environmental information on prior conditions would be helpful in evaluating the conclusions made by the NRC staff.

2. Specific existing regulatory requirements are not clearly identified. The levels of pollutants released, such as in the case of total dissolved solids, are not directly compared to any required water quality criteria or effluent standard. Statements should either be made identifying requirements or stating that one does not exist.

3. "Predetermined levels" to which radioactive releases will be monitored and controlled are referred to, but are not specifically identified. It would benefit the reviewer if these were.

4. Pictures of the area, and of the likely pond location, might be of interest and helpful.

5. We feel that the Summary and Conclusions could be better organized and that Nos. 5 and 6 could be at the end.

6. It is our opinion that to state that geological and seismic information is available elsewhere and provide references to this fact only is not adequate. A somewhat more detailed discussion of this information would enhance the Statement.

7. The meteorology is somewhat skimpy and a thorough picture of the meteorology of the area is not presented. For example, on page 6-1, it is indicated that measurements of the vertical temperature gradients on a tower have been made and that the data has been analyzed. However, in presenting the meteorological section on page 2-15, no mention was made of these data which are necessary to determine the stability of the atmosphere. A more complete picture of the meteorology should be presented to support the conclusion.

8. Section 9.2.1.3 (page 9-14), which provides a treatment of dry cooling towers as an alternative cooling system, should be changed as follows:

a. In the first line of the third paragraph, the words "the consumption of" should be inserted between "without" and "large quantities."

b. In the fourth sentence of the fourth paragraph, it is stated that "noise generation problems of mechanical-draft towers will be equivalent to or more severe than those of wet cooling towers." We are not aware of any factual basis for this statement. Indeed, it would seem that wet cooling tower noise may be higher due to water cascade noise. Unless the statement can be supported, we would suggest it be deleted.

c. The last sentence of the fourth paragraph should make reference to the fact that a 330 MW direct-condensing dry-cooled fossil plant is under construction in the U.S..

IMAGED 01/15/2005

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

PEP ER-75/659

RECEIVED SEP 16 1975

SEP 12 1975

Dear Mr. Dicker:

Thank you for your letter of July 3, 1975, transmitting the draft environmental statement for the Wolf Creek Generating Station, Unit 1, in Coffey County, Kansas.

Our comments are presented according to the format of the statement or by subject.

Geology and Seismology

The brief section on geology and seismology in section 2.4, consisting of approximately 150 words, without the benefit of maps, cross section, or columns, is inadequate as a basis for evaluating related environmental impacts of construction and operation of a nuclear reactor. The reader is left to assume that the additional details provided by the applicant elsewhere adequately assess the seismic risk associated with the site. Although this may in truth be the case, the omission of relevant data on this important environmental component for a nuclear power site is hardly reassuring. Furthermore, the reference to "recent time" is rather vague and indefinite. It might be construed as implying that the area has experienced major seismic activity without specifically indicating when events occurred. The final statement should summarize more effectively the significant features of the geology and seismology and should comment on the adequacy of the information provided in the applicants environmental report.

With respect to the geology we have this additional comment to provide on the applicant's environmental report. It is stated by the applicant on page 2.4-8, that "the Heumader Member... forms the bedrock at the proposed plant site". However, the surficial geologic map in figure 2.4-6, shows the Jackson Park shale member as the uppermost member throughout the plant site, while the Heumader shale member underlies

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the margin of the proposed cooling lake to the west, south, and southeast of the plant site. The descriptive text on page 4.1-11, suggests that the Jackson Park shale member consists largely of weathered rock within the limits of the plant site, but the geology should be clarified and the text should be made consistent with the maps.

Groundwater

The proposed preoperational and operational monitoring programs, discussed on pages 6-1 and 6-6, should indicate, at least in a general way, the location of wells to be sampled and the aquifer tapped by each well. The use of four wells suggests either a distribution radially away from potential sources of contaminants or a sequence of four extending in a southwesterly direction, down the reported preoperational hydraulic gradient -- and possibly sampling both the weathered bedrock aquifer and the alluvium. The statement should be specific in describing this mitigating measure.

The effects of hydraulic gradients induced by seepage of about 3.5 cfs from the cooling lake should be evident in the evaluation of the monitoring programs. Northerly and easterly gradients will apparently be induced over an appreciable distance within the life of the project, as noted in section 5.2.2 and figure 9.3; therefore net effects on movement of possible contaminants should be considered in order to make the sampling meaningful.

Water Supply System

No adequate description of the designs, volumes of earthwork, or environmental impacts of construction of the dams and dikes has been found in the draft environmental statement or environmental report. The amount of earthwork would evidently be significant, as seven dams would be constructed, having a total length of 24,000 feet, and two dikes having a combined length of 13,850 feet. The source of fill material has not been identified, as far as we have been able to determine. Little information on design of these structures has been provided, other than the statement in the environmental report, page 7.2-3, that the main dam "will be designed and constructed to minimize its possible failure". It would be advisable to provide assurance that the seven dams and two dikes will be designed and constructed to minimize potential environmental impacts as well, and to outline the proposed measures for achieving this or for mitigating potential impacts.

The water required to make up natural and forced evaporation from the proposed cooling lake would be drawn predominantly from John Redmond Reservoir on the Noesho River. Mean annual flows of the river have varied from 82 to 4930 cfs during 13 years of record at the USGS gage at Strawn about 13 miles upstream from the site. During the severe drought of the nineteen fifties the mean flow during a 55 month period was only 92 cfs, so that the proposed minimum draft from John Redmond Reservoir represents about 45 present of the flows recorded then. This percentage would be still greater should a similar drought recur because of increased evaporation from three major reservoirs constructed in the basin since then. The applicant has concluded from a systems analysis, described on page 2.5-4a through 4f of his environmental report, that 41 cfs would be available for the cooling lake throughout a recurrence of such a drought. Not enough of the data and results are shown to permit a verification of this conclusion, which, based on the discussion on page 5-2, apparently was accepted by the NRC staff without an independent review. The most critical calculation is the evaporation from John Redmond Reservoir, however neither the method used nor the results are shown. Also of considerable significance is the capacity of the conservation pool of this reservoir, given as 82,500 acre-feet at 1039 feet elevation by the applicant. It is our understanding that this level is maintained only during the summer months, after which the pool is drawn down to 56,500 acre-feet at 1036 feet elevation for the rest of the year. It does not appear that this lower level which would have required additional releases early in the drought has been taken into consideration in the analysis. The combined estimated monthy inflows to the three reservoirs, shown on tables 2.5-3b, 3g, and 3n of the environmental report, are significantly higher than the flows actually observed at Strawn during the fifties, possibly indicating that there are losses in the stream channel above Strawn which were ignored in the analysis. A review of this analysis for the final statement is recommended.

In reviewing the consequences of major accidents at the reactor on page 7-3, the so called Class 9 accidents were not evaluated, although they could be severe. Reference is made to the draft of the Reactor Safety Study released for comments in August 1974. Our review of that draft indicated that effects of accidents on water resources were not considered in detail, both in respect to radio-nuclides

escaping from the containment to the atmosphere and those entering the ground; the study also used generalized site conditions which may not apply at any specific site. It is recommended that a detailed evaluation of the potential effects on water resources be made at this site.

Mineral Resources

A number of gravel deposits lie within the project area, however, our records indicate no sand and gravel production in Coffey County since 1968. Numerous other pits are present on terraces of the Neosho River, and they should provide an adequate source of supply in the foreseeable future. Consequently, we anticipate that the project would have no major adverse impact on this sector of mineral supply.

Far more serious, the project area lies within a petroleum producing region known as the eastern stripper district. Although most production is from scondary recovery operations south of the project, a new well was brought in near the southeast corner of the area in November 1973. Consequently, the potential for new discoveries cannot be discounted. We suggest that the revised statement indicate how mineral rights will be purchased or subordinated and whether or not drilling operations will be permitted on project property after the facility is completed.

With regard to the latter, we would point out that directional drilling from locations outside the project boundary probably would not be effective. Pay horizons in the region are shallow (1,400-2,300 feet), and because offset distances are generally limited to less than the depth to target, closure of this area effectively would preclude exploration in the major portion of the project area. If no petroleum exploration or development would be allowed, it should be so stated in the section on irreversible and irretrievable commitments. We recommend that reasonable allowances be made for future oil and gas exploration.

Phillips Petroleum Co. operates two product pipelines and a pumping station within the project area. The station is located at Sharpe, and the pipelines would be inundated by the northern portion of the cooling pond. We recommend that Phillips be notified of project plans in order that arrangements can be made to relocate and/or protect the facilities and insure their continued operation.

Fish and Wildlife

The draft environmental statement more adequately describes the impact that construction and operation will have on the area's fish and wildlife resources than the environmental report. We are pleased to see that many of our questions with regard to the environmental report have been answered. We believe, however, that the environmental statement should be expanded to more clearly assess the following.

About 20 bald and golden eagles are sighted each year at the nearby Flint Hills NWR. Wintering eagles may be attracted to open bodies of water. Any existing or proposed local electrical distribution facilities near the project area should be designed to minimize the threat of accidental electrocution of large raptors. Helpful references are REA Bulletin 61-10, Powerline Contacts by Eagles and Other Large Birds; and Idaho Power Company, Power Lines and Birds of Prey.

The wisdom of causing the complete cessation of Wolf Creek's flow is highly questionable. Surely, minimum flows can be maintained and still enable the cooling lake to fill within a reasonable period of time. A natural stream's banks, bordering vegetation, and bottomlands are critical for survival formany forms of life. The draft statement only recognizes effects of halted flows on the aquatic environment of the stream. The statement should include a description of how eliminating the stream flow will effect all fauna and flora in the Wolf Creek flood plain. Additionally, it should be recognized that the term, "intermittent stream" does not normally include a stream that is completely dried for up to 64 months. These differences are not described.

The project site contains important fish and wildlife habitat and resources. In section 5.6.5, we read, "...the applicant states that there are no plans to develop the cooling lake or any parts of the site for recreational use...." Also, in section 4.3.1.1, "...the applicant plans, to the extent possible, to continue in production agricultural land outside the cooling lake and the inclusion area...."

However, the Nuclear Regulatory Commission recommends in section 4.4.5 that, "...it is the staff's opinion that a feasbility study should be undertaken by the applicant to explore the possible benefits associated with public access and use of the cooling lake."

A fish and wildlife management and public use plan for the site and transmission line rights-of-way is being prepared jointly by the U.S. Fish and Wildlife Service and the Kansas Forestry, Fish and Game Commission. The plan will include preservation of natural areas and the restoration of others as well as providing facilities for public use, including access for fishing, hunting and related recreational uses to assure maximum public benefit. The final statement should at least recognize the existence of this plan. Hopefully, time will permit that the final statement can include the applicant's acceptance or rejection of this plan, or subsequent plans when formulated.

The draft statement, in section 5.5.2.1, recognizes that, "Makeup withdrawal from the John Redmond Reservoir could extend both duration and severity of naturally occurring drought conditions in the Neosho River and consequently pose serious problems for the aquatic biota, particularly fish populations". The draft statement further states in section 10.2 that, "During drought, the withdrawal of makeup water from John Redmond Reservoir will in effect, extend the duration and severity of low flow conditions in the Neosho River downstream of the dam...". Again, in section 10.3. 3.2, the draft statement declares that, "...a distinct possibility exists that reduced flows in the Neosho River due to makeup withdrawal may stress some fish populations beyond their ability to recover...". In view of the potentially critical impact on the fish population in the Neosho River during a drought period, the final statement should be expanded to include a presentation of thehydrology of the Neosho River with the facility in operation and discuss the downstream effects more fully than has been done in the draft statement. Any possibilities for mitigating drought effects on the fish populations through reservoir regulation or other means should be mentioned.

With respect to the impact on fish as discussed in section 2.7.2.2, the construction and subsequent operation of the Wolf Creek facility will only aggravate the conditions described by Cross and Braasch (42). Although recent legislation has lessened the occurrence of feed lot pollution, altered regimen of flows incurred by the John Redmond Reservoir, and soon, the Wolf Creek facility, will increase the incidence of unnatural species composition of fishes in the Neosho River.

We suggest that the statement show an artist's conception of the Wolf Creek Generating Station's Cooling lake during the drought discussed in section 10.1.2.1.

Section 4.3.1.3. on the impact on natural plant communities is not clear. Does the applicant intend to promote the expansion of the bluestem prairie? In addition, this section states that 5% of woodland of Coffey County will be eliminated; section 10.4.2.4 states that 10% of the woodland of Coffey County will be eliminated.

The reference in section 4.3.1.6 to the greater prairie chicken's being endangered is misleading. Attwater's greater prairie chicken, Tympanuchus cupido attwateri, is on the National endangered species list because this is very local and scattered over 11 counties in small, disjunct populations in the gulf coastal prairie of Texas, chiefly in Refugio and Colorado Counties. There are in excess of one million greater prairie chickens (T. cupido) in Kansas, enough that they are the object of a devoted group of hunters. Table B.6 is misleading for the same reason.

Section 4.3.2.2. discusses the effects of dam closure on lower Wolf Creek. This section should be expanded to include the effects of dam closure on the terrestrial vegetation and related fauna that are dependent on natural flows from Wolf Creek.

The staff evaluation in section 4.5.2 has listed additional precautions which are admirable and reflect NRC's concern for our natural resources. However, we suggest that (6) should be changed to read: "Limbs and other cleared debris along transmission lines should be made into brush piles in order to provide wildlife habitat," and (14) should ask for the formulation of a detailed clearing plan in concert with the Kansas Forestry, Fish and Game Commission.

Impacts on aquatic biota in the Neosho River resulting from operation at reduced flow are discussed in section 5.5.2.1. This section refers to "normal flows" when, in reality, there have been no truly normal flows since the closure of the John Redmond dam. The Neosho madtom (Noturus placidus) and other riffle-dependent species have been replaced by species that prefer higher bank flows, resulting from abnormal releases from John Redmond dam. This is not a normal condition, but an example of changes brought about by man's influence upon natural phenomena.

Referring to Table 5.23., the Plains Killifish, Fundulus kansae, is hardly a typical species and not applicable here because: (1) It is a lotic species, (2) it actually has a preference to salinity, and (3) it is not typically found in this drainage.

When compared with Figure 3.7, the discussion of transmission lines in section 9.2.4 is unclear. The routing of transmission lines described here does not correspond to the aforementioned figure.

Increased turbidity due to construction is referred to in section 10.1.2.2. It is not clear just where this turbidity is expected to occur, when in essence, Wolf Creek will be dried up.

Section 10.3.6 on land resources states that, "If drought conditions persist, reduced productivity is expected and will occur in the John Redmond Reservoir as well as in the Wolf Creek cooling lake". To this should be added "...and the Neosho River for an undetermined distance downstream".

Outdoor Recreation

We believe that the statement is deficient in its discussion of recreation facilities and use in the area and the probable impacts of the proposed project upon such facilities and use.

The discussion of the site in chapter 2, does not contain a detailed description of recreation facilities in the area. It is indicated that the John Redmond Reservoir, the Flint Hills National Wildlife Refuge and several smaller camping/picnicking facilities are in reasonable proximity to the project site; however, no additional information is presented concerning these resources. We feel that the final statement should include an adequate description of these facilities which should encompass data concerning size, activities available and participation.

In section 4.4.5 the impact on the recreational capacity of area is reviewed. It is indicated that some of the recreation facilities at John Redmond Reservoir will be briefly disrupted during construction. This disruption is characterized as temporary though in some instances it may last as long as 1.5 years. One and a half years seems to be a somewhat lengthy "temporary" disruption. Its importance, however, can not be properly assessed because the related information is not adequate. The final statement should present in detail information regarding the number of facilities disturbed and the number of people denied recreation opportunities because of the disturbance.

We note that it is also stated that it is the opinion of the NRC staff that the applicant should conduct a feasibility study to explain the possible benefits associated with public access and use of the cooling lake. We heartily concur in this opinion and hope that the NRC staff may make such a study a prerequisite to the granting of a license.

Historic and Archeologic Sites

We note that the archeological potential of the Wolf Creek Generating Station was assessed and that archeological remains along Wolf Creek were found to be unimpressive. However, the statement does not give details relating to scope or extent of this assessment. In the event that this was not a complete archeological field reconnaissance survey of the entire 10,500 acres of the plant site, road and utility relocations, transmission line corridors, railroad right-of-way, and cemetery relocation, it will be necessary to again consult with a professional archeologist concerning the need for further survey of these areas. The results of any necessary survey should be fully detailed in the final environmental statement as well as any recommendations made by the archeologists conducting the survey.

Subsequent to such a survey, the State Historic Preservation Officer (Mr. Nyle H. Miller, Executive Director, Kansas State Historical Society, 120 West 10th Street, Topeka, Kansas 66612) should be consulted with regard to properties in the area of project activities which may be on or eligible for inclusion on the National Register of Historic Places.

The final environmental statement should also present procedures to be implemented in the event that previously unknown cultral resources are encountered during project construction.

Supplemental Comments

Discrepancies between the summary and the text should be eliminated. The makeup water line is given as four miles long in the summary on page i, while its length is given later as two miles on page 4-4. The land area required for a new rail access route is given as 180 acres in the summary on page i and on page 4-4 while elsewhere it is given as 150 acres, for example, on page 3-19, and page 4-2. The applicant has given the area required for the rail access route as 140 to 160 acres in the environmental report on page 4.3-4.

We hope these comments will be helpful to you.

Sincerely yours,

Stanley D. Doremus

Deputy Assistant Secretary of the Interior

Mr. Gordon K. Dicker, Chief
Environmental Projects Branch 2
Division of Reactor Licensing
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
1735 BALTIMORE – ROOM 249
KANSAS CITY, MISSOURI 64108

September 10, 1975

RECEIVED SEP 16 1975

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Muller:

The Environmental Protection Agency has reviewed the U.S. Nuclear Regulatory Commission's Draft Environmental Impact Statement issued July 3, 1975, in conjunction with the application of the Kansas Gas and Electric Company and the Kansas City Power and Light Company for a permit to construct the Wolf Creek Generating Station, Unit 1. Our detailed comments are attached.

We believe the proposed plant may not be able to meet the liquid dose requirements of the design objectives of Appendix I of 10 CFR 50 normal operations of the uranium fuel cycle. The calculated doses do not take into account the buildup of radioactivity in the Wolf Creek cooling lake.

The draft statement did not adequately discuss the project's effects on ground water quality. The final statement should assess the potential increase of pollutants, including increased levels of radioactivity, in the ground water as a result of recharge from the cooling lake.

In view of the above and in accordance with our procedures, we have classified the project ER (Environmental Reservations) and have rated the draft statement Category 2 (Insufficient Information). If you or your staff have any questions concerning our classification or comments, we will be glad to discuss them with you.

Sincerely yours,

Charles V. Wright
for Jerome H. Svore
Regional Administrator

Attachment

EPA #D-NRC-H06000-KS

ENVIRONMENTAL PROTECTION AGENCY

KANSAS CITY, MISSOURI 64108

September 1975

ENVIRONMENTAL IMPACT STATEMENT COMMENTS

Wolf Creek Generating Station, Unit 1

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INTRODUCTION AND CONCLUSIONS

The Environmental Protection Agency (EPA) has reviewed the U.S. Nuclear Regulatory Commission's Draft Environmental Impact Statement (draft statement) issued on July 3, 1975, in conjunction with the application of the Kansas Gas and Electric Company and Kansas City Power and Light Company for a permit to construct the Wolf Creek Generating Station, Unit 1. The proposed plant will be located in Coffey County, Kansas, approximately five miles northeast of Burlington, Kansas. The proposed generating station will produce up to 3,425 megawatts thermal and will exhaust waste heat in a closed-cycle system incorporating a cooling lake. Makeup water for this system will be obtained from the John Redmond Reservoir. Blowdown discharge will be from the cooling lake into Wolf Creek which, in turn, flows into the Neosho River. The following are our major conclusions:

1. Our review and evaluation of the draft statement for Wolf Creek indicates the proposed plant may be unable to meet the liquid dose requirements of the design objectives of Appendix I of 10 CFR 50 for normal operations of the uranium fuel cycle. The calculated doses from the liquid effluents (radiological) do not take into account the buildup of radioactivity in the Wolf Creek cooling lake. The liquid doses should be presented in the context of the design objectives of Appendix I of 10 CFR 50 and EPA's proposed environmental radiation standards for the uranium fuel cycle.

2. The State of Kansas will enforce state water quality standards in the Neosho River below a designated mixing zone around the mouth of Wolf Creek. Effluent limitations as stipulated in the National Pollutant Discharge Elimination System (NPDES) permits will apply at the point the cooling lake discharges into Wolf Creek. In addition, the discharge of certain pollutants to the lake may be limited by conditions stipulated in the discharge permit.

3. The draft statement did not adequately address the impacts of cooling lake recharge on the ground water aquifer. The increase in both the concentration of pollutants and the level of radioactivity in the aquifer should be discussed and evaluated in the final statement. In addition, the long-term effects of cooling lake recharge should be assessed.

4. EPA believes an operational intake monitoring program should be conducted to determine the extent of fish loss due to entrapment and impingement and to evaluate the need for corrective measures. We request the final statement evaluate alternative designs and operational procedures should the monitoring reveal unacceptable impacts.

RADIOLOGICAL ASPECTS

Radioactive Waste Management

Although the draft statement indicates gaseous effluents from the Wolf Creek Generating Station will be able to meet the dose criteria of the design objectives in Appendix I to 10 CFR 50, there is an inconsistency between the Environmental Report and the draft statement which could significantly affect radioiodine doses. The draft statement indicates the containment building ventilation is purged through a high efficiency particulate aerosol filter and a charcoal adsorber. However, the Environmental Report (Table 3.5-7 and Figure 3.5-2) does not show a charcoal adsorber. The statement should clarify this inconsistency and, if necessary, present revised radioiodine source terms and doses.

Dose Assessment

According to the results presented in the draft statement and based on our independent calculations, it appears the Wolf Creek Generating Station (Unit 1) will not be able to meet the liquid dose criteria of the design objectives of Appendix I to 10 CFR 50. Furthermore, it appears the calculated potential doses from liquid effluents, as indicated in the draft statement and the Environmental Report, have not taken into account the buildup of radioactivity in the Wolf Creek cooling lake. For example, the cooling lake concentration of Cesium-137 (one of the dosimetrically significant radionuclides) will increase by more than a factor of six over forty years of plant operation based on the cooling lake flow data presented in the draft statement. Consequently, the final statement should calculate the doses from liquid effluents taking into account the buildup of radioactivity in the Wolf Creek cooling lake. The resultant doses should be presented in the context of the design objectives of Appendix I to 10 CFR 50 and EPA's proposed environmental radiation standards for the uranium fuel cycle.

Reactor Accidents

EPA has examined the Atomic Energy Commission (AEC)(predecessor of the NRC) analysis of accidents and their potential risks which were developed in the course of the evaluation of reactor safety in the design of nuclear plants. Since these issues are common to all nuclear plants of a given type, EPA concurred with AEC's approach to evaluate the environmental risk for each accident class on a generic basis. AEC had in

the past and NRC is expected to continue to devote extensive efforts to ensure safety through plant design and accident analyses in the licensing process.

During the past two years, AEC sponsored an effort to examine reactor safety and the resultant environmental consequences and risks of accidents on a more quantitative basis. We have strongly encouraged this effort and urge its continuation under NRC. On August 20, 1974, AEC issued for public comment the draft Reactor Safety Study (WASH-1400) which is the culmination of an extensive effort to quantify the risks associated with light-water cooled nuclear power plants. EPA has conducted a review of this draft document, including both in-house and contractural efforts, which culminated in release of agency comments to NRC on August 15, 1975. We have concluded the Reactor Safety Study represents a very comprehensive and useful analysis of the risks associated with light-water reactors. EPA will review the final Reactor Safety Study when it is issued and will provide public comment at that time.

If future NRC efforts in this area indicate unwarranted risks are being taken at the Wolf Creek Generating Station, we are confident NRC will ensure appropriate corrective action. Similarly, if EPA efforts identify any environmentally unacceptable conditions related to reactor safety, we will make our views known. Until our review of the Reactor Safety Study is completed, we believe there is sufficient assurance that no undue risks will occur as a result of the continued planning for the Wolf Creek Generating Station.

Transportation

EPA, in its earlier reviews of the environmental impacts associated with the transportation of radioactive material, agreed with AEC that many aspects of this program could be treated on a generic basis. NRC has codified this generic approach (40 F.R. 1005) by adding a table to their regulations (10 CFR Part 51) which summarizes the environmental impacts resulting from the transportation of radioactive materials to and from light-water reactors. This regulation permits the use of the impact values listed in the table in lieu of assessing the transportation impact for individual reactor licensing actions if certain conditions are met. Since this nuclear power plant appears to meet these conditions and EPA has agreed the transportation impact values in the table are reasonable, this approach appears adequate for this action.

While the impact value resulting from the routine transportation of radioactive materials was chosen at the level which included 90% of either reactors currently operating or under construction, the basis for the impact or risk of transportation accidents is not clearly defined. There are current efforts by both EPA and the Energy Research and Development Administration (ERDA) and/or NRC to fully assess the radiological impact of transportation accidents. As the quantitative results of these analyses become available, EPA intends to conduct reviews to ascertain the acceptability of potential transportation risks. If EPA efforts identify any environmentally unacceptable conditions related to transportation, we will make our views known. Until our reviews of the transportation accident analyses are completed, we believe there is sufficient assurance that no undue risks will occur as a result of transportation accidents for this nuclear power plant.

<u>Fuel Cycle and Long-Term Dose Assessments</u>

Under the President's Reorganization Plan No. 3 of 1970, EPA is responsible for establishing generally applicable environmental radiation protection standards. On May 29, 1975, the Agency proposed such standards to limit unnecessary radiation exposures and radioactive materials in the general environment resulting from the normal operation of facilities comprising the uranium fuel cycle. The Agency concluded environmental radiation standards for nuclear power industry operations should include such considerations as total radiation dose to populations, maximum individual dose, the risk of health effects attributable to these doses (including the future risks arising from the release of long-lived radionuclides to the environment) and the effectiveness and costs of effluent control technology. The proposed standards are expressed in terms of individual dose limits to members of the general public and limits on quantities of certain long-lived radioactive materials in the general environment.

The concept of environmental dose commitment is a recent development which we believe should be included in the assessment of the environmental impact of the fuel cycle. The information presented in the draft statement indicates the "Maximum Effect" in terms of annual person-rems (man-rems) within a 50-mile radius. As many of the radionuclides involved persist in the environment over extremely long periods, their impact is not adequately represented by an annual dose. Instead, we recommend the maximum effect of fuel cycle releases be indicated by an environmental dose commitment; that is, by the projected person-rems which will be accumulated over several half-lives of the radioisotopes released annually from these facilities. (This would involve decades for very long-lived isotopes.) Also, such evaluations should be done for the total

U.S. population exposure. Radionuclides of importance in this approach include Krypton-85, Iodine-129, Tritium, Radium, Carbon-14, and the Actinides.

AEC issued a document entitled, "Environmental Survey of the Uranium Fuel Cycle" (WASH-1248) in conjunction with a regulation (10 CFR 50, Appendix D) for application in completing the cost-benefit analyses for individual light-water reactor environmental reviews (39 F.R. 14188). The information therein is employed in NRC draft statements to assess the incremental environmental impacts that can be attributed to fuel cycle components which support nuclear power plants. In our opinion, this approach appears adequate for plants currently under consideration and such estimates of the incremental impacts for the Wolf Creek Generating Station are reasonable. However, as suggested in our comments on the proposed rulemaking (January 19, 1973), if this is to continue for future plants, it is important for NRC to periodically review and update the information and assessment techniques used. EPA intends to monitor developments in the fuel cycle area we believe relevant to continued improvement in assessing environmental impacts.

The summary presentation (Table 5.14) of the environmental effects of the uranium fuel cycle addresses only the incremental environmental impacts expected as a result of the operation of a nominal 1000 Mwe nuclear reactor. However, there are impacts associated with the ultimate disposal of radioactive waste which, to our knowledge, have not yet been adequately evaluated or are largely unknown. These impacts include:

- Commitment of land and resources for an ultimate disposal site;
- Economic and resource commitments of future generations; including societal and institutional commitments;
- Economic, resource and energy costs of ultimate waste disposal as balanced against the present benefits realized by energy production.

While we agree that the individual nuclear power plant environmental statements may not be the proper vehicle for assessing the considerations, the environmental statement can, and should, indicate any pertinent studies (and their expected completion dates) which are being conducted by NRC or other responsible agencies that will provide analyses of these issues. If no such efforts can be documented, we believe that NRC should either include these considerations in an updated version of

WASH-1248 or should urge ERDA to consider them in their studies directed at developing an ultimate radioactive disposal technology.

High-Level Waste Management

Environmental impacts will arise as a consequence of the techniques and procedures utilized to manage high-level radioactive wastes. These impacts have some relevance to the environmental considerations regarding each nuclear power plant in that the reprocessing of spent fuel from each facility will contribute to the total waste problem. EPA concurs, however, with NRC's approach of handling waste management impacts on a generic basis rather than by including a specific in-depth analysis in each nuclear power plant environmental statement. As part of this effort, AEC issued for comment a draft statement, September 10, 1974, entitled, "The Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste" (WASH-1539).

Though a comprehensive long-range plan for managing radioactive wastes has not yet been fully demonstrated, acceptance of the continued development of commercial nuclear power is based on the belief the technology to safely manage such wastes can be devised. EPA is available to assist both NRC and the Energy Research and Development Agency (ERDA) in their efforts to develop an environmentally acceptable waste management program to meet this critical need. In this regard, EPA provided extensive comments on WASH-1539 on November 21, 1974. Our major criticism was the draft statement lacked a program for arriving at a satisfactory method of "ultimate" high-level waste disposal. We believe this is a problem which should be resolved in a timely manner since the country is committing an increasingly significant portion of its resources to nuclear power and waste material from the operating plants is presently being accumulated. ERDA now intends to prepare a new draft statement which will discuss waste management and emphasize ultimate disposal in a more comprehensive manner. EPA concures with this decision. We will review the new draft statement when it is issued and will provide public comments.

NON-RADIOLOGICAL

General

The Wolf Creek Generating Station will employ a pressurized water reactor rated at approximately 3,425 megawatts thermal (MWt). Condenser cooling water for this facility will be drawn from and discharged to Wolf Creek Lake, a 5,090-acre impoundment which will be formed by an earth rolled dam across Wolf Creek. Makeup water for the cooling lake will be supplied by the John Redmond Reservoir and will be pumped from an intake structure located immediately downstream of the John Redmond Dam. Releases (blowdown) of water from the cooling lake will flow into lower Wolf Creek and then to the Neosho River.

Cooling System Design and FWPCA Requirements

Section 301 of the Federal Water Pollution Control Act Amendments of 1972 (FWPCA) stipulates effluent limits for various point sources discharging to navigable waters shall require the application of the "Best Practicable Control Technology Currently Available" no later than July 1, 1977, and the "Best Available Technology Economically Achievable" no later than July 1, 1983. The levels of technology corresponding to these terms were defined in EPA's "Steam Electric Power Generating Point Source Category Effluent Guidelines and Standards," (F.R. Vol. 39, No. 196, October 8, 1975). These guidelines, in addition to other requirements, call for closed-cycle cooling and set limits for the discharge of various chemicals. Further, the guidelines permit cooling lakes and ponds where the utility can demonstrate such a lake or pond is "...used or is under construction as of the effective date of this regulation to cool recirculated cooling water before it is recirculated to the main condensers." The Wolf Creek Lake complies with this requirement and thus, no limitation will be placed on the discharge of heated water to the lake.

The State of Kansas is responsible for the issuance of a discharge permit for this facility under the National Pollutant Discharge Elimination System (NPDES) as directed by Section 402 of the FWPCA. The discharge permit will apply at the point of release of the cooling lake water to lower Wolf Creek and must meet applicable effluent limitations. In addition, the discharge of certain pollutants to the cooling lake may be limited by conditions stipulated in the discharge permit.

The intake of makeup water from the Neosho River must be consistent with Section 316(b) of the Act which requires the "...location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." Issuance of the discharge permit will be based upon review and analysis of all relevant information supplied by the applicant. Consideration will be given to the requirements of Section 301, 316(b), and all other provisions of the FWPCA and the final permit will be conditioned accordingly.

The Kansas Department of Health and Environment has determined the state water quality standards will be enforced in the Neosho River below the mouth of Wolf Creek except for a designated mixing zone. It is suggested the applicant request confirmation from the Kansas Department of Health and Environment of the applicability of the state water quality standards to both Wolf Creek and the Neosho River. This determination should be included in the final EIS.

Although the state has indicated the water quality standards do not apply to Wolf Creek, the existing high concentrations of organophosphates, hexane soluble materials, ammonia, iron, turbidity and indicator organisms suggests Wolf Creek has poor water quality. Concentrations of these parameters, from both John Redmond Reservoir and the Wolf Creek drainage basin, may increase in the cooling lake during periods of high runoff or excessive evaporation. The final statement should provide estimates of the expected concentrations of the above parameters in the proposed cooling lake. In addition, the data should include information on possible pesticide accumulations in the lake. The anticipated effect of the cooling lake discharges to Wolf Creek and the Neosho River should also be discussed.

Effluent guidelines concerning area runoff have been published in 40 CFR, Part 423. Sections 4.3.2.1 and 4.5.2 of the draft EIS should be reassessed to indicate compliance with the regulations on the control of siltation and turbidity during construction.

Ground Water

The statement indicates (Section 5.2.2) ground water levels will be affected and ground water quality may be altered within an approximate two-mile radius from the generating station. The primary uses of the shallow wells in the area of influence are for domestic and livestock water supplies (Section 2.2.3). Eight wells were tested in the vicinity of Wolf Creek and of the 32 samples taken, 23 did not meet the recommended standard of 500 mg/l for total dissolved solids concentration for public use, and 12 samples did not meet the recommended standard of 250 mg/l for

sulfates. The final statement should discuss the predicted increase in radioactivity levels and the concentrations of nitrites, nitrates, chlorides, zinc and iron in the ground water due to recharge from the cooling lake.

The Environmental Report indicated the level of total dissolved solids may increase to 1,980 mg/l in the ground water due to cooling lake recharge to the aquifer. This level is not only above the U.S. Public Health Service's recommended level of 500 mg/l for domestic use, but also above the proposed EPA livestock drinking water standard of 1,000 mg/l. The dissolved solids, as well as other pollutants, including radioactive materials, will persist in the ground water for a long time after the generating station's waste discharges have ended. This long-term degradation of the aquifer, with the potential impact on water supplies, should be fully evaluated in the final statement.

Continuous recharge of the shallow and deep aquifers is expected to occur for the life of the cooling lake. Figure 3.2 shows the discharge schematics of the waste systems for the Wolf Creek Generating Station. The outfalls for each system lie directly in the cooling lake. Therefore, all wastes from the plant have a potential of becoming introduced into the ground water through recharge. Consequently, the statement in Section 2.2.3.1 regarding effluent discharges to the Neosho River should be clarified to include the potential for ground water recharge via the cooling lake.

Water Supply

During the seven-day, one in ten-year drought conditions, the severity and duration of the low flow in the Neosho River will increase over the similar condition without the Wolf Creek power facilities (Section 5.5.2.1). Not only will this affect the aquatic biota, but it may also affect the public water supply at Burlington, Kansas, since the community draws its water from the Neosho River. The expected changes in the water quantity and quality to the water supply facilities at Burlington and water districts downstream (Section 2.2.3.2) should be assessed in the final statement.

Cooling Water Makeup Facilities (Entrainment and Impingement)

Section 3.4.3 provides information on the source of makeup water for the Wolf Creek cooling lake. The statement should indicate the percent of time(s) when water will be withdrawn from the 30-inch pipe through the dam and when water is withdrawn from the Neosho River below the dam.

The discussion concerning entrainment and impingement (Section 5.5.2.3) should be clarified. The report discusses decreased fish production resulting from entrainment and possibly severe impingement losses. The report further states, "Severe impingement losses (i.e., losses great enough to significantly reduce overall fishery production in the cooling lake) will necessitate design or operation changes to either reduce fish impingement to safe levels or ensure the return of impinged fish to the cooling lake alive." The type of changes in the design or operation of the facility that might be necessary should be discussed in the final statement.

As indicated previously, Section 316(b) of FWPCA (location, design, construction and capacity of cooling water intake structures) will apply to the intake structure to be located on the Neosho River below the John Redmond Dam. The design of the intake structure should reflect the best technology available to minimize entrainment and impingement losses. A monitoring program should be conducted to determine the amount of fish loss. Should monitoring reveal unacceptable losses, alternative design and/or operational procedures should be considered.

Impingement losses could possibly be reduced if all makeup water was taken directly from the John Redmond Reservoir at a depth having a relatively low fish population. The final statement should explain why the intake water is being taken from the stilling basin rather than directly from the reservoir except under emergency conditions.

Air Quality

The draft EIS did not adequately discuss the probable impact of the power plant on the ambient air quality. The following topics should be discussed in greater detail in the final EIS.

1. Applicant Commitments (Section 4.5.1): The local and State regulations regarding open-burning and fugitive dust control activities and related permit requirements (if any) should be specified in the final statement.

2. Traffic Congestion/Roadway Improvements (Sections 4.4.1; 4.5.1, No. 4.a; 4.5.1, No. 4.b; 5.6.1): The effect of construction and normal plant activity on traffic flow patterns should be further evaluated. Intersections where peak-hour traffic may prove to be a problem should be identified. The degree to which existing roads will be upgraded and new roads constructed should also be specified to permit an evaluation of the potential fugitive dust problem.

3. Concrete-mix Plant (Section 4.5.2, No. 11): The dust control measures to be implemented at the concrete-mix plant should be specified.

4. Diesel-engines/Oil-fired Auxiliary Steam Boiler (Section 5.5.1.1): Anticipated emission estimates should be compared to applicable state emission standards established for such equipment and facilities. Potential nonauxiliary sources and related amounts of pollutants such as CO, SO_2, NO_2, O_x, HC and particulates should be evaluated in the final statement.

5. Uranium-fuel Cycle (Section 5.4.3): The major sources of the gases which are designated as Effluents (Chemicals) in Table 5.14 (page 5-17) should be identified. The primary impacted areas should also be identified.

6. Impact on Air Quality (Section 10.1.1.3): The projected increase in ambient air pollutant concentrations of smoke and dust during construction activities should be quantified. The aerial extent of such pollutants should also be identified.

Solid Waste Operations

Information in Section 4.5.1, No. 2.b pertains to the non-radioactive solid waste resulting from construction activities. The environmental statement should provide a discussion on alternative management measures for solid waste generated during construction activities or routine operation. The local and State regulations regarding landfill or other types of disposal and related permit requirements should be specified in the final statement.

Additional Comments

1. The final statement should include a discussion of the Wolf Creek emergency plan and relate it to Kansas state and local emergency plans as added protection for the public. In addition, the final statement should include a discussion of plans for controlling emergencies developing as a result of accidents involving toxic substances and fires on the site, as well as actions to be taken if the cooling lake dam should fail.

2. Appendix D and Tables 2 and 3 provide the capital investment summaries for a single unit 1150 MWe nuclear plant (i.e., Wolf Creek Generating Station) and a 1150 MWe coal-fired plant with SO_2 removal as an alternative to the Wolf Creek plant. The dollar comparisons should be clarified. The nuclear plant costs (Total Costs) are based on July 1973, dollars as opposed to April 1976, dollars for the coal-fired plant. The costs should use the same dollar base to give a clear evaluation of the comparative economics of the two generating systems.

3. In comparing the capital investments, the costs for decommissioning the nuclear plant was not included. The environmental report estimated decommissioning costs for Wolf Creek to be approximately 21 to 50 million dollars for a "Type III" decommissioning. This information should be included in the economic comparative analysis of the two power plants. Furthermore, the operational costs identified in Table 9.2 (page 9-5) should reflect the added decommissioning costs for both nuclear and the fossil fuel plants.

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
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TULSA, OKLAHOMA 74102

S+N-50-482

SWTOD-N

15 October 1975

RECEIVED
OCT 20 1975

Director
Division of Reactor Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

Please refer to our letters of 6 and 19 August 1975, furnishing comments on the draft environmental impact statement for the Wolf Creek Generating Station in Kansas.

Revised regulations extending our jurisdiction for permitting the discharge of dredged or fill material were published in the Federal Register on 25 July 1975. Since furnishing our August comments on the EIS, we have been given additional implementing guidance and have determined that a Section 404 permit will be required for some of the work related to the Wolf Creek Generating Station.

On 6 October 1975, Mr. Dino Scaletti of your office stated that the final EIS was being typed but that minor revisions could still be made. We hereby request that the following revisions be made so that the EIS will cover work to be permitted under Section 404 of the Federal Water Pollution Control Act.

a. Table 1.1, page 1-2. Under Federal insert: Agency - Department of the Army; Permit - Section 404 permit for filling operation in navigable waters; Status - Submitted October 1975.

b. Section 3.4.3, page 3-5. Insert the following paragraph between the 1st and 2nd paragraphs of this section: The main dam of the Wolf Creek cooling impoundment will be constructed on rock exposed by excavating 1,700,000 cubic yards of material. The excavated material will be disposed of at the Wolf Creek site. It is projected that construction of the main dam will require the following quantities of material for construction:

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1. 5,227,000 cubic yards of alluvial soil (clay) from borrow areas in the Wolf Creek Watershed within the basin of the proposed impoundment.

2. 378,000 cubic yards of sand obtained from local sources.

3. 184,000 cubic yards of rock obtained from local quarries.

4. 3,600 cubic yards of concrete.

c. Section 3.4.3, page 3-7. Insert the following information after the 1st sentence of the 2nd paragraph on page 3-7: The makeup water intake structure will be constructed on rock exposed by excavating approximately 32,000 cubic yards of rock. This material will be hauled from the area after excavation and disposed of at the Wolf Creek plant site. The makeup intake structure will be constructed of approximately 1,950 cubic yards of concrete. After construction of the structure, about 5,000 cubic yards of alluvial soil (clay), originating from borrow areas in the basin of the proposed Wolf Creek impoundment, will be backfilled around the structure.

d. Section 3.4.3, page 3-7. Insert the following paragraph between the 3rd and 4th paragraphs on page 3-7: An eight inch "raw water" pipeline, to provide makeup to the water treatment facility, will be constructed across the Wolf Creek within the cooling impoundment basin. Construction of this pipeline should require the excavation of approximately 100 cubic yards of material. About 100 cubic yards of alluvial soil (clay) will be required to backfill the pipeline at the crossing of Wolf Creek.

Sincerely yours,

WELDON M. GAMEL
Chief, Engineering Division

Appendix B

BIOTA OF THE TERRESTRIAL ENVIRONS

Table B.1. Diagnostic soil characteristics for soil series reported to occur at the Wolf Creek Generating Station site[a]

Bedrock material	Topographic position	Color of surface	Color of subsurface	Soil series
Alluvium	Level floodplains	Dark gray	Mottled dark gray	Leanna silt loam
			Dark gray	Oak wood silt clay loam
			Dark grayish brown	Verdigris silt loam
		Dark brown or grayish brown	Dark brown	Mason silt loam
		Black	Dark gray	Osage silty clay
	Gentle sloping areas	Dark grayish brown	Mottled reddish brown or yellowish red	Olpe gravelly silt loam
		Very dark gray	Mottled dark gray	Woodson silt loam
Limestone	Hilltops	Dark brown	Reddish brown	Clareson
	Rim of hills	Dark brown	Reddish brown	Sogn
	Sloping uplands	Grayish brown	Mottled dark grayish brown	Kenoma silt loam
		Dark grayish brown	Dark reddish brown	Lula silt loam
	Sloping limestone ridges	Very dark brown	Mottled dark brown	Labette silt loam
Shales	Ridge tops	Dark brown	Mottled dark brown	Bates loam
	Convex gentle sloping uplands	Very dark brown	Mottled yellowish brown	Dennis silt loam
			Mottled brown	Elam silty clay loam
		Black	Mottled dark grayish brown	Summity silty clay
	Gentle sloping uplands	Grayish brown	Mottled dark grayish brown	Kenoma silt loam
Sandstone	Sloping hilltops and moderately steep slopes	Dark brown	Dark brown	Collinsville

[a]ER, Sect. 2.2.2.8.

Table B.2. Dominant and common associate species of climax communities occurring in the vicinity of Wolf Creek Generating Station

Scientific name	Ecosystem distribution code[a]	Northern floodplain forest[b]	Oak–hickory forest	Bluestem prairie
Deciduous megophanerophytes				
Gymnocladus dioica	13	C		
Quercus alba	7		D	
Tilia americana	11		C	
Totals		1	2	0
Deciduous mesophanerophytes				
Acer negundo	10	C[c]	*c*	
Acer saccharinum	10	C[c]	*c*	
Aesculus glabra sargentii	12		C	
Asimina triloba	10		C	
Carya cordiformis	10	*c*	D[c]	
Carya ovata	7		D	
Celtis occidentalis	10	D[c]	*c*	
Fraxinus americana	7	C	C	
Fraxinus pennsylvanica subintegerrima	9	C[c]	C[c]	
Gleditsia triacanthos	9	C[c]	C[c]	
Juglans nigra	10	C[c]	C[c]	
Morus rubra	9	C[c]	C[c]	
Ostrya virginiana	9		C	
Platanus occidentalis	9	C[c]		
Populus deltoides	9	D[c]		
Prunus serotina	11		C	
Quercus macrocarpa	7	C[c]	C[c]	
Quercus muehlenbergii	7		C	
Quercus rubra	7	*c*	D	
Quercus velutina	7		D[c]	
Salix amygdaloides	13	D		
Salix nigra	9	D[c]		
Staphylea trifolia	12		C	
Tamarix gallica	13	C		
Ulmus americana	7	D[c]	C[c]	
Ulmus rubra	10	C[c]	*c*	
Totals		16	17	0
Deciduous nanophanerophytes				
Amorpha canescens	4			C
Ceanothus ovatus	6			C
Ribes missouriense	12	*c*	C[c]	
Rosa arkansana suffulta	4			C
Symphoricarpos orbiculatus	7	C[c]	C[c]	*c*
Totals		1	2	3
Deciduous vining phanerophytes				
Celastrus scandens	10	C		
Parthenocissus quinquefolia	9	C[c]	*c*	
Rhus toxicodendron vulgaris	8	C[c]	C[c]	
Vitis riparia	13	C		
Totals		4	1	0
Active chamaephyte				
Antennaria neglecta	6			C[c]
Totals		0	0	1
Proto hemicryptophytes				
Asclepias tuberosa	6			C
Aster laevis	6			C
Lespedeza capitata	6			C
Liatris mucronata	6			C
Liatris hirsuta	6			C
Lithospermum incisum	6			C
Petalostemum purpureum	5			C
Phlox pilosa	6			C
Psoralea tenuiflora floribunda	6			C
Ratibida columnifera	3			C[c]
Ratibida pinnata	6			C
Totals		0	0	2

Table B.2. (continued)

Scientific name	Ecosystem distribution code[a]	Northern floodplain forest[b]	Oak–hickory forest	Bluestem prairie
Partial rosette hemicryptophyte				
Erigeron strigosus	6			C
Silphium laciniatum	6			C
Totals		0	0	2
Gaminophytic hemicrypotophytes				
Koeleria cristata	2			C
Panicum oligosanthes scribnerianum	5			C[c]
Sporobolus asper	3			C[c]
Sporobolus heterolepis	5			C
Stipa spartea	3			C
Totals		0	0	5
Geophytes				
Aster ericoides	4			C[c]
Baptisia leucantha	6			C
Baptisia leucophaea	6			C
Cypripedium calceolus	12		C	
Helianthus grosseserratus	6			C
Hydrophyllum appendiculatum	12		C	
Liatris punctata	3			C
Liatris scariosa	6			C
Phlox divaricata	10	C	C	
Podophyllum peltatum	12		C	
Psoralea argophylla	4			C
Sanguinaria canadensis	12		C	
Solidago altissima	6			C
Solidago missouriensis	13	C		
Solidago rigida	6			C
Urtica procera	13	C		
Totals		2	5	10
Graminophytic geophytes				
Andropogon gerardi	2			D
Andropogon scoparius	2			D[c]
Bouteloua curtipendula	2			C
Elymus canadensis	5			C
Elymus virginicus	10	C[c]	C[c]	
Panicum virgatum	1			D[c]
Sorghastrum nutans	2			D[c]
Totals		1	1	6
Helophytes				
Polygonum punctatum	13	C		
Totals		1	0	0
Therophytes				
Bidens polylepis	13	C		
Galium tinctorium	6			C
Helianthus annuus	7	C	C	
Polygonum bicorne	13	C		
Polygonum lapathifolium	13	C		
Polygonum persicaria	13	C		
Senecio glabellus	13	C		
Totals		6	1	1

Footnotes and references for Table B.2

[a]Ecosystem distribution codes:

Ecological group	No. of Ecosystems
1. Ubiquitous sp.	70
2. Grassland—open woodland sp.	54—58
3. Great plain grassland sp.	15—19
4. Tall grass—midgrass prairie sp.	9
5. Oak savanna—tall grass prairie sp.	8
6. Bluestem prairie sp.	1
7. Eastern forest sp.	19—27
8. Eastern forest—neotropical sp.	25
9. Eastern deciduous—southern forest sp.	15
10. Eastern deciduous forest sp.	9
11. Lake—eastern deciduous forests sp.	17
12. Oak—hickory forest sp.	1
13. Northern floodplain forest sp.	1

[b]Northern floodplain forest codes:

C = common associate

D = Dominate

[c]Sighted by applicant at site in an example of that plant community.

Sources:

1. A. W. Kuchler, "Potential Natural Vegetation of the Coterminous United States," *Amer. Geog. Soc. Pub.* 36 (1964).

2. A. W. Kuchler, "A New Vegetation Map of Kansas," *Ecology* 55: 586—604 (1974).

Table B.3. Herptiles occurring in the vicinity of Wolf Creek Generating Station[a]

	Habitat distribution code[b]	Cultivated field	Open pastures prairies	Mixed-shrub pasture	Oak–hickory forest	Flood-plain forest	Aquatic
Mudpuppy, *Necturus maculosus maculosus*	18						C
Small-mouthed salamander, *Ambystoma texanum*	12			O			
Barred tiger salamander, *Ambystoma tigrinum mavortium*	22						
Plains spadefoot, *Scaphiopus bombifrons*	9						
American toad, *Bufo americanus americanus*[c]	3	O			F	F	
Rocky mountain toad, *Bufo woodhousei woodhousei*	1						
Blanchard's cricket frog, *Acris crepitans blanchardi*[c]	1					C	
Eastern gray treefrog, *Hyla versicolor versicolor*	17					F	
Western chorus frog, *Pseudacris triseriata triseriata*	1						
Great plains narrow-mouthed toad, *Gastrophyrne olivacea olivacea*	1						
Eastern narrow-mouthed toad, *Gastrophyrne carolinensis*	1						
Bullfrog, *Rana catesbeiana*	18					C	
Rio Grande leopard frog, *Rana pipiens berlandieri*[c]	1	O				C	
Northern crawfish frog, *Rana areolata cirulosa*	3						
Common snapping turtle, *Chelydra serpentina serpentina*	18						C
Alligator snapping turtle, *Macroclemys temmincki*	18						
Stinkpot, *Sternothaerus odoratus*	18						
Yellow mud turtle, *Kinosternon flavescens flavescens*	18						
Three-toed box turtle, *Terrapene carolina triunguis*	3						
Ornate box turtle, *Terrapene ornata ornata*[c]	3						
Map turtle, *Graptemys geographica*	18						
Mississippi map turtle, *Graptemys kohni*[c]	18						
Ouachita map turtle, *Graptemys pseudogeographica ouachitensis*	18						
False map turtle, *Graptemys pseudogeographica pseudogeographica*	19						
Western painted turtle, *Chrysemys picta belli*	18						C
Red-eared turtle, *Pseudemys scripta elegans*[c]	18						C
Smooth softshell, *Trionyx muticus*	19						
Western spiny softshell, *Trionyx spinifer hartwegi*	19						C
Eastern collared lizard, *Crotaphytus collaris collaris*	10						
Eastern earless lizard, *Holbrookia maculata perspicua*	6						
Texas horned lizard, *Phrynosoma cornutum*	10						
Six-lined racerunner, *Cnemidophorus sexlineatus*	3	C	C	F			
Ground skink, *Lygosoma laterale*	3						
Five-lined skink, *Eumeces fasciatus*	3		O	O	C		
Great plains skink, *Eumeces obsoletus*	3		F	C	O		
Southern coal skink, *Eumeces anthracinus pluvialis*	15						
Northern prairie skink, *Eumeces septentrionalis septentrionalis*	3		C			O	
Western slender glass lizard, *Ophisaurus attenuatus attenuatus*[c]	3			O			
Diamond-backed water snake, *Natrix rhombifera rhombifera*	18					F	F
Blotched water snake, *Natrix erythrogaster transversa*	18					C	F
Northern water snake, *Natrix sipedon sidedon*	18					C	F
Graham's water snake, *Natrix grahami*	18					C	O
Texas brown snake, *Storeria dekayi texana*	12			O	F	O	
Red-sided garter snake, *Thamnophis sirtalis parietalis*[c]	1	O	F	F	F	O	
Western plains garter snake, *Thamnophis radix haydeni*	18						
Western ribbon snake, *Thamnophis sauritus proximus*	18					C	
Central lined snake, *Tropidoclonion lineatum annectens*	3		C				
Eastern hognose snake, *Heterodon platyrhinos*	3						
Plains hognose snake, *Heterodon nasicus nasicus*	11						
Prairie ringneck snake, *Diadophis punctatus arnyi*	3		O	O	C		
Western worm snake, *Carphophis amonenus vermis*	16				C		
Eastern yellow-bellied racer, *Coluber constrictor flaviventris*	3	F	F	F	F		
Eastern coachwhip snake, *Masticophis flagellum flagellum*	15						
Rough green snake, *Opheodrys aestivus*	18						
Great plains rat snake, *Elaphe guttata emoryi*	5	O		C			
Black rat snake, *Elaphe obsoleta obsoleta*	3	O		O	C		
Bullsnake, *Pituophis melanoleucus sayi*	5	C	C	F			
Speckled kingsnake, *Lampropeltis getulus holbrooki*	3	O	C	O			
Red milk snake, *Lampropeltis doliata syspila*	3			O	C		
Prairie kingsnake, *Lampropeltis calligaster calligaster*[c]	3	O	C	F			

Table B.3 (continued)

	Habitat distribution code[b]	Cultivated field	Open pastures prairies	Mixed-shrub pasture	Oak–hickory forest	Flood-plain forest	Aquatic
Western flat-headed snake, *Tantilla gracilis hallowelli*	3						
Northern copperhead, *Agkistrodon contortrix mokeson*	3	O	O	O	C		
Western massasauga, *Sistrurus catenatus tergeminus*	11						
Timber rattlesnake, *Crotalus horridus horridus*	3	O	O	O	O		

[a]Occurrence codes:

C = Characteristic occurrence.

F = Frequent occurrence.

O = Occasional occurrence.

[b]Habitat distribution codes:	Number of habitats:
1. Generally ubiquitous sp.	12–16
2. Farmland–wetland sp.	6–10
3. Ubiguitous terrestrial sp.	7–11
4. Farmyard–woodland sp.	2–6
5. Farmland–brushland sp.	5–7
6. Farmland sp.	3–5
7. Farmyard–city sp.	2
8. Cropland sp.	1
9. Grassland sp.	2
10. Prairie–desert sp.	4
11. Prairie sp.	1
12. Brushland–woodland–wetland sp.	7–11
13. Brushland–woodland sp.	5–6
14. Brushland sp.	2–3
15. Woodland sp.	2–4
16. Forest sp.	1
17. Swamp sp.	1
18. Ubiquitous wetland sp.	5–6
19. River sp.	1
20. Lentic wetland sp.	2–4
21. Pond–marsh sp.	2
22. Pond sp.	1

[c]Sighted at the site.

Sources:

1. R. Conant, *A Field Guide to Reptiles and Amphibians*, Houghton Mifflin Company, Boston, Mass., 1958.
2. H. H. Collins, *Complete Guide to American Wildlife*, Harper & Brothers, New York, 1959.
3. R. F. Clarke, *An Ecological Study of Reptiles and Amphibians in Osage County, Kansas: Emporia State Research* Studies, vol. 7, pp. 1–52.

Table B.4. Mammals occurring in the vicinity of Wolf Creek Generating Station[a]

	Habitat distribution code[c]	Cultivated field	Open pasture	Prairie	Mixed shrub pasture	Lowland woods	Aquatic
Common opossum, *Didelphis marsupialis*[b]	1					X	
Least shrew, *Cryptotis parva*	1						
Shorttail shrew, *Blarina brevicauda*[b]	1			X		X	
Eastern mole, *Scalopus aquaticus*[b]	6						
Little brown bat, *Myotis lucifugus*	7						
Masked brown bat, *Myotis subulatus*	3						
Eastern pipistrel, *Pipistrellus subflavus*	3						
Big brown bat, *Eptesicus fuscus*	3						
Red bat, *Lasiurus borealis*	3						
Hoary bat, *Lasiurus cinereus*	16						
Evening bat, *Nycticeius humeralis*	7						
Mexican freetail bat, *Tadarida brasiliensis*	7						
Raccoon, *Procyon lotor*[b]	15					X	
Longtail weasel, *Mustela frenata*	3						
Mink, *Mustela vison*	18						
River otter, *Lutra canadensis*	18						
Badger, *Taxidea taxus*[b]	5			X			
Spotted skunk, *Spilogale putorius*	3						
Striped skunk, *Mephitis mephitis*[b]	3						
Coyote, *Canis latrans*[b]	3		X			X	
Red fox, *Vulpes fulva*	3						
Woodchuck, *Marmota monax*	3						
Thirteen-lined ground squirrel, *Citellus tridecimliniatus*	3						
Franklin ground squirrel, *Citellus franklini*	1						
Eastern gray squirrel, *Sciurus carolinensis*	16						
Eastern fox squirrel, *Sciurus niger*[b]	15					X	
Southern flying squirrel, *Glaucomys volans*	15						
Plains pocket gopher, *Geomys bursarius*	6						
Hispid pocket mouse, *Perognathus hispidus*	6						
Beaver, *Castor canadensis*	12						
Plains harvest mouse, *Reithrodontomys montanus*[b]	1		X	X	X		
Western harvest mouse, *Reithrodontomys megalotis*	3						
Deer mouse, *Peromyscus maniculatus*[b]	3		X	X		X	
White-footed mouse, *Peromyscus leucopus*[b]	13					X	
Northern grasshopper mouse, *Onychomys leucogaster*	10						
Eastern woodrat, *Neotoma floridana*	13						
Rice rat, *Oryzomys palustris*	2						
Hispid cotton rat, *Sigmodon hispidus*[b]	2			X	X		
Southern bog lemming, *Synaptomys cooperi*	3						
Prairie vole, *Microstus ochrogaster*	6					X	
Pine vole, *Pitymys pinetorium*	15						
Muskrat, *Ondatra zibethicus*	18						
Norway rat, *Rattus norvegicus*	7						
Black rat, *Rattus rattus*	7						
House mouse, *Mus musculus*[b]	3			X		X	
Meadow jumping mouse, *Zapus hudsonius*	3						
Black-tailed jackrabbit, *Lepus californicus*	10						
Eastern cottontail, *Sylvilagus floridanus*[b]	3				X	X	
Whitetail deer, *Odocoileus virginianus*[b]	13				X	X	

[a]Code X = Habitat at site in which species was observed by the applicant.
[b]Observed at the site
[c]Habitat distribution code

Habitat distribution code	Number of habitats
1. Generally ubiquitous sp.	12–16
2. Farmland–wetland sp.	6–10
3. Ubiquitous terrestrial sp.	7–11
4. Farmyard–woodland sp.	2–6
5. Farmland–brushland sp.	5–7
6. Farmland sp.	3–5
7. Farmyard–city sp.	2
8. Cropland sp.	1
9. Grassland sp.	2
10. Prairie–desert sp.	4
11. Prairie sp.	1
12. Brushland–woodland–wetland sp.	7–11
13. Brushland–woodland sp.	5–6
14. Brushland sp.	2–3
15. Woodland sp.	2–4
16. Forest sp.	1
17. Swamp sp.	1
18. Ubiquitous wetland sp.	5–6
19. River sp.	1
20. Lentic wetland sp.	2–4
21. Pond–marsh sp.	2
22. Pond sp.	1

Sources:
1. W. H. Burt and R. P. Grossenheider, *A Field Guide to the Mammals*, Houghton Mifflin Company, Boston, Mass., 1964.
2. H. H. Collins, *Complete Guide to American Wildlife*, Harper & Brothers, New York, 1959.

Table B.5. Birds occurring in the vicinity of the Wolf Creek Generating Station[a]

	Time of residence[b]	Habitat distribution code[c]	Cultivation field	Open pasture	Prairie	Mixed shrub pasture	Lowland woods	Aquatic
Pied-billed grebe, *Podilymbus podiceps*	S	20						
Double-crested cormorant, *Phalacrocorax auritus*[d]	S	18						X
Mallard, *Anas platyrhynchos*[d]	W	2	XX					X
Pintail, *Anas acuta*	W	2						
Blue-winged teal, *Anas discors*[d]	S	21	XX					X
Common goldeneye, *Bucephala clangula*	W	18						
Bufflehead, *Eucephala albeola*	W	18						
Common merganser, *Mergus merganser*	W	18						
Turkey vulture, *Cathartes aura*[d]	S	3						
Goshawk, *Accipiter gentilis*	W	16						
Cooper's hawk, *Accipiter cooperii*	P	16						
Sharp-shinned hawk, *Accipiter striatus*	P	15						
Marsh hawk, *Circus cyaneus*[d]	P	2			+1.00, 2.6974[e]			
Rough-legged hawk, *Buteo lagopus*	W	2						
Red-tailed hawk, *Buteo jamaicensis*[d]	P	12			+1.00, 0.3178			
Red-shouldered hawk, *Buteo lineatus*	W	16						
Swainson's hawk, *Buteo swainsoni*[d]	S	3		X	X			
Broad-winged hawk, *Buteo platypterus*	S	15						
Golden eagle, *Aquila chrysaetos*	W	1						
Bald eagle, *Haliaeetus leucocephalus*	W	18						
Pigeon hawk, *Falco columbarius*[d]	S	12						
Sparrow hawk, *Falco sparverius*[d]	S	1	XX	X	X			
Greater prairie chicken, *Tympanuchus cupido*	P	11						
Bob-white, *Colinus virginianus*[d]	P	3		−0.29, 0.0749	+0.51, 4.9530	+0.08, 0.0001		
Common egret, *Casmerodius albus*	S	1						
Great blue heron, *Ardea herodias*[d]	P	18					X	X
Little blue heron, *Florida caerulea*	S	2						
Green heron, *Butorides virescens*[d]	S	18		+1.00, 2.6974				
Black-crowned night heron, *Nycticorax nycticorax*	S	18						
American bittern, *Botaurus lentiginosus*	S	20						
Least bittern, *Ixobrychus exilis*	S	18						
Sandhill crane, *Grus canadensis*	S	1						
Virginia rail, *Rallus limicola*	S	20						
Sora, *Porzana carolina*	S	2						
Black rail, *Porzana jamaicensis*	S	20						
King rail, *Rallus elegans*	S	1						
Common gallinule, *Gallinula chloropus*	S	21						
American coot, *Fulica americana*	S	2						
Killdeer, *Charadrius vociferus*[d]	S	2		+0.46, 1.8011	+0.19, 0.0560			
Upland plover, *Bartramia longicauda*[d]	S	6		+1.00, 2.6974				
Spotted sandpiper, *Actitis macularia*	S	18						
American woodcock, *Philohela minor*	S	13						
Common snipe, *Capella gallinago*	W	1						

Table B.5 (continued)

	Time of residence[b]	Habitat distribution code[c]	Cultivation field	Open pasture	Prairie	Mixed shrub pasture	Lowland woods	Aquatic
Least tern, *Sterna albifrons*	S	18						
Rock dove, *Columba livia*[d]	P	2	XX					
Mourning dove, *Zenaidura macroura*[d]	P	3		−0.16, 0.0062	+0.74, 0.6232	−0.06, 0.0607	+0.74, 0.6232	
Yellow-billed cuckoo, *Coccyzus americanus*[d]	S	12		−0.35, 0.0019	−0.35, 0.0019	−0.27, 0.0188	+0.32, 0.9647	
Black-billed cuckoo, *Coccyzus erythropthalmus*	S	15						
Screech owl, *Otus asio*	P	4						
Great horned owl, *Bubo virginianus*[d]	P	12						
Long-eared owl, *Asio otus*	W	13						
Short-eared owl, *Asio flammeus*	W	2						
Barn owl, *Tyto alba*	P	3						
Barred owl, *Strix varia*	P	16						
Saw-whet owl, *Aegolius acadicus*	W	13						
Chuck-will's widow, *Caprimulgus carolinensis*	S	16						
Whippoorwill, *Caprimulgus vociferus*	S	16						
Common nighthawk, *Chordeiles minor*[d]	S	3		+1.00, 2.6974				
Chimney swift, *Chaetura pelagica*[d]	S	7						
Ruby-throated hummingbird, *Archilochus colubris*	S	7						
Belted kingfisher, *Megaceryle alcyon*	P	18						
Yellow-shafted flicker, *Colaptes auratus*[d]	P	4		−0.64, 1.225	−0.29, 0.0749	−0.20, 0.0001	+0.51, 4.9530	
Red-bellied woodpecker, *Melanerpes carolinus*[d]	P	4					+1.00, 5.702	
Red-headed woodpecker, *Melanerpes erythrocephalus*[d]	P	4					+1.00, 2.697	
Yellow-bellied sapsucker, *Sphyrapicus varius*	W	15						
Hairy woodpecker, *Dendrocopos villosus*[d]	P	16					+1.00, 2.697	
Downy woodpecker, *Dendrocopos pubescens*[d]	P	4			+0.10, 0.0019		+0.55, 4.033	
Scissor-tailed flycatcher, *Muscivora forficata*[d]	S	5		+1.00, 9.0253				
Eastern kingbird, *Tyrannus tyrannus*[d]	S	1		+0.55, 4.033	+0.10, 0.0019			
Western kingbird, *Tyrannus verticalis*	S	6						
Great crested flycatcher, *Myiarchus crinitus*[d]	S	4					+1.00, 4.9530	
Eastern phoebe, *Sayornis phoebe*[d]	S	2				XX	X	
Acadian flycatcher, *Empidonax virescens*	S	15						
Eastern wood pewee, *Contopus virens*[d]	S	4					+1.00, 9.025	
Horned lark, *Eremophila alpetris*[d]	P	1		−0.02, 1.3283	−0.02, 1.3283	+0.35, 0.5491		
Barn swallow, *Hirundo rustica*[d]	S	2		+0.32, 0.3283	−0.02, 1.3283	+0.02, 0.2747		
Cliff swallow, *Petrochelidon pyrrhonota*	S	2						
Tree swallow, *Iridoprocne bicolor*	S	18						
Bank swallow, *Riparia riparia*	S	2						
Rough-winged swallow, *Stelgidopterx ruficollis*[d]	S	18	XX	X	X			
Purple martin, *Progne subis*	S	1						
Blue jay, *Cyanocitta cristata*[d]	P	4		−0.29, 0.0749		+0.57, 0.0001	+0.51, 4.953	
Blacked-billed magpie, *Pica pica*	S	1						
Common crow, *Corvus brachyrhynchos*[d]	P	1			−0.27, 0.0896	+0.27, 0.0161	+0.32, 6.909	
Blacked-capped chickadee, *Parus atricapillus*[d]	P	4		−0.64, 1.225	−0.64, 1.225	−0.60, 0.7735	+0.63, 15.145	
Tufted titmouse, *Parus bicolor*[d]	P	4					+1.00, 2.697	

Table B.5 (continued)

	Time of residence[b]	Habitat distribution code[c]	Cultivation field	Open pasture	Prairie	Mixed shrub pasture	Lowland woods	Aquatic
White-breasted nuthatch, *Sitta carolinensis*[d]	P	4					+1.00, 2.697	
Red-breasted nuthatch, *Sitta canadensis*	W	4						
Brown creeper, *Certhia familiaris*	W	4						
House wren, *Troglodytes aedon*[d]	S	3					+1.00, 9.025	
Bewick's wren, *Thryomanes bewickii*	P	3						
Carolina wren, *Thryothorus ludovicianus*	P	4						
Long-billed marsh wren, *Telmatodytes palustris*	S	20						
Short-billed marsh wren, *Cistothorus platensis*[d]	S	20						
Mockingbird, *Mimus polyglottos*[d]	P	1		+0.42, 2.7016	–0.44, 0.0841	+0.07, 0.0101		
Catbird, *Dumetella carolinensis*[d]	S	3			+1.00, 1.3178			
Brown thrasher, *Toxostoma rufum*[d]	S	14		+0.23, 0.4580	+0.23, 0.4580	–0.37, 0.0101		
Robin, *Turdus migratorius*[d]	P	1		–0.35, 0.0019	–0.35, 0.0019		+0.55, 4.033	
Wood thrush, *Hylocichla mustelina*	S	4						
Eastern bluebird, *Sialia sialis*[d]	P	3				+0.13, 0.0713	+0.55, 1.013	
Blue-gray gnatcatcher, *Polioptila caerulea*	S	3						
Golden-crowned kinglet, *Regulus satrapa*	W	4						
Cedar waxwing, *Bombycilla cedrorum*	W	4						
Loggerhead shrike, *Lanius ludovicianus*[d]	P	3		+0.32, 0.0005		+0.35, 0.0055		
Starling, *Sturnus vulgaris*[d]	P	3		–0.35, 0.2277	–0.67, 1.669	+0.48, 0.0424	+0.49, 3.869	
White-eyed vireo, *Vireo griseus*	S	3						
Bell's vireo, *Vireo bellii*[d]	S	3			+1.00, 9.025			
Yellow-throated vireo, *Vireo flavifrons*	S	4						
Red-eyed vireo, *Vireo olivaceus*[d]	S	4					+1.00, 9.025	
Warbling vireo, *Vireo gilvus*	S	4						
Black-and-white-warbler, *Mniotilta varia*	S	15						
Prothonotary warbler, *Prothonotaria citrea*	S	18						
Blue-winged warbler, *Vermivora pinus*	S	15						
Parula warbler, *Parula americana*	S	4						
Yellow warbler, *Dendroica petechia*	S	1						
Cerulean warbler, *Dendroica cerulea*	S	12						
Prairie warbler, *Dendroica discolor*	S	13						
Ovenbird, *Seiurus aurocapillus*	S	4						
Louisiana waterthrush, *Seiurus motacilla*	S	12						
Maryland yellowthroat, *Geothlypis trichas*[d]	S	12				X		XX
Yellow-breasted chat, *Icteria virens*	S	12						
Kentucky warbler, *Oporornis formosus*	S	15						
Hooded warbler, *Wilsonia citrina*	S	15						
American redstart, *Steophaga ruticilla*	S	4						
House sparrow, *Passer domesticus*[d]	P	7			+1.00, 16.4893			
Eastern meadowlark, *Sturnella magna*[d]	P	2		+0.67, 1.6692	+0.35, 0.2277	+1.00, 3.617		
Western meadowlark, *Sturnella neglecta*	S	6						
Yellow-headed blackbird, *Xanthocephalus xanthocephalus*	S	2						
Red-winged blackbird, *Agelaius phoeniceus*[d]	P	1		–0.35, 0.2277	+0.32, 1.327	+0.23, 0.4122	–0.67, 1.669	

Table B.5 (continued)

	Time of residence[b]	Habitat distribution code[c]	Cultivation field	Open pasture	Prairie	Mixed shrub pasture	Lowland woods	Aquatic
Brewer's blackbird, *Euphagus cyanocephalus*[d]	S	2						
Common grackle, *Quiscalus quiscula*[d]	P	2		+0.15, 0.1663	+0.15, 0.1663	+0.27, 0.0992		
Brown-headed cowbird, *Molothrus ater*[d]	S	3		+0.06, 0.0037	+0.22, 0.6319	+0.12, 0.0364		
Orchard oriole, *Icterus spurius*[d]	S	4		+0.32, 0.0005	+0.32, 0.0005			
Baltimore oriole, *Icterus galbula*[d]	S	4				XX	X	
Scarlet tanager, *Piranga olivacea*	S	4				X		
Summer tanager, *Piranga rubra*	S	4						
Cardinal, *Richmondena cardinalis*[d]	P	4		–0.75, 4.119	+0.18, 0.0896	–0.17, 3.0161	+0.59, 3.430	
Rose-breasted grosbeak, *Pheucticus ludovicianus*	S	4						
Evening grosbeak, *Hesperiphona vespertina*	W	4						
Indigo bunting, *Passerina cyanea*[d]	S	3					+1.00, 9.025	
Purple finch, *Carpodacus purpureus*[d]	W	4					+1.00, 0.3178	
Pine siskin, *Spinus pinus*	W	3						
American goldfinch, *Spinis tristis*[d]	P	3		+0.10, 0.0270	–0.13, 0.0270	–0.51, 1.2633	+0.10, 0.0270	
Dickcissel, *Spiza americana*[d]	S	6		+0.18, 0.3128	+0.18, 0.3128	+0.08, 0.0001		
Rufous-sided towhee, *Pipilo erythrophthalmus*	P	3						
Savannah sparrow, *Passerculus sandwichensis*[d]	S	2		X	X			
Grasshopper sparrow, *Ammodramus savannarum*[d]	S	6		+0.66, 3.199	–0.02, 0.3283			
Henslow's sparrow, *Passerherbulus henslowii*	S	8						
Vesper sparrow, *Pooecetes gramineus*	S	5						
Lark sparrow, *Chondestes grammacus*[d]	S	3		X	X	XX		
Slate-colored junco, *Junco hyemalis*[d]	W	1				XX	X	
Tree sparrow, *Spizella arborea*[d]	W	5		+0.02, 0.0749	+0.18, 0.3128	+0.08	–0.64, 1.225	
Chipping sparrow, *Spizella passerina*	S	4						
Field sparrow, *Spizella pusilla*[d]	S	3		+0.42, 2.701	+0.03, 0.0841	–0.37, 0.0101		
Harris' sparrow, *Zonotrichia querula*[d]	W	12			+1.00, 1.3178			
Swamp sparrow, *Melospiza georgiana*	W	2						
Song sparrow, *Melospiza melodia*[d]	P	1		X	X	XX		
Chestnut-collared longspur, *Calcarius ornatus*	W	2						
Lapland longspur, *Calcarius lapponicus*	W	2						
Smith's longspur, *Calcarius pictus*	W	2						

Footnotes and references for Table B.5

[a] X, birds observed only along 20 mile census route – primary habitat; XX, birds observed only along 20 mile census route – secondary habitat.

[b] Time of residence:

S, summer.
W, winter.
P, year round.

[c] Habitat distribution code	Number of habitats
1. Generally ubiquitous sp.	12–16
2. Farmland wetland sp.	6–10
3. Ubiquitous terrestrial sp.	7–11
4. Farmyard–woodland sp.	2–6
5. Farmland–brushland sp.	5–7
6. Farmland sp.	3–5
7. Farmyard–city sp.	2
8. Cropland sp.	1
9. Grassland sp.	2
10. Prairie–desert sp.	4
11. Prairie sp.	1
12. Brushland–woodland–wetland sp.	7–11
13. Brushland–woodland sp.	5–6
14. Brushland sp.	2–3
15. Woodland sp.	2–4
16. Forest sp.	1
17. Swamp sp.	1
18. Ubiquitous wetland sp.	5–6
19. River sp.	1
20. Lentic wetland sp.	2–4
21. Pond–marsh sp.	2
22. Pond sp.	1

[d] Observed at site.

[e] Cole's index of interspecific association; based on number of birds sighted along transect (ER, Tables 2.7-32–2.7-35); chi squared value for number of birds sighted along linansects (ER, Tables 2.7-32–2.7-35).

Sources:

1. C. S. Robbins, B. Brun, and H. S. Zim, *A Guide to Field Identification – Birds of North America,* Golden Press, New York, 1966.
2. H. H. Collins, *Complete Guide to American Wildlife,* Harper and Brothers, New York, 1959.
3. R. T. Peterson, *A Field Guide to the Birds,* Houghton Mifflin Company, Boston, Mass., 1947.
4. R. T. Peterson, *A Field Guide to Western Birds,* Houghton Mifflin Company, Boston, Mass., 1961.
5. R. T. Peterson, *A Field Guide to the Birds of Texas,* Houghton Mifflin Company, Boston, Mass., 1963.

Table B.6. Rare, threatened, endangered, peripheral, status undetermined and sensitive species whose ranges overlap the site

Species	Status code[a]
Plants	
Mosquito fern, *Azolla mexicana*	R
Water weed, *Elodea nutallii*	R
Sedge, *Carex microdonta*	R
Sedge, *Carex sparganioides aggregata*	R
Soapweed, *Yucca glauca glauca*	R
Prairie white fringed orchid, *Habenaria leucophaea*	R
Hophorn beam, *Ostrya virginiana*	R
Dwarf hackberry, *Celtis tenuifolia georgiana*	R
Whitlow grass, *Draba brachycarpa*	R
Dodder, *Cuscuta pentagona*	R
Gerardia, *Tomanthera densiflora*	R
Aster, *Aster ontarionis*	R
Dwarf dandelion, *Krigia oppositifolia*	R
Pineapple weed, *Matricaria matricarioides*	R
Goldenrod, *Solidago canadensis hargeri*	R
Goldenrod, *Solidago speciosa rigidiuscula*	R
Invertebrates	
Deer toe mussel, *Truncilla truncata*	R
Fluted mussel, *Lasmigona costata*	R
Pocketbook mussel, *Proptera capax*	R
Warty-backed mussel, *Quadrula nodulata*	R
Young fan-tailed mussel, *Cyprogenia aberti*	R
Green snail, *Campeloma subsolidum*	R
Land snail, *Triodopsis cragini*	R
Fish	
Spotted gar, *Lepisosteus osculatus*	P
American eel, *Anguilla rostrata*	R,r
Gravel chub, *Hybopsis x-punctata*	e,R
Blue sucker, *Cycleptus elongatus*	r
High-finned carpsucker, *Carpiodes velifer*	e
Spotted sucker, *Minytrema melanops*	R
River redhorse, *Moxostoma carinatum*	e
Freckled madtom, *Noturus nocturnus*	R
Neosho madtom, *Norturus placidus*	E,R
Channel darter, *Percina copelandi*	R
Herps	
Eastern narrow-mouthed toad, *Gastrophyrne carolinensis*	P,R
Northern crawfish frog, *Rana areolata cirulosa*	e
Alligator snapping turtle, *Macroclemys temmincki*	e,R
Texas horned lizard, *Phrynosoma cornutum*	C
Six-lined racerunner, *Cnemidophorus sexlineatus*	R
Ground skink, *Lygosoma laterale*	R
Mammals	
Mexican freetail bat, *Tadarida brasiliensis*	R
Mink, *Mustela vison*	R
Badger, *Taxidea taxus*[b]	R
Gray fox, *Urocyon cinereoargenteus*	R
Bobcat, *Lynx rufus*	R
Woodchuck, *Marmota monax*	r
Franklin ground squirrel, *Citellus franklini*	r
Eastern chipmunk, *Tamias striatus*	e,R
Southern flying squirrel, *Glaucomys volans*	R
Plains harvest mouse, *Reithrodontomys montanus*[b]	R
Northern grasshopper mouse, *Onychomys leucogaster*	R
Southern bog lemming, *Synaptomys cooperi*	R
Meadow jumping mouse, *Zapus hudsonius*	R
Porcupine, *Erethizon dorsatum*	R
Nine-banded armadillo, *Dasypus novemcinctus*	R
Birds	
Double crested cormorant, *Phalarocorax auritus*[b]	d
Turkey vulture, *Carthartes aura*[b]	d

Table B.6 (continued)

Species	Status code[a]
Goshawk, *Accipiter gentilis*	R
Cooper's hawk, *Accipter cooperii*	d
Sharp-skinned hawk, *Accipter striatus*	d
Marsh hawk, *Circus cyaneus*[b]	d
Red-shouldered hawk, *Buteo lineatus*	Th
Bald eagle, *Haliaeetus leucocephalus*	E
Osprey, *Pandion haliaetus*	d
Pigeon hawk, *Falco columbarius*[b]	d
Greater prairie chicken, *Tympanuchus cupido* pinnatus,	E,S
Great blue heron, *Ardea herodias*[b]	d
Little blue heron, *Florida caerulea*	S
Black-crowned night heron, *Nycticorax nycticorax*	d
American bittern, *Botaurus lentiginosus*	S
Virginia rail, *Rallus limicola*	S
Black rail, *Porzana jamaicensis*	S,R
King rail, *Rallus elegans*	S
Common gallinule, *Gallinula chloropus*	P
Purple gallinule, *Porphyrula maritinica*	R
Least tern, *Sterna albifrons*	P
Barn owl, *Tyto alba*	d
Saw-whet owl, *Aegolius acadicus*	R
Whippoorwill, *Caprimulgus vociferus*	Th
Redheaded woodpecker, *Melanerpes erythrocephalus*[b]	d
Scissor-tailed flycatcher, *Muscivora forficata*[b]	d
Tree swallow, *Iridoprocne bicolor*	P
House wren, *Troglodytes aedon*[b]	d
Bewick's wren, *Thryomanes bewickii*	d
Eastern bluebird, *Sialia sialis*[b]	d
Loggerhead shrike, *Lanis ludovicianus*[b]	d
Blue-winged warbler, *Vermivora pinus*	P
Cerulean warbler, *Dendroica cerulea*	P
Prairie warbler, *Dendroica discolor*	P
Hooded warbler, *Wilsonia citrina*	P,r
Rose-breasted grosbeak, *Pheucticus ludovicianus*	R
Henslow's sparrow, *Passerherbulus henslowii*	P
Smith's longspur, *Calcarius pictus*	R

[a]Status code:

R = Rare in upper and middle Neosho River basin.
r = Rare in Kansas.
P = Peripheral to Kansas.
S = Species sensitive to habitat destruction in Kansas.
E = Threatened in the United States.
e = Endangered in Kansas but not nationally.
C = Commercial Kansas species which are recommended for protection.
Th = Threatened in Kansas.
U = Status undetermined for United States.
d = Declining populations in United States.

[b]Sighted by applicant at the proposed Wolf Creek sites.

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Appendix C

BIOTA OF THE AQUATIC ENVIRONS

Table C.1. Periphyton mean biomass and composition by major taxa in the site area

Collection date	Location[a]	Percent of total periphyton[b] (dominant species)			Mean periphytic biomass (mg/dm^2)
		Bacillar/diophyta	Chlorophyta	Cyanophyta	
April 12	1			100.0 (Am)	210.6
	2	17.1		82.9 (Pt)	73.9
	3	94.8 (Gp)		5.2 (Pt)	90.7
	4P	100.0 (Ns)			57.2
June 11	1	99.9 (Np)	0.1		87.0
	2	100.0 (Nd)			75.5
	3	100.0 (Nd)			323.1
	4P	100.0 (Nd)			63.2
Sept. 10	1	20.0 (Nf)	47.5 (O)	32.5 (Lm)	212.3
	2	13.3 (Nm)		86.7 (Lm)	128.7
	3	27.1 (Nm)	43.5 (C)	29.4 (Lm)	112.7
	4P	74.0 (Gb)	3.5	22.4 (Lm)	167.7
Dec. 10	1				23.2
	2	100.0 (Nd)			53.0
	3	91.2 (Nf)		8.8 (Ot)	134.2
	4P				12.3

[a] Location code:
1 = John Redmond Reservoir.
2 = Upstream end of proposed cooling lake on Wolf Creek.
3 = Immediately below proposed dam.
4P = Above Wolf Creek's confluence with Neosho River.

[b] Dominant species code:
Am = *Anacystis montana*
C = *Cladophora*
Gp = *Gomphonema parvulum*
Gb = *Gomphonema bohemicum*
Lm = *Lyngbya martensiana*
Nm = *Navicula minima*
Nd = *Nitzschia dissipata*
Nf = *N. frustulum*
Np = *N. palea*
Ns = *N. subhybrida*
O = *Oedegonium*
Ot = *Oscillatoria tenius*
Pt = *Phormidium tenue*

Table C.2. Staff summary of fish species collected by applicant in Wolf Creek, John Redmond Reservoir, and the Neosho River

Name	Number collected at each sampling station					Sport value	Preferred habitat and food habits	Spawning preferences: temperature (°F), time, site
	1[a]	2[b]	3[c]	4[d]	Total			
Lepisosteidae								
Lepisosteus platostomus shortnose gar	0	0	0	2	2	Rough	Shallow backwaters for young.[1] Stronger currents and deep water of mainstream as adults. Emerging gnats, mayflies, crayfish, bluegill, carp.[2]	66–74° (May–June). Strew adhesive eggs over weeds in shallow water.[3]
Clupeidae								
Dorosoma cepedianum gizzard shad	54	0	0	2	56	Forage	Pelagial waters of large rivers, lakes, reservoirs.[2,4,5] Bottom filter feeder on detritus, molluscs; also on plankton.[6,7]	64–75° (May–Aug.).[8] Random spawning over gravel bars or silt beds in shallow water.[8]
Cyprinidae								
Campostoma anomalum stoneroller	0	1	1	0	2	Forage	Clear streams and small rivers with sand and gravel bottoms, especially with riffles.[2,8] Diatoms, blue-green algae, chironomids.[2]	60° (May–June).[8] Small streams over gravel bottom, edge of pools.[8]
Cyprinus carpio carp	4	0	1	1	6	Rough	Warm, muddy rivers and lakes.[9,10] Omnivorous bottom feeders.[11,12]	(62°).[13] Adhesive eggs streams in very shallow water over muck bottom with debris.[13,9]
Notemigonus chrysoleucus golden shiner	2	32	17	1	52	Forage	Ponds, quiet sections of streams.[2] Omnivorous.[2]	68°. Eggs adhesive on vegetation.[2]
Notropis buchanani ghost shiner	74	0	0	35	109	Forage	Relatively calm eddies along main channel of rivers and at lower end of gravel bars.[1]	(May–Aug.).[1]
Notropis lutrensis red shiner	75	142	186	42	445	Forage	Clean sand-bottomed streams and running water.[5] Omnivorous – mostly insects, crustaceans, and algae.[2,14]	68° (June–July).[8] Nests in newly flooded weeds and debris in streams, pools.[2,8]
Phenacobius mirabilis suckermouth minnow	0	5	2	0	7	Forage	Riffles in permanently flowing tributaries with sand and gravel bottoms.[1,15] Insect larvae, especially dipterans.[2]	(April–Aug.).[1] Spawn two or more times during breeding season.[1]
Pimephales notatus bluntnose minnow	0	0	10	0	10	Forage	Permanently flowing small streams with rocky bottoms, especially shallow areas of clear pools.[1] Algae, especially diatoms, microcrustaceans, insect larvae of both benthos and plankton.[16]	70–75° (May–July).[1] Often at night. Attaches adhesive eggs to under surfaces of objects such as limestone or shale rocks on stream bottoms.[1,3] Hatching in 8–9 days.[3]
Pimphales promelas fathead	1	14	5	0	20	Forage	Silty lakes and streams.[4] Bottom feeders – diatoms, periphyton.[2]	61° (May–Aug.).[8] Quiet, shallow water (3 ft); eggs attached.[2,7,8,17]

Table C.2. (continued)

Name	Number collected at each sampling station 1[a]	2[b]	3[c]	4[d]	Total	Sport value	Preferred habitat and food habits	Spawning preferences: temperature (°F), time, site
Pimephales vigilax bullhead minnow	10	0	4	92	106	Forage	Backwaters and pools of rivers and clear streams.[4,5] Bottom feeder – ooze, insects.[2]	(April–June).[18] Shoal areas.[19]
Catostomidae								
Carpiodes carpio river carpsucker	23	0	3	1	27	Rough	Bottoms of silty rivers.[4,10] Omnivorous bottom feeder.[2,4]	57–82° (March–July).[5] Eggs strewn randomly in shallow water (1–3 ft) over sand and silt or weed beds; ascends rivers to spawn in stronger current.[5,8]
Ictiobus bubalus smallmouth buffalo	3	0	2	3	8	Rough	Channels of large rivers.[9] Omnivorous bottom feeder.[19,20,21]	60–65° (April).[4,8] Shallow water (1–3 ft), over weeds and mud.[8]
Moxostoma erythrurum golden redhorse	0	0	1	0	1	Rough	Pools of permanently flowing streams with firm clay, gravel or rocky bottoms.[1] Larval insects.[1]	70° or higher. (May).[1] Shallow pools with rocky bottoms, near riffles.[1]
Moxostoma macrolepidotum northern shorthead redhorse	0	0	1	0	1	Rough	Clear, swift flowing riffles approximately two feet deep with bottoms of gravel or rubble.[1] Benthic insects, cladocera.[2]	(April–May).[1] Gentle riffles.
Cyprinodontidae								
Fundulus notatus blackstripe topminnow	0	3	25	0	28	Forage	Surface of quiet marginal stream and lake waters where current is moderate or lacking.[4,18] Surface feeder – insects, floating material.[2,4,10]	(March–July).[18] Clean, fresh water of pools, lakes, and streams where little current exists.[18]
Ictaluridae								
Ictalurus melas black bullhead	0	35	13	0	48	Rough	Sluggish creeks and rivers, with shallow, silty water, avoids large bodies of water.[4,10] Omnivorous.[4,22]	68° (May–June).[8] Water 2–4 feet deep over mud or sand.[8]
Ictalurus punctatus channel catfish	13	0	1	0	14	Game	Lakes, larger rivers, and streams with stronger currents.[4,10] Omnivorous.[4,9]	75° (May–June).[8,9] Nests in dark secluded places (logs, rocks, etc.).[9,10]
Pylodictus olivaris flathead catfish	1	0	0	0	1	Game	Large, quiet, slow rivers.[10] Carnivorous – fish, live invertebrates.[9,23]	75° (late May–Aug.).[8,9] Nests in dark, secluded places (logs, rocks, etc.).[9,10]
Percichthyidae								
Morone chrysops white bass	76	0	0	5	81	Game	Large rivers and lakes.[10] Carnivorous – mostly fish (gizzard shad), some crustacea and insects.[1,10,24]	58–75° (March–April).[25] Migrate up tributaries or spawn at surface over gravel shoals or hard bottoms in reservoirs or lakes.[9,10,24,25]

Table C.2 (continued)

Name	Number collected at each sampling station: 1[a]	2[b]	3[c]	4[d]	Total	Sport value	Preferred habitat and food habits	Spawning preferences: temperature (°F), time, site
Centrarchidae								
Lepomis cyanellus green sunfish	0	6	25	2	33	Game, forage	Warmer waters of small ponds, sluggish creeks.[4,10] Carnivorous – mainly insect larvae, plus crayfish, and small fish.[9,26]	60° (April–Aug.).[8,9] Nesting colonies in shallow water near shore.[8,9]
Lepomis humilis orangespotted sunfish	1	14	14	10	39	Forage	All sizes of streams and lakes, commonly in silty water.[4,10] Carnivorous on insect larvae, small fish, crayfish.[9,27]	75–90° (spring).[5,10] Nest-builder.[10]
Lepomis macrochirus bluegill sunfish	0	0	5	0	5	Panfish, forage	Clear, quiet pools with vegetation.[4,5] Omnivorous.[26]	70° (May–Sept.).[8,28] Nests in quiet, shallow, littoral water (1–4 ft).[8]
Micropterus punctulatus spotted bass	0	0	0	1	1	Game	Medium-sized streams, rivers, lakes.[4] Carnivorous – fish, insects, crayfish.[9,26,29,30]	64° (spring).[9,22] Nest-builders upstream in small tributaries.[9]
Micropterus salmoides largemouth bass	0	1	1	0	2	Game	Weedy or brushy mud-bottomed lakes and ponds, sluggish streams and fairly clear reservoirs. Carnivorous – mostly fish, some large insects.[9,22,26,29,31,32]	60° (Feb.–May).[8,33,34] Nests in quiet water (2–8 ft) on any bottom but soft mud.[9]
Pomoxis annularis white crappie	20	2	2	18	42	Panfish	Warm, turbid rivers and lakes.[4,10] Carnivorous – insects, small fish.[9,35,36]	65–75° (March–May).[28] Nest beds on gravel or hard bottom (2–8 ft).[33] Eggs adhesive on plants.[37,38]
Percidae								
Etheostoma nigrum johnnydarter	0	1	0	0	1	Forage	Shallow pools near riffles of small, high gradient streams.[1] Mainly bloodworms.[1]	(April–May).[1] Nests under stones.[1]
Percina caprodes logperch	0	1	0	0	1	Rough	Shallow riffles in clear streams, shallow water on gravel bottom of lakes.[4,10] Carnivorous bottom forager – insect larvae, crustaceans, periphyton.[1]	54–72° (spring).[10,39] Scatters eggs over sand or gravel bars in riffles.[1,4,10]
Stizostedion vitreum walleye	2	0	0	0	2	Game	Deep water of large reservoirs.[1] Carnivorous – mainly fish, some insects, crustaceans.[1]	45–50° (March–April).[1] Adhesive eggs strewn over rock rip-rapped areas of reservoirs; riffles in tributaries of reservoirs.[1]

Table C.2. (continued)

Name	Number collected at each sampling station					Sport value	Preferred habitat and food habits	Spawning preferences: temperature (°F), time, site
	1[a]	2[b]	3[c]	4[d]	Total			
Scianidae								
Aplodinotus grunniens freshwater drum	7	0	0	3	10	Rough	Large, silty rivers and lakes.[2,9] Bottom feeder – mollusca, chironomids, crustacenas, small fish.[9,10 40]	64–76°. Semibuoyant eggs broadcast over gravel or clay.[9,40]
Grand total	366	257	319	218	1160			

[a]Sampling station 1: John Redmond Reservoir – open water near dam.
[b]Sampling station 2: Wolf Creek – near upper end of future impoundment.
[c]Sampling station 3: Wolf Creek – near future dam location.
[d]Sampling station 4: Neosho River – below confluence with Wolf Creek.

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Table C.3. Fishes other than those collected by the applicant known to have occurred in or near the Neosho River–Wolf Creek study area

Family and species	Common name
Lepisosteidae	
Lepisosteus osseus	Long-nose gar
Cyprinidae	
Hybopsis x-punctata[a]	Gravel chub
Notropis camurus[a]	Blunt-faced shiner
Notropis pilsbryi[a]	Dusky-striped shiner
Notropis rubellus[a]	Rosey-faced shiner
Notropis stramineus[a]	Sand shiner
Notropis umbratilis	Red-finned shiner
Notropis volucellus	Mimic shiner
Pimephales tenellus	Slim minnow
Semotilus atromaculatus[a]	Creek chub
Catostomidae[a]	
Carpiodes velifer[a]	High-finned carpsucker
Cycleptus elongatus	Blue sucker
Ictiobus cyprinellus	Big-mouth buffalo
Ictiobus niger	Black buffalo
Moxostoma carinatum	River redhorse
Ictaluridae	
Ictalurus natalis	Yellow bullhead
Noturus flavus[a]	Stonecat
Noturus nocturnus[a]	Freckled madtom
Noturus placidus[a]	Neosho madtom
Poeciliidae	
Gambusia affinis	Mosquitofish
Atherinidae	
Labidesthes sicculus	Brook silverside
Centrarchidae	
Lepomis megalotis	Longear sunfish
Percidae	
Etheostoma chlorosomum	Blunt-nosed darter
Etheostoma flabellare	Fan-tailed darter
Etheostoma spectabile[a]	Orange-throated darter
Percina copelandi	Channel darter
Percina phoxocephala[a]	Slendar-headed darter

[a]Suffered declines in abundance from 1952 to 1967.

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APPENDIX D

COST ESTIMATES FOR ALTERNATIVE BASE-LOAD GENERATION SYSTEMS

A recently developed computer program was used to rough check the applicant's capital cost estimate for the proposed nuclear power station and to estimate the costs for fossil-fueled alternative generation systems.

This computer program, called CONCEPT[1-3] was developed as part of the program analysis activities of the AEC Division of Reactor Research and Development, and the work was performed in the Studies and Evaluations Program at the Oak Ridge National Laboratory. The code was designed primarily for use in examining average trends in costs, identifying important elements in the cost structure, determining sensitivity to technical and economic factors, and providing reasonable long-range projections of costs. Although cost estimates produced by the CONCEPT code are not intended as substitutes for detailed engineering cost estimates for specific projects, the code has been organized to facilitate modifications to the cost models so that costs may be tailored to a particular project. Use of the computer provides a rapid means of calculating future capital costs of a project with various assumed sets of economic and technical ground rules.

DESCRIPTION OF THE CONCEPT CODE

The procedures used in the CONCEPT code are based on the premise that any central station power plant involves approximately the same major cost components regardless of location or date of initial operation. Therefore, if the trends of these major cost components can be established as a function of plant type and size, location, and interest and escalation rates, then a cost estimate for a reference case can be adjusted to fit the case of interest. The application of this approach requires a detailed "cost model" for each plant type at a reference condition and the determination of the cost trend relationships. The generation of these data has comprised a large effort in development of the CONCEPT code. Detailed investment cost studies by an architect-engineering firm have provided basic cost model data for light water reactor nuclear plants,[4-5] and fossil-fueled plants.[6-7] These cost data have been revised to reflect plant design changes since the 1971 reference date of the initial estimates.

The cost model is based on a detailed cost estimate for a reference plant at a designated location and a specified date. This estimate includes a detailed breakdown of each cost account into costs for factory equipment, site materials, and site labor. A typical cost model consists of over a hundred individual cost accounts, each of which can be altered by input at the user's option. The AEC system of cost accounts[8] is used in CONCEPT.

To generate a cost estimate under specific conditions, the user specifies the following input: plant type and location, net capacity, beginning date for design and construction, date of commercial operation, length of construction workweek, and rate of interest during construction. If the specified plant size is different from the reference plant size, the direct cost for each two-digit account is adjusted by using scaling functions that define the cost as a function of plant size. This initial step gives an estimate of the direct costs for a plant of the specified type and size at the base date and location.

The code has access to cost index data files for 20 key cities in the United States. These files contain data on cost of materials and wage rates for 16 construction crafts as reported by trade publications over the past fifteen years. These data are used to determine historical trends of site labor and material costs, providing a basis for projecting future costs of site labor and materials. These cost data may be overridden by user input if data for the particular project are available.

This technique of separating the plant cost into individual components, applying appropriate scaling functions and location-dependent cost adjustments, and escalating to different dates is the heart of the computerized approach used in CONCEPT. The procedure is illustrated schematically in Fig. D.1.

ESTIMATED CAPITAL COSTS

The assumptions used in the CONCEPT calculations for this project are listed in Table D.1. Table D.2 compares the total plant capital investment estimates for the proposed nuclear station utilizing once-through cooling on artificial reservoirs. The following costs (in mid-1974 dollars) for developing the cooling reservoirs are included in the estimates:

	5000-acre reservoir	2500-acre reservoir
Material	$ 5,950,000	$ 5,300,000
Labor	38,500,000	33,950,000
Land	5,418,000	3,323,000

Estimated costs for alternative fossil-fueled plants are presented in Table D.3. The estimated costs for SO_2 removal equipment are based on a study performed by Oak Ridge National Laboratory.[9] The assumptions used in that study are summarized in Table D.4.

As stated previously, the above cost estimates produced by the CONCEPT code are not intended as substitutes for detailed engineering cost estimates, but were prepared as a check on the applicant's estimate and to provide consistent estimates for the nuclear plant and fossil-fueled alternatives.

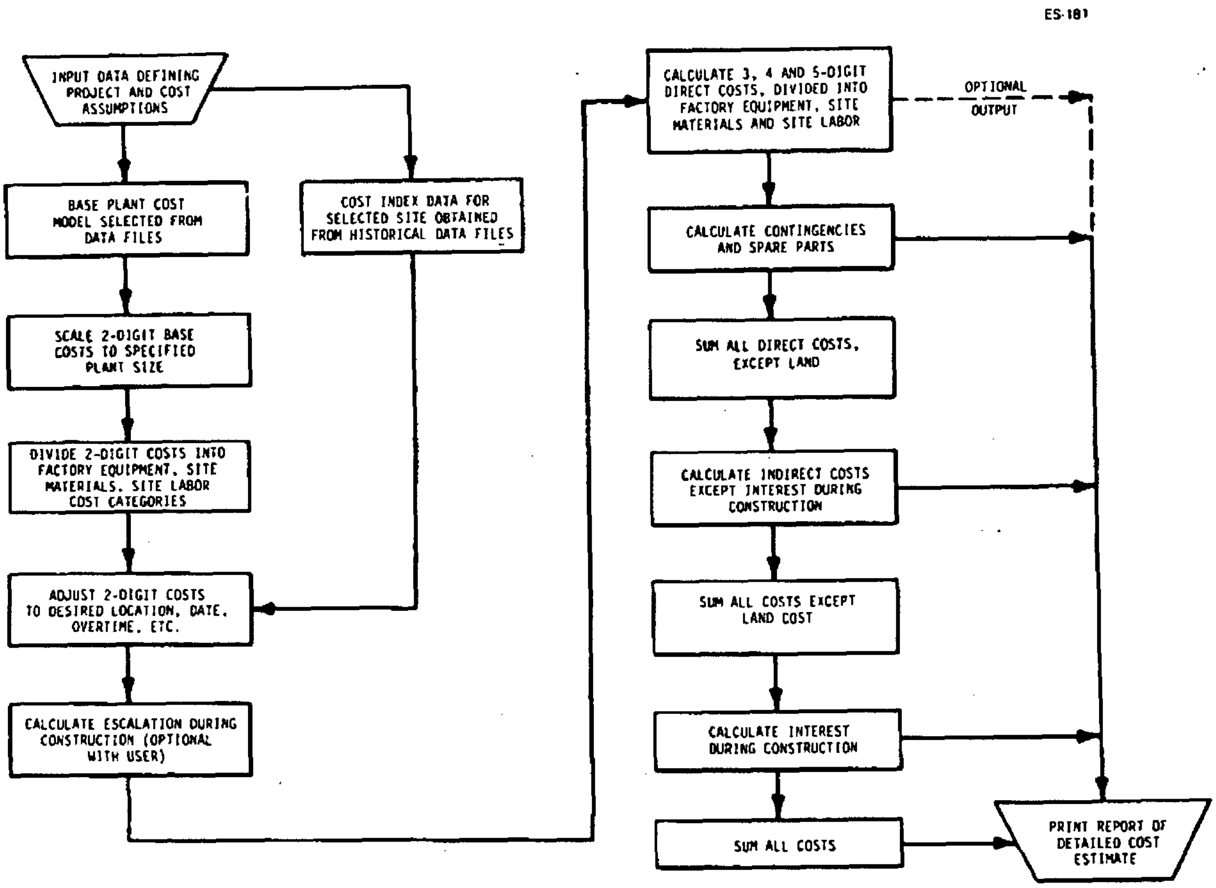

Fig. D.1. Use of the CONCEPT program for estimating capital costs.

Table D.1. Assumptions used in CONCEPT calculations

Plant name	Wolf Creek Generating Station
Plant type	Single-unit PWR with cooling reservoir
Alternate plant types	Single-unit coal-fired
Unit size	1150 MWe-net
Plant location	
Actual	Coffey County, Kansas
CONCEPT calculations	Kansas City
Interest during construction	7.5%/year, simple
Escalation during construction	
Site labor	7%/year
Site materials	7%/year
Purchased equipment	7%/year
Site labor requirements	10.1 man-hours/kWe
Length of workweek	40 hr
Start of design and construction date	
Nuclear steam system ordered	July 1973
Fossil alternatives	April 1976
Commercial operation dates	April 1982

Table D.2. Plant capital investment summary for a single-unit 1150-MWe pressurized water reactor nuclear power plant with alternative heat rejection systems

(Revised April 1975)
(Kansas Gas and Electric, Wolf Creek Generating Station)

	5000-acre reservoir	2500-acre reservoir
Net capability, MWe	1150	1150
Direct costs (millions of dollars)[a]		
Land and land rights	5	3
Physical plant		
Structures and site facilities	101	96
Reactor plant equipment	90	90
Turbine plant equipment	90	90
Electric plant equipment	31	31
Miscellaneous plant equipment	6	6
Subtotal (physical plant)	318	313
Spare parts allowance	2	2
Contingency allowance	23	22
Subtotal (total physical plant)	343	337
Indirect costs (millions of dollars)[a]		
Construction facilities, equipment, and services	21	21
Engineering and construction management services	52	51
Other costs	16	16
Interest during construction	126	123
Total costs		
Plant capital cost at start of project[a]		
Millions of dollars	563	551
Dollars per kilowatt	490	479
Escalation during construction	203	199
Plant capital cost at commercial operation		
Millions of dollars	766	750
Dollars per kilowatt	666	652

[a] July 1973 dollars.

Table D.3. Total plant capital cost investment cost estimated for a single-unit 1150-MWe coal-fired plant as an alternative to the Wolf Creek Generating System

(Revised April 1975)

	Without SO_2 abatement system		With SO_2 abatement system	
	5000-acre reservoir	2500-acre reservoir	5000-acre reservoir	2500-acre reservoir
Direct costs (millions of dollars)[a]				
Land and land rights	5	3	5	3
Physical plant				
Structures and site facilities	90	84	98	92
Boiler plant equipment	100	100	130	130
Turbine plant equipment	80	80	82	82
Electric plant equipment	19	19	26	26
Miscellaneous plant equipment	5	5	5	5
Subtotal (physical plant)	294	288	341	335
Spare parts allowance	2	2	2	2
Contingency allowance	21	21	24	24
Subtotal (total physical plant)	317	311	367	361
Indirect costs (millions of dollars)[a]				
Construction facilities, equipment, and services	18	17	29	28
Engineering and construction management services	27	27	31	30
Other costs	10	10	13	13
Interest during construction	90	87	107	104
Total costs				
Plant capital cost at start of project[a]				
Millions of dollars	467	455	552	539
Dollars per kilowatt	406	396	480	469
Escalation during construction	92	90	108	106
Plant capital cost at commercial operation				
Millions of dollars	559	545	660	645
Dollars per kilowatt	486	474	574	561

[a] April 1976 dollars.

Table D.4. Basis for SO_2-removal equipment cost estimate (for coal-fired plant)

Type of process	Wet scrubbing of flue gas by a limestone slurry
Cost basis	Integrated installation in a new plant (no backfitting required)
Fuel composition (design values)	
Sulfur content (% by weight)	2.5
Ash content (% by weight)	25
Energy value (Btu/lb)	10,000
Abatement level (% SO_2 removal, minimum)	76
Plant operating date[a]	
Net plant heat rate without SO_2 control (Btu/kWhre)	9000
Capability loss due to SO_2 control, %	2.5
Net plant heat rate (Btu/kWhre)	9230
Assumed plant capacity factor	0.80
Annual Mass Flows[a]	
Fuel consumption (tons/MWe net)	3230
Limestone used (tons/MWe net)	400
Sulfur removed (tons/MWe net)	60
Waste disposal (tons/MWe net)	
Slurry	460
Fly ash	720

[a]With once-through cooling.

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APPENDIX E

MODELS AND ASSUMPTIONS FOR ASSESSMENT OF POTENTIAL RADIOLOGICAL IMPACT FROM NORMAL OPERATION

This Appendix describes the models and assumptions used to make upper-bound estimates of population dose for interim assessment of the potential radiological impact from normal operation of nuclear power stations in the United States.

DOSE DEFINITIONS

Individual doses from specific radionuclides were estimated using standard internal dosimetric techniques in accordance with the recommendations of the International Commission on Radiological Protection (ICRP).[1,2,3] All internal dose conversion calculations have been made using the maximum permissible concentrations listed in ICRP publications II and VI. Data on breathing rates, organ masses, and other physiological parameters are those implied by the standard man of ICRP II.

The isotopic concentration levels in the environment used in the dose calculations were conservatively assumed to be those that would exist during the final year of plant life. A 30-year plant operational lifetime was assumed for calculating buildup of long-lived activity in the environment. Calculated doses represent a 50-year dose commitment that would be received by the population during 1 year of exposure to radioactive releases from the facility at the levels described; that is, the calculated doses reflect the dose that a person would receive over 50 years from radioactive materials to which that person was exposed for 1 year. For isotopes with a short effective half-life, the exposure essentially all occurs in the year of the intake. For isotopes with a longer effective half-life, the dose resulting from intake in any 1 year may be spread over a long period. The 50-year dose commitment method computes the dose associated with any given year's intake, even if that dose is due to a long-lived isotope and is spread out over the lifetime of the person exposed.

Liquid effluents

The liquid effluent population dose estimates previously used by the staff were conservative. For example, fish were assumed to have come to equilibrium with the radioactivity content of the water in which they were caught. Thus, the man-rem developed previously has been accepted for this evaluation and incorporated into the sum. In any case, the liquid effluents contribute only small fractions of the total impact of the station.

Atmospheric effluents

For a uniform population density the population dose may be written as

$$\text{Population dose} = K\overline{\Psi}P \ ,$$

where $\overline{\Psi}$ is the spatially averaged concentration time integral appropriate for a population of P individuals.

Radioiodine and particulates (depositing effluents)

At any point, the concentration time integral, Ψ, will be related to the ground concentration, w, and the deposition velocity, V_g, by

$$V_g = w/\Psi \ .$$

Thus, the population dose can be expressed as

$$\text{Population dose} = (K\overline{W}P)/V_g \ ,$$

where $\overline{W}$ is the average ground concentration appropriate for the population P. In the above equation only the average ground concentration, $\overline{W}$, is needed. Noting that whatever is released will eventually settle, we can define the average $\overline{W}$ over a large arbitrary area as

$$\overline{W} = Q/A \quad ,$$

where Q is the total source released. This gives

$$\text{Population dose} = KQ\ P/A\ V_g \quad ,$$

where P/A is the average population density (people per square meter), Q is the total source released (curies), V_g is the deposition velocity (meters per second), and K is the dose conversion factor (rem per Ci/sec/m^3). The above equation was used to determine upper bound population doses for the generic case.

The doses resulting from ground plane irradiation of the population were primarily based on the Oak Ridge EXREM III Code.[4] Data on certain other isotopes were based on Battelle studies.[5] Basically, the method used consists of determining the gamma energy at 100 cm above an assumed infinite ground plane. Buildup of long-lived activity on the ground from 30 years of continuous deposition includes ingrowth of daughter products. No beta doses from ground plane irradiation were treated as vegetation on the ground, clothing, and the travel distance in air all combine to make this dose contribution very small. In any case, the contribution to the total U.S. population dose from ground plane radiation is negligible.

Food uptake. For exposure from airborne radioisotopes resulting from food uptake, the population exposure is determined not by the density of people in the area of the food crop, but by the number of persons that can be fed by the affected crop. The staff has considered the exposure associated with three principal pathways: direct ingestion of affected vegetation, consumption of meat from animals fed on affected vegetation, and consumption of milk from animals fed on affected vegetation.

For the interim estimates, ground deposition was computed as described above. Vegetation density used was 2300 grams/m^2 of vegetation and 440 grams/m^2 of pasture,[6] which is typical of average agricultural and pasture land.

Concentrations of isotopes on the soil assumed buildup of the isotope from continuous deposition over the 30-year facility lifetime. Also included was ingrowth of radioactive daughter products. Isotopes were assumed to be deposited directly on vegetation as well as deposited on soil and taken up by plant roots. No loss of radioisotopes from soil by weathering or other removal mechanisms is included, so that the calculated results tend to be conservative.

Concentrations of isotopes directly deposited on vegetation assumed an effective 13-day weathering removal half-life from plant leaves in addition to the radiological half-life. Since both soil deposition and vegetation deposition are treated assuming the full original airborne concentration (i.e., deposition of isotopes on the soil was not depleted to account for the isotopes deposited on vegetation before they reach the soil), material weathered from the plants to the soil has already been accounted for. Thus, the doses do not need to be separately treated. Of the amount directly deposited on vegetation, 30% was assumed to be absorbed by the plant.

This results in a computed concentration of radioisotopes in agricultural vegetation in the affected area. For that portion of the vegetation that is assumed to go directly to human consumption, a decay time of 7 days was assumed in the transfer of foodstuffs from the field to ultimate consumption.

In addition to the portion going directly to human consumption, vegetation containing radioisotopes as computed above is assumed to be fed to meat and milk animals. Cattle were assumed to have ingested at a rate equivalent to 200 kg/day of grass.[7] Assuming a grass dry matter content of 25%, the above rate corresponds to 50 kg/day of dry grass. This ingestion rate is not to be considered as the daily mass intake of feed, but the "grass equivalent" intake. The development of this estimate is outlined below.

To maintain a high productivity, animals are generally offered feeds, such as grains and harvested forages, to supplement or to totally replace the pasture intake.[7,8,9] The U.S. Department of Agriculture[9] has estimated that one-fifth of the diet of milk cattle is obtained from pasturing. This percentage is based on the energy requirements of milking animals.

In evaluating the transport of radioiodine (I-131) in the milk pathway, it is generally accepted that a pasture intake of 10 kg/day of dry grass is applicable.[10-12] Assuming the energy content of various feeds is equivalent to grass, the above statement implies a total daily intake rate of 50 kg/day of dry grass or 200 kg/day of wet grass. Beef animals were assumed to be subject to the same feeding practices as milk cattle.

For the animal feed coming from stored feeds, a 2-month delay was assumed which results in decay of short-lived isotopes. For the portion coming directly from pastureland uptake, no decay was assumed between deposition and animal uptake.

Transfer factors from animal uptake to milk and meat were taken from another source.[13] For population dose estimates, a 1-day milk supply delay factor was used, and a 70 day meat supply delay factor was used between consumption of vegetation by the animal and ultimate consumption of meat or milk from that animal by persons in the population. This gives a concentration of radioisotopes in meat and milk from agricultural lands in the affected area.

To convert from concentration of activity in foodstuffs to population dose, we have assumed that the affected land has an average agricultural productivity equivalent to assuming that the entire U.S. population was fed from that portion of the land area of the U.S. east of the Mississippi. With an average diet for an adult consisting of

Vegetation	- 400 g/day
Meat	- 250 g/day
Milk	- 350 g/day ,

this results in an average land productivity of

Vegetation	- 100 kg/day/sq mile
Meat	- 65 kg/day/sq mile
Milk	- 90 kg/day/sq mile .

This compares fairly conservatively with the agricultural land productivity for the U.S. of about 50 kg/day/sq mile for milk[14] and 10 kg/day/sq mile for meat.[15]

Noble gases, carbon-14, and tritium (nondepositing effluents)

Short-lived noble gases were assumed to disperse to the atmosphere without deposition, but radioactive decay which limits spread of the gas was explicitly treated. The population dose, assuming an infinite integration along the plume path length, is given by

$$\text{Population dose} = KQ\, P/\lambda L\, A \;,$$

which is the same form as used for particulate deposition, except that the deposition velocity is replaced by λL, where λ is the radioactive decay constant (sec^{-1}) and L is the height of the assumed vertical air mixing. An L value of 1000 m was used in the calculations.

The long-lived gaseous radioisotopes, krypton-85 and carbon-14, were assumed to be distributed by dilution in the earth's atmosphere. Both were considered to build up over 30 years of plant life. Carbon-14 was assumed to be released in oxide form which maximizes its availability to the population via food chains. Other chemical forms such as methane would not be as readily available.

The carbon-14 was considered to be completely mixed in the troposphere with no removal mechanisms operating; that is, the absorption of carbon by the ocean and long-lived biota not strongly coupled to man were neglected with the ocean being the major sink. The neglect of carbon sinks yields an overestimate of the steady-state or end of plant life (30-year plant life) atmospheric concentration by a factor of about six.

Unlike radioactivity ejected into the stratosphere and then appearing in the high latitude troposphere as a weapon testing, the emission of concern here is directly introduced into the midlatitudes of the troposphere. Transfer of tropospheric air between the two hemispheres, although inhibited by wind patterns in the equatorial region, is considered to yield a hemisphere average tropospheric residence time of about 2 years with respect to hemispheric mixing.[18] This time constant is quite short with respect to the expected plant life-time, and mixing in both hemispheres can be assumed for end of plant life evaluations.

Doses were calculated assuming all carbon in the body reaches the same equilibrium ratio of carbon-14 to natural carbon as exists in the air.

Tritium was assumed to mix uniformly in the world's hydrosphere. The hydrosphere was assumed to include all the atmospheric water and the upper 70 m of the oceans. Having determined this equilibrium concentration of tritium in the world, doses to man were calculated by assuming all hydrogen in the body reaches the same equilibrium ratio of tritium to hydrogen as exists in the air and water of the environment.

Population density and changes — local impact

The doses calculated for shine dose from radioactive materials deposited on the ground and for short-lived noble gases were based on a population density of 160 persons/sq mile, characteristic of the U.S. population east of the Mississippi River. These components of dose would be increased if the close-in populations, the populations principally exposed, exceeded this value substantially. However, as noted, these components do not significantly affect the total and would be reviewed on an individual case basis for the Appendix I (10 CFR Part 50) cost-benefit analysis.

Local food uptake exposures are not based on population density, but rather on agricultural productivity and, consequently, are not affected directly by population growth but more by changes in land use. Similarly, the principal future impact on estimates from liquid effluents would result if water use patterns in the nearby areas are changed (e.g., if a drinking water intake for a large city is constructed near the plant discharge). Such future changes are difficult to predict.

To assure adequate control of releases, allowing for future changes in water or land use, the operating license technical specifications will provide for periodic reassessment of changes in land and water use patterns. This will provide a periodic reassessment of the adequacy of facility performance in order to maintain exposures of the public health within the Appendix I (10 CFR Part 50) guides.

CONCLUSIONS

The main contributions to the population dose to the U.S. are from carbon-14 and iodine-131. The generic estimates are about 2 man-rems/year for carbon-14 and about 300 man-rems/year for iodine-131 per curie released for each year of plant operation, for 30 years. All other releases and pathways contribute relatively insignificant portions of the total population dose.

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APPENDIX F

WATER QUALITY CRITERIA FOR INTERSTATE AND
INTRASTATE WATERS OF KANSAS

Kansas State Board of Health
Regulations

28-16-28. WATER QUALITY CRITERIA FOR INTERSTATE AND INTRASTATE WATERS OF KANSAS. Water quality criteria are listed herein for all surface waters of the state, both interstate and intrastate, including all tributary watercourses. All waters of the state whose existing quality is better than the applicable water quality criteria as established herein as of the date the water quality criteria become effective will not be lowered in quality until it has been determined by the Kansas State Board of Health that the change is justifiable as a result of necessary social and economic development and that all beneficial uses of waters affected will not be impaired. In no case shall the quality of waters of the state be reduced below the quality criteria as established herein.

I. Water Use Classification.

Water use classifications for all waters of the state are listed in section IX of the criteria. Water uses are grouped into the following two categories:

A. Class A waters shall be protected for the following water uses:

1. Body contact recreation. These waters are intended for uses where the human body may come in direct contact with the raw water to the point of complete submergence with the possibility of ingestion, such as swimming, water skiing, and skin diving.

2. The preservation and propagation of desirable species of fresh warm water aquatic biota, semi-aquatic life, waterfowl, and wildlife.

3. Public water supply.

4. Industrial water supply.

5. Agricultural purposes.

B. Class B waters shall be protected for the following water uses:

1. Secondary contact recreation. These waters are intended for uses such as fishing, wading, boating or other activities where ingestion of the water is not probable.

2. The preservation and propagation of desirable species of fresh warm water aquatic biota, semi-aquatic life, waterfowl, and wildlife.

3. Public water supply.

4. Industrial water supply.

5. Agricultural purposes.

APPROVED as to
form and legality.
Attorney General
by _______, Ass't.

II. Treatment Requirements

A minimum of secondary treatment shall be provided for all municipal wastes by July 1, 1977. Best practicable control technology currently available shall be applied to all industrial wastes by July 1, 1977. The objective of treatment or control will be to reduce the organic load, oil, grease, solids, alkali, acids, toxic materials, color and turbidity, taste and odor products, and other deleterious materials to the lowest practicable level.

Seasonal disinfection (April 1 through October 31) of treated wastes shall be provided for those municipalities or industries which contribute bacterial loadings to rivers or streams which are tributary to waters used for body contact recreation, and which waters are within the zone of bacterial influence.

III. Flow Criteria

The water quality criteria for all waters shall apply at all times except during periods when streamflows are less than the average minimum seven-day low flow which occurs once in ten years, or when stream flow is less than 1 cfs, whichever value is greater. Quality criteria will be met insofar as is practicable when streamflows are less than those stipulated.

IV. Mixing Zones

The water quality criteria listed herein shall apply below the mixing zone for each individual discharge. The total area and/or volume of a receiving stream assigned to mixing zones shall be limited to that which will: 1) not interfere with biological communities or populations of important species to a degree which is damaging to the ecosystem; and 2) not diminish other beneficial uses disproportionately.

V. Zones of Passage

Zones of passage must be provided in streams, reservoirs, or lakes wherever mixing zones are allowed, and such zones shall be continuous water routes of the volume, area, and quality necessary to allow passage of free-swimming and drifting organisms with no significant effects on their populations. Because of varying local physical and chemical conditions and biological phenomena, no single value can be given on the percentage of river width necessary to allow a sufficient zone of passage. As a guideline, mixing zones should be limited to no more than 1/4 of the cross-sectional area and/or volume of flow of a stream or reservoir, leaving at least 3/4 free as a zone of passage.

APPROVED as to
form and legality.
Attorney General
by ______, Ass't.

VI. Analytical Testing

All methods of sample collection, preservation, and analysis used in applying any of the rules and regulations in these standards shall be in accord with those prescribed in "Standard Methods for the Examination of Water and Wastewater", thirteenth edition, or other methods acceptable to the Board.

VII. General Criteria

The cumulative effect of waste discharges to waters of the state will be guided by the 1962 U.S. Public Health Service drinking water standards. Pollutional substances contributed by man-made point source waste discharges shall be maintained below maximum permissible concentrations which would be detrimental for public water supplies, the preservation and propagation of desirable diversified aquatic life, recreational requirements, agricultural needs, industrial needs, and other established beneficial use. All waters shall be controlled so that public health hazards or nuisance conditions will not develop due to man-made point source discharges.

VIII. Specific Criteria

A. Bacteria

1. In Class A waters, the fecal coliform content based on not less than five samples taken during separate 24-hour periods over not more than a 30-day period, shall not exceed a geometric mean of 200 per 100 ml sample, nor shall more than 10 percent of total samples during any 30-day period exceed 400 per 100 ml sample.

2. In Class B waters, the fecal coliform content shall not exceed 2,000 per 100 ml sample.

   It is recognized that the bacterial criteria for Class A and B waters will be violated as a result of contributions from natural non-point sources during periods when those waters are being influenced by surface runoff.

B. Dissolved Oxygen

1. In Class A waters, the dissolved oxygen content shall be maintained at or above 5 mg/l. Dissolved oxygen concentrations less than 5 mg/l shall not be due to man-made point source waste discharges.

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by ________, Ass't.

2. In Class B waters, the dissolved oxygen content shall be maintained at or above 5 mg/I (except for 4 mg/l for short periods of time within a 24 hour period). Dissolved oxygen concentrations less than the above levels shall not be due to man-made point source waste discharges.

C. Temperature

Man-made point source discharges shall not elevate the temperature of the receiving water above 90°F. Heat of artificial origin shall not be added to a stream in excess of the amount that will raise the temperature of the water more than 5°F above natural conditions. The epilimnion of lakes shall not be raised more than 3°F above that temperature which existed before the addition of heat of artificial origin. The normal daily and seasonal temperature variations before the addition of heat due to other than natural causes should be maintained. The measurement system used in each case should provide for temperature measurements which reflect the temperature differential induced after a reasonable mixing zone. A zone of passage for free-swimming and drifting aquatic biota must be provided for the water affected by each discharge.

<u>It is recognized that on occasion natural thermal conditions may exceed the maximum allowable temperature requirements. Deviations from temperature requirements as a result of waste discharge will not be allowed without special permission.</u>

D. pH

Man-made point source waste discharge shall not cause the pH of waters of the state to vary below 6.5 nor above 8.5.

E. Ammonia

Man-made point source waste discharge shall not cause the undissociated ammonium hydroxide concentration of waters of the state to exceed 0.15 mg/l as N.

F. Oil and Grease

All waters shall be essentially free of visible oil and grease. Dissolved or emulsified grease concentrations shall be kept below levels which will interfere with established beneficial use.

G. Solids

There shall be no man-made deposits of solids in waters of the state, either organic or inorganic, which will be detrimental to established beneficial use. All waters shall be free of floating debris, scum, and other floating materials attributable to municipal, industrial, or other waste disposal practices in amounts sufficient to be unsightly or detrimental to established beneficial use.

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Attorney [illegible]
by [illegible], Ass't.

H. Turbidity

There shall be no turbidity increase in waters of the state, of other than natural origin, that will cause substantial visible contrast with the natural appearance of the water or be detrimental to established beneficial use.

I. Taste and Odor Producing Substances

Taste and odor producing substances from man-made point sources shall be limited to concentrations in the receiving water that will not interfere with the production of potable water by reasonable water treatment processes, or impart unpalatable flavor to fish, or result in noticeable offensive odors in the vicinity of the water, or otherwise interfere with established beneficial use of the water.

J. Color

Man-made point source discharges of color producing substances shall be limited to concentrations which will not be detrimental to established beneficial use of the receiving water.

K. Toxic Substances

Toxic substances or synergistic effects of toxic substances from man-made point sources shall be limited to concentrations in the receiving water that will not be harmful to human, animal, plant or aquatic life, or otherwise interfere with established beneficial use of the water.

IX. Designation of Water Uses

All watercourses which reach zero natural flow annually are exempted from water use classification and the application of water quality criteria, except: 1) those waters specifically listed in the following table, and 2) those waters that can be reasonably expected to support aquatic wildlife because of pooling during periods of no flow.

Unlisted tributary watercourses which are perennial or which can be reasonably expected to support aquatic wildlife because of pooling during periods of no flow shall be classified as Class B waters.

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form and legality.
Attorney General
by [signature], Ass't.

Waters	Water Use Class
Neosho River Basin	
Neosho River	B
John Redmond Reservoir	A
Council Grove Reservoir	A
Cottonwood River	B
Marion Reservoir	A
Chase County State Lake	A
Spring River	B
Shoal Creek	B
Verdigris River Basin	
Verdigris River	B
Toronto Reservoir	A
Fall River	B
Fall River Reservoir	A
Elk River	B
Elk City Reservoir	A
Montgomery County State Lake	A
Wilson County State Lake	A
Woodson County State Lake	A
Caney River	B
Caney Creek	B
Little Arkansas River Basin	
Little Arkansas River	B
Lower Arkansas River Basin	
Arkansas River below Walnut Creek	B
Ninnescah River	B
North Fork Ninnescah River	B
Cheney Reservoir	A
South Fork Ninnescah River	B
Kingman County State Lake	A
Rattlesnake Creek	B
Cow Creek	B
Chikaskia River	B
Medicine Lodge River	B
Salt Fork Arkansas River	B

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Attorney General
by WNW, Ass't.

Upper Arkansas River Basin

Arkansas River above Walnut Creek	B
Kearny County State Lake	A
Pawnee River	B
Walnut Creek	B

Walnut River Basin

Walnut River	B
Whitewater River	B

Cimarron River Basin

Cimarron River	B
North Fork Cimarron River	B
Crooked Creek	B
Meade County State Lake	A

Smoky Hill River Basin

Smoky Hill River	B
Scott State Park Lake	A
Cedar Bluff Reservoir	A
Kanopolis Reservoir	A
Big Creek	B
Chapman Creek	B

Upper Republican River Basin

South Fork Republican River	B
Arikaree River	B
Beaver Creek	B
Sappa Creek	B
Prairie Dog Creek	B
Norton Reservoir	A

Solomon River Basin

Solomon River	B
Waconda Lake	A
North Fork Solomon River	B
Kirwin Reservoir	A
South Fork Solomon River	B
Webster Reservoir	A
Ottawa County State Lake	A

APPROVED as to
form and legality.
Attorney General
by WNW, Asst.

Lower Republican River Basin

Republican River	B
Milford Reservoir	A
Lovewell Reservoir	A

Big Blue River Basin

Big Blue River	B
Tuttle Creek Reservoir	A
Little Blue River	B
Black Vermillion River	B

Missouri River Basin

Missouri River	B
Wolf River	B
South Fork Nemaha River	B
Big Blue River	B
Indian Creek	B

Kansas River Basin

Kansas River	B
Deleware River	B
Perry Reservoir	A
Wakarusa River	B
Clinton Reservoir	A
Vermillion Creek	B
Soldier Creek	B
Stranger Creek	B
Mill Creek (Wabaunsee County)	B

Marais des Cygnes River Basin

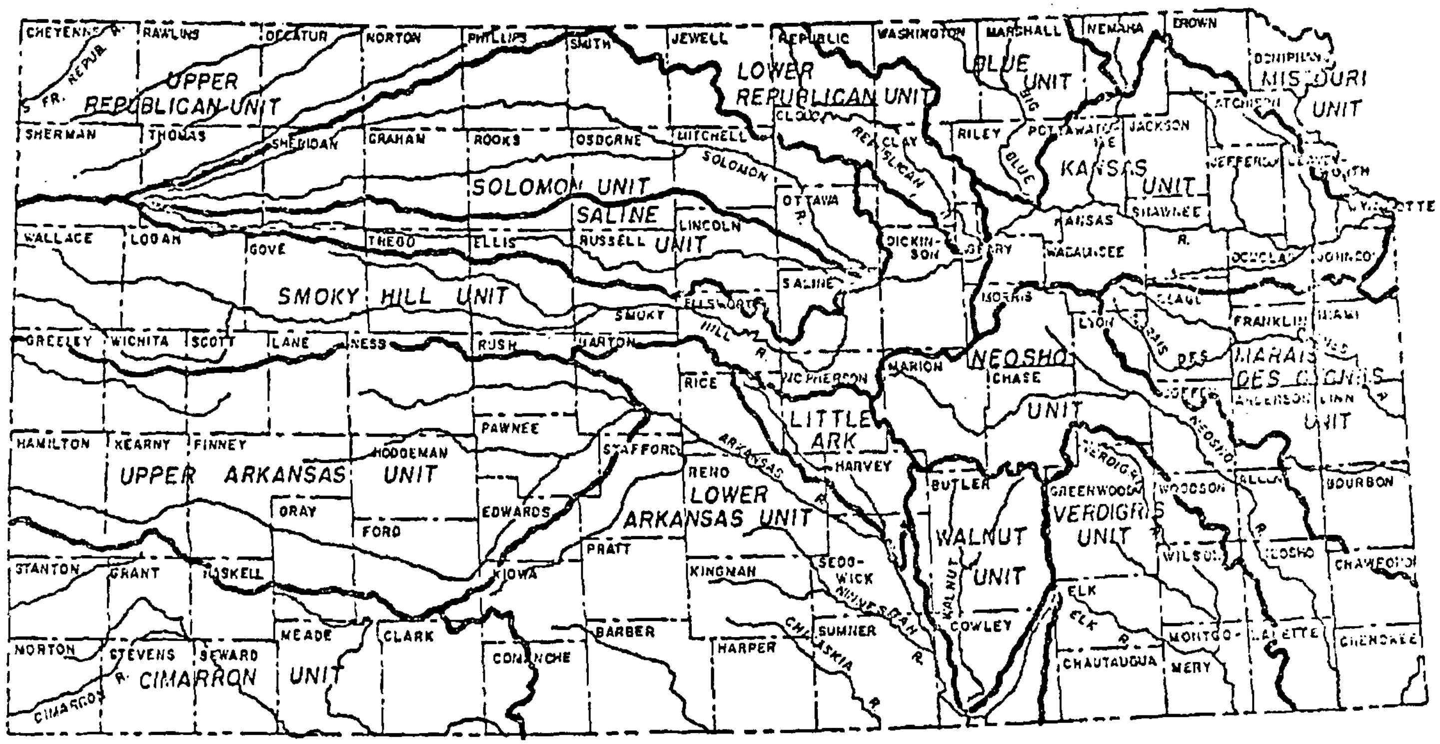
Marais des Cygnes River	B
Melvern Reservoir	A
Dragoon Creek	B
Pomona Reservoir	A
Lyon County State Lake	A
Marmaton River	B
Crawford County State Lake	A
Little Osage River	B

Saline River Basin

Saline River	B
Wilson Reservoir	A

(Authorized by K.S.A. 65-165 through 65-171d; adopted 13 April 1973, amended 1973)

APPROVED as to form and legality. Attorney General by W.H., Ass't.



MAJOR RIVER BASINS OF KANSAS

APPROVED as to form and legality. Attorney General by Z.H.W... Ass't.

APPENDIX G

Correspondence

THE STATE OF KANSAS

WATER RESOURCES BOARD
4th Floor, Mills Building
109 W. 9th Street
Telephone (913) 296-3185
TOPEKA, KANSAS 66612

September 26, 1975

Mr. D. C. Scaletti
NRC Environmental Project Manager
Division of Reactor Licensing
Office of Nuclear Regulatory Commission
Washington, D. C. 20555

RE: NRC Docket STN 50-482

Dear Mr. Scaletti:

A member of your staff requested information on the status of water supply agreements between the state and federal government on Marion and Council Grove Lakes and data on the Kansas Water Resources Board's two percent chance drought storage-yield analysis for John Redmond.

On August 29, 1974, the Kansas Water Resources Board signed an agreement for 24,400 acre-feet of storage for water supply in Council Grove Lake. On October 1, 1975, the state will make first repayment on this agreement of $52,200 for its annual charge and interest. The Secretary of Army has not signed the agreement. A draft of an agreement on Marion Lake was received by the Board on August 7, 1975, from the Tulsa District and is under review in this office.

A copy of Appendix B, "2% Chance Drought, Storage-Yield Analysis" filed with notice for acquisition of a state water reservation right to divert and store flows of the Neosho River in John Redmond Reservoir is enclosed. This notice was filed April 3, 1974, with the Division of Water Resources, Kansas State Board of Agriculture and on May 13, 1974, the Board was notified by the Division that they had assigned water reservation right number 5, file number 22, 197-AR-5. The yield from conservation storage capacity in John Redmond through a drought having a two percent chance of occurrence in any one year with the reservoir in operation as shown in K.S.A. 82a-938, is 53,000 acre-feet per annum.

Sincerely,

Keith S. Krause

Keith S. Krause
Executive Director

KSK:dk

Enclosure

APPENDIX B

2% CHANCE DROUGHT
STORAGE YIELD ANALYSIS

John Redmond Reservation
Right

PROBABILITY CONCEPT APPLIED TO GENERALIZED SURFACE-STORAGE REQUIREMENTS FOR SELECTED SUSTAINING YIELDS

Introduction

The engineering profession is often required to evaluate the firm water yield to be anticipated from surface sources, both regulated and unregulated. This paper describes briefly the flow-adequacy relationships that were developed from existing streamflow data in Kansas. Utilization of drought-frequency curves in appraising the adequacy of natural flows and in determining stream volume deficiencies on a calculated risk basis is described. Procedures for estimating the total quantity of storage required to offset evaporation losses, andto sustain a given streamflow against a selected frequency of drought are outlined. Consideration is given to regional generalizations useful in site reconnaissance and preliminary design investigations. Attention is drawn to the relative effect of site evaporation efficiency on total storage requirement. An example comparing the regional results with the observed record is discussed.

The Available Data

Any appraisal of surface water problems should, of course, be based on all the factual data available as to the yield characteristics of the area in question. Streamflow records are available at approximately 125 points in or closely adjacent to the State of Kansas. However, the basic data picture is not as favorable as that statistic would indicate. Many of the stations have extremely short periods of record. Many have had to be operated without consideration of the desirability of need for interstation correlation, and with rare exception the available data are from sites having drainage areas in excess of 100 square miles. Thus, the investigator faces at the very outset a laborious task of reducing to a usable form a mass of streamflow data which in some instances must be characterized as random in nature.

The Utopian situation would provide a long-term continuous streamflow record at the point on the stream where storage is, or will be, located. However, one finds Utopia but infrequently in hydrologic work, and as a consequence it becomes necessary to rely on judgment, applied mathematics, and a relative amount of ingenuity in a majority of cases. Observing first that the accuracy of such judgment is directly proportional to the number of firm guideposts available, a decision was made by the Kansas Water Resources Board to analyze the surface-water yield characteristics for all gaged areas in the state. Accordingly, the Board sought the counsel of the United States Geological Survey in determining how available data on the surface waters of the state could be correlated and/or otherwise analyzed and made available for use by all interested parties. Subsequently, the two agencies entered into a cooperative analytical program, which program is still in effect at this time. The program has resulted in nine technical reports which are tabulated in the following table.

Technical Report Series, Kansas Streamflow Characteristics

Technical Report No. 1, Flow Duration, June 1959.
Technical Report No. 2, Low-Flow Frequency, June 1960.
Technical Report No. 3, Flood Frequency, October 1960.
Technical Report No. 4, Storage Requirements to Sustain Gross Reservoir Outflow, April 1962.
Technical Report No. 5, Storage Requirements to Control High Flow, June 1964.
Technical Report No. 6A, Base Flow Data, June 1965.
Technical Report No. 6B, Base Flow Distribution, October 1966.
Technical Report No. 7, Annual Streamflow Summary Tables, June 1967.
Technical Report No. 8, In Channel Hydraulic Geometry of Streams in Kansas, June 1971.
Technical Report No. 9, Mean Annual Runoff as Related to Channel Geometry, January 1972.

Generally speaking, the available streamflow records in Kansas are relatively free of large-scale consumptive losses resulting from the activities of man. There are exceptions, and where those exceptions occur, the original information has to be adjusted accordingly. Furthermore, while man-controlled regulation of streamflow in Kansas has not been too important in the past, it is rapidly becoming more significant. The cooperative studies referred to above employed all possible statistical and correlation tools now known to adjust and/or extend all Kansas records of six years or longer to a common base period 1921 to 1956. For this base period three distinct characteristics pertinent to this paper were developed at each station analyzed: (1) duration curves (TR #1), (2) drought-frequency relationships (TR #2), and (3) sustained draft versus natural volume deficiency relationships (TR #4). In all cases, data from individual stations were regionally adjusted against one another.

The foregoing reference to the general history and status of these cooperative studies is warranted because the bulk of the following remarks will be devoted to the application of the relationships developed. However, no attempt will be made to discuss the statistical or correlative methodology used in developing those summary relationships. The techniques are adequately described in TR #1, TR #2, and TR #4. Most of the credit for the development of that methodology rests with personnel of the U.S. Geological Survey.

Drought Frequencies as a Basis of Design Criteria

There is a need for wider recognition of the fact that the design criteria which are utilized in developing storage requirements does not represent 100 percent drought-proof protection. Consequently, there is a need to define yield-storage relationships, on a calculated risk or frequency basis. To do this, it becomes necessary to prescribe certain standard definitions which will be used throughout this discussion.

One may well ask what constitutes a drought condition on a given stream. In the practical vein, the stream may be termed drought-ridden only when it is unable to fulfill the demands placed upon it. Thus, in one reach of the stream a flow of 10 cfs adequately provides all the water needed, whereas in the succeeding reach, the demand may exceed 25 cfs. Obviously, droughts cannot be defined in terms of use because the reference base is ever changing. Instead, a somewhat arbitrary definition must be employed. For the purpose of this discussion, droughts are defined as the annual minima of the discharges.

Thus, the one-day drought flow in any year is the minimum daily flow for that year. Similarly, the 30-day drought for any year is the minimum average discharge occurring during a 30-day period in that year. When considering periods longer than one year, for example a 24-month period, special care must be taken to establish procedures that make each drought period selected for use in the statistical array independent of all other similar periods utilized in the array.

Definition of a stream drought as indicated above provides a basis for the preparation of drought-frequency relationships. Upon compilation of the annual droughts in a statistical array, the determination of their selected position on the frequency scale is calculated by the same method commonly utilized for flood frequency analysis where the array is comprised of the annual flood peaks.

The drought-frequency relationship for the study is shown on Figure 1. The drought discharges are plotted as the ordinate, and the recurrence interval for each drought discharge as determined by the statistical array of annual droughts is represented on the abscissa. The smooth curve represents regionally correlated analysis for the stream-gaging station. Pertinent to the present discussion is the fact that Figure 1 can serve as a useful tool in determining on a calculated risk basis, the volume deficiency that must be supplied by storage if a sustained flow of a given amount is to be maintained.

Initial Volume Deficiencies

Consider now the question--what volume of water must be delivered from storage to the site represented by the data on Figure 1, if some selected sustained flow is to be maintained against all droughts having a given percent chance of occurrence. The answer to this question must be obtained by comparing the volume of water actually delivered by the stream under such a drought condition with the volume desired. This comparison may be diagrammed as shown in Figure 2, a definition sketch. The ordinate represents volume (usually

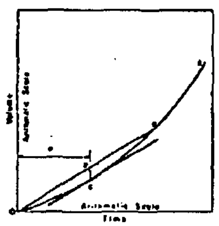


Figure 2

expressed in acre feet) and the abscissa represents time (expressed in days, months, or years). The line OA is developed from data represented on the drought-frequency curve for the percent chance of occurrence condition selected. For example, the volume of water delivered by the stream during a two percent chance (recurrence interval 50 years), six-month drought would be the product

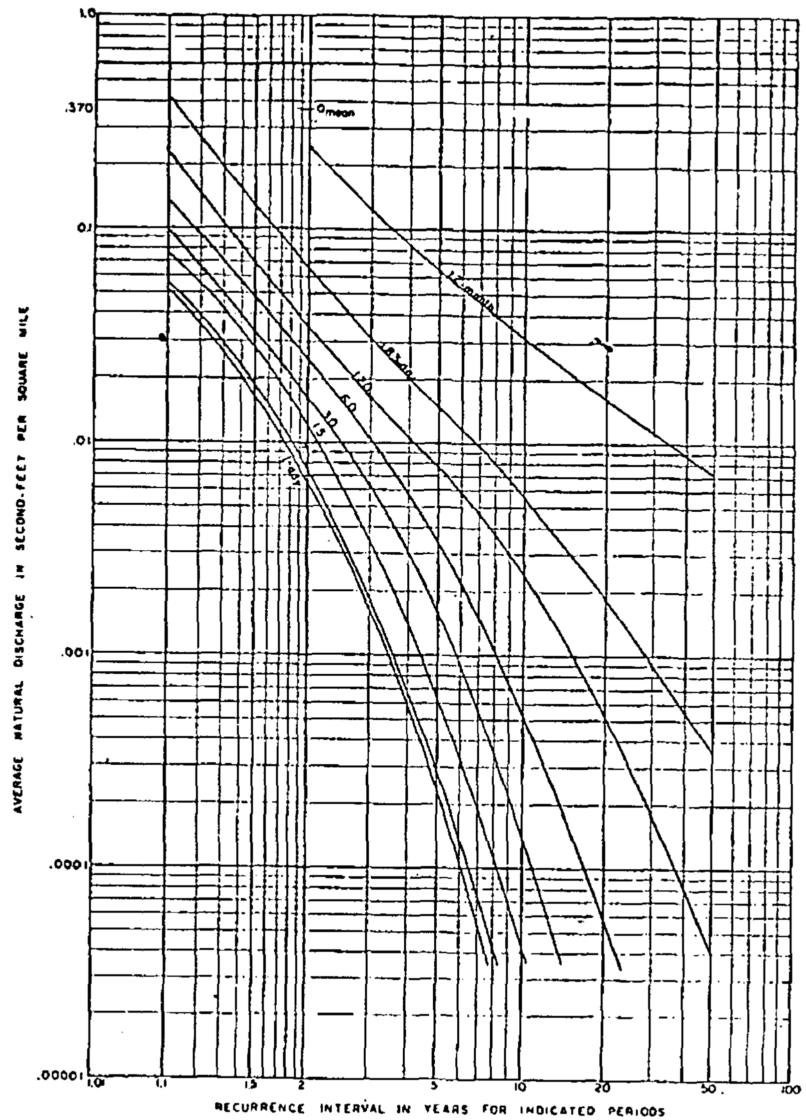


Figure1 .-Low-flow frequency curves for (No.120) Neosho River at Strown, Kans. (Total drainage area, 2933 sq mi)

of the six-month, two percent chance drought discharge shown on the drought-frequency curve and the six-month period. This computation represents one point on the curve OA. Computation of similar volumes delivered by the stream for the various length droughts and subsequent plotting of these volumes against time results in the development of the line OA. Thus, the ordinate of any point on line OA equals the volume of water that the stream will deliver under the selected chance of stream-drought occurrence for the corresponding period represented on the abscissa.

Similarly, the desired sustained draft can be plotted and is represented b· the line OB. OB is linear in nature in response to the imposed condition of a sustained uniform draft. The maximum vertical differential between line OA, the volume delivered by the stream, and line OB, the volume required, represents the deficient volume that must be delivered to this site if the imposed conditions are to be fulfilled. The magnitude of the maximum volume deficiency is determined by scaled measurement of the line CD. Note that the ordinate to point C represents the volume delivered by the stream and the ordinate to point D represents the volume required.

By varying the sustained draft rate, thus changing the position of point B and the value and location of CD, it is possible to determine the volume deficiency values corresponding to various selected drafts. Such data may then be plotted and a graphical relationship of sustained flow versus volume deficiency for the selected drought condition obtained.

Figure 3 represents the storage-required frequency curves for the study from Technical Report #4. It should be noted that curves do not reflect losses due to evaporation.

Attention is directed to the time P measured along the abscissa from the origin to line CD in Figure 2. Inasmuch as CD represents the maximum volume deficiency between inflow and desired outflow, P is theoretically equal to the time elapsing between the initial condition of full reservoir and the time of maximum reservoir drawdown. Numerals, Figure 3, represent effective detention period in years on the two percent curve to deplete the indicated storage starting with a full reservoir.

VOLUME DEFICIENCY CONVERTED TO STORAGE

Volume deficiencies determined must be adjusted for certain loss factors before a reasonable approximation of the actual storage requirement can be made. The two primary losses to be considered are those of evaporation from the impounded area and transmission in delivering the water from the site to the point of use. The latter loss may or may not be significant depending on whether the flow is transported in natural channels, artificial channels, or closed conduits. Since it varies so widely between cases, it is better handled by including it as part of the estimated demand to be fulfilled. The evaporation loss on the other hand, appears susceptible to generalized approximations which are useful for problems of site reconnaissance, preliminary design, and "rule" type operational studies.

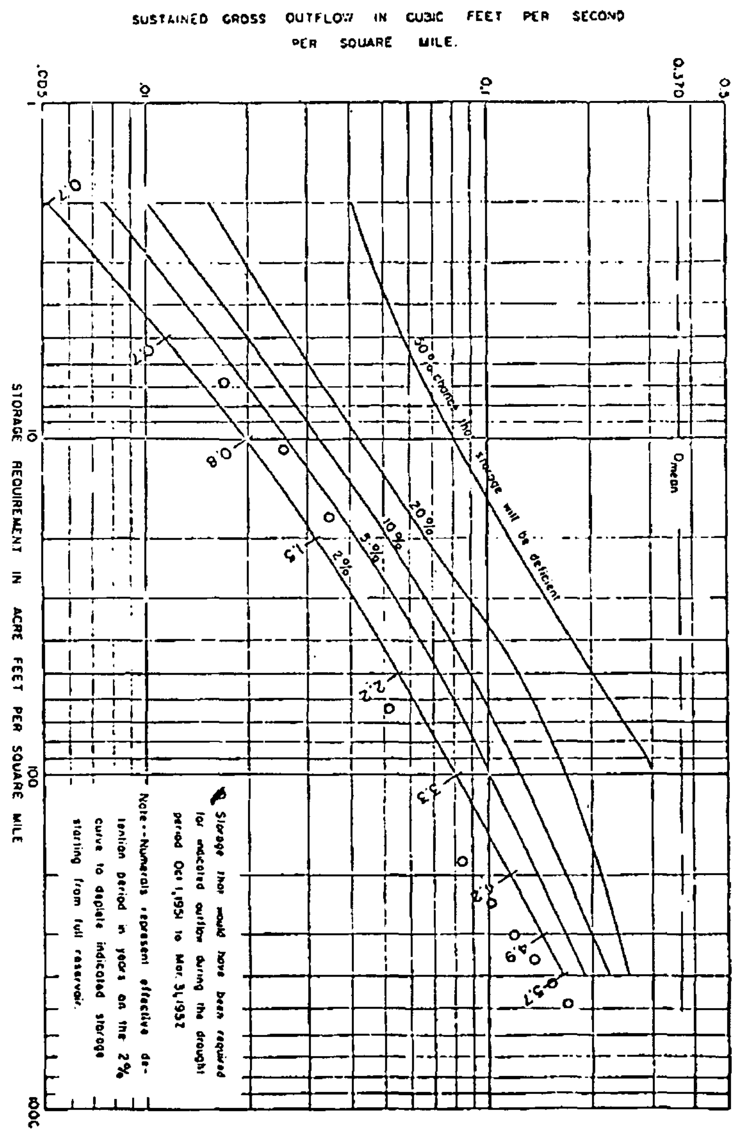


Figure 3 --Storage-required frequency curves for (No.120) Neosho River at Strawn, Kans.
(Total drainage area, 2,933 sq mi)

STORAGE REQUIREMENTS FOR EVAPORATION

The previous section describes the derivation of storage-gross outflow relations on a probability basis. These relations to be useful must be adjusted to account for evaporation losses. Smith and Steps (1958, p. 20) indicated that the evaporation loss may be approximated by the product of the average surface area during the period of detention, the net evaporation rate, and the detention time. The total storage requirement to sustain a given outflow (Q_o) is then the sum of the initial storage requirement, as indicated by the storage-gross outflow relation, and the evaporation loss; or

$$V_2 = V_1 + \bar{S}\,Et$$

where: V_2 = total storage requirement

V_1 = initial storage requirement

$\bar{S}$ = average surface area during the period of detention

E = net evaporation rate

t = detention time at the selected Q_o and the corresponding V_1

Average Surface Area

The average surface area ($\bar{S}$) during the period of reservoir drawdown may be expressed as some percentage of the surface area at full pool, and has been termed by Meyers (1962, p. 77) as the effective-area ratio. This ratio is a function of the distribution of the inflow, the reservoir site characteristics, the rate of sustained outflow, and the evaporation rate. Hazen (1914) made no allowance for a changing surface area in computing evaporation loss. In a discussion of Hazen's paper, Marsh (1914, p. 1644) suggested that the water area corresponding to a storage of two-thirds of the maximum quantity of storage would represent more nearly the average surface area. Hudson and Roberts (1955, p. 44) calculated effective-area ratios for several Illinois reservoirs based on the assumption that the total outflow rate (includes evaporation) was continuous and uniform and that the reservoir was completely depleted. When applying these same assumptions to the major reservoirs in Kansas, the calculated effective-area ratios ranged from 0.555 to 0.634 and averaged about 0.6. The actual routing of several Kansas reservoirs through a drought period has shown that 0.6 is a good estimate. It must be noted that this ratio does not apply to reservoirs where a large inactive or dead pool is to be maintained. Subsequent studies may provide a basis for adjusting this value for given conditions, but for the present time 0.6 is assumed for the effective-area ratio during the period of detention. If the full pool surface area is termed A_2, the average surface area may be expressed as:

$$\bar{S} = 0.6\,A_2$$

Net Evaporation Rate

The net evaporation rate (E) at a reservoir for a given chance drought is the difference between the expected total lake evaporation rate and the probable rainfall rate. Evaporation records have not been collected in Kansas at an adequate number of stations and for a sufficient length of time to assign probability values to evaporation rates. Examination of the few long-term evaporation records which are available disclosed that the annual gross evaporation rates at the respective stations were fairly constant during the major droughts. Therefore, the average rate during adverse periods has been used for the two percent chance drought. The records at several precipitation stations in Kansas were analyzed and the annual precipitation rate was computed for various chance droughts. Figure 4 shows the areal distribution across Kansas of the probable net evaporation rate from a lake surface for a two percent chance drought.

The study referred to above noted in eastern Kansas, the only evaporation record of reasonable length is that obtained at Manhattan. The record extends through the two major droughts experienced during the 1930's and 1950's. Records at that station were adjusted to annual equivalent lake losses by making corrections for pan coefficiencies and adjusting for unrecorded winter season losses. Those records indicate that extreme values of annual gross evaporation are relatively constant. A plot of maximum gross annual evaporation against time indicated that all values up to and above six consecutive years accumulation fell between average annual rates of 62 and 55 inches per year. In fact, even the most adverse ten-year period averaged 53 inches of evaporation per year. Hence, a practical assumption that annual gross evaporation is constant during drought periods appears warranted.

Although gross evaporation may not vary over 10 percent from Manhattan to the eastern border of the state, it appears possible that net evaporation (gross evaporation minus rainfall) might vary as much as 20 to 35 percent. Fortunately, long-term precipitation data are available. As a practical matter, available precipitation data were analyzed and frequency relationships determined for one year through ten year running totals. Net evaporation-frequency data for various length droughts were estimated by subtracting the appropriate rainfall from the assumed gross evaporation rate.

Detention Time

The length of time for which the evaporation losses must be computed is given by the detention time (t). The detention time is the length of time from the start of reservoir drawdown to where the maximum storage is required to supply a given outflow rate. The rate of inflow (on the average) after the point of maximum storage will be greater than the outflow rate; therefore, the reservoir begins to fill and is past the critical period. The detention time is not always available on the storage-gross outflow curve; therefore, the following equation has been derived to calculate detention time:

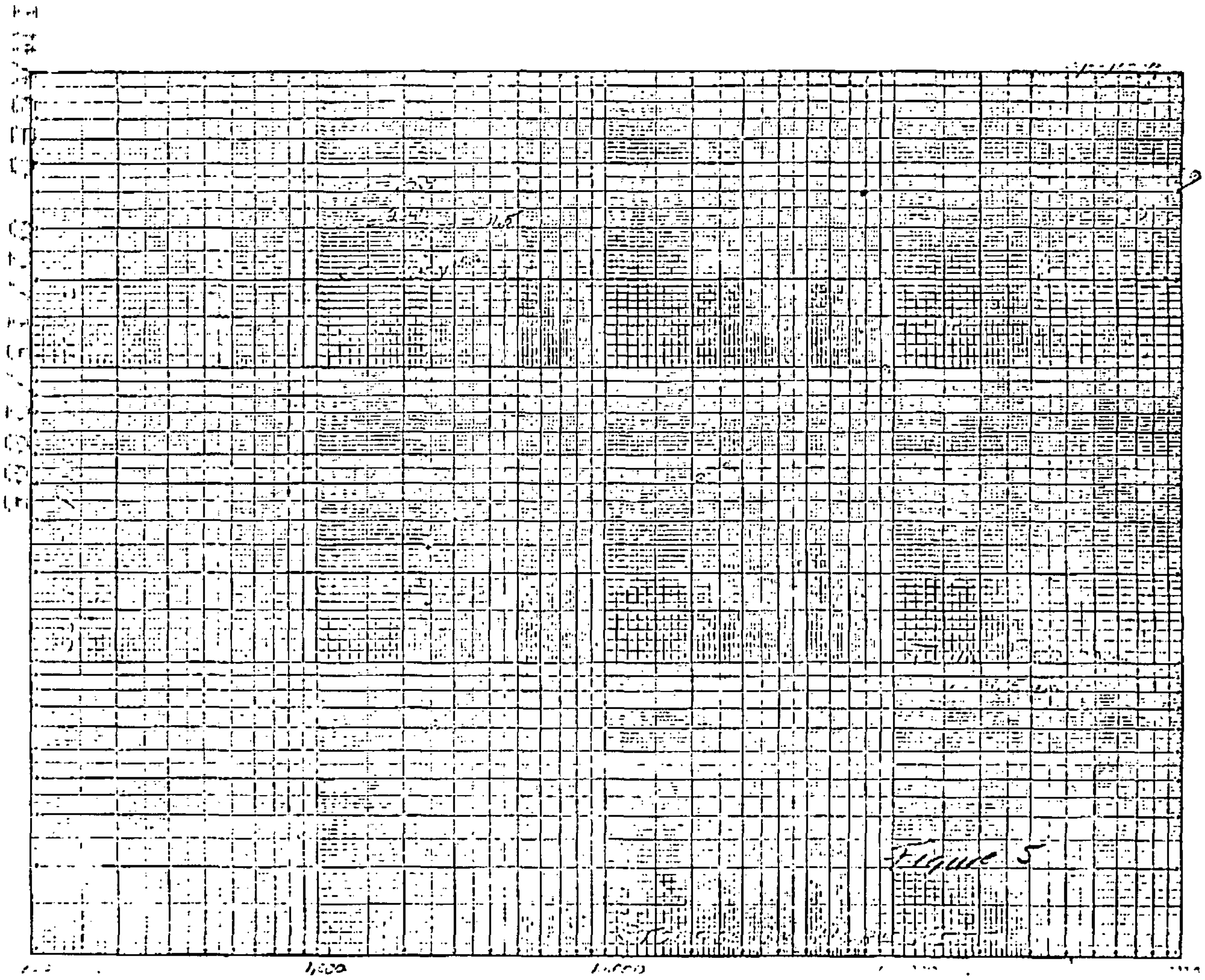
$$t = \frac{V_1}{nQ_o}$$

t = detention time in years

V_1 = initial outflow in acre-feet per year

Q_o = gross outflow in acre-feet per year

n = the slope of a line tangent to the point on the storage-gross outflow curve when plotted on logarithmic paper.



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G-7

NET EVAPORATION RATE - 2% CHANCE

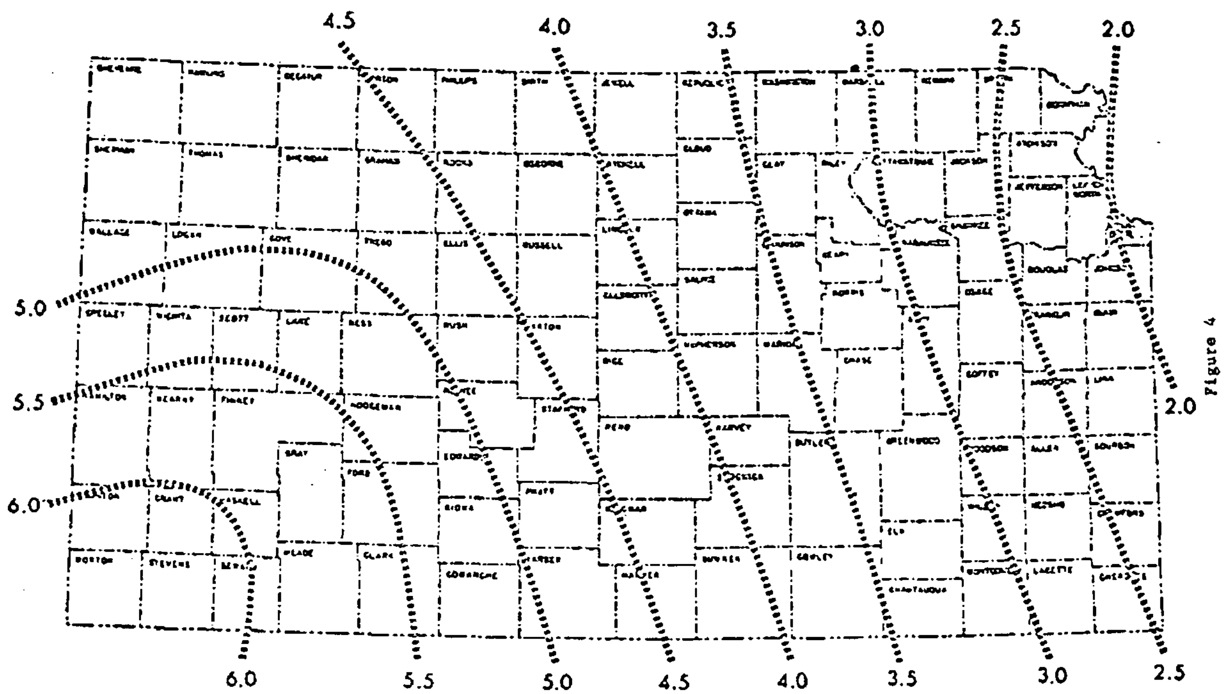


Figure 4

Figure 4

Quantities in feet per year

KWRB-HK

the storage requirement and gross outflow values may be expressed as per unit drainage area, and units other than acre-feet may be used as long as the appropriate conversion factors are included.

Graphical Solution

A mathematical solution of equation 1 must be a trial and error process because the average surface area is a function of the full pool surface area which in turn is related to the total storage requirement. Smith and Steps (1958) outlined a graphical analysis which made the solution by successive approximations easier. Kubic (1964) introduced the solution eliminating the necessity of making successive approximations. The following method is a further refinement of these methods and makes use of clear plastic templates.

Two conditions were studied. The first assumed no upstream depletion due to major reservoir operations. The second assumed completion of Council Grove, Marion, and Cedar Point reservoirs.

Uncontrolled Conditions

Step No. 1

Figure 3 shows the 2 percent chance curve that storage will be deficient for the Neosho River at Strawn. No adjustment was made in the 2 percent chance curve for the dam site. For initial volumes (V_1), increments of 5, 10, 20, 50, 100, 200, 300, and 500 acre-feet per square miles (Figure 3), the sustained gross outflows (Q_o) in cfsm and effective detention (t) in years were tabulated on Form A. For example, picking a value of 100 AF/SM for V_1 on abscissa, then moving vertically to the 2 percent chance curve results in Q_o of 0.08 cfsm and t of 3.3 years. From Figure 4, net evaporation for 2 percent chance at Council Grove Reservoir is 2.9 feet per year. Effective area ratio "K", was assumed to be 0.6 as noted in the previous discussion. Multiplying K x E x t for V_1 of 100 AF/SM (0.6 x 2.9 x 3.3) resulted in an evaporation index of 5.7 which was recorded on Form A.

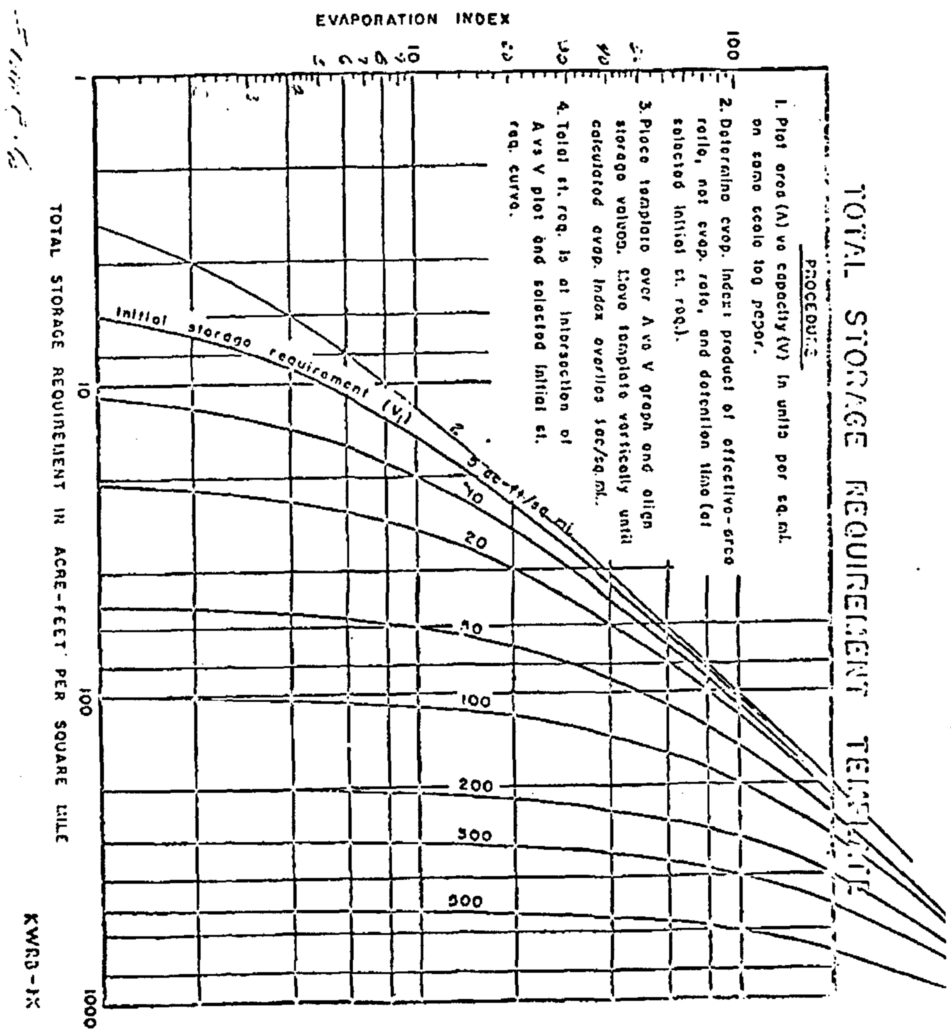
Step No. 2

The next step involves the use of a plot relating storage capacity and surface area (Figure 5) and a template (Figure 6) to determine the total storage requirement. Since one plot is in absolute values (AF) and the other in unit (AF/SM) a drainage area index is set on Figure 5. The index is located at point of 3015 (square miles) on the abscissa and ordinate. For our example, V_1 of 100 AF/SM, the evaporation index of 5.9 is placed over the drainage area index. The total storage requirement (V_2) is located at the intersection of the curve on Figure 5 and the selected initial storage curve (V_1) or a value of 435,000 acre-feet.

The above procedural steps are followed until sufficient values of V_2 are calculated to plot the storage-yield curve for a 2 percent chance occurrence. The resultant curve is shown as Figure 7.

Controlled Conditions

A number of different techniques were studied to develop the initial storage required--frequency curve for the 2 percent chance when part of the drainage area is controlled by upstream major reservoirs. It was concluded for this reservoir the drainage area controlled by the upstream reservoirs would be subtracted from the gross drainage area and the initial storage curve would change. Calculations then proceed as previously explained and results tabulated on Form A and plotted on Figure 7.



Form A

STORAGE-YIELD COMPUTATIONS

By GP. Date 6-2-64 Site JOHN REDMOND

Location S. 9 & 10, T21S, R15E Percent Chance 2

County Coffey Stream Neosho River

Storage-Gross Outflow Curve Fig. 110, TR #4 Drainage Area 3,015 Uncontrolled; 2,450 After Controlled by 1. Cedar Point 2. Marion 3. Council Grove

USGS Gage # 120

Formulas:

(1) $V_2 = V_1 + \bar{S}\,E\,t$

(2) $\bar{S} = k\,A_2$

(3) $t = \frac{V_1}{n\,Q_o}$

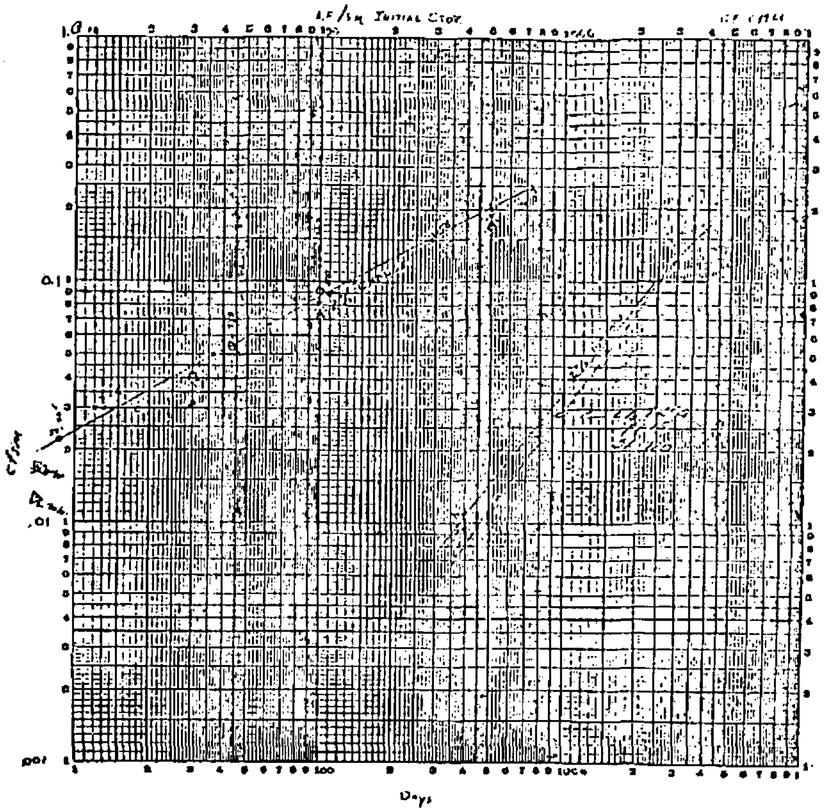
(4) $V_2 - V_1 = k\,A_2\,E\,t$

where:
- V_2 = total storage requirement in acre-feet
- V_1 = initial storage requirement in acre-feet
- $\bar{S}$ = average surface area during period of detention in acres
- E = net evaporation rate in feet per year
- t = detention time at the selected Q_o and corresponding V_1 in years
- k = effective-area ratio
- A_2 = pool surface area for total storage in acres
- Q_o = gross outflow in acre-feet per year
- n = slope of line tangent to the storage-gross outflow curve on logarithmic paper at the selected Q_o and corresponding V_1

E = 2.9' k = 0.6 K x E = 1.74

Q_o CFS Uncontrolled	Q_o CFS Controlled	Q_o MGD	Q_o CFS/Sq Mi	V_1 Ac-Ft	V_1 Ac-Ft/Sq Mi	n	t (Years)	Evaporation Index (k E t)	V_2 Ac-Ft/Sq Mi	V_2 Ac-Ft Uncontrolled	V_2 Ac-Ft Controlled
16.2	27.4		.012		5		0.7	1.22		19,600	16,200
60.3	49.0		.02		10		0.8	1.39		38,000	31,600
96.5	78.4		.032		20		1.5	2.61		85,000	71,000
169	137		.056		50		2.2	3.83		213,000	177,000
241	196		.08		100		3.3	5.74		435,000	362,000
362	294		.12		200		4.2	7.31		870,000	720,000
			.145		300		4.9	8.52			
			.17		400		5.7	9.92			
15.7	12.7		.0052		2		0.7	1.22		8,000	6,700

Additional Remarks



METHOD FROM TR#2 AND GS TEMPLETE
FOR DETERMINING INITIAL STORAGE

depletion time		cfsm Q_o	AF/SM V
days	yrs		
365	1	.022	29
730	2	.059	43
1100		.090	116
1750		.15	205
2300		.305	500

- o GS TEMPLETE } TR#2
- s FREQ MASS CURVE } TR#2
- A TR#4 METHOD REGIONALIZED
- e TR#4 UNCORRECTED
- · VALUES BY SUBTRACTING AREAS
- x AVG GS TEMPLETE (TR#2) and TR#4 METHOD (as suggested in TR#4)

Figure 8

JOHN REDMOND RESERVOIR

TOTAL REQUIRED STORAGE VS. SUSTAINED OUTFLOW

HP 6-3-64

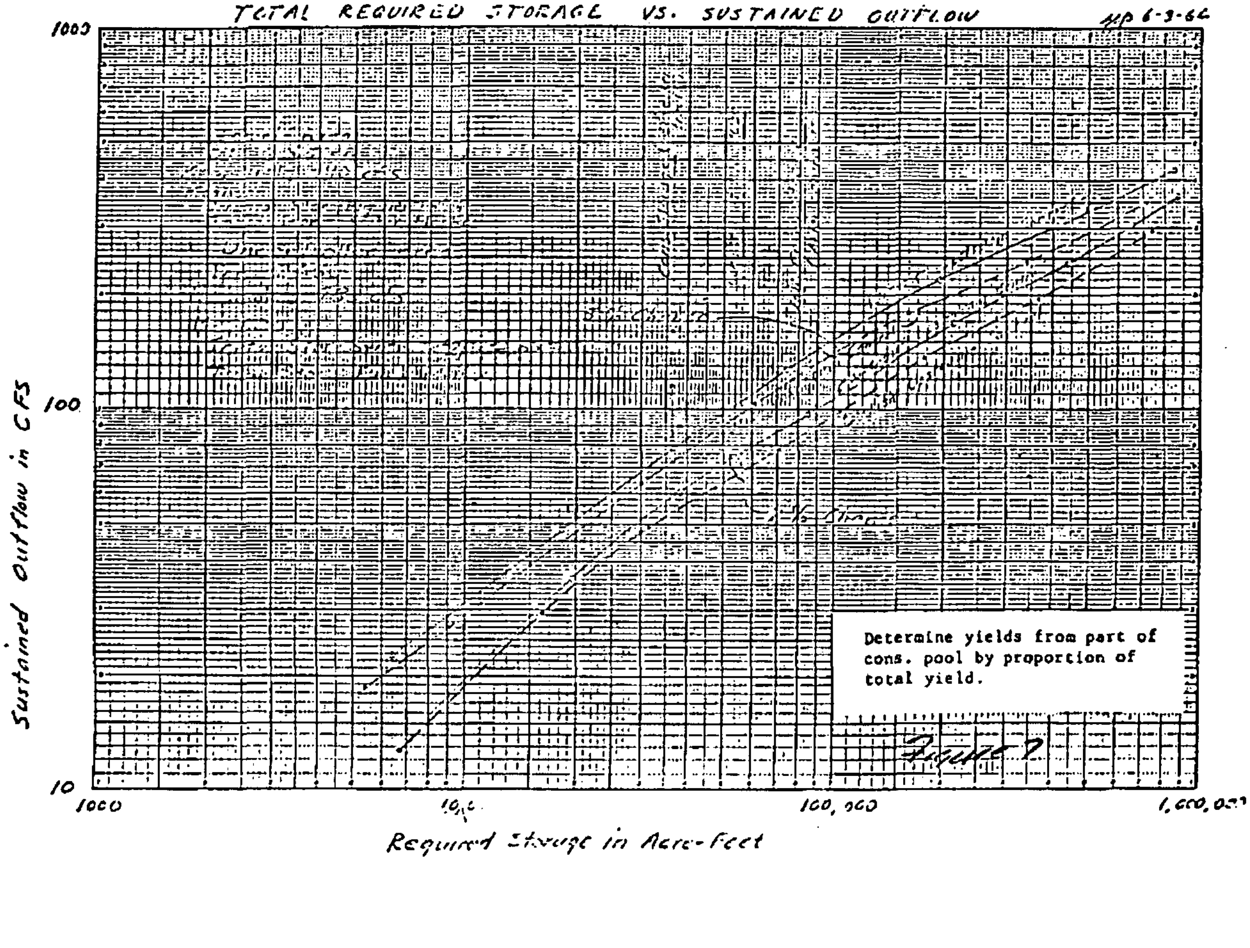


Figure 7

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DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
POST OFFICE BOX 61
TULSA, OKLAHOMA 74102

SWTED-H

29 September 1975

Mr. Dino Scalletti
NRC Environmental Project Manager
Division of Reactor Licensing
Office of Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Scalletti:

An approximate check of the water supply yield in John Redmond Reservoir indicates that the reservoir may be able to yield 41 c.f.s. As we have indicated previously in our discussions with Mr. MacClain, a more detailed investigation such as a daily reservoir routing would be necessary to confirm this.

We sell only storage space in projects and indicate only approximate yields; therefore, we have no plans to make a detailed study of this nature.

Sincerely yours,

WELDON M. GAMEL
Chief, Engineering Division

SHAW, PITTMAN, POTTS & TROWBRIDGE
910 SEVENTEENTH STREET, N.W.
WASHINGTON, D.C. 20006

(202) 296-3000
CABLE "SHAWLAW"
TELEX: 440143
BRADLEY SHAW
OF COUNSEL

RECEIVED 10-22-75 U.S. NUCLEAR REGULATORY COMMISSION Mail Section

September 8, 1975

DOCKETED USNRC SEP 1? 1975

Samuel W. Jensch, Esquire
Chairman
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Re: Kansas Gas and Electric Company and Kansas City Power & Light Company (Wolf Creek Generating Station, Unit No. 1) - Docket No. STN 50-482

Dear Mr. Chairman:

I have enclosed, for the information of the Atomic Safety and Licensing Board and the parties, a copy of a certification, pursuant to Section 401 of the Federal Water Pollution Control Act, as amended, 33 U.S.C. §1341, by the Kansas Department of Health and Environment for the Wolf Creek Generating Station, Unit No. 1. The certification is in the form of a letter, dated September 2, 1975, from Mr. Melville W. Gray, Director, Division of Environment, to Mr. Mike Miller, Environmental Coordinator of Kansas Gas and Electric Company.

Applicants intend to offer the certification into evidence at the hearing on environmental and site suitability matters.

Sincerely yours,

Gerald Charnoff

Gerald Charnoff

Enclosure

cc: Dr. George C. Anderson
Mr. Lester Kornblith, Jr.
Albert V. Carr, Jr., Esquire
William H. Griffin, Esquire
James T. Wiglesworth, Esquire
William H. Ward, Esquire
Edward G. Collister, Jr., Esquire
Ralph Foster, Esquire
Secretary, USNRC

12150

State of Kansas . . . ROBERT F. BENNETT, Governor

DEPARTMENT OF HEALTH AND ENVIRONMENT

DWIGHT F. METZLER, Secretary

Topeka, Kansas 66620

September 2, 1975

Mr. Mike Miller
Environmental Coordinator
Kansas Gas and Electric Company
P.O. Box 208
Wichita, Kansas 67201

Re: Public Law 92-500, Section 401
Certification for the Wolf Creek
Generating Station, Unit No. 1,
Burlington, Kansas

Dear Mr. Miller:

In response to your request for a Section 401 Certification for the above referenced facility, the following is offered:

> The Kansas Department of Health and Environment hereby certifies that any proposed discharge(s) from the above referenced facility will be in compliance with all applicable Water Quality Criteria Standards of the State of Kansas and Sections 301, 302, 306, 307 and any other applicable section(s) of the Federal Water Pollution Control Act.

It is the policy of the Kansas Department of Health and Environment not to issue a National Pollutant Discharge Elimination System Permit to a new facility until we have approved plans and specifications for the proposed waste abatement processes and have made and approved a final inspection of these facilities. If the final inspection indicates that everything is in order the permit will then be issued. The permit that will be issued will reflect all applicable Water Quality Criteria Standards of the State of Kansas and the effluent guidelines and standards, as promulgated by the Environmental Protection Agency, for the Steam Electric Power Generating Point Source Category.

If you have any questions, please contact our office, (913) 296-3825.

Sincerely yours,

Melville W. Gray

Melville W. Gray, P.E.
Director
Division of Environment

MWG:bb

WICHITA STATE UNIVERSITY

WICHITA, KANSAS 67208
PHONE 316/689-3195

DEPARTMENT OF ANTHROPOLOGY

RECEIVED OCT 29 1975

October 21, 1975

Mr. Dino Scaletti
U. S. Nuclear Regulatory Commission
Environmental Projects, Branch 2
Washington, D. C. 20555

Dear Mr. Scaletti:

In response to your telephone inquiry, there are no archeological resources significant enough for National Register consideration left in the project area for the Wolfcreek Generating Station, Coffey County, Kansas. Our field work there produced useful information from three sites. However, there is little chance that any further field work would recover additional significant data.

Yours very truly,

Arthur H. Rohn

ARTHUR H. ROHN
Professor and Chairman
Anthropology Department

ARH:ws
cc: Michael E. Miller, Environmental Coordinator, K.G.&E.
Tom Witty, State Archaeologist

12481

WOLF CREEK GENERATING STATION
UNIT NO. 1

ENVIRONMENTAL REPORT
OPERATING LICENSE STAGE

COPY NO.

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CHAPTER 1.0

PURPOSE OF THE FACILITY AND ASSOCIATED TRANSMISSION

1.1 SYSTEM DEMAND AND RELIABILITY

The Wolf Creek Generating Station, Unit No. 1 (WCGS), an 1150 MWe base load plant, is a major addition which will supply both capacity and energy to the systems of the applicants. The plant is scheduled for service in time to meet the 1983 summer peak loads.

Joint ownership of WCGS is on the basis of an undivided 41.5 percent each for the Kansas Gas and Electric Company (KG&E) and the Kansas City Power and Light Company (KCPL) and 17 percent for the Kansas Electric Power Cooperative, Inc. (KEPCo). Allocation of power produced by the plant will also be on a 41.5 percent, 41.5 percent, 17 percent basis, 477.25 MW to KG&E, 477.25 MW to KCPL, and 195.5 to KEPCo. KG&E is the agent for the three utilities during the construction period and will continue in that role during operations. KEPCo was added as a co-owner subsequent to the submission of the ER(CPS).

KG&E, of Wichita, Kansas, provides electrical service to approximately 220,000 customers in 25 counties of Southeast Kansas, including the Wichita Metropolitan Area. Wholesale service is provided to 25 communities and 8 rural electric cooperatives. The estimated population in the 8,100 square mile service area is 587,000 persons.

KCPL, a Missouri corporation of Kansas City, Missouri, provides electrical service to about 339,000 customers in 94 communities of 23 west Missouri and east Kansas counties. Wholesale service is provided to 8 other communities, 3 electric cooperatives and two utilities. Its service area covers approximately 4,700 square miles with a population of about one million persons. Customers in Missouri account for approximately 75 percent of the total sales of energy and those in Kansas for about 25 percent. The Kansas City Metropolitan Area is the source of 90 percent of the utility's revenues. KCPL also provides steam service to 260 downtown buildings in Kansas City, Missouri. Its service area is contiguous to that of KG&E at KCPL's southwest boundary.

KEPCo, of Topeka, Kansas, was organized in February, 1975 as a rural electric generation and transmission cooperative. All-requirement wholesale power agreements have been executed by 25 of its 26 members, rural electric distribution cooperatives located in the eastern two-thirds of Kansas. At this time KEPCo has neither generation nor transmission facilities, and the ownership of 17 percent of WCGS will represent KEPCo's first owned generating capacity. However, in the long term KEPCo intends to own and/or control all of the power resources required to meet the total power obligation of its members and to meet the reserve requirements of any pool agreements. Investigations are continuing on plans for joint ownership of future load generating capacity and for participation through ownership or purchase in the existing generation capacity of major Kansas utilities.

KEPCo proposes to transmit power purchased from major utilities over the transmission lines of other utilities to interconnections with member cooperatives which will distribute power over their individually owned distribution networks. Arrangements are being made for coordination, transmission and delivery of 90 MW of power purchased from the Southwestern Power Administration (SPA), commencing in the Spring of 1980.

In the long term KEPCo intends to build transmission lines, as future plans are developed with major power suppliers in Kansas.

The combined service area for KEPCo's members extends over the eastern two-thirds of Kansas and includes rural communities in areas that are also served by KG&E and other major utilities. KEPCo's members provide electric service to an estimated population of about 355,000 in individual service areas that are predominantly rural.

To meet the past and projected demand for peak power and for energy within their service areas, the three utilities have planned and implemented programs of additions to their generating capacity as follows:

NET CAPACITY INCREASES

Period	KG&E		KCPL		KEPCo	
	MW	Percent	MW	Percent	MW	Percent
1969-1979	732	62.6	866	51.1	0	0
1979-1989	847	45.0	1186	45.5	196	*

* Represents all of KEPCo's owned capacity.

These additions to capacity, shown in Tables 1.1-4a and 1.1-5a for KG&E and KCPL, have been and will be made to meet past and projected growth in peak demand and annual energy requirements as follows:

INCREASES IN PEAK DEMAND AND ENERGY REQUIREMENTS[(a)], 1969-1989, IN PERCENT

Period	Peak Demand KG&E	Peak Demand KCPL	Peak Demand KEPCo	Energy Requirements KG&E	Energy Requirements KCPL	Energy Requirements KEPCo
1969-1979	55.3%	47.8%	(b)	71.7%	57.2%	(b)
1979-1989	40.3	42.4	103.6%	29.6	48.0	102.5%

(a) Based on "normalized" loads for KG&E and KCPL in 1979.
(b) Not available.

"Normalized" loads were used for 1979 in order to give a more realistic impression of the changes that have occurred and are projected to occur. Relatively mild weather was experienced in 1979, particularly with respect to the summer peak. As indicated above, the changes in peak demand and energy requirements follow closely the changes in net capacity, despite the fact that planning for capacity additions takes place many years in advance of the completion of an addition to capacity. Tables 1.1-12, 1.1-13 and 1.1-14 provide details on past and projected loads.
Reserve margins both with and without WCGS are shown below for the early years of WCGS operation.

RESERVE MARGINS IN PERCENT

Year	With WCGS KG&E	With WCGS KCPL	Without WCGS KG&E	Without WCGS KCPL
1983	44.9	36.4	18.3	16.5
1984	38.3	31.6	12.9	12.4
1985	40.0	27.1	15.5	8.5
1986	35.8	22.6	12.1	4.8
1987	31.6	18.4	8.6	1.1
1988	28.5	14.3	6.0	- 2.4
1989	25.5	25.7	3.6	9.6
1990	22.4	20.0	1.0	4.5

The 477 MW increment represented by its share of WCGS capacity is a large addition to the capacity of each utility. Shares of WCGS capacity in 1983 will represent 18.4 percent of KG&E's capacity, 14.6 percent of KCPL's capacity and 100 percent of KEPCo's owned capacity. Because it is a major addition for each utility, the reserve margins as shown above will be adequate for most of the period shown, with WCGS in operation. Without WCGS, however, KG&E's margin would fall below the required 15 percent in 1984 and after 1985, and KCPL's margin would be below its internal planning requirement of 20% in 1983 and thereafter. Reserve margin requirements are discussed in Section 1.1.3.

In addition to meeting projected peak loads and energy requirements, WCGS will provide a reliable source of power that is not dependent upon fossil fuels. In the recent past KG&E depended completely on natural gas from local sources for fuel, while KCPL depended primarily on coal and secondarily on natural gas, from local sources. The changes in fuel mix that have occurred and are projected are shown in Table 1.1-15 and summarized below:

FUEL MIX - PERCENTAGE DISTRIBUTION OF ANNUAL NET GENERATION

	KG&E			KCPL		
	1970	1980	1990	1970	1980	1990
Coal	-	53.2	54.2	69.2	94.4	71.6
Oil	0.5	3.8	11.5	0.1	3.7	4.5
Gas	99.5	43.0	6.6	30.7	1.9	0.8
Nuclear	-	-	27.7	-	-	23.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

KG&E and KCPL will continue to reduce the use of natural gas and minimize the use of oil in compliance with the 1978 Fuels Use Act and national energy policy. The importance of WCGS in making this possible is evident in the tabulation above.

Diversification of fuel sources will tend to increase the reliability of the systems of the Applicants and of the region by reducing their dependence on fossil fuels for generation. The value of such diversification is demonstrated by the tabulation below, which shows the planned fuel mix in percentage of generation in 1983, both with and without WCGS.

1983 FUEL MIX, IN PERCENT

Fuel	With WCGS KG&E	With WCGS KCPL	Without WCGS KG&E	Without WCGS KCPL
Coal	55.6%	67.6%	55.6%	92.6%
Oil	0.5	2.9	11.2	5.5
Gas	22.6	1.1	33.1	1.9
Nuclear	21.3	28.4	0	0
	100%	100%	100%	100%

NOTE: May not add due to rounding

The costs of fossil fuels are increasing rapidly, as shown in Table 1.1-16. In the period 1970 to 1985 the costs for individual fuels are expected to have increased by factors ranging from 5 to 17. In addition, the availability of fossil fuels is questionable, although natural gas has been more abundant than was thought possible a few years ago. Even so, the use of natural gas as boiler fuel must be discontinued by 1990 in accordance with the 1978 Fuels Use Act. However, if the reduction of oil consumption continues to be stressed by the Administration, natural gas may be made available to utilities on an opportunity basis for a longer period of time. In late 1979 suppliers of gas to Kansas utilities would not make firm commitments on supply quantities and prices.

The associations of which KG&E and KCPL are members or participants are shown in the following table:

Regional Pools and Associations	KG&E	KCPL
Southwest Power Pool (SPP)	X	X
Missouri-Kansas Pool (MOKAN)	X	X
Companies-Associated - Southwestern Power Administration (SPA)	X	X
South Central Electric Companies	X	
Kansas City - Twin Cities		X
Missouri-Kansas-Oklahoma Interconnection Agreement	X	

As indicated above, both KG&E and KCPL are members of the SPP which is one of the nine regional coordinating groups of the Natural Electric Reliability Council (NERC). KG&E and KCPL are also members of MOKAN, an association of nine Kansas and west Missouri utilities. KEPCo intends to become a member of SPP and MOKAN once it has received its appropriate authorizations from the Rural Electrification Administration (REA) and the Kansas Corporation Commission (KCC). Details on pools and associations are provided in Table 1.1-6, and pool planning criteria are discussed in Section 1.1.2.3.

Each of the Applicants is engaged in a major effort to increase energy conservation through programs to reduce waste, to improve energy conversion processes and to reduce the growth rate in demand for peak power and total energy. None of the Applicants is conducting advertising programs that will stimulate the growth in demand. In fact, each is involved in public relations campaigns to encourage wise use of energy. Both KG&E and KCPL have had energy conservation advertising programs since 1972. All media have been used - enclosures to billing statements, spot radio and television announcements, newspaper and magazine advertisements in their service areas, distribution of booklets and pamphlets, group meetings and advisory services and seminars on conservation. Consumer consultants have advised hundreds of audiences on the efficient use of appliances and equipment, and energy management seminars have been held for architects and builders and for commercial and industrial customers.

Both utilities encourage the use of energy efficient appliances and equipment, and KG&E offers a computer service for analyzing individual customers' needs and potential savings from insulation, storm windows, improved equipment, and other conservation measures. Both utilities schedule one-on-one meetings with major customers to review conservation methods.

KCPL has been active in residential, commercial and industrial energy conservation audits. The billing system has been used at least three times to advise residential customers on insulation audits that can be provided by an outside contractor for Energy Efficiency Systems. At least 20,000 audits have been conducted, and energy conservation measures have been introduced directly into 2500 homes. Other installations have been made by homeowners and by contractors. Building energy analyses are provided for the design of new residential, commercial and industrial construction.

A program has been developed for all customers, emphasizing energy management techniques to control both usage and cost. The major objectives are to reduce the growth rate in peak demand and to stimulate the use of off-peak hours so as to divert energy consumption from peak load hours. Included in this program are advertising and group presentations that stress the use of energy efficient appliances and equipment, proper insulation and conservation practices. Technical information is made available to all customers, and energy management training seminars are conducted for industrial and commercial customers. Home service programs include material on energy conservation for students and teachers.

During 1979 and 1980 KCPL is testing the effectiveness of peak time interruption of air conditioning and of voluntary reduction of consumption during "peak alerts". A company group is working with builders to analyze the effectiveness of energy efficient designs and building materials. KCPL has also participated in Edison Electric Institute's National Energy Watch and has developed the "150 Plus Energy Conserving Program". Energy conserving home certificates are awarded to homes that meet specified standards. Possession of such a certificate by a builder or owner is a positive feature in sales appeal. Studies are being conducted by KCPL on home conservation improvements such as ceiling insulation.

KG&E's program is much the same as that of KCPL in terms of public contact to stimulate an awareness of the need for conservation. Energy Efficiency Awards are given to dwelling units and commercial structures that meet high energy conservation standards. The use of electric heating is discouraged in homes that are poorly insulated. KG&E has adopted an action program to reduce energy consumption at all company facilities, and all utilities are complying with the national 65° winter - 78° summer mandate. Power is being transmitted at higher voltages in new lines, and worn out conductors are replaced by larger conductors to reduce line losses. The most efficient generating units are used for base load.

Experiments are being conducted by KG&E on off-peak pumping for irrigation, and both KG&E and KCPL are experimenting with ice storage air conditioning systems in which off-peak generation at lower rates will be used to produce ice for use in daily air conditioning. Kansas utilities have a joint research and development program to analyze the effects of voltage reduction on energy saving.

Industrial rates are designed to encourage customers to schedule production so that the greatest load requirements come during off-peak months and daily off-peak perods.

All utilities are involved in load management plans and research. The four basic areas of load management are:

1. Direct control;
2. Passive control;
3. Price signals; and,
4. Customer education.

Each of the Applicants has initiated studies to determine whether direct control of residential central air conditioning will provide positive changes in the load curves and be acceptable to the customer. Radio controlled equipment is being used in the initial tests, and the results, expected in 1980 or 1981, will be used to determine the justification for larger scale projects. Such tests may also be conducted on other equipment such as electric heating. KEPCo's member systems are conducting load control research on irrigation under a KCC program.

Passive load control involves load limiting devices owned by the customer and installed on his equipment. The results of a May, 1978 survey of industry by KCPL revealed that 51 percent of the industrial and commercial customers surveyed had installed or were considering passive control devices. It appears that customers who will benefit from such devices will install them.

Price signals are conveyed to customers through rate design, such as increased rates, interruptible rates and time-of-day pricing. Neither KCPL nor KG&E has had much in the way of positive response to proposals for time-of-day pricing; few industrial and commercial customers are willing or able to change work shifts. In KCPL's survey 83 percent of the respondents indicated no interest in time-of-day pricing, 94 percent showed no interest in peaking generators or cogeneration, and 69 percent did not want interruptible rates. KCPL does have one demand curtailment contract with Armco, its largest electric load customer. The contract provides for reduction of up to 100 MW of load, as requested by KCPL. Only one KG&E customer has taken advantage of an experimental off-peak rate, a customer whose major load is during the night.

The area of customer education on conservation is the one in which most effort is concentrated. One promising program instituted by KCPL is "Peak Watch". Customers of KCPL and the Missouri Public Service Company are urged to reduce their loads on days when both utilities predict a new peak.

Most of the member cooperatives of KEPCo have adopted the Kansas Energy Efficiency Alert program (KEE-92°) which utilizes radio stations to broadcast information on weather conditions that will affect peak loads. Messages advise on the rising demand for electricity in peak periods and recommend actions for holding the peak down. The individual cooperatives follow programs similar to those of KG&E and KCPL to educate their customers on energy efficient appliances and equipment and on the need and means for reducing demand and consumption. In addition, low-interest loans have been made available to some rural electric consumers for installation of insulation and other energy conservation measures. These loans are administered by KEPCo members and the REA.

It is difficult to measure the effectiveness of the utilities' load management and conservation programs in terms of reduced rates of growth in peak demand and total energy consumption. There are many other factors involved including length and severity of hot and cold weather, energy price, fuel competition, changing demands for housing, and the use of more energy efficient equipment. However, all utilities believe that their load management and conservation programs have been effective in reducing the rates of growth.

Minor inconsistencies will exist between data previously reported to the Federal Energy Regulatory Commission, to the REA, and to both SPP and MOKAN and data shown in various tables herein. KG&E and KCPL, like most other utilities, continuously test and re-rate generation capacity, update load forecasts, and report load data for various reporting periods; i.e., as of the time of the summer peak, as of the end of a fiscal or calendar year, or for a contract year, beginning June 1 of each year.

1.1.1 LOAD CHARACTERISTICS

Most of the utilities in the SPP and MOKAN regions experience their annual peak loads in the summer, with relatively little diversity. Since they are in the same general climatic zone, there is little difference between a simultaneous peak and a non-coincident peak load. For example, KG&E and KCPL frequently experience a summer peak on the same day or within the same few days. As shown in Table 1.1-18 in five out of the last eight years, the two companies had their peak loads on the same day or within one to eight days of each other, commonly in July and August. For each utility the peak comes in the afternoon when residential air conditioning is turned on, regardless of cost. KEPCo, too, experiences its peak loads in July and August. In the last ten years five peak loads have come in July and four in August.

Most utilities in MOKAN and SPP are experiencing growth in demand, which reduces the opportunity for large transfers of energy between utilities. Because of this growth and the lack of diversity during the summer months the option is precluded of purchasing large blocks of power.

Tables 1.1-7a and 1.1-7b through 1.1-11 present consolidated data on SPP and MOKAN. In the period from 1965 to 1977 the summer peak demand in SPP grew by 144 percent for an average annual increase of 7.7 percent. In the same period the accredited capacity increased 169 percent for an average annual increase of 8.6 percent. (Comparable data are not available for other periods because of membership changes.) For the following period, from 1978 to 1988, the summer peak load is projected to increase 79 percent for an average annual growth rate of 6 percent. Annual energy is projected to grow 82 percent at an average annual rate of 6.2 percent.

In the long term from 1989 to 1998 a 60 percent increase in peak load is projected for SPP at a lower average annual growth rate of 5.4 percent. Reserve margins for SPP are projected to decline from 20 to 25 percent in the early 1980's to 17 to 18 percent in the late 1990's.

In MOKAN the system peak load increased 44.9 percent from 1971 to 1979 for an average annual growth of 4.7 percent. Accredited capacity grew 55.7 percent for an average annual growth rate of 5.7 percent. For the period 1979 to 1988 the system peak load is projected to grow at a rate of 5.4 percent and accredited capacity at a rate of 4.3 percent. It should be noted that the annual peak in 1979 was 7.8 percent lower than had been projected, lower even than the 1978 peak by 77 MW, as a result of mild summer weather.

The installed capacity balance for MOKAN, shown in Table 1.1-11 is projected to be negative in 1984 if WCGS is not in operation. SPP projects installed capacity margins of 15 percent or more for the period 1983-1988 (Table 1.1-9). However, because of forced outages, the actual summer margins at the times of peak loads, shown in Table 1.1-7b have frequently been below the required 15 percent. In 5 out of the last 8 years the actual operating margins at the times of summer peaks have been below 15 percent.

Unlike the situation for pools, councils and utilities in other regions, the winter peaks in this general region are not approaching the summer peaks in magnitude.

1.1.1.1 Load Analysis

Tables 1.1-12, 1.1-13 and 1.1-14 present for the Applicants their historical and projected growth in peak loads and annual energy requirements. As a basis for the discussion which follows, the annual peak loads and energy requirements are shown below for five year intervals over the period 1968 to 1988.

PEAK LOAD AND ANNUAL ENERGY

Year	Peak Load in MW KG&E	KCPL	KEPCo	Annual Energy in GWH KG&E	KCPL	KEPCo
1968	923	1276	*	4146	5552	*
1973	1202	1257	259	5516	7598	1160
1978	1533	2097	377	7184	9011	1640
1983	1790	2398	583	8068	10832	2626
1988	2152	2862	792	9613	13179	3520

* Not available

The nature of the growth that has occurred and is expected to occur for KG&E is summarized in the following tabulation.

KG&E GROWTH IN PEAK DEMAND AND ENERGY

Period	Peak Demand Percentage Increase	Avg. Annual Growth	Energy Requirements Percentage Increase	Avg. Annual Growth
1968-1973	30.2%	5.4%	33.0%	5.9%
1973-1978	27.5	5.0	30.2	5.4
1968-1978	66.1	5.2	73.3	5.7
1978-1983	16.8	3.1	12.3	2.3
1983-1988	18.7	3.5	19.1	3.6
1978-1988	38.6	3.3	33.8	3.0

Growth in both peak demand and annual energy was relatively high in the late 1960's and early 1970's but fell off somewhat in the mid 70's to an average rate of growth which is projected by KG&E to continue over the long term. KEPCo is to become its own power supplier in 1980, and KG&E will no longer report KEPCo's peak load as a part of the KG&E peak load. This reporting change tends to distort future growth rates slightly.

In Figures 1.1-1 and 1.1-2 the expected load duration curves are given for KG&E for the first two years of operation with WCGS. In Figures 1.1-5, 1.1-6 and 1.1-7 hourly load curves are presented for summer and winter peak days and for a typical spring/fall day.

The following tabulation summarizes recent and anticipated growth trends for KCPL:

KCPL GROWTH IN PEAK DEMAND AND ENERGY

Period	Peak Demand		Energy Requirements	
	Percentage Increase	Avg. Annual Growth	Percentage Increase	Avg. Annual Growth
1968-1973	37.7%	6.6%	36.9%	6.5%
1973-1978	19.4	3.6	18.6	3.5
1968-1978	64.3	5.1	62.3	5.0
1978-1983	14.4	2.7	20.2	3.7
1983-1988	19.3	3.6	21.7	4.0
1978-1988	36.5	3.2	46.3	3.9

As with KG&E, KCPL has experienced a decline in growth for both peak demand and annual energy and projects for the future growth rates similar to those recently experienced.

As shown in Table 1.1-13, annual energy requirements dropped significantly in 1974 due to the recession, which affected the Kansas City area far more than the Wichita area and the agricultural areas served by KG&E.

KCPL's expected load duration curve for 1983 and 1984 operation is presented in Figure 1.1-3. Hourly load curves are presented for summer and winter peak days and for a typical spring/fall day in Figures 1.1-8, 1.1-9 and 1.1-10.

The following tabulation summarizes KEPCo's recent and projected peak demands and annual energy requirements:

KEPCO GROWTH IN PEAK DEMAND AND ENERGY

Period	Peak Demand		Energy Requirements	
	Percentage Increase	Avg. Annual Growth	Percentage Increase	Avg. Annual Growth
1973-1978	45.3%	7.8%	44.0%	7.6%
1978-1983	54.9	9.2	57.2	9.5
1983-1988	35.7	6.3	34.0	6.0
1978-1988	110.2	7.7	110.7	7.7

With the exception of 1976 and 1977 for annual energy and 1977 for summer peak, there has been a continuing high rate of growth. Based on studies made for KEPCo, (Lee, Jan., 1978 and June, 1978), it is believed that the relatively high growth of the past will be sustained. Most of KEPCo's load is in rural areas that are experiencing population gains as well as increased per capita use of energy.

KEPCo's expected load duration curves for 1983 and 1984 is presented in Figure 1.1-4.

To meet increasing demands for peak power and annual energy within their service areas, both KG&E and KCPL have construction programs for making additions to their generating capacities as the needs develop. Historical and planned additions over the 20 year period described in the above analyses are as follows: (Tables 1.1-4a, 1.1-4b, 1.1-5a and 1.1-5b)

TWENTY YEAR CHANGES IN GENERATING CAPACITY

Accredited Generating Capacity

	MW*	
Year	KG&E	KCPL
1968	1153	1187
1978	1930	2560
1988	2730	3271

Ten Year Increases in Capacity

	MW		Percent	
Period	KG&E	KCPL	KG&E	KCPL
1968-78	777	1373	67.4	115.7
1978-88	800	711	41.5	27.7

* At time of Summer Peak

Between 1968 and 1978 KG&E's installed capacity increased by 777 MW, an increase of 67.4 percent, or an average annual increase of 5.3 percent. In the same decade, KCPL's capacity increased by 1373 MW, an increase of 115.7 percent, or an average annual increase of 8.0 percent. In the ten year period from 1978 to 1988 KG&E's capacity is scheduled to increase by 800 MW or 41.5 percent, for an average annual increase of 3.5 percent. In the same period KCPL's capacity is scheduled to increase 711 MW or 27.7 percent, for an average annual increase of 2.5 percent.

KEPCo will not have any owned capacity until WCGS is on line in April 1983, when it will have 195.5 MW of generating capacity.

Accredited summer capacity changes for the applicants by primary fuel from 1978 to 1988 were and are scheduled to be:

NET CAPACITY CHANGES, 1978-1988 IN MW

	Gas	Oil	Coal	Nuclear	Total
KG&E	0	0	+323	+477	+800
KCPL	-80	0	+314	+477	+711
KEPCo	0	0	0	+196	+196

As adjusted for weather anomalies, KG&E and KCPL anticipate slower growth rates in peak load for the decade 1978-88 than were experienced in the period 1968-78. The reasons for a slower rate of growth are primarily conservation and a reduction in demand due to higher prices. Mild summer weather in some years has also slowed the growth in summer peaks. A part of the apparent decline in growth for KG&E is due to the change in reporting of the peak load for KEPCo, discussed above. KEPCo expects to add more customers as the move continues of population from urban to the suburban and rural areas which its members serve.

The projected growth rates for peak load for KG&E and KCPL are lower than those of SPP and NERC, while those for KEPCo are higher. A comparison follows:

AVERAGE ANNUAL GROWTH RATES FOR PEAK LOAD

Period	KG&E	KCPL	KEPCo	SPP	NERC (US)
1978-83	3.1%	2.7%	9.2%	6.0%	5.3%
1983-88	3.5	3.6	6.3	5.9	4.5
1978-88	3.3	3.2	7.7	6.0	4.9

NOTE: These intervals were selected because comparable date are not available for others.

The growth in annual energy follows a pattern similar to that for peak load for all of the Applicants. Each projects a continuing growth but at a slower rate than in the past.

1.1.1.2 Demand Projections

1.1.1.2.1 KG&E Method

Peak and energy forecasting by KG&E involves a combination of techniques - surveys of present and planned use; extrapolation of historical use; and analyses of economic conditions, population growth, household formation, household income, industrial development, price of electricity, price and availability of competitive energy sources, and other considerations for each specific market category. A disaggregated approach to markets is taken, with the applications of experienced judgement. The forecast for energy sales is prepared separately for five categories - residential, commercial, industrial, street and highway lighting, and sales for resale. Basic assumptions are made that apply to all categories, and specific assumptions are made that are applicable to individual categories. The general assumptions relate largely to population, economic conditions and development. Forecast updates are made at the end of each calendar year, for the following ten year period.

1.1.1.2.1.1 Residential Forecast

Residential energy consumption forecasts are based on statistical data collected on population and household sizes and income, saturation trends for major appliances and electric heating, including heat pumps, energy substitution, improved appliance efficiencies, improved thermal conditions, decreasing size of dwellings and increasing number of apartments.

Customer growth is estimated on the basis of the trends in population growth and the number of persons per household. As shown in Table 1.1-19, the average growth rate for residential customers has been 1.9 percent per year, substantially higher than the growth rate of 0.9 percent for population in the Wichita Metropolitan Area. The greater growth in the number of residential customers is attributed in part to high employment but largely to a decline in the number of persons per household, which leads to increased household formation.

Consumption of electricity by various classes of residential users is the next consideration. Among the significant classes of users is that of residential electric heating. As shown in Table 1.1-20 KG&E's electric heating customers comprised nearly 13 percent of the total customers at the end of 1979, with steady growth in numbers over the past ten years. This important class of user consumes more than twice as much electric energy per year as is consumed in homes without electric heating. Because of future uncertainties on the availability of and the price competition with natural gas, it is necessary to observe this customer class very closely. It appears that penetration of the residential home heating market is declining because of competition from gas, which continues to be available at relatively low cost, compared to other fuels.

Average annual consumption of energy by all residential customers has grown steadily since 1970, as shown in Table 1.1-21 and is projected to continue to increase but at a slower rate. As shown in Table 1.1-22 residential use accounts for one-fourth of KG&E's total consumption. Although consumption continues to grow, the residential share of the total energy market is projected to decline slightly. The State of Kansas has mandated that new and replacement air conditioning equipment must carry a high energy efficiency rating (EER). In addition, electric heating may not be introduced into new homes that do not meet prescribed insulation standards.

Builders and banks are useful sources for information on the number of housing units planned and being developed. Consideration of these trends along with the factors discussed above permits the development of estimates on residential energy consumption.

1.1.1.2.1.2 Industrial Forecast

Major factors considered in the industrial category are production levels, the price of electricity and the prices and availability of alternative energies. KG&E's major customers, accounting for 78 percent of annual industrial energy consumption, are surveyed periodically, and projections of peak load and energy requirements over the next ten year period are obtained from each customer. Most of the industrial customers are able to provide fairly accurate estimates of their anticipated load and energy requirements over a five year period.

It is recognized that the state of the economy and external events may affect the planning of many of the industries in the KG&E service area. Some of the customers, such as those with grain mill products have energy growth rates that correlate with regional population growth. The energy consumption of others, involved in petroleum refining, petroleum and gas production, petrochemical production, pipeline transportation and coal mining depends upon pricing and availability of energy resources, demand for products and recovery techniques. There could be major changes in the requirements of these industries for both capacity and energy, depending upon national energy policies and international petroleum availability.

Two problems involved in forecasting energy demands are particularly related to industry. For many industry groups an economic recession may mean an abrupt cut-back by a major industrial facility. This may have a significant effect on peak loads and on energy consumption. And, in some industries a plant may be put back on line with very little notice. A utility must be prepared for significant swings in load and energy consumption. In planning major new plants or expansions, industry personnel advise a utility of their requirements several years in advance of start-up. Depending upon the size of the plant, this may or may not affect a utility's capacity planning. But, there are instances in which a utility has planned to accommodate the requirements of a major new plant only to find that because of economic conditions start-up has been delayed for a year or more. That economic conditions can clearly play a role in load planning is indicated in Table 1.1-24 which shows the changes that have occurred in Kansas and Missouri economic conditions in recent years.

The local aircraft industry is in a boom stage at this time but could be adversely affected if there were a deep and lasting recession.

Many industrial plants have made all possible cost-effective conservation modifications and have installed load control equipment.

Although KG&E has an off-peak rate, only one user has adopted it, a plant that conducts most of its energy consuming operations during these hours. New or expanded industrial operations may be able to make more effective use of the rate.

KG&E has no interruptible customers, but it does have a number of continuous process plants in which product would be damaged by service interruptions.

Projected energy and load requirements described by the major industrial users are combined with historical trends to provide a basis for forecasting industrial load growth. As shown in Table 1.1-22 the industrial category has been the largest for KG&E and is projected to remain so.

1.1.1.2.1.3 Commercial Forecast

Commercial projections are developed through consideration of population and income growth, past trends and the extent to which electricity will be substituted for other energy, considering price and availability. Historically the commercial market has lagged both the economy and the growth in population and household income. Continuing surveys are made of the major users in the commercial category - hospitals, major shopping centers, the school systems, colleges, and governmental entities to determine what changes in use are likely to occur and if and when energy (fuel) switching will take place. The greater availability of natural gas has deterred some switching to electric space heating, but any future reductions in natural gas availability will affect commercial users before residential users.

Builders and banks are visited regularly to determine what construction is taking place, what is planned and what the electrical requirements will be. Attention is also given to the conservation efforts of commercial users.

All of these factors are considered in projecting commercial usage. Commercial use accounts for about 20 percent of KG&E's total consumption. (Table 1.1-22)

1.1.1.2.1.4 Projection of Other Uses

"Other uses" than industrial, residential and commercial accounts for less than 18 percent of total consumption. The category "other uses", consists of street and highway lighting and sales for resale. Street and highway lighting represents only about one percent of total consumption and is projected graphically, with adjustments for expansion of urban areas and the increased efficiency of lighting sources. This category is not expected to achieve an increased growth rate.

The sales for resale category includes sales to rural electric cooperatives, distribution municipals and generating municipals. Growth rate patterns for this group are different than for KG&E as a whole. Rural electric cooperative requirements have grown faster than those of KG&E while those of the distribution municipals have grown slower. The generating municipals project a growth rate slightly higher than that for KG&E as a whole.

For each of the segments in the sales for resale category individual projections of requirements are obtained and consolidated for projection purposes. Changes in supply or in the economics of generation are also taken into account for the various units. For example, the rural electric cooperatives' requirements from KG&E will be reduced by outside supply and through ownership by KEPCo of a 17 percent share of WCGS. It is anticipated that all of the requirements of the distribution municipals served at wholesale by KG&E will be met. The generating municipals are expected to expand their purchases because in most cases their plants burn gas and oil which will become increasingly costly and may even be unavailable. During peak periods, however, the generating municipals are expected to use their own plants to provide support in meeting peak loads.

1.1.1.2.1.5 Forecast of Peak Demand

KG&E demand forecasts are also made annually and based in part upon assumptions similar to those used in making the energy consumption projections. In addition, a procedure has been developed that approximates the demand forecast. This procedure is based upon several years of observations which have shown that the daily peak loads in April are very steady since they are independent of heating and cooling effects. The total April load, less the industrial load, then becomes a base on which the weather-sensitive load builds. Major industrial loads are steady throughout the year and are very little affected by heating or cooling requirements. Using the April base, a ratio is established as a measurement of the weather-sensitive portion of KG&E's

loads. Conservation is considered in that the April base load is below the long term trend by an amount that is realistically assumed to be due to conservation efforts and is so projected into the future. A projected April base is multiplied by a trend in the ratio of peak to April base, and the projected industrial load, based on survey information, is added to obtain a total system peak demand. It has been recognized that the difference between a hot and a cool summer can mean a variation of about 5 percent in the annual system peak.

In addition, tests of reasonableness are applied in which peak load forecasts are compared with total energy requirements, and past and projected summer month energy usage data are analyzed to insure internal consistency.

1.1.1.2.1.6 Econometric Model

KG&E has not believed that an econometric model would provide sufficiently improved forecasting to justify its cost. There are so many subjective inputs involved in the development of energy and load forecasts that the sophistication of a more complex approach seemed unlikely to yield greater accuracy or assure more confidence in the results. However, consideration is being given to the development of a model to support the existing methodology.

1.1.1.2.2 KCPL Method

In past years, KCPL has utilized a disaggregated approach to energy and load forecasting, combining survey, economic and population data with trends, in much the same manner as KG&E. Recently, however, KCPL has developed an econometric model which is used as a tool in the development of forecasts of peak loads and annual energy requirements. The model uses historical relationships over time between the demand for electricity - energy and peak - in key months and certain economic factors. Demand and energy projections developed with the model are based upon statistical analysis of factors that have been shown (or are hypothesized) to influence the demand for electricity. The major factors used in the model are population, real income levels, the level of industrial production activity and the real prices of electricity, natural gas and other fuels. Other variables used are the number of residential customers, air conditioning saturation and EERs, and weather related variables.

1.1.1.2.2.1 KCPL Econometric Model

In late 1979 an econometric model was adopted as a tool in long term load forecasting. It is recognized in developing the model that review, refinement and updating will be required to take into consideration events, developments and policies that cannot now be accurately measured in terms of effect upon demand for electricity. Among these are:

(1) The uncertainty of the national and international situation with respect to the supply and price of oil;

(2) The potential for electro-mechanical control of customer peak use of electric equipment as a means for load management; and,

(3) The effect of the Presidential order on thermostat settings for which insufficient data now exist.

All projected demands are normalized to adjust for weather anomalies.

As a result of extensive study of the econometric model projections and discussion by the key executives and offices of the Company, it was decided that the official KCPL long-term forecast for 1979-1990 will be a 3.6 percent compound growth in net system peak and a 4.0 percent compound growth in energy sales.

Projected peak loads and annual energy are given in Table 1.1-13. However, in place of the actual 1979 peak summer load of 1964 MW, the figure of 2082 MW is used in making the load projections as a "normalized load," adjusted for the mild summer. The projections also take into account the provision for an up-to-100 MW curtailment of load for Armco.

The major assumptions used in simulating the econometric model are as follows:

1. The real price of electricity is assumed to increase at 0% annually for the demand forecast and decline at 1% annually for the energy scenario. The rationale behind the dichotomy in energy and demand price growth is based on the current rate making philosophies which are shifting more of the cost of electricity into the on-peak periods. The increase in the real price of energy is expected to be less than the general rate of inflation because demand conservation will result in an improved load factor causing a downward pressure on the per unit cost of energy.

2. According to the Natural Gas Policy Act of 1978 (H.R. 5289, P.L. 95-621), a portion of the National Energy Plan, the ceiling price of "new" natural gas, as defined by the Act, will gradually be allowed to rise according to an established formula until January 1, 1985, when price controls would be removed. Based on the estimates of Price Waterhouse, and Company, Data Resources, Inc., and the Electric Power Research Institute, it is projected that the "most likely" scenario for real natural gas price increases will be 4% annually for 1979-1985, 7.5% from 1985-1990, and 1.5% thereafter.

3. Total real income, real income per capita, and industrial activity are projected to increase at 2.7%, 1.8%, and 3.2% respectively over the long term. These estimates were either supplied directly or derived from macroeconomic projections from the March 1979 Wharton Econometric Model and the population projections explained below.

4. Population projections provided by the University of Missouri call for a compound growth rate of .45% in the Missouri portion of the Kansas City SMSA (Clay, Jackson, and Platte Counties) served by KCPL. This rather low population growth rate is related primarily to the expected population decreases in Jackson County through 1990.

A discussion follows of the additional factors that were considered in developing the econometric model.

The KCPL service area encompasses portions of both Missouri and Kansas, but there are extreme differences in the social, population and economic characteristics of the two states. The Missouri portion of the service area can best be viewed as a mature urban-economic area. There is a well established industrial base with 70% of Missouri industrial KWH sales being made to the durable goods production sector. In recent years, the Kansas City, Missouri central city area has experienced a net out-migration through population shift to the suburbs. The reduction in population levels has caused a corresponding loss of commercial customers in the central city area. To complicate matters further, the majority of the high growth areas on the Missouri side of the Kansas City SMSA are within the service areas of neighboring utilities.

In contrast, the Kansas portion of the service area can be characterized as an economic area still in the development state. In the early 1960's, this area was primarily a "bedroom" community with little industrial activity of its own. It was characterized by very high rates of population growth and high income levels which continue today. More recently, the area has been characterized by rapid growth in the commercial sector with the construction of shopping centers and office buildings. The industrial sector, stimulated by incentives such as a "right to work" law, a developing labor force, government issued revenue bonds and certain tax benefits is beginning to develop. In contrast to Missouri, Kansas industrial development tends to be in the area of non-durable production.

Because of these structural and economic differences between the two states, accurate modeling and forecast results required that energy sales be modeled by state.

Energy sales to Kansas customers are expected to grow at a faster rate than sales to Missouri customers. This is a direct result of the high levels of population growth and economic development now being experienced and expected to continue in Kansas. For example, in Johnson County, strong population growth is projected (1.7%) throughout the forecast period by Johnson County Community College.

Household size in all portions of the SMSA is projected to continue its decline of recent years. Household size in Jackson and Clay Counties is projected to decrease from approximately 2.6 Persons/Household in 1978 to 2.2 Persons/Household in 2010. Johnson County household size is projected to decrease from 3.0 to 2.4 Persons/Household over the same period. Decreasing household size implies a greater number of residential customers for a given population level.

Sensitivity analyses were conducted on both the energy and demand models using various high and low growth scenarios for the driving variables. The growth range produced for the energy forecast is from 1.6% to 4.5% and the growth range for the demand forecast is from 1.7% to 5.5%.

The table below summarizes projected energy growth rates by state, by sector, and in total over the period from 1979 to 2010.

PROJECTED ENERGY GROWTH RATES BY STATE AND SECTOR

1979 - 2010

	Missouri	Kansas	Total KCPL
Residential	4.0%	4.4%	4.1%
Commercial	2.4	5.6	3.5
Industrial	2.5	6.5	3.1
Other	3.1	4.5	3.4
Average	2.9%	5.2%	3.6%

The percentage breakdown of total KCPL Kwh sales among the various sales classifications for the past five years is shown below.

KCPL KWH SALES

Industrial	27%
Commercial	39
Residential	29
Other	5
Total	100%

Customers in each of these sectors use electricity for different reasons. Industrial customers use electricity in the manufacturing process for such things as machinery drive, process heating, furnaces and environmental equipment applications. Commercial customers typically use electricity in lighting, heating, refrigeration, air conditioning, and specialized appliance use. However, the commercial class is a broad class with considerable heterogeneity of end uses (e.g., supermarkets, offices, schools, gas stations, cable TV amplifiers, traffic signals). As a result, there are very diverse usage patterns which are different from those of other sales classifications.

The residential sector, though, is relatively homogeneous, with customers using electricity for the same purposes -- lighting, cooking, heating, cooling, and operating various appliances. To the extent differences in usage levels among households exist, they are not so extreme as in other classes and can be accounted for by proper model specification.

Because of the differing usage patterns, each sales classification has been modeled separately in order to isolate those factors that exert a level of influence on sales in one sector and a different level or no influence in other sectors.

The net system peak demand was modeled on a total company basis due to the lack of historical demand data by class.

The structure of the forecast is shown in Figure 1.1-11. All energy modeling was done on an off-calendar year, semi-annual basis using the periods October through March and April through September to facilitate the estimation of weather effects upon sales levels. Demand modeling was based on peak demands during the months of July and August when there is the greatest probability of a system peak occurring.

The data base was developed as follows:

1. Semi-annual data bases from 1967-1978 were developed for each of the sales classifications, residential, commercial, industrial, etc. Sales and customer statistics were taken from KCPL billing records, annual reports, and appliance surveys.

2. Production indices were provided by the Kansas City Federal Reserve Board.

3. The U.S. Department of Labor supplied price index information, and the Gas Service Company of Kansas City, Missouri, supplied local gas price information.

4. Historical and projected population estimates were provided by the U.S. Census Bureau, the University of Missouri, and the Johnson County Community College.

5. Weather data were obtained from the National Oceanic and Atmospheric Administration.

6. Income and household size data were obtained from Sales and Marketing Management Magazine.

7. Typical electric bills used in all the model estimations were derived from KCPL's tariff and load research data. All typical bills include any applicable fuel adjustments or fuel surcharges and were calculated at fixed demand and energy levels.

8. The Wharton Econometric Forecasting Associates was the source of projections of national economic variables that are used as driving variables in the majority of the service area models. The March 1979 Wharton Model was used as a source for Federal Reserve Board (FRB) production indices and income per capita projections. The FRB Production Index is projected to increase at 3.3% through 1989. Real per capita income is projected to grow at 1.8% through 1989.

9. The natural gas price projections were based upon information supplied by the Electric Power Research Institute, Price Waterhouse and Company, and Data Resources, Inc., and assume deregulation by 1985, pursuant to the National Energy Act. Real gas prices are projected to increase at a long-term rate of 3.1% compounded annually.

10. All simulations are weather normalized. Weather normalized energy sales estimates were obtained by using long-run (41-year) averages for cooling and heating degree days in model simulations. The average cooling degree hours for the peak day and the previous three days used in the demand model were averaged over the historical data-base period to establish a normal level.

Statistical testing procedures were developed as follows:

1. A criterion was set that all driving or independent variables must pass statistical significance tests indicating a high probability that they have an effect different from zero upon the dependent variable in question (e.g., KWH, KW, customers). The mathematical sign associated with any particular independent variable coefficient was required to conform with a priori economic theory. In some cases where the estimated coefficient was strongly confirmed by theory, but the associated significance level of the coefficient was questionable, the independent variable was kept in the model.

2. A secondary check on independent variables was undertaken to ensure that the associated coefficients were of a proper magnitude (i.e., that observed by other researchers).

3. Tests were conducted on each model for the presence of severe autocorrelation, and corrections were made if required.

1.1.1.2.2.2 Industrial Forecast

In order to demonstrate the principles of the econometric model, the methodology for the industrial category is described in detail. The other categories are described in general.

Industrial KWH sales in Missouri have accounted for approximately 33 percent of total Missouri KWH sales in recent years. One large customer, Armco Steel, accounts for more than 40 percent of Missouri Industrial sales and for this reason, Armco KWH usage was projected independently of other Missouri industrial sales.

The model for the industrial class hypothesizes that sales are a function of the level of industrial output, the price of electricity and the price of competitive fuels. As a means of analyzing industrial electricity consumption as it relates to real physical output, the Federal Reserve Board Production index was used as a proxy for localized output in lieu of a suitable localized production index.

Since electricity is used as a factor input in the industrial process for such things as machinery drive, process heat, etc., it is an obvious assumption that as the level of production increases or decreases, electricity consumption should do likewise.

It is also assumed that the industrial consumption of electricity is price sensitive both to electric prices and the price of energy alternatives. This price elasticity effect will manifest itself in terms of either conservation or substitution effects and is measured in terms of its own elasticity, cross elasticity, or combined elasticity.

Implicit within the industrial model described below are certain technological changes contained in the historic data and, consequently, certain technological changes are implicitly incorporated within the forecast itself.

The model derived for the Missouri Industrial Sales classification is:

DEPENDENT VARIABLE: LMIKWH

Right Hand Variable	Estimated Coefficient	Standard Error	"T" Statistic
C	20.019	.952	21.0
LSFRB	.554	.093	6.0
PZ	- .215	.050	- 4.3
SEAS	.069	.009	7.6
DDCUS	.034	.014	2.5
PPZ	- .006	.001	- 4.2

$R^2 = .963$

$R^2 = .948$

DW = 2.18

LMIKWH = Log (Missouri Industrial Sales Exluding Armco)*
LSFRB = Log (FRB Production Index)
PZ = Log (Real Price of Electricity/Real Price of Gas Fuels)
SEAS = Seasonal Production Variable
DDCUS = Dummy to Account for Customer Reclassification in 1970
PPZ = PZ Subsequent to 1973 Oil Embargo, 0 Otherwise (Test for changing price elasticity)

* All Log values referenced in this documentation are natural logs

The variable PZ is the ratio of electric price to gas price and as such represents a combined price elasticity for both gas and electricity.

Armco Steel is involved in the production of wire, wire rope, steel products and ingots. Future yearly estimates of electric usages to 1983 were obtained from Armco and reflect greater intensity of future use. Alternative modeling efforts were undertaken to analyze the relation of Armco usage to external production indices. These models showed that there has been a historical relationship between the FRB durable index and Armco usage, but because of the nature of the large discrete Armco load additions, the models were judged to have relatively low explanatory power. After analyzing a detailed survey questionnaire answered by Armco, the forecast supplied by Armco, and applying judgment it was concluded that subsequent to 1983 Armco usage would increase by 2% per year.

The independent variable assumptions described above were used to simulate the industrial model and were combined with results based on the Armco estimates.

As a followup to the statistical portion of the forecast, a customer survey was completed by approximately 34 large industrial customers. Analysis of the survey indicates that a significant amount of the growth in the near future as in the recent past, will come in the form of environmental protection devices. To investigate further the other effects environmental constraints may have on industrial growth, officials were interviewed in the Environmental Protection Agency (EPA) and the Mid-American Regional Council (MARC). The Kansas City area is presently under a new industrial construction moratorium ordered by the EPA. However, conditional approval of a plan submitted by Missouri is expected by January 1, 1980, and conditional approval for the Kansas plan is expected sometime in 1980. Conditional approval of each state's plan will allow the resumption of industrial construction activity. All industrial permits submitted prior to July 1, 1979 are permitted to go ahead with construction so the effect on industrial construction is expected to be minimal if conditional approval of each state's plan is given as expected.

The MARC did not feel that meeting these standards would present much of a problem for industrial growth in this area at the present time and cited the fact that, in comparison with other cities, the Kansas City area does not seem to be in bad shape. It was noted, however, that high-pollution industrial growth such as the construction of power plants in the metropolitan area would definitely present problems. Within the next year, MARC will have completed a study attempting to quantify the effects on industrial growth of complying with Federal Clean Air Standards. When this is done, their findings will be incorporated in KCPL's forecast.

It is noted that environmental constraints may come into play that could reduce future KWH consumption levels below what the models are now projecting. In particular, this may be the case in such industries as primary metals, chemicals and petroleum products.

Another important point developed by the survey is that many firms have implemented an energy conservation program. There remains potential for further conservation efforts, but a portion of the historical data analyzed for the forecast was obtained during a period of time when these conservation programs were in place, and their effect is implicitly assumed in future projections.

A description of the methodology used in developing the Kansas industrial forecast is also included below.

The majority of the assumptions used in modeling the Kansas sales classifications are the same as those detailed in the section on the Missouri energy forecast. Redundant explanations are omitted from the Kansas energy forecast explanation.

Industrial KWH sales in Kansas have accounted for approximately 9.0% of total Kansas sales in recent years and have shown dramatic growth over the historical period analyzed. The industrial base was so small that the addition of new industrial customers resulted in extremely high percentage growth rates. Efforts by governmental and private sectors in Kansas to promote industrial development are described below:

1) The Kansas Right-to-Work law guarantees all workers the freedom to choose a union or non-union shop. Only 15% of the non-agricultural labor force is union affiliated.

2) Tax-Exempt Industrial Revenue Bonds are issued by municipalities for the purpose of purchasing land, constructing buildings and equipment for lease and eventual sale. Users of this method of financing are exempt from ad valorem taxes for a period of ten years. The cost of the building and all permanent fixtures are exempt from the state sales tax.

3) The attitude of the state government in encouraging industrial expansion is reflected by the Job Expansion and Credit Act which permits a credit against state income tax for ten years, based upon the number of jobs created and the amount of investment up to a maximum reduction of 50%.

4) The Kansas Freeport Law exempts from taxation all personal property, moving through the state or consigned to a warehouse from a point outside the state, which is in transit to a final destination outside Kansas. Goods manufactured in-state, stored in a bonded warehouse are also tax exempt if over 35% of the preceding year's shipments went out of state.

5) Realtors in Kansas have developed excellent Industrial Parks in Johnson County, Kansas with land readily available for industrial sites, complete with speculative buildings and rail facilities.

It should also be noted that the high population growth in Johnson County has made a large, diversified and well trained labor force available to prospective industrial employers.

As in Missouri, there is one relatively large industrial customer, Pittsburg & Midway (P&M) Coal Mining Company, which accounts for roughly 12% of Kansas industrial sales. A special set of circumstances surrounds P&M Mining in that it has a "captive" customer, and its sole function is to supply coal for the La Cygne #1 generating unit. For this reason, P&M electrical usage was projected independently of other Kansas industrial KWH sales.

The model derived for the Kansas Industrial Sales (excluding the P&M Mining) classification is:

DEPENDENT VARIABLE: LKIKWH

Right Hand Variable	Estimated Coefficient	Standard Error	"T" Statistic
C	17.82	1.983	9.0
LSFRB	1.02	.295	3.5
LRKP	-1.13	.244	-4.6
LKGAS	.55	.076	7.2
DDCUS	.40	.060	6.6

$R^2 = .992$

$R^2 = .989$

DW = 2.18

LKIKWH = Log (Kansas Industrial Sales Excluding Pittsburg & Midway Mining Kwh)
LSFRB = Log (FRB Production Index)
LRKP = Log (Real Price of Electricity)
LKGAS = Log (Real Price of Gas Fuels Variable)
DDCUS = Dummy Variable to Account for Customer Reclassification in 1970

For P&M a relationship was estimated that related electricity used at the mine to the tons of coal burned at La Cygne No. 1. Using KCPL's fuel budget for future years at La Cygne No. 1, projections of electric sales to the mine were made. It is estimated that the P&M mine will use 20,000 MWH in 1979, growing slightly to 22,000 MWH in 1990, and remaining constant thereafter. It should be stressed that the long-term level of usage is necessarily limited by the amount of recoverable coal in the ground.

The simulation results of the Kansas industrial model were combined with the P&M estimates to yield the total Kansas industrial KWH forecast.

As shown in Table 1.1-22, industrial use is expected to decline slightly as a percentage of total consumption.

1.1.1.2.2.3 Commercial Forecast

Total commercial sales of electricity have accounted for approximately 38 percent of Missouri sales and 30 percent of Kansas sales in recent years. Table 1.1-22 indicates that commercial sales are expected to decline slightly as a percentage of total sales over the next ten years.

Factors specifically considered in the commercial models were:

(1) Commercial activity and KWH usage which have been shown to be positively related to the level of total real income in a given area. The effects of population and population density upon commercial KWH consumption are implicitly considered through the use of the total real income independent variable;

(2) Price elasticities for electricity and gas fuels which are estimated in each commercial model.

(3) Cooling degree days, which are positively related to level of usage because of the high level of commercial air conditioning loads and the fact that as temperature rises increasingly high loads are placed on the system.

Separate statistical models were developed for Missouri and Kansas.

1.1.1.2.2.4 Residential Forecast

In recent years residential sales have accounted for about 23 percent of Missouri energy sales and over 30 percent of Kansas energy sales. As shown in Table 1.1-22 overall residential energy sales are expected to increase as a percentage of total KCPL sales.

Because the residential category is more homogeneous, it is better suited to economic analysis than the other categories. Analysis can proceed almost directly in conformance with a standard set of economic assumptions regarding income, prices and weather. Modeling methodologies are based on determing the number of customers and the average level of use. The number of customers is a function of population and household size, and these numbers were modeled on a county by county basis in both Missouri and Kansas, using available population data, historic relationships between population and customers and regression and time trend analysis. Average use was estimated by analyzing income levels, appliance saturation, energy prices and operating costs, and the intensity of use and the efficiency of the appliances and equipment. For heating and cooling equipment the severity of weather largely determines intensity of use. Projections were weather normalized to remove this effect. Electrical appliances and equipment saturation studies have provided data on trends for various types of household equipment. Price elasticity was also analyzed for its effect upon intensity of use.

1.1.1.2.2.5 Other Forecasts

Detailed analyses were made of other classifications such as traffic signals, street lighting, public authorities, and sales for resale.

Each classification was modeled if data permitted, or sales were projected on the basis of historical sales analysis and judgmental trending.

1.1.1.2.3 KEPCo Method

The KEPCo projections for peak load and annual energy (Table 1.1-14) are based on the April 1977 Power Requirements Study (PRS) of KEPCo and its member systems. Each of the 26 member systems and 3 non-member cooperatives prepared an individual PRS which was based on a thorough review of the existing and potential needs of the system. KEPCo's PRS was prepared in accordance with REA Bulletin No. 120.1. System managers developed growth projections with consideration to the following factors:

(a) Historic growth rates, as indicated by mathematical trends;

(b) The effects of conservation policies, both long and short term;

(c) The effect of increasing electrical rates;

(d) Rising costs for and decreased availability of other energy sources and the effect these changes will have on conversion to electrical energy, particularly for heating and irrigation;

(e) The economy of the area served by the cooperative and the impact upon that economy of national economic and energy policies;

(f) The nature of new commercial loads and the probability of the requirement to serve them;

(g) Increased electrical loads for irrigation pumping;

(h) The impact of load management programs;

(i) The effect of extreme variables in weather and the impact of drought conditions; and

(j) Other factors considered likely to affect growth in load and energy consumption.

Detailed irrigation requirements studies were also conducted for those KEPCo members which serve substantial irrigation loads.

Further analyses were conducted in 1978 (Lee, Jan. 1978, June, 1978) on the validity of the projections made by the cooperatives. It was concluded as a result of these analyses that the PRS, with some minor reductions in projected irrigation loads, presented reasonable projections for future growth in loads and energy consumption.

A summary of the rationale follows.

1.1.1.2.3.1 Projected Number of Residential Consumers

The PRS projects the greatest growth in the number of residential consumers for systems that serve areas close to major industrial and commercial centers. These increases represent a continuing pattern of development, an extension of trends that have been established and are believed likely to continue. The counties in which the cooperatives operate show continued population growth in the rural and suburban areas, supported by a strong and diversified industrial, agricultural, commercial and services industry base. In addition further exploitation of the Kansas oil fields, using secondary and tertiary recovery, will add greater strength to the industrial base. Moreover, the labor force in Kansas is projected to expand at an average annual rate of 2.9 percent, largely in the industrial and services sectors.

The anticipated growth in numbers of residential customers is shown in Table 1.1-19.

1.1.1.2.3.2 Estimated Usage by Residential Consumers

Increases in average KWH usage by residential consumers is based on the trend toward construction of all electric homes in the rural areas served by KEPCo's members. In addition, many existing homes are being converted to electric heat and equipped for supplemental electric heating. (See Table 1.1-20) Recognition was given to a Kansas Corporation Commission (KCC) order on conservation and efficient use of energy and to the fact that higher prices are a deterent to use. Growth in average annual consumption by residential customers is shown in Table 1.1-21.

1.1.1.2.3.3 Projected Number of Large Commercial Consumers and Their Usage

The number of large commercial users is increasing, and the trend is expected to continue due to the strength of the Kansas economy. Included in the classification are agribusiness, oil and gas production, pumping and processing, small manufacturing and other commercial operations.

There is expected to be a requirement for 7 to 9 MW for a coal slurry pipeline, and plans exist for other oil pumping stations.

1.1.1.2.3.4 Irrigation Estimates

Natural gas is still being used as a fuel for irrigation pumping and has been given a priority by the KCC. The long-term availability of natural gas or other petroleum fuels for pumping is uncertain as are the costs of these fuels. Use of electricity in irrigation continues to grow however, because of the need for an assured and reliable energy source for pumping. This is a category that must be continually monitored for change.

In the 1978 analyses of the projections made by the cooperatives (Lee, 1978), it was further concluded that deviations in 1977 from the 1976 projections were due to abnormal weather conditions and temporary changes in the local economies.

1.1.1.2.4 Recent Growth History

Recent and projected average annual growth rates based on Table 1.1-12, 1.1-13 and 1.1-14 are shown below for the three utilities. These growth rates were discussed in Section 1.1.1.1.

AVERAGE ANNUAL GROWTH IN PEAK DEMAND AND ENERGY

	Peak Demand			Energy Demand		
Time Period	KG&E	KCPL	KEPCo	KG&E	KCPL	KEPCo
1968-1973	5.4%	6.6%	*	5.9%	6.5%	*
1973-1978	5.0	3.6	7.8%	5.4	3.5	7.6%
1968-1978	5.2	5.1	*	5.7	5.0	*
1978-1983	3.1	2.7	9.2	2.3	3.7	9.5
1983-1988	3.5	3.6	6.3	3.6	4.0	6.0
1978-1988	3.3	3.2	7.7	3.0	3.9	7.7

* Not available

The past and projected growth rates in peak demand for both KG&E and KCPL are below those projected by SPP and NERC. SPP projects a growth rate of 6.0 percent and NERC a growth of 4.9 percent for the United States in the period 1978-1988. In December, 1978 the Department of Energy developed a forecast of growth in summer peak demand of 4.9 percent for the U.S. in the period 1979-97 (Department of Energy, 1978). It is believed that the estimates by the utilities are conservative, particularly for KG&E which is in an area of low unemployment. The decline in annual energy and peak load growth experienced and projected can be attributed both to conservation efforts and to higher prices for electrical energy. Energy consumption is more likely to be affected by price increases than peak loads. During summer periods of extreme heat, air conditioning is universally used, regardless of price, whereas on more moderate days some of the air conditioning may not be used. The same applies to periods of extremely cold weather for those who use electric space heating.

The effect of the Presidential Order on maximum winter and minimum summer temperature standards for heating and cooling in public buildings cannot yet be determined. It is clear, however, that it will slow some of the growth in summer and winter peak loads and in energy consumption.

Customers of the Applicants have been given a negative stimulus in the form of rising prices that should have inhibited consumption and encouraged conservation. Table 1.1-23 shows the changes that have occured since petroleum shortages first occured and prices began to rise rapidly. In the period 1972 to 1979, average prices per KWH more than doubled for each category of user, with industrial users experiencing the largest unit increases. The escalation of rates for KG&E in the last 6 - 7 years has averaged 15.9 percent per year for industrial, 11.1 percent for commercial and 12.7 percent for residential users. Though KCPL's unit rates haven't risen so fast, they were substantially higher than KG&E's rates in 1973 and continue to be slightly higher. KCPL's rates have risen at an average annual rate of 11.4 percent for industrial, 9.7 percent for commercial and 9.4 percent for residential users. The rates of increase over the past few years for KEPCo members have been higher than for KG&E and KCPL, with an average annual increase of 16.4 percent for industrial/commercial, 19.0 percent for irrigation and 15.1 percent for residential.

From 1972 to 1979, a period of high rates of increase in costs for boiler fuels and consequently for electrical energy, KG&E increased the number of residential customers served by nearly 18 percent and KCPL by 11 percent. From 1974 to 1979 KEPCo's average number of customers also increased by 11 percent. (See Table 1.1-19)

As shown in Table 1.1-21, average annual use by residential customers has increased 27 percent for KG&E and 17 percent for KCPL over the same period. From 1974 to 1979, KEPCo's average annual use by residential customers increased 30 percent. Despite the dramatic increases in rates, customer use has continued to grow. Much of this increase in average consumption is due to the large number of homes with electric space heating. But as shown in Table 1.1-20 even homes without electrical space heating showed an increase of 20 percent in average annual consumption from 1972 to 1978.

Comparisons of forecast and actual peak loads and energy for KG&E and KCPL are provided in Tables 1.1-25 and 1.1-26. Despite the great uncertainties due to weather, both utilities have been remarkably accurate in predicting short range loads and energy.

1.1.1.3 Power Exchanges

Table 1.1-18 presents a statement of system operations for both KG&E and KCPL at peak hour conditions for the past 7 summer peaks. Net interchanges by KG&E at the time of peak load never exceeded 10 percent of the peak load, but firm and emergency purchases frequently ranged from 22 to 49 percent of the net load. Emergency sales were as high as 20 to 29 percent of the net load. KCPL's net interchanges were as high as 20 percent of the net load due to relatively high receipts of non-firm power, amounting to as much as 28 percent of the net load.

As shown in Tables 1.1-1 and 1.1-2 KG&E and KCPL plan to make capacity purchases and sales in the future.

The purchases and sales in MW at the time of peak load for the period 1973 to 1979 (See Table 1.1-18) were as follows:

PEAK LOAD PURCHASES AND SALES (MW)

	KG&E		KCPL	
Year	Purchases	Sales	Purchases	Sales
1973	260	167	290	213
1974	190	109	395	95
1975	357	292	291	95
1976	673	537	608	268
1977	523	642	714	95
1978	147	154	621	98
1979	345	260	465	202

KG&E and KCPL have generally been net purchasers at the time of the peak load. As members of SPP and MOKAN, KG&E and KCPL will continue to make short term sales in order to adhere to their reliability agreements and to enhance the economy and reliability of operations.

KEPCo relies upon purchased power to meet all of its needs and will still be meeting most of its requirements through purchases even after WCGS is on line.

Anticipated interchange budgets are provided in Tables 1.1-27, 1.1-28 and 1.1-29 for the first two years of WCGS operation. KG&E and KCPL expect to sell more energy than they purchase when WCGS is in operation.

KG&E and KCPL maintain interconnections with other utilities as follows:

SYSTEM INTERCONNECTIONS

KG&E

345-kV - Associated Electric Cooperative, Inc. and Union Electric Co.
161-kV - Empire District Electric Co. (3)
345-kV - Kansas City Power & Light Co. (2)
161-kV - Kansas City Power & Light Co.
345-kV - Kansas Power and Light Co.
138/115-kV - Kansas Power and Light Co.
69-kV - Kansas Power and Light Co.
161-kV - Kansas Power and Light Co. and Omaha Public Power District
345-kV - Oklahoma Gas and Electric Company
138-kV - Oklahoma Gas and Electric Company
345-kV - Public Service Organization of Oklahoma
138-kV - Public Service Organization of Oklahoma
138-kV - Western Power Division of Central Telephone & Utilities Corp.

KCPL

161-kV - Associated Electric Cooperative Inc.
161-kV - Board of Public Utilities
345-kV - Iowa Public Service Co.
345-kV - Interstate Power Co.
345-kV - Kansas Gas and Electric Company (2)
161-kV - Kansas Gas and Electric Company
345-kV - Kansas Power & Light Co.
161-kV - Kansas Power & Light Co.
161-kV - Missouri Power & Light Co.
345-kV - Missouri Public Service Co. (2)
161-kV - Missouri Public Service Co.
345-kV - Northern States Power Co.
345-kV - Omaha Public Power District
345-kV - St. Joseph Light & Power Co.
161-kV - St. Joseph Light & Power Co.
161-kV - Southwestern Power Administration
345-kV - Union Electric Co.
161-kV - Union Electric Co.

1.1.2 SYSTEM CAPACITY

KG&E and KCPL participate in interchange agreements, but each utility is responsible for planning and arranging its own power supply and for the adequacy and reliability of its own generation system. KEPCo will participate in interchange agreements when it has capacity and has become a member of SPP and MOKAN.

KG&E and KCPL maintain ten year peak load and energy forecast and generation schedules to determine when capacity additions will be needed and to insure that adequate margins are provided. These schedules are reviewed annually and more frequently if advisable in order to assess what kind of capacity may be required and the lead times necessary to develop the capacity. Projected fuel costs and availability and the financing of future capacity are important factors in developing long-range plans for expansion. Units selected for capacity additions are those that are judged to be the most cost-effective in meeting future needs, considering fuel constraints.

KEPCo's first capacity will be the 90 MW from SPA in 1980, and the first owned capacity will be the 196 MW from WCGS in 1983. As with the other Applicants, KEPCo maintains peak load and energy forecast schedules in its planning process. Its long-term objective is to own all capacity required to serve the needs of its members.

Tables 1.1-4a and 1.1-5a present for KG&E and KCPL the installed capacities by plant and unit for the period 1974-1990. Actual and proposed capacity changes are shown in Tables 1.1-4b and 1.1-5b.

Load and capability data for KG&E and KCPL over the period 1965-1990 are given in Tables 1.1-1 and 1.1-2. Similar data are provided over the period 1971-1994 for KEPCo in Table 1.1-3. Each of these three tables shows peak and system responsibility, accredited and system capacity and capacity balance, the latter both with and without WCGS. Without WCGS each company will suffer deficiencies in its capacity balance.

Table 1.1-7a presents load and capability data for the SPP for the period 1965-1977, and Table 1.1-7b provides a comparison of forecast and actual capability for the period 1971-1978. Of particular interest in the latter table is the fact that, because of forced outages, in all but two of the eight years shown, the actual operating margins at the times of summer peak loads were lower than those forecast.

In five of those years the actual operating margins were below the SPP margin requirement of 15 percent as a result of the forced outages.

SPP monthly energy and peak loads are given in Table 1.1-8 for the years 1978-1980, and both seasonal loads and annual energy are given for 1978 and projected for 1979-1988. SPP projects a growth rate of 6.2 percent for summer peak loads and 6.0 percent for annual energy over the period 1978-1988.

Table 1.1-9 presents projected capability maintenance, exchange and reserve data for the period 1979-1988. The margins shown for summer peaks are above 20 percent until after 1986 when they decline to 19.2 percent in 1987 and 17.1 percent in 1988. It should be noted, however, that these margins are based upon the assumption that planned capacity additions will be built on time. It is likely that many of the additions will be delayed and that some may be cancelled particularly in the latter part of the 1980's. As a result, the margins given are optimistic. The addition of the 1150 MW of WCGS capacity (KEPCo plans to join SPP) will account for 1.8 percent of the summer net dependable capacity of SPP in 1983.

A longer term forecast for SPP is given in Table 1.1-10 for the period 1989-1998. This table shows generally declining margins over that time period, although, as projected, the margins remain above the 15 percent SPP requirement. However, nearly all of the capacity additions projected for this period are to be nuclear and coal, and there is doubt that some of these facilities will be built or that many will be completed on schedule.

MOKAN load and capability data for the period 1971-1988 are shown in Table 1.1-11. The capacity balances of MOKAN will be negative after 1983, without WCGS. When KEPCo becomes a member, the capacity balance will be negative in 1983.

Peak hour conditions in the systems of KG&E and KCPL for the period 1973-1979 are given in Table 1.1-18 and discussed in Section 1.1.1.3. Over this period KG&E was generally a net purchaser of amounts ranging from 4 to 9 percent of its net load except in 1977 when it sold 7.5 percent of its generation and in 1978 when there was virtually no net interchange. For the entire period shown KCPL was a net purchaser of power in amounts ranging from 4.5 to 28 percent of its net load.

1.1.2.1 Capacity Planning

Capacity planning by KG&E and KCPL must be closely related to the availability of fuels. Table 1.1-15 shows the major shifts that have taken place in fuel mix and those that are contemplated. In 1970 KG&E had no coal capacity and 99.5 percent of its energy production was fueled by gas. In 1975 gas accounted for 66.8 percent of production, coal for 18.3 and oil for 14.9. By 1980 coal will account for 53.2 percent of production, gas for 43.0 and oil for 3.8 percent. By 1985 with diversification into nuclear fuel the use of gas will decline to 13.7 percent, coal will account for 57.2 percent of energy production and high-cost oil for

0.3 percent. Nuclear will provide 28.7 percent of the annual net generation. KCPL will remain predominantly a coal fueled utility, but its 1980 dependence on coal for 94.2 percent of generation will decline to 67.9 percent in 1985, and gas, which provided 30.7 percent of the generation in 1970, will decline to 0.9 percent. Oil use which was insignificant in 1970 was 4.0 percent in 1975 and is expected to be 4.2 percent in 1985 when nuclear will account for 27.0 percent of generation.

The importance of WCGS in providing for diversification of fuel sources is shown in Table 1.1-30 which provides the projected fuel mix for the first three years of planned operation both with and without WCGS. Without WCGS much greater reliance must be placed upon gas and oil by KG&E and coal by KCPL.

The importance of WCGS to peak day operations is illustrated in Table 1.1-31. In 1985 WCGS should provide 27 percent of KG&E's peak day generation. Without WCGS, gas, oil and purchases would make up the difference. For KCPL, WCGS would provide 17 percent of the peak day production. Without WCGS the difference would be made up by purchases and by additional consumption of oil. For both companies it is assumed that purchases would be possible which may not be the case.

Major capacity additions under construction or being planned or considered by KG&E and KCPL are as follows:

CAPACITY ADDITIONS
KG&E

Season or Month and Year	Unit	Function	Fuel	Capacity - MW
Spring 1980	Jeffrey No. 2(*)	Base	Coal	136
April 1983	WCGS	Base	Nuclear	477
Spring 1983	Jeffrey No. 3(*)	Base	Coal	136
Spring 1985	Jeffrey No. 4(*)	Base	Coal	136

* Jeffrey units will be operated by Kansas Power and Light; KG&E will have a 20 percent share of each.

CAPACITY ADDITIONS
KCPL

Month and Year	Unit	Function	Fuel	Capacity MW
March 1980	Iatan No. 1(*)	Base	Coal	455
April 1983	WCGS	Base	Nuclear	477
March 1989	Unspecified	Base	Coal	455

* The Iatan unit will be operated by KCPL which will retain a 70 percent ownership.

As a means of increasing reliability, diversifying fuel mix and developing a gradual build-up in generating capacity, KG&E has acquired and plans to acquire a 20 percent interest in each unit of the Jeffrey Energy Center. Four 680 MW units are planned, each of which will provide KG&E with additions of 136 MW of base load generating capacity in 1980, 1983 and 1985, and WCGS will provide 477 MW in 1983.

KCPL will rely on larger units to meet growth in demand, with a 70 percent, 455 MW interest in Iatan No. 1 in 1980 and the possible addition of an unspecified unit to provide 455 MW in 1989. WCGS will provide 477 MW in 1983, and two additions of 650 MW each are tentatively being considered for the early 1990's, but no dates have been selected nor has a decision yet been made on fuel.

Over the period 1980-1990 there will also be other reratings and retirements for both utilities, as shown in Tables 1.1-4b and 1.1-5b.

1.1.2.2 Fuel Sources And Prices

1.1.2.2.1 Coal

In 1979 KG&E used more than 1.9 million tons of coal and KCPL used about 4.2 million tons. Most of both companies' requirements are purchased under long-term contracts. Coal for La Cygne No. 1 is supplied by the Pittsburg & Midway Coal Mining Company at La Cygne, Kansas under a contract that expires in the year 2002. Approximately 1,630,000 tons are to be provided each year. In years when the entitlement amount cannot be met, additional quantities are purchased on the spot market.

Coal for La Cygne No. 2 is supplied by the Amax Coal Company from Gillette, Wyoming, under a contract that expires in 1996. The annual entitlement is 1,890,000 tons which is supplemented by spot purchase. KCPL has contracts with the Peabody Coal Company in Missouri and Oklahoma calling for delivery of 2,150,000 tons per year under contracts that expire in 1986 and 1996. KCPL also has a contract with the Arch Mineral Corporation in Hanna, Wyoming, calling for 500,000 tons per year, under a contract expiring in 1986. Iatan No. 1 is being supplied with 2.4 million tons of Wyoming coal per year through October, 1982 by the Amax Coal Company. KCPL's wholly-owned subsidiary, WYMO Fuels, Inc. is expected to supply Iatan No. 1 after expiration of the Amax contract. KCPL's share would be about 1.7 million tons per year.

Coal for the Jeffrey Energy Center, in which KG&E has a 20% interest, is to be supplied under a contract with the Amax Coal Company which expires in 2013. KG&E's share for Jeffrey No. 1 will be about 480 thousand tons per year.

Table 1.1-15 indicates the significant change that has occurred in the ten year period, 1970-1980, during which KG&E has converted from a gas-fueled unit to one that uses coal as its primary generation source. KCPL's use of coal has also increased as the use of gas has declined. Further fuel diversification will be provided by WCGS which will also permit KG&E and KCPL to reduce gas consumption.

1.1.2.2.2 Oil

KG&E burned 466,000 barrels of oil in 1979 and KCPL about 576,000 barrels. KG&E purchases most of its oil from local producers. KCPL issues annual purchase orders for its anticipated requirements and makes spot purchases when necessary. KG&E and KCPL minimize the use of oil whenever possible.

1.1.2.2.3 Natural Gas

During 1979 about one-third of KG&E's gas was provided by the Kansas Gas Supply Company under two contracts that expire in 1990. Much of the remaining requirement was obtained under month-to-month interstate interruptible gas contracts. KG&E used about 45 billion cubic feet of natural gas in 1979.

KCPL's use of natural gas has been declining; about 7 billion cubic feet were burned in 1979. Gas has been purchased from the Gas Service Company on an interruptible basis to displace the more expensive oil used for startup and flame stabilization at steam stations. It is also used to provide additional steam production for electric generation and steam sales when coal burning equipment is out of service for repair. At times it is also necessary for KCPL to burn natural gas to meet air quality regulations.

1.1.2.2.4 Nuclear Fuel

KG&E and KCPL have received from Westinghouse Electric Corporation a quantity of uranium hexafluoride equivalent to 619,000 pounds of uranium concentratea and expect to receive another 100,000 pounds. The original contractual arrangements with Westinghouse and the questions of deliveries and prices are the subject of litigation in process.

The companies have contracted to purchase another 500,000 pounds of uranium concentrates which, combined with the 719,000 pounds expected from Westinghouse, will complete the initial core load for WCGS. Contracts also exist for the conversion to uranium hexafluoride of these concentrates and for those required for six subsequent reloads.

1.1.2.2.5 Fuel Costs

Tables 1.1-32 and 1.1-33 present actual and projected fuel costs. December 1979 inventory costs for KG&E and KCPL are as follows:

FUEL COSTS IN CENTS PER MMBTU
DECEMBER 1979

Fuel	KG&E	KCPL
Coal	97.2	87.7
Oil	176.7	202.2
Gas	162.0	130.8
System Cost	128.0	93.8

Projected 1983 fuel costs provide a comparison of fossil and nuclear fuel costs.

FUEL COSTS IN CENTS PER MMBTU
1983

Fuel	KG&E	KCPL
Coal	118.1	132.6
Oil	366.7	708.7
Gas	236.0	219.7
Nuclear	64.0	59.1
System Cost	132.8	132.0

The importance of nuclear fuel in providing lower cost energy is clearly demonstrated in this comparison. Additional perspective on rising fuel costs is given by Tables 1.1-16 and 1.1-17. Changes in the decade 1970-1980 are given below:

TRENDS IN FUEL COSTS
CENTS PER MMBTU

Fuel	KG&E		KCPL	
	1970	1980	1970	1980
Coal	26.7	92.2	25.3	103.5
Oil	25.4	196.7	76.2	542.0
Gas	22.3	162.6	27.5	165.0

Trends in fuel costs for overall system operations for the past and projected to 1990 from Tables 1.1-32 and 1.1-33 are as follows:

SYSTEM COSTS IN CENTS PER MMBTU

Year	KG&E	KCPL
1970	22.3	26.1
1975	58.5	50.3
1980	126.2	122.2
1985	133.2	159.2
1990	227.3	216.8

With increases in individual fuel costs ranging from factors of 3.5 to 7.7 between 1970 and 1980 and system fuel costs increasing by factors of 4.7 to 5.6 in the same period, it is clear that the impact on total operating costs has been serious. Table 1.1-34 shows that in the period 1968-1978 fuel costs more than doubled as a percentage of total operating costs. For KG&E fuel costs were 22.6 percent of operating costs in 1968 and 48.1 percent in 1979. For KCPL they were 33.2 percent in 1968 and 66.9 percent in 1978.

1.1.2.3 Bulk Power Planning

Both KG&E and KCPL are members of SPP, the regional reliability council, and of MOKAN. KEPCo intends to apply for membership in both SPP and MOKAN.

SPP is a regional member of NERC and has established planning criteria to which all interconnected member bulk power systems must subscribe. Planning criteria set forth by SPP are intended to serve as guidelines for the development of more specific criteria by each system or control area (Southwest Power Pool, 1978). Individual company members of SPP have been assigned to groups as shown in Table 1.1-6. These assignments are based on individual company location, and a company can request reassignment to another group or to be included in more than one group.

SPP has developed its criteria such that instability or cascading outages will not occur. Among the major criteria are the following:

1. Sufficient reactive capacity shall be available within the SPP system to maintain system voltage within 5 percent of normal at the major busses of the transmission system.

2. To prevent the isolation of a portion of the SPP system, resulting from multiple contingencies, under-frequency relays shall be installed for selective removal of load.

3. Planning for capacity additions must provide a total generating capacity available to SPP that exceeds the predicted annual peak obligation by a margin of 15 percent, or alternatively, a probability study shall be made so as to ensure that the probability of load exceeding available capacity shall not be greater than one occurrence in ten years, and provided that in no case shall the reserve be less than 12 percent greater than the predicted peak load obligation.

4. Special generating unit and plant design features are recommended to provide greater system reliability.

5. In order to be assured of adequate generating capacity, sufficient quantities of standby fuel are to be provided, when practicable, to permit normal system operation, based on experience relative to curtailments and interruptions.

Criteria are also set for the bulk system, and it is noted that within the SPP system there are sub-areas with natural electrical boundaries and large amounts of load which could become isolated in the event of a severe system disturbance. These sub-areas can include portions or all of one or more companies. Criteria for planning transmission additions for the sub-areas in SPP are as follows:

1. Each sub-area shall maintain service continuity after the loss of the single more important system component (either transmission line or generating unit), taking into account planned maintenance schedules.

2. Stability shall be maintained between the sub-area and neighboring systems when the loss of the single most important system component is caused by a three-phase fault at the worst location, cleared in 0.1 second.

3. A sub-area may suffer interruption of load as a result of less probable contingencies; however, such contingencies should not result in the collapse of the SPP system. These less probable contingencies shall include, but not be limited to, the following:

    a. The loss of a complete substation or switching section (all equipment of one voltage);

    b. The loss of all units in a generating station which have in common such components as transmission substation, control room, fuel supply, etc.;

    c. The loss of all transmission lines on a common right-of-way;

    d. The loss of any two generating units in the same sub-area during annual peak conditions (whether scheduled or not); and

    e. The loss of any two transmission lines in the same sub-area during annual peak conditions.

Planning principles have also been established on protective relaying, adequate communications systems and instrumentation to ensure safe operations and to analyze outages, short circuits and protective relay performance.

It is the policy of SPP to maintain as high an interconnection capability with adjoining regions as is economically feasible as a means of ensuring reliability in the event of major transmission and generation outages.

MOKAN is an association of investor-owned electric utilities in Kansas and Missouri that have agreed to coordinate planning and operations among their systems and to provide reserve sharing responsibilities. Each MOKAN member is also a member of SPP. MOKAN participants are required to plan their generation and transmission additions and their interchange transactions so as to provide for each system a reserve capacity margin of not less than 15 percent of its estimated annual peak load responsibility. The requirement exists to pay capacity charges in the event of a reserve margin deficiency. (KCPL maintains an internal minimum reserve margin of 20 percent, and the advisability has been discussed within the pool of raising the pool requirement to more than its present 15 percent requirement.) MOKAN ensures greater reliability for the member companies and also for municipal and cooperative electric utilities located in or near the service area. In addition to reserve margin requirements, other coordinating arrangements are listed below. Not all participants are included in all of the following:

1. Stand by service;
2. Construction and operation of 345-kV interconnection facilities;
3. Economy energy transactions;
4. Overall system planning; and
5. System maintenance scheduling.

As previously noted, KG&E and/or KCPL are signators to other coordinating agreements. (See tabulation of agreements in Section 1.1) One or both are involved in the following four agreements, as indicated:

(1) The Companies - Associated - Southwestern Power Administration Agreements (KG&E and KCPL) involve the following coordinating arrangements:

    1. Purchase of hydro-electric peaking power from SPA by Missouri Companies and Associated;

2. Integrated operation and interchange of power between the Missouri Companies and Associated;

3. Purchase of hydro peaking power by Missouri Companies from Associated;

4. Reserve capacity sales to Associated by Missouri Companies;

5. Standby service to Associated; and

6. Interchange of requisitioned power service between Missouri Companies and Associated.

As of May 31, 1979 The Companies' hydro-electric peaking power entitlement under this agreement was reduced to zero.

(2) The South Central Electric Companies Coordination Agreement (KG&E) involves:

1. The exchange of seasonal diversity;

2. Deferred diversity capacity;

3. Firm power purchases;

4. Economy energy sales;

5. Emergency service; and,

6. Coordinated maintenance schedules.

(3) The Kansas City - Twin Cities Coordination Agreement (KCPL) provides for:

1. Construction and operation of 345-kV interconnection facilities for power exchanges; and

2. Interchange of:

   a. Emergency energy;
   b. Scheduled outage energy;
   c. Economy energy;
   d. Short term power; and,
   e. Participation power

(4) The Missouri-Kansas-Oklahoma Interconnection Agreement (KG&E) provides for:

1. Construction and operation of 345-kV transmission lines and interconnections for power exchanges;

2. Interchange of:

   a. Emergency energy;
   b. Economy energy;
   c. Excess energy;
   d. Replacement energy;
   e. Participaton power; and
   f. Firm power; and

3. Direct scheduling of power transfers

1.1.3 RESERVE MARGINS

1.1.3.1 Reserve Requirements And Margins

System generating capacity requirements and reserve margins for both KG&E and KCPL are determined on the basis of projected system peak loads and system peak responsibilities plus the required minimum reserve. The internal planning minimum reserve margin for KG&E is 15 percent, and it is 20 percent for KCPL and up to 25 percent in the first year of operation for a new plant. Both SPP and MOKAN have required minimum reserve margins of 15 percent, and MOKAN assesses a capacity charge on a member company with a reserve margin deficiency. Tables 1.1-1 and 1.1-2 provide detail for KG&E and KCPL on historical and projected loads, capability and capacity balances based on MOKAN requirements. Neither utility uses loss of load probability studies as a sole determination of a necessary reserve margin, although KCPL is now conducting some loss of load probability studies to refine its reserve margin planning. Reserve margins are calculated on the basis of each system's net 1 hour peak load and the corresponding accredited generating capacity which for KG&E and KCPL would represent the summer peak loads and the accredited summer generating capacity. Margin estimates for the early years of WCGS operation from 1983 to 1990 both with and without WCGS follow:

RESERVE MARGINS

Year	KG&E				KCPL			
	With WCGS		Without WCGS		With WCGS		Without WCGS	
	MW	Percent	MW	Percent	MW	Percent	MW	Percent
1983	804	44.9	327	18.3	873	36.4	396	16.5
1984	719	38.3	242	12.9	786	31.6	309	12.4
1985	780	40.0	303	15.5	697	27.1	220	8.5
1986	720	35.8	243	12.1	604	22.6	127	4.8
1987	655	31.6	178	8.6	508	18.4	31	1.1
1988	605	28.5	128	6.0	409	14.3	- 68	- 2.4
1989	555	25.5	78	3.6	761	25.7	284	9.6
1990	500	22.4	23	1.0	654	21.3	177	5.8

With WCGS both KG&E and KCPL will be well within internal and pool requirements for the entire period with the exception of 1987 when KCPL will be below its internal requirement and 1988 when KCPL will be below both internal and pool requirements. WCGS represents a large block of capacity which boosts the margins of both companies in the early years of operation. However, without WCGS KG&E would be below its internal and the pool requirements in 1984 and after 1985, declining to virtually no margin in 1990. KCPL would be below its internal requirement for the full period and below pool requirements after 1983. Data are not presented for KEPCo because, as shown on Table 1.1-3, KEPCo will be dependent upon firm purchases to meet its commitments for the foreseeable future.

At the time of the anticipated 1983 summer peak WCGS will represent a significant percentage of the accredited generating capacity of each of the owners, as shown below:

PERCENTAGE OF CAPACITY REPRESENTED BY WCGS
1983

KG&E	KCPL	KEPCo
18.4%	14.6%	100.0%

Upon going into service, WCGS will be the largest generating unit for both KG&E and KCPL and the only unit for KEPCo. The next largest units will be La Cygne No. 1 for KG&E with 370 MW of capacity and Iatan No. 1 for KCPL with 455 MW of capacity.

In 1983, 58.6 percent of the accredited generating capacity of KG&E will consist of 4 large units, ranging from 315 to 477 MW in capacity. KCPL's 5 large units, ranging in capacity from 315 to 477 MW, will constitute 63.2 percent of its accredited generating capacity. Without WCGS, the loss of production on any of these units would bring the utility involved drastically below required reserve margins. In addition to Wolf Creek, two other units, La Cygne No. 1 and No. 2 are owned jointly by KG&E and KCPL, each utility owning half of each unit.

1.1.3.2 <u>Scheduled And Forced Outages</u>

1.1.3.2.1 Scheduled Outages

KG&E develops a two-year and a ten-year overhaul schedule each summer, and those schedules are updated as conditions dictate. In preparing the schedules there is coordination among other utilities with which jointly-owned units are operated. Overhaul schedules depend upon the size of a unit, the number of hours of operation during a year, types of fuel used and the necessity for special work or repairs. The length of time planned for boiler overhaul is based on past experience. Kansas law and insurance company regulations require an annual internal inspection of all boilers.

Units larger than 200 MW require outages of 3 to 6 weeks and smaller units about 2 weeks. Turbine generator work is generally performed during boiler maintenance, with a major overhaul at intervals ranging from 5 to 10 years.

Outages are scheduled for particular times of the year so as to optimize availability with respect to anticipated load and the operating costs of units. No outages are scheduled during the system's peak load period from mid-June to mid-August. Coal burning units are not scheduled for outages during the winter peak load period of December through February because natural gas curtailments may occur in this period and there may be shortages of fuel oil.

Large unit outages are scheduled for March through May and September through November, the periods of minimum system load.

KCPL's general plan for scheduling outages is similar to that of KG&E. The frequency of scheduled maintenance is based on KCPL's experience, the utility industry's experience and the manufacturer's recommendation. Generator maintenance is planned annually for the next 5 year period.

A combination of three methods is used for scheduling unit maintenance. The first is a manual method in which the largest units are scheduled in the valley of the annual load, and the smaller units are scheduled around these outages. The second method uses a Power System Simulator computer program which analyzes the costs of different maintenance schedules. An output from the program is a schedule for maintenance based on KCPL load and maintenance cycles. The third method uses the Maintenance Evaluation Program (MEVAL) an optimizing computer program which is on the Control Data Cybernet timesharing system.

The combined results of the three methods are used to develop an optimum schedule which is cost-effective and within all given constraints.

1.1.3.2.2 Forced Outages

KG&E has had relatively few forced outages on its wholly-owned gas/oil-fired plants in recent years, and these have been minor in terms of effect on the system. In March of 1978 severe icing caused a short in a 138-kV line that tripped Gordon Evans No. 2 off line. Gordon Evans No. 1 was restricted to 68 MW due to the loss of fuel oil burner pump motors as a result of the incident. The outage was of short duration.

In July of 1979 a wind storm damaged the fan venturis on the cooling tower of Gordon Evans No. 2 which caused the unit load to be restricted to 160 MW. Capacity was recovered in stages and was fully restored within 11 days.

Experience on the La Cygne Plant jointly owned by KG&E and KCPL has been less favorable as summarized below:

LA CYGNE OUTAGE EXPERIENCE

Year	Unit	Date Off	Date On	Outage Duration In Hours	Cause
1973	La Cygne No. 1	9/17	10/06	450	Unknown
1974	"	6/25	7/19	586	Repair cold reheat line
	"	11/21			
1975	"		2/17	2112	Hydrogen fan repair
	"	4/04	4/30	638	Hydrogen fan failure
	"	10/14	11/14	733	" " "
1976	"	8/23	9/20	690	Turbine blade damage
1977	"	11/10	12/25	1071	Reblade low pressure turbine
1978	"	6/08	7/16	944	Hydrogen fan failure
1979	"	7/08	8/17	920	Immediate pressure turbine repair
1978	La Cygne No. 2	10/22	11/10	461	Boiler slag removal

Some of these outages lasted for several weeks and occurred during summer peak periods. Over the past 7 years forced outages on La Cygne No. 1 have amounted to a high percentage of its availability. This unit is currently KG&E's largest and KCPL's second largest.

Other forced outages experienced by KCPL during the same time period were:

OTHER KCPL OUTAGE EXPERIENCE

Year	Unit	Date Off	Date On	Outage Duration In Hours	Cause
1976	Hawthorn No. 5	10/19	10/27	206	Mill area explosion
	Hawthorn No. 4	10/21	11/4	349	Inspect and wash air heater
1978	Hawthorn No. 5	2/10	2/28	436	Reheater leaks
	Hawthorn No. 4	11/03	11/18	374	Induced draft fan
	Hawthorn No. 1	11/18			Damage to turbine generator exciter
1979			7/14	6240	
	Hawthorn No. 2	1/10	2/9	718	Control valves
	Hawthorn No. 2	2/24	10/17	2032	High pressure turbine
	Hawthorn No. 4	4/21	4/30	231	Generator reduction gears
	Hawthorn No. 5	7/3	7/12	288	Repair reheat tube leaks

1.1.4 EXTERNAL SUPPORTING STUDIES

Documents filed annually in response to a FERC request are consolidated by SPP into the "Southwest Power Pool Regional Reliability Council Coordinated Bulk Power Supply Program" which is submitted to the Economic Regulatory Administration of the Department of Energy. The most recent issue is that of April 1, 1979.

Data extracted from the 1979 report are presented in Tables 1.1-7a, 1.1-7b, 1.1-8, 1.1-9 and 1.1-10 on past loads, margins and capability, and estimates given on future energy, loads, capacity and margins.

It is the policy of SPP to maintain as high an interconnection capability with adjoining regions as is economically feasible. Joint studies are made of potential system emergencies and their effects on the systems involved. Through these studies the effectiveness of existing and planned interconnections can be periodically measured and the design of systems updated so that interconnection capability and reliability can be maintained.

Transmission load studies coordinated by SPP establish the maximum import capacity through system interconnections. An individual member of MOKAN and SPP does not necessarily carry enough reserve capacity to cover the outage of its own system's largest unit. Rather, reliance is placed on neighboring member systems through interconnections for emergency and maintenance support. Implicit in the use of a 15 percent reserve margin (rather than the capacity of the largest unit by each SPP member) is the interconnection capability which will provide the necessary reliability for continuity of service. Periodic studies verify the reliability of this concept.

1.1.5 REFERENCES

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TABLE 1.1-1

KG&E LOAD AND CAPABILITY DATA

ACTUAL 1965-1979 AND PROJECTED 1980-1990

IN MW

Year	System Capacity Responsibility: System Peak Responsibility: System Load Net 1 Hour	Firm Purchases (minus)	Firm Sales (plus)	System Peak Responsibility	Required Reserve (a)	Total System Responsibility	Accredited Generating Capacity	Peaking Capacity Purchases (Hydro)	Peaking Capacity (Kansas) Purchase (plus)	Peaking Capacity (Kansas) Sales (minus)	System Capacity: Capacity Sales (minus)	Capacity Purchases (plus)	Planned Capacity Additions	Total System Capacity	Capacity Balance: As Planned	Capacity Balance: Without WCGS #1 (b)
1965	746	-	-	746	75	821	764	-	40	-	10	55	-	849	+ 28	
1966	839	50	-	789	79	868	764	-	50	-	10	10	-	814	- 54	
1967	848	-	16	864	86	950	1,153	-	50	-	217	19	-	1,005	+ 55	
1968	923	65	30	888	107	995	1,153	-	50	-	129	-	-	1,074	+ 79	
1969	998	290	200	908	109	1,017	1,151	-	50	-	180	-	-	1,021	+ 4	
1970	1,077	100	-	977	117	1,094	1,151	-	50	-	75	75	-	1,201	+ 107	
1971	1,079	125	65	1,019	122	1,141	1,153	-	50	-	-	-	-	1,203	+ 62	
1972	1,133	145	77	1,065	138	1,203	1,153	-	50	-	50	50	-	1,203	0	
1973	1,192	100	-	1,092	164	1,256	1,566	-	50	-	80	-	-	1,536	+ 280	
1974	1,325	100	-	1,225	184	1,409	1,565	-	50	-	200	-	-	1,415	+ 6	
1975	1,337	100	-	1,237	186	1,423	1,564	-	40	-	50	-	-	1,554	+ 131	
1976	1,387	100	-	1,287	193	1,480	1,564	-	40	-	75	75	-	1,604	+ 124	
1977	1,423	100	14	1,337	201	1,538	1,879	-	33	-	297	125	-	1,740	+ 202	
1978	1,533	100	16	1,449	217	1,666	1,899	-	32	-	125	25	-	1,831	+ 165	
1979	1,473	100	15	1,388	208	1,596	1,883	-	25	25	-	-	-	1,883	+ 281	
1980	1,585	163	172	1,574	239	1,833	1,981	-	25	25	-	-	-	1,981	+ 171	
1981	1,645	137	182	1,690	254	1,944	1,981	-	25	25	-	-	-	1,981	+ 49	
1982	1,710	137	199	1,772	266	2,038	1,981	-	25	25	-	-	-	1,981	- 51	
1983	1,790	137	170	1,823	273	2,096	2,594	-	25	25	39	-	-	2,555	+ 470	- 7
1984	1,875	137	192	1,930	290	2,220	2,594	-	25	25	39	-	-	2,555	+ 358	- 119
1985	1,950	137	209	2,022	303	2,325	2,730	-	25	25	39	-	-	2,691	+ 383	- 94
1986	2,010	137	232	2,105	316	2,421	2,730	-	25	25	39	-	-	2,691	+ 270	- 207
1987	2,075	137	255	2,193	329	2,522	2,730	-	25	25	39	-	-	2,691	+ 158	- 319
1988	2,125	137	274	2,262	339	2,601	2,730	-	25	25	39	-	-	2,691	+ 138	- 339
1989	2,175	137	289	2,331	350	2,681	2,730	-	25	25	39	-	-	2,691	+ 24	- 453
1990	2,230	137	313	2,406	361	2,767	2,730	-	25	25	39	-	-	2,691	- 102	- 579

(a) Reserve requirements: 10%-1963 through 1967; 12%-1968 through 1971; 13%-1972; 15%-1973 and following

(b) For 1983 and thereafter

Source: MOKAN Pool Report which is for contract year beginning 1 June. Because of reporting period, figures may differ from those in other reports.

TABLE 1.1-2

KCPL LOAD AND CAPABILITY DATA

ACTUAL 1965-1979 AND PROJECTED 1980-1995

IN MW

	System Capacity Responsibility							System Capacity								
	System Peak Responsibility								Peaking Capacity (Kansas)						Capacity Balance	
Year	System Load Net 1 Hour	Firm Purchases (minus)	Firm Sales (plus)	System Peak Responsibility	Required Reserve (a)	Total System Responsibility	Accredited Generating Capacity	Peaking Capacity Purchases (Hydro)	Purchases (plus)	Sales (minus)	Capacity Sales (minus)	Capacity Purchases (plus)	Planned Capacity Additions	Total System Capacity	As Planned	Without WCGS #1 (b)
1965	1,020	-	45	1,065	107	1,172	1,099	194	-	76	15	-	-	1,202	+ 30	
1966	1,186	65	53	1,174	117	1,291	1,123	243	-	95	55	-	-	1,216	- 75	
1967	1,186	20	10	1,176	118	1,294	1,123	243	-	95	-	116	-	1,387	+ 93	
1968	1,276	180	50	1,146	138	1,284	1,187	243	-	95	-	11	-	1,346	+ 62	
1969	1,409	150	150	1,409	169	1,578	1,694	243	-	95	255	7	-	1,594	+ 16	
1970	1,499	-	3	1,502	180	1,682	1,686	243	-	95	100	-	-	1,734	+ 52	
1971	1,574	40	36	1,570	188	1,758	1,684	243	-	95	75	95	-	1,852	+ 94	
1972	1,676	55	40	1,661	216	1,877	1,813	243	-	95	55	55	-	1,961	+ 84	
1973	1,757	40	63	1,780	267	2,047	2,224	243	-	95	150	-	-	2,222	+ 175	
1974	1,907	-	-	1,907	286	2,193	2,224	243	-	95	-	-	-	2,372	+ 179	
1975	1,903	-	18	1,921	288	2,209	2,334	194	-	76	-	-	-	2,452	+ 243	
1976	1,920	100	-	1,820	273	2,093	2,361	194	-	76	100	-	-	2,379	+ 286	
1977	1,980	-	-	1,980	297	2,277	2,675	162	-	63	225	25	-	2,574	+ 297	
1978	2,097	-	-	2,097	315	2,412	2,560	155	-	60	25	25	-	2,655	+ 243	
1979	1,964	-	-	1,964	393	2,357	2,560				-	-	-	2,560	+ 203	
1980	2,157	-	-	2,157	431	2,588	2,824				150	-	+ 264	2,674	+ 86	
1981	2,235	-	-	2,235	447	2,682	2,904				300	-	+ 80	2,604	- 78	
1982	2,315	-	-	2,315	463	2,778	2,874				-	-	- 30	2,874	+ 96	
1983	2,398	-	-	2,398	480	2,878	3,271				-	-	+ 397	3,271	+ 393	- 84
1984	2,485	-	-	2,485	497	2,982	3,271				-	-	-	3,271	+ 289	- 188
1985	2,574	-	-	2,574	515	3,089	3,271				-	-	-	3,271	+ 182	- 295
1986	2,667	-	-	2,667	533	3,200	3,271				-	-	-	3,271	+ 71	- 406
1987	2,763	-	-	2,763	553	3,316	3,271				-	50	-	3,321	+ 5	- 472
1988	2,862	-	-	2,862	572	3,434	3,271				-	150	-	3,421	- 13	- 490
1989	2,965	-	-	2,965	593	3,558	3,726				-	-	+ 455	3,726	+ 168	- 309
1990	3,072	-	-	3,072	614	3,686	3,686				-	-	- 40	3,686	0	- 477
1991	3,183	-	-	3,183	637	3,820	3,686				-	150	-	3,836	+ 16	- 461
1992	3,298	-	-	3,298	660	3,958	3,686				-	275	-	3,961	+ 3	- 474
1993	3,417	-	-	3,417	683	4,100	4,141				-	-	+ 455	4,141	+ 41	- 436
1994	3,540	-	-	3,540	70P	4,248	4,141				-	100	-	4,241	- 7	- 484

(a) Reserve requirement: 10%-1963 through 1967; 12%-1968 through 1971; 13%-1972; 15%-1973 through 1978; 1979 and following, 20% KCPL internal minimum reserve.
(b) For 1983 and thereafter.

Source: MOKAN Pool Report and KCPL. MOKAN Pool data are reported for contract year beginning 1 June. Because of reporting period, figures may differ from those in other reports.

TABLE 1.1-3

KEPCO LOAD AND CAPABILITY DATA

ACTUAL 1971-1979 AND PROJECTED 1980-1994

IN MW

	System Capacity Responsibility						System Capacity						
		System Peak Responsibility										Capacity Balance	
Year	System Load Net 1 Hour	Firm Purchases (minus)	Firm Sales (plus)	Total System Peak Responsibility	Required Reserve (a)	Total System Responsibility	Accredited Generating Capacity	Peaking Capacity Purchases (Hydro)	Capacity Purchases (plus)(c)	Planned Capacity Additions	Total System Capacity	As Planned	Without WCGS #1 (b)
1971	202.8												
1972	219.6												
1973	259.3												
1974	293.4												
1975	318.5												
1976	348.9												
1977	337.4												
1978	376.8												
1979	413.3												
1980	484.2	514.2	30	0	0	0	0	90	0	0	0	0	0
1981	514.4	545.4	30	0	0	0	0	90	0	0	0	0	0
1982	548.4	578.4	30	0	0	0	0	90	0	0	0	0	0
1983	583.8	478.3	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1984	621.3	515.8	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1985	661.5	556.0	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1986	702.4	596.9	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1987	745.9	640.4	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1988	792.1	686.6	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1989	841.4	735.9	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1990	893.8	788.3	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1991	949.7	844.2	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1992	1,009.7	904.2	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1993	1,072.9	966.8	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5
1994	1,139.6	1,034.1	90	195.5	39.1	234.6	195.5	90	39.1	0	234.6	0	- 195.5

(a) Reserve requirement: 20 percent of generation output
(b) For 1983 and thereafter
(c) Reserve capacity purchase only

Source: KEPCo

WCGS-ER(OLS)

TABLE 1.1-4a

KG&E

INSTALLED CAPACITY IN MW[a]

1974-1989

Plant & Unit	Primary Fuel	Function	Capacity Factor Range Major Units In Percent	Actual							Projected									
				1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
LaCygne No. 1[b]	Coal	Base	36.0 - 43.0	412	412	412	400	400	400	370	370	370	370	370	370	370	370	370	370	370
LaCygne No. 2[b]	Coal	Base	60.0 - 70.0				315	325	325	315	315	315	315	315	315	315	315	315	315	315
Jeffrey No. 1[c]	Coal	Base						136	136	138	138	138	138	138	138	138	138	138	138	138
Jeffrey No. 2[c]	Coal	Base	60 Est.							136	136	136	136	136	136	136	136	136	136	136
Jeffrey No. 3[c]	Coal	Base	60 Est.										136	136	136	136	136	136	136	136
Jeffrey No. 4[c]	Coal	Base	60 Est.												136	136	136	136	136	136
Wolf Creek[d]	Nuclear	Base	54.0 - 75.0										477	477	477	477	477	477	477	477
Gordon Evans No. 1	Gas & No. 6 Oil[e]	Base & Intermediate[f]	34.8 - 58.9	162	162	163	146	149	149	149	149	149	149	149	149	149	149	149	149	149
Gordon Evans No. 2	Gas & No. 6 Oil[e]	Base & Intermediate[f]	34.8 - 58.9	381	381	381	350	359	359	359	359	359	359	359	359	359	359	359	359	359
Murray Gill No. 1	Gas & No. 6 Oil[g]	Base & Intermediate[h]	24.9 - 41.9	51	51	51	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Murray Gill No. 2	Gas & No. 6 Oil[g]	Base & Intermediate[h]	24.9 - 41.9	78	78	79	74	74	74	74	74	74	74	74	74	74	74	74	74	74
Murray Gill No. 3	Gas & No. 6 Oil[g]	Base & Intermediate[i]	44.7 - 64.4	120	120	121	100	108	108	108	108	108	108	108	108	108	108	108	108	108
Murray Gill No. 4	Gas & No. 6 Oil[g]	Base & Intermediate[i]	44.7 - 64.4	121	121	121	100	106	106	106	106	106	106	106	106	106	106	106	106	106
Neosho No. 1 & 2	Coal	Peaking		48	48	48	38	47												
Neosho No. 3	No. 6 Oil[j]	Intermediate[k]	3.3 - 62.1	75	75	75	75	69	69	69	69	69	69	69	69	69	69	69	69	69
Ripley No. 1, 2 & 3	Gas & No. 6 Oil[l]	Intermediate & Peaking[m]	2.6 - 42.1[n]	89	89	90	86	88	88	88	88	88	88	88	88	88	88	88	88	88
Wichita No. 3 & 4	Gas & No. 2 Oil	Peaking		24	24	24	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Wichita No. 5	No. 2 Oil	Peaking		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Total Installed Capacity				1564	1564	1568	1753	1930	1883	1981	1981	1981	2594	2594	2730	2730	2730	2730	2730	2730

(a) Total or KG&E allocation, when jointly owned. Summer rating.
(b) 50% share. KCPL is operator.
(c) 20% share. KCPL is or will be operator.
(d) 41.5% share. KG&E will be operator.
(e) Gas through 1984 - then No. 6 Oil.
(f) Base through 1983 - then intermediate.
(g) Gas through 1984 - No. 6 Oil thereafter.
(h) Base 1979, 1981, 1982 - otherwise intermediate.
(i) Base 1974 through 1979 and in 1981 - otherwise intermediate.
(j) To be converted completely to No. 6 Oil in 1985. Has some No. 2 Oil capability.
(k) Base in 1974 and 1982, intermediate otherwise until 1981, then peaking from 1983 on.
(l) Gas through 1986 - No. 6 Oil thereafter.
(m) Base in 1974, intermediate 1975, 1977 and 1982 - otherwise peaking.
(n) Capacity factor was 91.2% in 1974 when used for base load.

NOTE: Generation capabilities, as tested, are reported to the MOKAN Pool as contract year values. These values may vary from those reported in FEPC Report No. 12, which gives year end values and those reported to SPP as summer peak values.

TABLE 1.1-4b

KG&E

ACTUAL AND PROPOSED CAPACITY CHANGES

Year	Date	Unit or Plant	Function on Load*	Nature of Change	MW Change	Primary Fuel*	Total Annual Net Change
1975	June 30	LaCygne No. 1	Base	Rerating	- 23	Coal	- 23
1976	June 30	LaCygne No. 1	Base	Rerating	+ 23	Coal	
	June 30	Murray Gill No. 2	Intermediate	Rerating	+ 1	Gas	
	June 30	Murray Gill No. 3	Base	Rerating	+ 1	Gas	
	June 30	Gordon Evans No. 1	Base	Rerating	+ 1	Gas	
	June 30	Ripley	Peaking	Rerating	+ 1	Gas	+ 27
1977	May 10	LaCygne No. 2	Base	Addition	+315	Coal	
	June 30	LaCygne No. 1	Base	Rerating	- 12	Coal	
	June 30	LaCygne No. 2	Base	Rerating	+ 10	Coal	
	June 30	Murray Gill No. 1	Intermediate	Rerating	- 5	Gas	
	June 30	Murray Gill No. 2	Intermediate	Rerating	- 5	Gas	
	June 30	Murray Gill No. 3	Base	Rerating	- 21	Gas	
	June 30	Murray Gill No. 4	Base	Rerating	- 21	Gas	
	June 30	Gordon Evans No. 1	Base	Rerating	- 17	Gas	
	June 30	Gordon Evans No. 2	Base	Rerating	- 31	Gas	
	June 30	Neosho No. 1 & 2	Peaking	Rerating	- 10	Coal	
	June 30	Ripley	Intermediate	Rerating	- 4	Gas	
	June 30	Wichita No. 3 & 4	Peaking	Rerating	- 4	Gas	+195
1978	July 31	Jeffrey No. 1	Base	Addition	+136	Coal	
	June 30	Gordon Evans No. 1	Base	Rerating	+ 3	Gas	
	June 30	Gordon Evans No. 2	Base	Rerating	+ 9	Gas	
	June 30	Murray Gill No. 3	Base	Rerating	+ 8	Gas	
	June 30	Murray Gill No. 4	Base	Rerating	+ 6	Gas	
	June 30	Neosho No. 1 & 2	Peaking	Rerating	+ 9	Coal	
	June 30	Neosho No. 3	Intermediate	Rerating	- 6	No. 6 Oil	
	June 30	Ripley	Peaking	Rerating	+ 2	Gas	+167
1979	June 30	Neosho No. 1 & 2	Peaking	Retirement	- 47	Coal	- 47
1980	Spring	Jeffrey No. 1	Base	Rerating	+ 2	Coal	
		Jeffrey No. 2	Base	Addition	+136	Coal	+ 98
		LaCygne No. 1	Base	Rerating	- 30	Coal	
		LaCygne No. 2	Base	Rerating	- 10	Coal	
1983	Spring	Jeffrey No. 3	Base	Addition	+136	Coal	
	April	Wolf Creek	Base	Addition	+477	Nuclear	+513
1985	Spring	Jeffrey No. 4	Base	Addition	+136	Coal	+136
1988				No Change			
1990				No Change			

* See footnotes to Table 1.1-4a for planned changes of function on load and of primary fuel for various units.

WCGS-ER(OLS)

TABLE 1.1-5a

KCPL

INSTALLED CAPACITY[a] IN MW

1974-1989

Plant & Unit	Primary Fuel	Function	Capacity Factor Range Major Units In Percent	Actual						Projected									
				1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
LaCygne No. 1[b]	Coal	Base	36.0 - 43.0	412	412	412	412	400	400	370	370	370	370	370	370	370	370	370	370
LaCygne No. 2[b]	Coal	Base	60.0 - 70.0				315	325	325	315	315	315	315	315	315	315	315	315	315
Montrose No. 1	Coal	Base	44.0 - 59.0	185	180	180	180	173	173	162	162	162	162	162	162	162	162	162	162
Montrose No. 2	Coal	Base	53.9 - 67.6	182	178	178	178	174	174	174	174	174	174	174	174	174	174	174	174
Montrose No. 3	Coal	Base	51.0 - 68.4	193	188	188	188	180	180	180	180	180	180	180	180	180	180	180	180
Hawthorn No. 5	Coal	Base	30.0 - 47.3	520	520	480	480	450	450	450	450	450	450	450	450	450	450	450	450
Iatan No. 1[c]	Coal	Base	60 Est.							455	455	455	455	455	455	455	455	455	455
Unspecified[c]	Coal	Base	60 Est.																455
Wolf Creek[d]	Nuclear	Base	54.0 - 78.0										477	477	477	477	477	477	477
Hawthorn No. 1	Coal	Intermediate	30.0 - 41.0	75	75	73	65	65	65	55	55	55	55	55	55	55	55	55	55
Hawthorn No. 2	Coal	Intermediate	34.1 - 44.5	78	78	73	65	65	65	55	55	55	55	55	55	55	55	55	55
Hawthorn No. 3	Coal	Intermediate	27.0 - 40.2	118	119	105	105	90	90	70	70	70	70	70	70	70	70	70	70
Hawthorn No. 4	Coal	Intermediate	31.0 - 36.0	133	133	105	105	90	90	70	70	70	70	70	70	70	70	70	70
Grand Ave. No. 1,5,7,8,9	Coal	Intermediate		99	99	99	70	70	70	70	70	40	40	40	40	40	40	40	40
Northeast No. 1,2,4,5,7	Gas-Steam	Peaking		128	135	135	80	80	80	80	80	80							
Northeast No. 11 & 12	No. 2 Oil)	(Peaking		101	101	101	95	95	95	95	95	95	95	95	95	95	95	95	95
Northeast No. 13 & 14	No. 2 Oil) Gas	(Peaking			116	116	101	101	101	101	101	101	101	101	101	101	101	101	101
Northeast No. 15 & 16	No. 2 Oil)turbines	(Peaking				116	101	101	101	101	101	101	101	101	101	101	101	101	101
Northeast No. 17 & 18	No. 2 Oil)	(Peaking					101	101	101	101	101	101	101	101	101	101	101	101	101
Total Installed Capacity				2224	2334	2361	2641	2560	2560	2824	2904	2874	3271	3271	3271	3271	3271	3271	3726

(a) Total or KCPL allocation when jointly owned. Summer rating.
(b) 50% share. KCPL is operator.
(c) 70% share. KCPL will be operator. St. Joseph Light and Power Co. owns 18% and Empire District Electric Co. owns 12%.
(d) 41.5% share. KG&E will be operator.

NOTE: Generation capabilities are based on summer peak values. Those may vary from those reported in FPC Report No. 12 which gives year end values.

TABLE NO. 1.1-5b

KCPL

ACTUAL AND PROPOSED CAPACITY CHANGES

1974-1989

Year	Date	Plant and Unit	Function on Load	Nature of Change	MW Change	Primary Fuel	Total Annual Net Change (MW Summer)
1975		Northeast 1	Peaking	Rerating	+ 2	Gas	
		Northeast 2	Peaking	Rerating	+ 1	Gas	
		Northeast 4	Peaking	Rerating	+ 1	Gas	
		Northeast 5	Peaking	Rerating	+ 3	Gas	
		Northeast 13, 14	Peaking	Addition	+ 116	No. 2 Oil	+ 110
		Hawthorn 3	Intermediate	Rerating	+ 1	Coal	
		Montrose 1	Base	Rerating	- 5	Coal	
		Montrose 2	Base	Rerating	- 4	Coal	
		Montrose 3	Base	Rerating	- 5	Coal	
1976		Northeast 15, 16	Peaking	Addition	+ 116	No. 2 Oil	
		Hawthorn 1	Intermediate	Rerating	- 2	Coal	
		Hawthorn 2	Intermediate	Rerating	- 5	Coal	+ 27
		Hawthorn 3	Intermediate	Rerating	- 14	Coal	
		Hawthorn 4	Intermediate	Rerating	- 28	Coal	
		Hawthorn 5	Base	Rerating	- 40	Coal	
1977		Grand Ave. 5	Intermediate	Rerating	- 6	Coal	
		Grand Ave. 7	Intermediate	Rerating	- 9	Coal	
		Grand Ave. 8	Intermediate	Deactivation	- 14	Coal	
		Northeast 1	Peaking	Rerating	- 29	Gas	
		Northeast 2	Peaking	Deactivation	- 22	Gas	
		Northeast 4	Peaking	Rerating	- 1	Gas	+ 280
		Northeast 5	Peaking	Rerating	- 3	Gas	
		Northeast 11, 12	Peaking	Rerating	- 6	No. 2 Oil	
		Northeast 13, 14	Peaking	Rerating	- 15	No. 2 Oil	
		Northeast 15, 16	Peaking	Rerating	- 15	No. 2 Oil	
		Northeast 17, 18	Peaking	Addition	+ 101	No. 2 Oil	
		LaCygne 2	Base	Addition	+ 315[a]	Coal	
		Hawthorn 1	Intermediate	Rerating	- 8	Coal	
		Hawthorn 2	Intermediate	Rerating	- 8	Coal	
1978		Hawthorn 3	Intermediate	Rerating	- 15	Coal	
		Hawthorn 4	Intermediate	Rerating	- 15	Coal	
		Hawthorn 5	Base	Rerating	- 30	Coal	
		Montrose 1	Base	Rerating	- 7	Coal	- 81
		Montrose 2	Base	Rerating	- 4	Coal	
		Montrose 3	Base	Rerating	- 8	Coal	
		LaCygne 1	Base	Rerating	- 12	Coal	
		LaCygne 2	Base	Rerating	+ 10	Coal	
1980	Mar	Iatan 1	Base	Addition	+ 455[b]	Coal	
		LaCygne 1	Base	Rerating	- 30	Coal	
		LaCygne 2	Base	Rerating	- 10	Coal	
		Montrose 1	Base	Rerating	- 11	Coal	
		Hawthorn 1	Intermediate	Rerating	- 10	Coal	- 264
		Hawthorn 2	Intermediate	Rerating	- 10	Coal	
		Hawthorn 3	Intermediate	Rerating	- 20	Coal	
		Hawthorn 4	Intermediate	Rerating	- 20	Coal	
		Northeast 1,2,4,5,7	Peaking	Not Accredited	- 80	Gas	
1981		Northeast 1,2,4,5,7	Peaking	Accredited	+ 80	Gas	+ 80
1982	Jan	Grand Ave. 5	Intermediate	Deactivation	- 7[c]	Coal	
	Jan	Grand Ave. 7	Intermediate	Deactivation	- 30	Coal	- 30
1983	Jan	Northeast 1	Peaking	Retirement	- 7	Gas	
		Northeast 4	Peaking	Retirement	- 30	Gas	+ 397
		Northeast 5	Peaking	Retirement	- 30	Gas	
		Northeast 7	Peaking	Retirement	- 13	Gas	
	April	Wolf Creek	Base	Addition	+ 477	Nuclear	
1988				No Change			
1989	Mar	Iatan 2 (b)	Base	Addition	+ 455	Coal	+ 455
1990	Jan	Grand Ave. 9	Intermediate	Retirement	- 40	Coal	- 40

[a] Joint Ownership: KCPL 50%
[b] Joint Ownership: KCPL 70%
[c] Winter Capacity only

PARTICIPATION IN POOLS AND ASSOCIATIONS

SOUTHWEST POWER POOL (SPP)

Southwest Power Pool Coordination Agreement, dated December 17, 1969, with various amendments, the latest of which is dated November 9, 1979.

Participating Parties:

Group A

Alexandria Light & Power Department, Louisiana
Arkansas Electric Cooperative Corporation
Cajun Electric Power Cooperative, Inc.
Central Louisiana Electric Company, Inc. (The)[b]
Gulf States Utilities Company[b]
Lafayette Utility System, Louisiana[b]
Middle South Utilities, Inc.
- Arkansas Power & Light Company
- Arkansas-Missouri Power Company
- Louisiana Power & Light Company
- Mississippi Power & Light Company
- New Orleans Public Service, Inc.

Group B

Grand River Dam Authority
New Mexico Electric Service Company[a]
Oklahoma Gas & Electric Company[b]
Public Service Company of Oklahoma[b]
Southwestern Electric Power Company[b]
Southwestern Power Administration[b]
Southwestern Public Service Company[b]
Western Farmers Electric Cooperative[b]
West Texas Utilities Company[b][c]

Group C

Board of Public Utilities, Kansas City, Kansas
Central Kansas Power Company, Inc.[b]
Chanute Municipal Utilities, Kansas
City Power & Light Department, Independence, Missouri
Coffeyville Municipal Water & Light Department, Kansas
Empire District Electric Company (The)[b]
Kansas City Power & Light Company[b]

(a) Non-member system. Is operated and data are reported by Southwestern Public Service Company
(b) Designated SPP Control Area
(c) System included in Electric Reliability Council of Texas

TABLE 1.1-6

(SHEET 2 of 4)

Kansas Gas & Electric Company[b]
Kansas Power & Light Company (The)[b]
Missouri Public Service Company[b]
St. Joseph Light & Power Company[b]
Sunflower Electric Cooperative, Inc.
Western Power Division, Central Telephone & Utilities Corporation[b]
Winfield Municipal Light & Water, Kansas

Group D

Associated Electric Cooperative, Inc.[a][b]
City Utilities, Springfield, Missouri
Missouri Edison Company[a]
Missouri Power & Light Company[a]
Missouri Utilities Company[a]

Group E (Non-Members)

City of Houma, Louisiana
City of Monroe, Louisiana
City of Natchitoches, Louisiana
City of Ruston, Louisiana
Jonesboro City Water & Light, Arkansas
Morgan City Municipal Utilities, Louisiana
Ottawa Water & Light, Kansas
Ponca City Water & Light, Oklahoma

MISSOURI KANSAS POOL (MOKAN)

General Participation agreement ("GPA")
- MOKAN Coordination agreement[c]
- Kansas Facilities agreement[c]
- Missouri Facilities agreement[c]
  - Missouri Coordination Agreement[c]

Amendments to General Participation agreement

Participating Parties:

- Central Kansas Power Company, Inc.
- Empire District Electric Company (The)
- Kansas City Power & Light Company
- Kansas Gas & Electric Company
- Kansas Power & Light Company (The)
- Missouri Public Service Company
- Saint Joseph Light and Power Company (Mo)

[a] Data for these member systems of SWPP are reported by contiguous councils
[b] Designated SWPP Control Areas
[c] These are not MOKAN-wide agreements, but they are MOKAN related

Western Power Division, Central Telephone & Utilities Corporation
Sunflower Electric Cooperative, Inc.

Note: Not all of the above participants are signatory to each agreement.

COMPANIES - ASSOCIATED - SOUTHWESTERN POWER ADMINISTRATION (SPA)

Associated - Companies contract
- Exhibit B, Amended
- Missouri Participation Agreement
- Service Schedule E-MPA
  - SPA - Companies Contract
  - SPA - Associated Contract
    - Amendatory Agreement
    - Concurrence by Companies

Western Missouri Participation Agreement
- Exhibit A, Amended

Peaking Capacity Sales Agreement - KG&E and KPL

Participating Parties:

Associated Electric Cooperation, Inc.
Empire District Electric Company (The)
Kansas City Power & Light Company
Kansas Gas & Electric Company
Kansas Power & Light Company (The)
Missouri Public Service Company
Southwestern Power Administration

Note: Not all of the above participants are signatory to each agreement

SOUTH CENTRAL ELECTRIC COMPANIES

Coordination Agreement
- Various interconnection agreements among the member companies.

Participating Parties:

Arkansas Power & Light Company
Central Louisiana Electric Company, Inc. (The)
Empire District Electric Company (The)
Gulf States Utilities Company
Kansas Gas & Electric Company
Louisiana Power & Light Company
Mississippi Power & Light Company
New Orleans Public Service, Inc.
Oklahoma Gas and Electric Company
Public Service Company of Oklahoma
Southwestern Electric Power Company

TABLE 1.1-6

KANSAS CITY - TWIN CITIES

Memorandum of Understanding - South Section
  Addendum No. 1 and No. 2
Coordinating Agreement
Facilities agreement
Service schedule for participation power
Service (KCPL and NSP)

Participating Parties:

Iowa Public Service Company
Interstate Power Company
Kansas City Power & Light Company
Northern States Power Company
Omaha Public Power District
St. Joseph Light & Power Company

MISSOURI-KANSAS-OKLAHOMA (MKO)

Missouri-Kansas-Oklahoma Interconnection
  Agreement, dated September 22, 1971

Participating Parties:

Associated Electric Cooperative, Inc.
Kansas Gas and Electric Company
Public Service Company of Oklahoma
Union Electric Company

TABLE 1.1-7a

SOUTHWEST POWER POOL[a]
LOAD AND CAPABILITY DATA
1965-1977
IN MW

	System Capacity Responsibility						System Capacity				
	System Peak Responsibility										
Year	System Load Net 1 Hour	Firm Purchases (minus)	Firm Sales (plus)	Total System Peak Responsibility	Recommended Minimum Reserve[b]	Total System Capacity Responsibility	Accredited Generating Capacity	Capacity Sales (minus)	Capacity Purchases (plus)	Total System Capacity	Capacity Balance
1965	13,196	514	31	12,713	1,526	14,239	15,286	240	-	15,046	807
1966	15,245	1,167	75	14,153	1,698	15,851	16,087	180	-	15,907	56
1967	15,978	1,227	-	14,751	1,770	16,521	18,587	180	-	18,409	1,888
1968	17,785	1,979	253	16,059	1,927	17,986	19,570	180	25	19,415	1,429
1969	20,008	1,996	425	18,437	2,212	20,649	22,133	675	-	21,458	809
1970	21,382	1,601	-	19,781	2,967	22,748	24,417	725	133	23,825	1,077
1971	22,936	1,500	25	21,461	3,219	24,680	27,754	1,233	108	26,629	1,949
1972	25,367	1,500	110	23,977	3,597	27,574	28,636	1,078	150	27,708	134
1973	26,671	1,650	-	25,021	3,753	28,774	31,414	478	152	31,088	2,314
1974	28,300	3,039	1,468	26,729	4,009	30,738	33,185	1,672	1,128	32,637	1,899
1975	28,526	3,107	1,999	27,418	4,113	31,531	37,690	1,732	1,678	37,636	6,105
1976	30,293	3,116	1,360	28,537	4,281	32,818	38,955	4,483	2,915	37,387	4,569
1977	32,140	2,891	1,261	30,510	4,577	35,087	41,089	4,218	2,885	39,756	4,669

[a] Actual load and capability data are for the SPP System as reorganized in 1969. Does not include systems added after 1969. Comparable data are not available after 1977.

[b] Recommended minimum reserve levels: 12%-1965-1969; 15%-1970 and following.

Source: Southwest Power Pool, March, 1978

WCGS-ER(OLS)

TABLE 1.1-7b

SOUTHWEST POWER POOL[a]
COMPARISON OF FORECAST AND ACTUAL 1971-1978 CAPABILITY
LOAD AND MARGINS
IN MW

Item	1971 Forecast 4-1-71[b]	1971 Actual	1972 Forecast 4-1-72[c]	1972 Actual	1973 Forecast 4-1-73	1973 Actual	1974 Forecast 4-1-74	1974 Actual	1975 Forecast 4-1-75	1975 Actual	1976 Forecast 4-1-76	1976 Actual	1977 Forecast 4-1-77	1977 Actual	1978 Forecast 4-1-78	1978 Actual
1. Net Dependable Capability	27,502	27,502	32,002	32,002	34,765	34,738	38,474	36,198	41,309	40,644	42,199	42,014	44,846	43,739	46,487	46,457
2. All Scheduled Purchases	4,410	4,410	5,567	5,567	5,809	5,726	6,206	6,206	2,084	2,084	2,464	2,464	2,164	7,457	5,411	8,688
3. All Scheduled Sales	4,169	4,169	4,734	4,734	3,839	4,332	4,112	4,112	678	678	1,320	1,320	879	6,258	3,704	4,343
4. Total Resources (1+2-3)	27,743	27,743	32,835	32,835	36,735	36,132	40,568	38,292	42,715	42,050	43,343	43,158	46,131	44,938	48,194	50,802
5. Inoperable Capability	---	---	---	---	---	---	---	---	---	---	---	---	---	549	135	304
6. Operable Resources (4-5)	27,743	27,743	32,835	32,835	36,735	36,132	40,568	38,292	42,715	42,050	43,343	43,158	46,131	44,389	48,059	50,498
7. Peak Hour Demand	23,653	22,187	27,896	27,552	30,568	29,367	32,711	32,078	34,735	32,200	35,307	33,764	37,090	36,847	38,946	39,191
8. Interruptible Demand	---	---	---	---	---	---	---	---	---	---	---	---	---	35	---	---
9. Demand Requirements (7-8)	23,653	22,187	27,896	27,552	30,568	29,367	32,711	32,078	34,735	32,200	35,307	33,764	37,090	36,812	38,946	39,191
10. Gross Margin (6-9)	4,090	5,556	4,939	5,283	6,167	6,765	7,857	6,214	7,980	9,850	8,036	9,394	9,041	7,577	9,113	11,307
11. Unavailable Capacity																
a. Scheduled Outages	111	150	92	375	67	78	745	748	377	1,326	20	2,353	---	600	44	---
b. Forced Outages	---	1,570	---	950	---	3,735	---	1,626	---	1,457	---	1,190	---	3,958	---	---
c. Fuel Limited	---	---	59	25	---	258	---	---		---	---	---	---	---	---	---
Total	111	1,720	151	1,350	67	4,071	745	2,374	377	2,783	20	3,543	0	4,558	44	5,720[d]
12. Net Margin (10-11)	3,979	3,836	4,788	3,933	6,100	2,694	7,112	3,840	7,603	7,067	8,016	5,851	9,041	3,019	9,069	5,587
13. Net Margin as Percent of Demand (9)	16.8	17.3	17.2	14.3	20.0	9.2	21.7	12.0	21.9	21.9	22.7	17.3	27.4	8.2	23.3	14.3

(a) As reported to FPC and FERC April 1, each year, under Docket R-362. The figures reported include all members of SWPP through April, 1978
(b) Revised June 28, 1971
(c) Revised May 1, 1972
(d) Breakdown not available

TABLE 1.1-8

SOUTHWEST POWER POOL

ENERGY AND PEAK LOADS

1978-1988

Monthly - 1978-1980

Month	Energy (GWH) 1978	Energy (GWH) 1979	Energy (GWH) 1980	Peak Load (MW) 1978*	Peak Load (MW) 1979	Peak Load (MW) 1980
Jan	15,609	16,446	18,003	26,922	28,325	29,349
Feb	14,113	14,285	15,750	26,051	26,903	28,414
Mar	13,975	14,743	15,852	24,727	25,714	27,193
Apr	13,322	14,371	15,324	23,867	26,227	27,774
May	15,278	16,017	16,661	30,668	32,317	34,151
Jun	17,582	18,725	19,723	36,570	38,492	41,226
July	20,826	21,271	22,524	38,339	40,819	43,418
Aug	19,711	20,957	22,684	38,378	40,975	43,580
Sep	17,627	18,210	20,380	36,249	38,220	40,640
Oct	14,297	15,819	17,458	27,499	30,038	32,081
Nov	13,878	15,142	16,542	25,371	27,895	29,787
Dec	15,332	16,124	17,414	26,800	29,304	31,292

Seasonally 1978-1988

Season		Load (MW)
S	78	39,191
W	78-79	28,350
S	79	41,094
W	79-80	29,349
S	80	43,705
W	80-81	31,292
S	81	46,492
W	81-82	33,290
S	82	49,468
W	82-83	35,461
S	83	52,477
W	83-84	37,867
S	84	55,679
W	84-85	39,978
S	85	59,081
W	85-86	42,407
S	86	62,559
W	86-87	44,918
S	87	66,200
W	87-88	47,563
S	88	69,987
W	88-89	50,330

Year	Energy (GWH)
1978*	191,550
1979	201,889
1980	217,765
1981	229,545
1982	244,391
1983	259,641
1984	276,037
1985	293,168
1986	311,214
1987	329,657
1988	349,140

* Actual

Southwest Power Pool 1979

TABLE 1.1-9

SOUTHWEST POWER POOL
PROJECTED CAPABILITY, MAINTENANCE, EXCHANGE
AND RESERVE, 1979-1988
IN MW

Resources	1979 Summer(a)	1979 Winter(b)	1980 Summer	1980 Winter	1981 Summer	1981 Winter	1982 Summer	1982 Winter	1983 Summer	1983 Winter
1. Net Dependable Capability	47,802	48,822	53,020	53,462	57,268	57,162	60,289	60,743	63,196	63,097
2. All Scheduled Purchases	5,303	3,608	5,236	3,577	4,304	3,286	4,353	3,538	3,797	3,108
3. All Scheduled Sales	3,377	4,516	4,238	4,731	3,698	4,461	3,558	3,760	3,582	3,932
4. Total Resources (1+2-3)	49,728	47,914	54,018	52,308	57,874	55,987	61,084	60,521	63,411	62,273
5. Inoperable Capability(b)	190	170	0	40	0	40	0	40	0	40
6. Operable Resources (4-5)	49,538	47,744	54,018	52,268	57,874	55,947	61,084	60,481	63,411	62,233
Demand										
7. Peak Hour Demand	41,094	29,349	43,705	31,292	46,492	33,290	49,468	35,461	52,477	37,867
8. Interruptible Demand	104	104	111	111	115	115	115	115	115	115
9. Demand Requirements (7-8)	40,990	29,245	43,594	31,181	46,377	33,175	49,353	35,346	52,362	37,752
Margin										
10. Gross Margin	8,548	18,499	10,424	21,087	11,497	22,772	11,731	25,135	11,049	24,481
11. Scheduled Outages	0	3,878	0	3,824	0	4,530	0	5,145	0	5,123
12. Net Margin (10-11)	8,548	14,621	10,424	17,263	11,497	18,242	11,731	19,990	11,049	19,358
13. Net Margin as Percent of Demand (9)	20.9	50.0	23.9	55.4	24.8	55.0	23.7	56.6	21.1	51.3

Resources	1984 Summer	1984 Winter	1985 Summer	1985 Winter	1986 Summer	1986 Winter	1987 Summer	1987 Winter	1988 Summer	1988 Winter
1. Net Dependable Capability	66,929	67,948	70,394	71,271	74,598	75,156	77,386	77,808	80,237	81,301
2. All Scheduled Purchases	3,977	3,409	4,083	3,289	4,446	3,652	4,702	3,908	4,518	3,818
3. All Scheduled Sales	3,442	4,319	3,286	3,784	3,503	3,997	3,307	3,797	2,911	3,488
4. Total Resources (1+2-3)	67,464	67,038	71,191	70,776	75,541	74,811	78,781	77,919	81,844	81,631
5. Inoperable Capability(b)	0	40	0	40	0	40	0	40	0	40
6. Operable Resources (4-5)	67,464	66,998	71,191	70,736	75,541	74,771	78,781	77,879	81,844	81,591
Demand										
7. Peak Hour Demand	55,679	39,978	59,081	42,407	62,559	44,918	66,200	47,563	69,987	50,330
8. Interruptible Demand	115	115	115	115	115	115	115	115	115	115
9. Demand Requirements (7-8)	55,564	39,863	58,966	42,292	62,444	44,803	66,085	47,448	69,872	50,215
Margin										
10. Gross Margin	11,900	27,135	12,225	28,444	13,097	29,968	12,696	30,431	11,972	31,376
11. Scheduled Outages	0	0	0	0	0	0	0	0	0	0
12. Net Margin (10-11)	11,900	27,135	12,225	28,444	13,097	29,968	12,696	30,431	11,972	31,376
13. Net Margin as Percent of Demand (9)	21.4	68.1	20.7	67.3	21.0	66.9	19.2	64.1	17.1	62.5

(a) Summer-1979 is June through September, Winter-1979 is December 1979 through March 1980
(b) Unavailable due to lack of fuel, manpower, etc.

Source: Southwest Power Pool, 1979

IMAGED 02/11/2005

TABLE 1.1-10

SOUTHWEST POWER POOL

LONG RANGE PEAK DEMAND, RESOURCES AND RESERVE

1989-1998

IN MW

Year	Peak Hour Demand	Increase Per Year %	Resources To Serve Demand	Reserve	Reserve as % of Peak Demand
1989	74,144	5.9	87,852	13,708	18.5
1990	78,363	5.7	92,735	14,372	18.3
1991	82,568	5.4	97,726	15,158	18.4
1992	87,049	5.4	103,311	16,262	18.7
1993	91,776	5.4	107,821	16,045	17.5
1994	96,748	5.4	114,564	17,816	18.4
1995	102,701	6.2	120,917	18,216	17.7
1996	107,116	4.3	126,946	19,830	18.5
1997	112,845	5.3	133,970	21,125	18.7
1998	118,911	5.4	139,208	20,297	17.1

STATEMENT OF PROJECTED CAPABILITY ADDITIONS

DURING THIS PERIOD

	Hydro	Nuclear	Fossil	Unknown or Other	Total
Percent	0.4	24.7	74.2	0.7	100.0

Source:

Southwest Power Pool, 1979

WCGS-ER(OLS)

TABLE 1.1-11

MOKAN POOL LOAD AND CAPABILITY DATA [a]

ACTUAL 1971-1979 AND PROJECTED 1980-1988

IN MW

	System Capacity Responsibility								System Capacity							
	System Peak Responsibility								Peaking Capacity (Kansas)						Capacity Balance	
Year	System Load Net 1 Hour	Firm Purchases (minus)	Firm Sales (plus)	System Peak Responsibility	Required Reserve (b)	Total System Responsibility	Accredited Generating Capacity	Peaking Capacity Purchases (Hydro)	Purchases (plus)	Sales (minus)	Capacity Sales (minus)	Capacity Purchases (plus)	Planned Capacity Additions	Total System Capacity	As Planned	Without WCGS (c)
1971	4,852	195	160	4,817	577	5,394	5,617	298	95	95	549	249		5,615	+ 221	
1972	5,208	262	264	5,210	676	5,886	5,790	298	95	95	403	353		6,038	+ 152	
1973	5,505	230	110	5,385	808	6,193	6,673	298	95	95	324	82		6,729	+ 536	
1974	6,026	188	56	5,894	885	6,779	6,950	298	95	95	264	89		7,073	+ 236	
1975	6,082	187	80	5,975	897	6,872	7,229	238	76	76	158	153		7,462	+ 590	
1976	6,279	334	68	6,013	902	6,915	7,141	238	76	76	323	368		7,424	+ 509	
1977	6,690	232	89	6,547	983	7,530	8,028	198	63	63	689	684		8,221	+ 691	
1978	7,108	231	90	6,967	1,045	8,012	8,404	190	60	60	390	335		8,539	+ 527	
1979	7,031	278	95	6,848	1,028	7,876	8,747	-	-	-	295	420	114	8,972	+1096	
1980	7,885	424	346	7,807	1,171	8,978	9,973	-	-	-	658	235	69	9,619	+ 641	
1981	8,228	389	362	8,201	1,232	9,433	10,085	-	-	-	732	360	-	9,713	+ 280	
1982	8,606	387	385	8,604	1,291	9,895	10,044	-	-	-	514	525	20	10,075	+ 180	
1983	9,094	384	362	9,072	1,361	10,433	11,563	-	-	-	776	325	318	11,430	+ 997	+ 43
1984	9,508	381	391	9,518	1,428	10,946	11,881	-	-	-	667	295	70	11,579	+ 633	- 321
1985	9,936	378	417	9,975	1,496	11,471	12,560	-	-	-	574	295	54	12,335	+ 864	- 90
1986	10,373	375	448	10,446	1,569	12,015	12,543	-	-	-	494	445	70	12,564	+ 549	- 405
1987	10,825	372	480	10,933	1,639	12,572	12,613	-	-	-	344	485	200	12,954	+ 382	- 572
1988	11,296	368	508	11,436	1,716	13,152	12,784	-	-	-	344	295	850	13,585	+ 433	- 521

(a) For contract year, beginning 1 June. Does not include Associated Companies
(b) Reserve 12% of peak responsibility in 1971, 13% in 1972, 15% in 1973 and following
(c) For 1983 and thereafter. Represents 954 MW assigned to KG&E and KCPL

MOKAN Pool Reports 1971-1979

TABLE 1.1-12

KG&E SYSTEM LOADS,
ANNUAL SYSTEM ENERGY AND PEAK DEMAND
ACTUAL 1968-1979
PROJECTED 1980-1990

Year	Annual Energy (GWH)	Increase GWH	Increase %	Summer* Peak Demand (MW)	Increase MW	Increase %	Winter* Peak Demand (MW)	Annual System Load Factor
1968	4,146	274	7.1	923	75	8.9	646	51.1
1969	4,455	309	7.5	998	75	8.1	681	50.9
1970	4,748	293	6.6	1,077	79	7.8	688	50.3
1971	4,818	70	1.5	1,079	2	0.2	745	51.0
1972	5,158	340	7.1	1,137	58	5.4	808	51.6
1973	5,516	358	6.9	1,202	65	5.7	829	52.4
1974	5,799	283	5.1	1,325	123	10.2	867	50.0
1975	6,199	400	6.9	1,337	12	1.0	1,003	52.9
1976	6,442	243	3.9	1,387	50	3.7	1,016	52.9
1977	6,685	243	3.8	1,423	36	2.6	1,056	53.6
1978	7,184	499	7.5	1,533	110	7.7	1,120	53.5
1979	7,189	5	0.0	1,473	- 60	- 3.9	1,160	55.7
1980	7,451	536	3.6	1,585	112	7.6	1,140	53.7
1981	7,489	116	0.5	1,645	60	3.8	1,195	52.0
1982	7,735	347	3.3	1,710	65	4.0	1,245	51.7
1983	8,068	323	4.3	1,790	80	4.7	1,300	51.5
1984	8,417	312	4.3	1,875	85	4.7	1,355	51.3
1985	8,716	328	3.6	1,950	75	4.0	1,415	51.0
1986	8,969	403	2.9	2,010	60	3.1	1,465	51.0
1987	9,330	319	4.0	2,075	65	3.2	1,520	51.3
1988	9,613	337	3.0	2,125	50	2.4	1,585	51.6
1989	9,917	385	3.2	2,175	50	2.4	1,650	52.0
1990	10,209	405	2.4	2,230	55	2.5	1,715	52.3

* Summer is the period from June through September
Winter is December through March of the following year

TABLE 1.1-13

KCPL SYSTEM LOADS

ANNUAL SYSTEM ENERGY AND PEAK DEMAND

ACTUAL 1968-1979

PROJECTED 1980-1990[(a)]

Year	Annual Energy (GWH)	Increase GWH	Increase %	Summer[(b)] Peak Demand (MW)	Increase MW	Increase %	Winter[(b)] Peak Demand (MW)	Annual System Load Factor
1968	5,552	476	9.4	1,276	90	7.6	864	49.7
1969	5,889	337	6.1	1,409	133	10.4	897	47.7
1970	6,324	435	7.4	1,499	90	6.4	965	48.2
1971	6,641	317	5.0	1,574	75	5.0	1,017	48.2
1972	7,174	533	8.0	1,676	102	6.5	1,117	48.9
1973	7,598	424	6.0	1,757	81	4.8	1,091	49.4
1974	7,556	-42	-0.6	1,907	150	8.5	1,106	45.2
1975	7,857	301	4.0	1,903	-4	-0.2	1,165	47.1
1976	8,026	169	2.1	1,920	17	0.8	1,215	47.7
1977	8,452	426	5.3	1,980	60	3.1	1,276	48.7
1978	9,011	559	6.6	2,097	117	5.9	1,312	49.1
1979	8,851	- 160	-1.8	1,964	-133	-6.3	1,365	53.8
1980	9,630	779	8.8	2,157	193	9.8	1,418	51.0
1981	10,016	386	4.0	2,235	78	3.6	1,474	51.2
1982	10,417	401	4.0	2,315	80	3.6	1,550	51.4
1983	10,832	415	4.0	2,398	83	3.6	1,635	51.6
1984	11,267	435	4.0	2,485	87	3.6	1,720	51.8
1985	11,717	450	4.0	2,574	89	3.6	1,810	52.0
1986	12,186	469	4.0	2,667	93	3.6	1,905	52.2
1987	12,673	487	4.0	2,763	96	3.6	2,005	52.4
1988	13,179	506	4.0	2,862	99	3.6	2,105	52.6
1989	13,707	528	4.0	2,965	103	3.6		52.8
1990	14,225	548	4.0	3,072	107	3.6		53.0

(a) Growth rates beyond 1990, out to 2010, are projected at 4.0 percent for annual energy and 3.6 percent for summer peak load

(b) Summer is the period from June through September
Winter is December through March of the following year

TABLE 1.1-14

KEPCO SYSTEM LOADS,

ANNUAL SYSTEM ENERGY AND PEAK DEMAND

ACTUAL 1971-1979 AND PROJECTED 1980-1995

Year	Annual Energy (GWH)	Increase GWH	Increase %	Summer[a] Peak Demand (MW)	Increase MW	Increase %	Winter[a] Peak Demand (MW)
1971	1,031.9			202.8			213.4
1972	1,108.3	76.4	7.4	219.6	16.8	8.3	222.6
1973	1,160.1	51.8	4.7	259.3	39.7	18.1	237.9
1974	1,239.6	79.5	6.8	293.4	34.1	13.2	247.4
1975	1,347.2	107.6	8.7	318.5	25.1	8.6	252.2
1976	1,406.0	58.8	4.4	348.9	30.4	9.5	271.7
1977	1,491.3	85.3	6.1	337.4	-11.5	-3.3	305.1
1978	1,640.2	148.9	10.0	376.8	39.4	11.7	350.2
1979	1,842.1	201.9	12.3	413.3	36.5	9.7	347.5
1980	2,198.5	356.4	19.3	484.2	70.9	17.2	370.8[b]
1981	2,332.0	133.5	6.1	514.4	30.2	6.2	
1982	2,474.8	142.8	6.1	548.4	34.0	6.6	
1983	2,625.9	151.1	6.1	583.4	35.0	6.4	
1984	2,786.6	160.7	6.1	621.3	37.9	6.5	
1985	2,957.2	170.6	6.1	661.5	40.2	6.5	
1986	3,133.9	176.7	6.0	702.4	40.9	6.2	
1987	3,321.2	187.3	6.0	745.9	43.5	6.2	
1988	3,520.0	198.8	6.0	792.1	46.2	6.2	
1989	3,730.9	210.9	6.0	841.4	49.3	6.2	
1990	3,954.8	223.9	6.0	893.8	52.4	6.2	
1991	4,192.6	237.8	6.0	949.7	55.9	6.2	
1992	4,444.9	252.3	6.0	1,009.7	60.0	6.3	
1993	4,712.5	267.6	6.0	1,072.9	63.2	6.3	
1994	4,996.7	284.2	6.0	1,139.6	66.7	6.3	
1995	5,298.7	302.0	6.0	1,211.3	71.7	6.3	

(a) Summer is the period from June through September. Winter is December through March of the following year.

(b) Estimated

Note: Data not available for years prior to 1971.

TABLE 1.1-15

FUEL MIX - PERCENTAGE DISTRIBUTION OF ANNUAL NET GENERATION

Fuel	1970	1975	1980	1985 Nominal Case	1985 Conservative Case	1990 Nominal Case	1990 Conservative Case
				KG&E			
Coal	-	18.3	53.2	57.2	57.2	54.2	54.2
Oil	0.5	14.9	3.8	0.3	0.3	11.5	15.2
Gas	99.5	66.8	43.0	13.7	15.9	6.6	6.6
Nuclear	-	-	-	28.7	26.6	27.7	24.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				KCPL			
Coal	69.2	88.4	94.4	67.9	71.4	71.6	74.6
Oil	0.1	4.0	3.7	4.2	4.5	4.5	4.8
Gas	30.7	7.6	1.9	0.9	0.9	0.8	0.8
Nuclear	-	-	-	27.0	23.2	23.1	19.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NOTE: May not add due to rounding.

TABLE 1.1-16

TRENDS IN FUEL COSTS BY FUEL
IN CENTS PER MILLION BTU

Fuel	1970	1975	1980	1985	1990
			KG&E		
Coal	26.6	40.6	92.2	132.3	170.8
Oil	25.4	136.5	196.7	443.6	712.9
Gas	22.3	45.1	162.6	280.5	429.0
Nuclear	-	-	-	66.1	96.7
System	22.3	58.5	126.2	133.2	227.3
			KCPL		
Coal	25.3	42.4	103.5	148.7	187.4
Oil	76.2	209.7	542.0	827.2	1271.2
Gas	27.5	58.4	165.0	265.7	428.0
Nuclear	-	-	-	60.5	64.2
System	26.1	50.3	122.2	159.2	216.8

TABLE 1.1-17

TRENDS IN FUEL COSTS FOR SYSTEM OPERATIONS IN CENTS PER MILLION BTU

	KG&E		KCPL	
Year	Nominal Case	Conservative Case*	Nominal Case	Conservative Case*
1968	21.8		22.5	
1969	22.1		23.0	
1970	22.3		26.1	
1971	24.3		29.4	
1972	24.4		30.6	
1973	27.1		32.9	
1974	33.3		38.2	
1975	58.5		50.3	
1976	67.2		60.0	
1977	99.3		74.4	
1978	109.3		87.8	
1979	122.7		96.0	
1980	126.2		122.2	
1981	134.7		137.5	
1982	162.3		148.2	
1983	132.8	132.8	132.0	136.6
1984	133.9	135.0	144.9	149.4
1985	133.2	138.2	159.2	164.5
1986	139.7	147.1	173.5	179.1
1987	149.1	157.6	186.3	192.5
1988	166.9	178.9	203.6	212.0
1989	184.1	196.6	204.1	210.5
1990	227.3	252.5	216.8	221.5

* For 1983 and later. Shows effect of two different assumptions on WCGS capacity: 65 percent for conservative case and 75 percent for nominal case.

TABLE 1.1-18

SYSTEM OPERATIONS, PEAK HOUR CONDITIONS
1973-1979
(IN MW)
KG&E

	1973	1974	1975	1976	1977	1978	1979
Peak Date	Aug. 20	Jul 22	Jul 21	Aug 10	Jul 20	Aug 17	Aug 6
Peak Hour	4-5 pm	4-5 pm	3-4 pm	4-5 pm	4-5 pm	5-6 pm	4-5 pm
Net Generation	1126.5	1259.2	1268.4	1260.2	1539.4	1531.4	1361.4
Purchases							
Firm Contract	+ 150.0	+ 150.0	+ 140.0	+ 213.0	+ 248.0	+ 147.0	+ 115.0
Emergency	+ 110.0	+ 40.0	+ 217.0	+ 460.0	+ 275.0	0	+ 230.0
Total	+ 260.0	+ 190.0	+ 357.0	+ 673.0	+ 525.0	+ 147.0	+ 345.0
Sales							
Firm Contract	- 80.0	- 90.0	- 40.0	- 73.0	- 269.0	- 105.0	- 15.0
Municipals	- 16.6	- 3.6	- 30.0	- 59.2	- 48.0	- 48.8	- 55.0
Emergency	- 70.0	- 15.0	- 222.0	- 405.0	- 325.0	0	- 190.0
Total	- 166.6	- 108.6	- 292.0	- 537.2	- 642.0	- 153.8	- 260.0
Inadvertent	- 18.0	- 16.0	+ 4.0	- 9.0	+ 3.0	+ 8.0	+ 27.0
Net Interchange	+ 75.4	+ 65.4	+ 63.0	+ 126.8	- 116.0	+ 1.2	+ 112.0
Net Load	1201.9	1324.6	1337.4	1387.0	1423.4	1532.6	1473.4

KCPL

	1973	1974	1975	1976	1977	1978	1979
Peak Date	Aug. 20	Jul 19	Aug 21	Aug 10	Aug 8	Aug 25	Aug 7
Peak Hour	3-4 pm	3-4 pm	3-4 pm	2-3 pm	4-5 pm	5-6 pm	4-5 pm
Net Generation	1678	1558	1660	1598	1419	1635	1687
Interchange							
Received							
Firm	+ 210	+ 243	+ 231	+ 288	+ 169	+ 196	+ 25
Non-Firm	+ 80	+ 152	+ 60	+ 320	+ 545	+ 425	+ 440
Total	+ 290	+ 395	+ 291	+ 608	+ 714	+ 621	+ 465
Delivered							
Firm	- 143	- 95	- 94	- 176	- 78	- 84	- 27
Non-Firm	- 70	0	- 1	- 92	- 17	- 14	- 175
Total	- 213	- 95	- 95	- 268	- 95	- 98	- 202
Inadvertent	+ 2	+ 49	+ 47	- 18	- 58	- 61	+ 14
Net Interchange	+ 79	+ 349	+ 243	+ 322	+ 561	+ 462	+ 277
Net Load	1757	1907	1903	1920	1980	2097	1964

TABLE 1.1-19

NUMBER AND GROWTH OF RESIDENTIAL CUSTOMERS

	KG&E		KCPL		KEPCo*	
Year	Year End No.	Growth for Year %	Average No. for Year	Growth for Year %	Average No. for Year	Growth for Year %
1968	163,508	1.2	251,257	-2.2		
1969	165,424	1.1	252,354	0.4		
1970	165,668	0.2	256,452	1.6		
1971	166,697	0.6	261,865	2.1		
1972	169,761	1.8	267,320	2.1		
1973	172,896	1.8	273,532	2.3		
1974	177,162	2.5	278,973	2.0	72,529	
1975	180,772	2.0	281,708	1.0	73,857	1.8
1976	187,013	3.5	284,296	0.9	75,209	1.8
1977	190,174	1.7	288,376	1.4	76,919	2.3
1978	194,773	2.4	293,402	1.7	77,974	1.4
1979	200,024	2.7	297,256	1.3	79,736	2.26
1980	204,497	2.2	301,686	1.5	81,540	2.26
1981	208,342	1.9	305,923	1.4	83,048	1.85
1982	212,282	1.9	310,590	1.5	84,585	1.85
1983	216,324	1.9	315,354	1.5	86,149	1.85
1984	219,657	1.5	320,221	1.5	87,743	1.85
1985	223,056	1.5			89,400	1.88
1986	226,366	1.5			91,054	1.85
1987	229,646	1.4			92,738	1.85
1988	232,760	1.4			94,454	1.85

* KEPCo data not available for earlier years.

TABLE 1.1-20

TRENDS IN USE OF ELECTRICITY*
RESIDENTIAL ELECTRIC HEATING

For Year Ending	Electric Heating Customers		Annual Consumption of Energy	
	Number	Percentage of Total Res.	Homes with Elec. Space Heating (KWH)	Homes without Elec. Space Heating (KWH)
		Kansas Gas & Electric Company		
1969	4,522	2.7	18,133	6,168
1970	5,197	3.1	20,566	6,878
1971	5,814	3.5	20,455	6,835
1972	7,411	4.4	19,698	7,151
1973	9,155	5.3	20,066	7,554
1974	12,833	7.2	18,319	7,427
1975	15.293	8.5	21,136	7,929
1976	19,376	10.4	18,779	7,800
1977	21,532	11.3	18,736	8,113
1978	23,586	12.1	20,179	8,596
1979	25,765	12.9		
		Kansas City Power and Light		
1969	3,887	1.5	-	
1970	4,803	1.9	19,395	
1971	6.043	2.3	18,220	
1972	6,749	2.5	18,454	
1973	7.348	2.7	18,940	
1974	7,911	2.8	18,248	
1975	8,633	3.1	20,709	
1976	9,278	3.3	19,441	
1977	10,286	3.6	19,726	
1978	11,105	3.8	21,637	
		Kansas Electric Power Cooperatives		
1974	3,741	5.2		
1975	4,863	6.6		
1976	4,749	6.3		
1977	5,267	6.8		
1978	5,474	7.0		

*Missing data are not available.

TABLE 1.1-21

AVERAGE ANNUAL CONSUMPTION OF ENERGY
BY RESIDENTIAL CUSTOMERS

	KG&E		KCPL		KEPCo*	
Year	KWH	% Incr.	KWH	% Incr.	KWH	% Incr.
1970	7,325	11.9	6,765	10.5		
1971	7,345	0.2	7,027	3.9		
1972	7,792	6.1	7,317	4.1		
1973	8,317	6.4	7,726	5.6		
1974	8,338	0.3	7,423	- 3.9	8,573	
1975	9,150	9.7	8,166	10.0	9.016	5.2
1976	9,090	- 0.7	7,717	- 5.5	9,317	3.3
1977	9.413	3.6	7,920	2.6	9,309	- 0.1
1978	10,136	7.7	8,404	6.1	10,017	7.6
1979	9,889	- 2.4	8,560	1.9	11,154	11.4
1980	10,049	1.6	8,560	0	12,420	11.4
1981	10,149	1.0	8,740	2.1	12,971	4.4
1982	10,289	1.4	8,930	2.2	13,547	4.4
1983	10,415	1.2	9,140	2.4	14,149	4.4
1984	10,542	1.2	9,350	2.3	14,777	4.4
1985	10,680	1.3			15,433	4.4
1986	10,818	1.3			16,118	4.4
1987	10,965	1.4			16,834	4.4
1988	11,133	1.5			17,582	4.4

* Earlier data not available.

TABLE 1.1-22

DISTRIBUTION OF ENERGY CONSUMPTION BY CATEGORY
ACTUAL 1964-1979, PROJECTED 1984
IN PERCENT

Category	1964	1969	1974	1979	1984
	Kansas Gas & Electric Company				
Residential	22.5	19.4	24.9	25.4	24.4
Commercial	17.5	14.8	18.6	19.4	20.5
Industrial	45.0	32.1	38.2	37.7	37.7
	Kansas City Power and Light Company				
Residential	25.9	28.2	29.7	28.7	29.9
Commercial	37.5	38.8	38.0	37.7	36.6
Industrial	32.1	28.9	28.0	28.7	28.4
	Kansas Electric Power Cooperatives*				
Residential			58.2	54.2	45.6
Comm. & Ind.			35.9	37.4	43.2
Irrigation			4.0	7.5	9.7

* Earlier data not available. 1984 distribution includes that of energy sold to Sunflower Cooperative.

TABLE 1.1-23

AVERAGE ANNUAL COSTS* BY CONSUMER CATEGORY
1971-1984
IN CENTS PER KWH**

	KG&E			KCPL			KEPCo		
Year	Residential	Commercial	Industrial	Residential	Commercial	Industrial	Residential	Commercial & Industrial	Irrigation
1971	1.99	1.96	1.04	2.66	2.21	1.28			
1972	1.96	1.94	1.04	2.63	2.20	1.30			
1973	1.95	1.96	1.06	2.76	2.32	1.39			
1974	2.17	2.24	1.24	3.01	2.57	1.58	2.69	2.28	2.65
1975	2.59	2.67	1.68	3.46	2.93	1.95	3.16	2.79	3.28
1976	2.82	2.86	1.91	3.86	3.28	2.20	3.80	3.24	3.78
1977	3.43	3.45	2.43	4.10	3.52	2.39	4.28	3.68	4.59
1978	3.78	3.82	2.72	4.54	3.90	2.67	4.72	4.19	5.32
1979	3.99	4.05	2.93	4.94	4.21	2.96	5.10	4.51	5.71
1980	4.07	4.13	3.01	5.64	4.89	3.49			
1981	4.15	4.21	3.09	5.88	5.13	3.72			
1982	4.27	4.33	3.21	5.73	5.01	3.61			
1983	4.17	4.23	3.11	5.54	4.84	3.47			
1984				5.57	4.89	3.51			

* Actual through 1978. Estimated thereafter.

** Missing data are not available.

TABLE 1.1-24

ECONOMIC GROWTH INDICATORS[a]
EMPLOYMENT AND UNEMPLOYMENT

Year	Employment: Total Non Agric.	Employment: Manufac-turing	Employment: Construc-tion	Employment: Trade	Employment: Services	Employment: Aircraft and Parts	Unemploy-ment	Population	Unemploy-ment U.S.
Wichita SMSA[b]									
1970	139,133	57,346	6,104	32,317	24,846	20,867	8.1	389,352	4.9
1971	132,683	45,054	6,163	31,342	24,550	15,650	9.1		5.9
1972	142,079	41,042	6,913	33,254	25,100	19,413	5.7		5.6
1973	153,763	48,558	6,983	35,263	27,129	24,404	3.6		4.9
1974	165,025	50,917	8,567	36,483	28,863	27,825	3.7		5.6
1975	167,962	52,442	7,563	36,883	30,354	30,221	5.7		8.5
1976	169,979	51,221	8,458	37,683	31,013	28,950	5.4		7.7
1977	175,942	51,317	10,008	38,425	32,521	27,829	4.8	394,900	7.0
1978	186,688	58,800	9,233	37,675	34,033	33,654	3.5		6.0
Sep '79		69,500	13,000	44,500	37,110		2.7		5.8
State of Kansas[b]									
1972	776,828	138,033	32,342	161,267	104,583		4.0	2,249,071 (1970)	
1973	836,250	157,717	34,958	175,842	113,450		3.1		
1974	891,183	163,058	36,792	181,150	122,525		3.4		
1975	1,000,767	161,883	36,800	182,642	132,642		4.6		
1976	872,456	161,733	41,308	201,225	139,958		4.2		
1977	994,900	168,642	44,142	209,558	148,833		4.1	2,320,996	
1978	1,045,083	183,258	44,200	215,708	154,550		3.2		
Sep '79		195,900	56,900	226,500	166,800		2.5		
Kansas City SMSA[c]									
1971	511,400	117,600	25,900	126,400	82,300		5.6	1,273,926 (1970)	
1972	526,300	118,500	27,500	131,700	86,900		4.3		
1973	549,600	122,100	26,900	138,500	95,400		4.2		
1974	554,300	117,000	25,200	141,500	99,900		4.6		
1975	550,000	108,600	25,000	140,700	103,600		6.8		
1976	571,200	114,100	24,700	146,100	110,800		6.0		
1977	595,500	119,700	24,400	153,500	116,600		5.7		
1978	617,800	123,600	28,000	157,700	120,700		4.2	1,317,600	
Sep '79	629,200	124,000	32,900	156,200	128,500		4.3		
State of Missouri[c]									
1971	1,655,000	427,100	71,300	379,200	262,700		4.9	4,677,623 (1970)	
1972	1,699,300	438,300	72,000	391,900	274,900		4.2		
1973	1,770,500	457,000	75,800	407,800	293,900		3.9		
1974	1,790,500	450,000	72,800	418,500	304,900		4.6		
1975	1,740,600	405,300	69,500	412,000	311,600		6.8		
1976	1,797,800	424,900	72,200	428,500	326,500		6.2		
1977	1,861,800	439,600	77,800	446,100	340,700		5.9	4,860,000	
1978	1,927,900	452,800	82,200	461,400	349,700		5.0		
Sep '79	1,975,100	448,100	93,000	474,200	365,100		4.5		

(a) Yearly averages
(b) Source, Center for Business and Economic Research
Wichita State University
(c) Source, Employment and Earnings
U.S. Dept. of Commerce

TABLE 1.1-25

KG&E

COMPARISON OF FORECAST AND ACTUAL PEAK LOADS AND
ENERGY BY YEARS 1972-1978 AND MONTHS 1977-1979

Forecast Month & Year	Forecast Date Made	Peak Load Forecast MW	Peak Load Actual MW	Peak Load Difference %	Forecast Date	Energy Sales Forecast GWH	Energy Sales Actual GWH	Energy Sales Difference %
1972	12/21/71	1130	1137	- 0.6	12/21/71	5209	5225	- 0.3
1973	*	*	1202	*	*	*	5516	*
1974	1/10/74	1350	1325	1.9	1/10/74	6268	5799	7.5
1975	1/28/75	1410	1337	5.2	1/28/75	6266	6199	1.1
1976	2/18/76	1460	1387	5.0	2/18/76	6845	6442	5.9
1977	2/21/77	1495	1423	4.8	2/21/77	6776	6685	1.3
1978	4/11/78	1540	1533	1.5	4/11/78	7231	7184	0.4
1979	3/29/79	1585	1473	7.1	3/29/79	7629		
Jan 1977	1/20/77	1020	1016	0.4		*	596	*
Feb		956	934	2.3			482	
Mar		897	872	2.8			507	
Apr		867	847	2.3			469	
May		1030	943	8.6			509	
Jun		1300	1276	1.8			617	
Jul		1495	1423	4.8			731	
Aug		1495	1404	6.1			657	
Sep		1375	1180	14.2			553	
Oct		1020	804	21.2			490	
Nov		971	906	6.7			506	
Dec		1047	1039	0.8			568	
					Total		6685	
Jan 1978	1/16/78	1050	1056	- 0.6	11/23/77	611	621	- 1.6
Feb		980	1018	- 3.9		525	547	- 4.2
Mar		920	1009	- 9.7		553	539	2.5
Apr		890	832	6.5		514	475	7.6
May		1060	1117	- 5.4		560	527	5.9
Jun		1340	1379	- 2.9		625	623	0.3
Jul		1540	1491	3.2		767	787	- 2.6
Aug		1540	1533	0.5		737	743	- 0.8
Sep		1400	1458	- 4.1		581	655	-12.3
Oct		1050	954	9.1		561	525	6.4
Nov		1000	987	1.3		559	535	4.3
Dec		1080	1112	- 3.0		619	606	2.1
					Total	7213	7184	0.4
Jan 1979	2/14/79	1120	1120	0.0	12/31/78	661	669	- 1.2
Feb		1100	1098	0.2		572	575	- 0.5
Mar		1020	940	7.8		596	552	7.4
Apr		920	915	0.5		540	502	7.0
May		1100	967	12.1		554	529	4.5
Jun		1400	1369	2.2		685	606	11.5
Jul		1585	1459	7.9		821	741	10.8
Aug		1585	1473	7.1		774	719	7.6
Sep		1500	1348	10.1		614	593	3.5
Oct		1000	1027	- 2.7		575	549	4.7
Nov		1040	1032	0.8		594	557	6.6
Dec		1160	1060	9.4		643	596	7.9
					Total	7629	7189	6.1

* Not available

TABLE 1.1-26

KCPL

COMPARISON OF FORECAST AND ACTUAL PEAK LOADS AND ENERGY BY YEARS 1972-1979 AND MONTHS 1977-1978

Forecast Month & Year	Forecast Date Made	Peak Load Forecast MW	Peak Load Actual MW	Peak Load Difference %	Forecast Date	Energy Sales Forecast GWH	Energy Sales Actual GWH	Energy Sales Difference %
1972	10/21/71	1700	1676	1.4	10/27/71	6573	6614	- 0.6
1973	10/31/72	1800	1757	2.4	11/01/72	6944	7081	- 2.0
1974	11/12/73	1900	1907	- 0.4	11/12/73	7554	6970	7.3
1975	10/02/74	1940	1903	1.9	10/31/74	7330	7247	1.3
1976	3/25/76	1995	1920	3.8	3/25/76	7831	7436	5.0
1977	11/09/76	2035	1980	2.7	11/09/76	8069	7900	2.1
1978	9/26/77	2110	2097	0.6	9/26/77	8366	8359	0.1
	11/09/76				11/09/76			
Jan 1977		1205	1215	- 0.8		633	656	- 3.6
Feb		1215	1156	4.9		598	624	- 4.4
Mar		1140	1106	3.0		581	614	- 5.7
Apr		1175	1178	- 0.3		588	549	6.6
May		1470	1403	4.6		604	590	2.3
Jun		1855	1670	10.0		629	655	- 4.1
Jul		2035	1956	3.9		769	801	- 4.2
Aug		2035	1980	2.7		828	820	1.0
Sep		1910	1641	14.1		876	758	13.5
Oct		1285	1108	13.8		691	647	6.4
Nov		1210	1183	2.2		641	579	9.7
Dec		1260	1255	0.4		631	607	3.8
					Total	8069	7900	2.1
	11/26/77				11/26/77			
Jan 1978		1250	1274	- 1.9		673	668	0.7
Feb		1260	1276	- 1.3		646	659	- 2.0
Mar		1180	1199	- 1.6		632	652	- 3.2
Apr		1215	1156	4.9		590	618	- 4.8
May		1530	1500	2.0		613	587	4.2
Jun		1930	1953	- 1.2		667	653	2.1
Jul		2110	2052	2.8		809	778	3.8
Aug		2110	2097	0.6		867	845	2.5
Sep		2005	2050	- 2.2		878	871	0.8
Oct		1325	1254	5.4		700	734	- 4.9
Nov		1255	1243	1.0		645	637	1.2
Dec		1300	1286	1.1		646	657	- 1.7
					Total	8366	8359	0.1

* Due to a strike no forecast was made for 1979 in 1978.

TABLE 1.1-27

KG&E and KCPL

INTERCHANGE BUDGET FOR 1983-84

KG&E

	1983		1984	
	Energy In MWH	Capacity In MW	Energy In MWH	Capacity In MW
Purchases				
Firm	0	0	0	0
Non-firm	400,000	0	400,000	0
Total	400,000	0	400,000	0
Sales				
Firm	240,000	55	240,000	70
Non-firm	760,000	50	760,000	30
Total	1,000,000	105	1,000,000	100

KCPL

Purchases				
Firm	59,250	25	59,250	25
Non-firm	310,739	-	346,739	-
Total	369,989	25	405,989	25
Sales				
Firm	58,065	25	58,065	25
Non-firm	574,600	-	572,400	-
Total	632,665	25	630,465	25

TABLE 1.1-28

KG&E

MONTHLY LOADS AND INTERCHANGE,
FIRST TWO YEARS WITH WCGS IN SERVICE

Year	Month	Peak (MW)	Energy (1000 MWH)	Purchases (1000 MWH)	Sales (1000 MWH)
1983	Jan	1250	740	60	90
	Feb	1253	620	60	90
	March	1150	618	30	80
	April	1040	570	20	80
	May	1240	600	20	70
	June	1580	705	30	80
	July	1790	830	40	70
	August	1790	784	40	70
	Sept.	1690	670	20	80
	Oct.	1130	590	20	90
	Nov.	1170	645	20	100
	Dec.	1300	696	40	100
1984	Jan.	1310	772	60	90
	Feb.	1290	647	60	90
	March	1200	645	30	80
	April	1090	595	20	80
	May	1300	625	20	70
	June	1650	735	30	80
	July	1875	865	40	70
	August	1875	820	40	70
	Sept.	1770	695	20	80
	Oct.	1180	615	20	90
	Nov.	1225	675	20	100
	Dec.	1365	728	40	100

TABLE 1.1-29

KCPL

MONTHLY LOADS AND INTERCHANGE,
FIRST TWO YEARS WITH WCGS IN SERVICE

Year	Month	Peak (MW)	Energy (1000 MWH)	Purchases (1000 MWH)	Sales (1000 MWH)
1983	March	1445	778	27	48
	April	1416	743	1	48
	May	1784	789	9	50
	June	2282	960	16	46
	July	2398	1111	29	46
	August	2398	1136	30	48
	Sept.	2388	899	10	46
	Oct.	1510	796	11	50
	Nov.	1510	731	13	46
	Dec.	1442	788	5	50
1984	Jan.	1485	801	28	48
	Feb.	1496	778	28	46
	March	1469	789	34	48
	April	1438	753	29	48
	May	1827	804	17	48
	June	2368	1002	36	48
	July	2485	1135	38	46
	August	2485	1174	45	48
	Sept.	2474	918	30	46
	Oct.	1539	815	21	50
	Nov.	1456	735	16	46
	Dec.	1466	777	30	48

TABLE 1.1-30

PROJECTED FUEL MIX
FIRST THREE YEARS OF PLANNED OPERATIONS WITH AND
WITHOUT WCGS (TOTAL GENERATION)
IN PERCENT

	Nominal Case						Conservative Case					
	1983		1984		1985		1983		1984		1985	
Fuel Type	With WCGS	Without WCGS	With WCGS	Without WCGS	With WCGS	Without WCGS	With WCGS	Without WCGS	With WCGS	Without WCGS	With WCGS	Without WCGS
KG&E												
Coal	55.6	55.6	56.7	56.7	57.2	57.2	55.6	55.6	56.7	56.7	57.2	57.2
Oil	0.5	11.2	0.4	13.7	0.3	15.3	0.5	11.2	0.4	13.7	0.3	15.3
Gas	22.6	33.1	18.0	29.6	13.7	27.4	22.6	33.1	18.5	29.6	15.9	27.4
Nuclear	21.3	0	25.0	0	28.7	0	21.3	0	24.4	0	26.6	0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
KCPL												
Coal	67.6	92.6	68.4	92.5	67.9	90.9	71.7	92.6	72.0	92.5	71.4	90.9
Oil	2.9	5.5	3.4	5.7	4.2	6.9	3.1	5.5	3.6	5.7	4.5	6.9
Gas	1.1	1.9	0.8	1.8	0.9	2.2	0.9	1.9	0.9	1.8	0.9	2.2
Nuclear	28.4	-	27.4	-	27.0	-	24.3	-	23.5	-	23.2	-
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NOTE: May not add due to rounding.

TABLE 1.1-31

PROJECTED FUEL MIX PEAK DAY
GENERATION PERCENTAGE DISTRIBUTION

Fuel	1980	1985 With WCGS	1985 Without WCGS	1990 With WCGS	1990 Without WCGS
KG&E					
Coal	50	43	50	46	46
Oil	0				
		30	43	30	44
Gas	50				
Nuclear	-	27	0	24	0
Purchases	0	0	7	0	10
Total	100	100	100	100	100
KCPL					
Coal	85	77	77	79	79
Oil	8	3	15	5	12
Gas	7	3	3	2	2
Nuclear	-	17	0	14	0
Purchases	0	0	5	0	7
Total	100	100	100	100	100

TABLE 1.1-32

KG&E ACTUAL AND PROJECTED FUEL COSTS
1979-1990

Month & Year	Coal $/Ton	Coal ¢/MMBTU	Oil $ Bbl	Oil ¢/MMBTU	Gas $/MCF	Gas ¢/MMBTU	Nuclear ¢/MMBTU	System ¢/MMBTU
1979								
Jan	15.37	84.83	10.93	173.49	1.40	140.00	-	116.44
Feb	15.55	85.78	11.10	176.19	1.42	142.00	-	116.30
Mar	16.35	86.62	11.19	177.62	1.44	144.00	-	133.44
Apr	15.99	89.97	11.29	179.21	1.48	148.06	-	128.89
May	15.75	88.22	-	-	1.49	149.30	-	112.45
Jun	16.11	89.18	11.13	176.67	1.51	151.28	-	118.53
Jul	16.14	89.70	11.11	176.35	1.52	152.52	-	122.26
Aug	16.45	91.96	11.05	175.40	1.54	153.52	-	121.61
Sep	16.44	91.26	-	-	1.55	154.78	-	119.25
Oct	16.44	92.04	11.02	174.92	1.56	155.91	-	133.62
Nov	16.85	95.18	11.12	176.51	1.58	158.25	-	124.56
Dec	17.29	97.19	11.13	176.67	1.62	162.00	-	127.96
1980								
Jan	15.84	91.52	12.27	194.76	1.36	138.00	-	139.15
Feb	15.83	91.41	12.64	200.63	1.38	140.00	-	125.56
Mar	16.48	90.34	13.06	207.30	1.57	158.83	-	132.99
Apr	16.19	90.30	-	-	1.52	154.51	-	117.85
May	16.11	92.54	-	-	1.58	159.95	-	125.13
Jun	16.21	91.75	-	-	1.61	163.93	-	117.02
Jul	16.14	91.99	-	-	1.66	168.29	-	121.54
Aug	16.05	91.71	-	-	1.68	170.08	-	126.83
Sep	16.20	92.20	-	-	1.67	168.88	-	122.75
Oct	16.16	94.47	-	-	1.71	173.10	-	139.98
Nov	16.58	93.56	-	-	1.68	170.13	-	123.48
Dec	16.38	94.28	-	-	1.68	171.05	-	122.63
By Year								
1979	16.17	90.18	11.12	176.41	1.50	151.64	-	122.72
1980	16.16	92.23	12.39	196.67	1.60	162.61	-	126.19
1981	16.78	95.85	15.87	251.90	1.84	186.64	-	134.73
1982	19.26	109.61	21.00	333.33	2.12	214.51	-	162.32
1983	20.70	118.12	23.10	366.67	2.33	236.04	63.95	132.75
1984	21.91	125.85	25.41	403.33	2.53	257.05	65.09	133.89
1985	23.07	132.25	27.95	443.65	2.76	280.49	66.07	133.16
1986	24.14	139.00	30.75	488.10	3.09	313.53	75.09	139.71
1987	25.23	145.45	33.82	536.83	2.43	348.32	84.02	149.12
1988	26.64	153.20	37.20	590.48	3.79	384.39	87.41	166.93
1989	28.07	162.00	40.92	649.52	4.12	417.95	91.52	184.11
1990	29.68	170.82	42.10	712.93	4.23	429.00	96.70	227.35

TABLE 1.1-33

KCPL ACTUAL AND PROJECTED FUEL COSTS
1979-1990

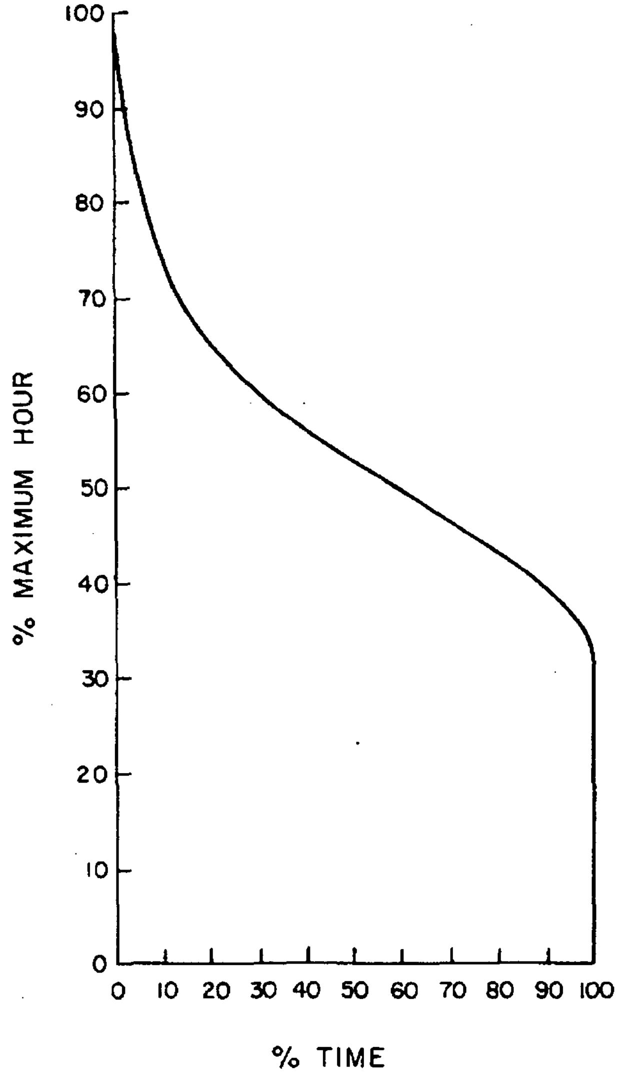
Month & Year	Coal $/Ton	Coal ¢/MMBTU	Oil $ Bbl	Oil ¢/MMBTU	Gas $/MCF	Gas ¢/MMBTU	Nuclear ¢/MMBTU	System ¢/MMBTU
1979								
Jan	15.20	77.03	15.11	264.38	4.07	642.11		88.97
Feb	15.55	78.19	15.34	268.49	1.23	132.69		94.30
Mar	16.77	83.39	14.87	263.62	0.99	130.66		93.56
Apr	16.76	84.95	14.88	260.68	0.84	130.93		93.67
May	16.21	83.76	13.48	250.44	1.01	127.82		92.42
Jun	16.56	84.51	15.25	268.22	1.10	131.49		98.65
Jul	16.52	85.23	15.27	268.80	1.09	131.21		98.35
Aug	16.83	85.87	15.40	268.72	1.14	130.99		97.12
Sep	16.85	86.67	13.50	241.79	1.05	131.97		95.93
Oct	17.58	90.87	15.27	263.53	1.06	128.22		106.10
Nov	16.95	86.69	14.75	259.01	0.81	132.65		97.59
Dec	17.02	87.67	12.58	202.19	1.00	130.77		93.84
1980								
Jan	17.55	91.47	31.37	544.41	0	0		110.86
Feb	18.62	96.96	30.93	535.34	0	0		120.78
Mar	19.19	99.44	30.73	532.67	1.56	164.35		129.00
Apr	18.29	95.65	31.23	537.47	1.56	165.04		123.38
May	17.89	96.49	32.06	556.09	1.57	165.38		113.49
Jun	18.20	97.86	31.76	545.23	1.57	164.90		115.91
Jul	18.37	98.51	31.80	543.77	1.57	165.10		116.09
Aug	18.15	98.22	31.82	552.84	1.57	164.95		111.75
Sep	18.83	100.81	31.93	546.39	1.56	164.58		113.42
Oct	18.83	102.57	30.97	537.35	1.57	164.46		122.66
Nov	18.20	99.87	32.48	555.13	1.60	160.00		112.30
Dec	19.17	102.20	31.59	544.35	0	0		118.56
By Year								
1979	16.6	84.5	15.0	263.2	1.07	132.3		96.0
1980	19.3	103.5	31.5	542.0	1.57	165.0		122.2
1981	21.5	115.9	34.1	586.9	1.72	181.5		137.5
1982	23.1	124.1	37.2	641.5	1.90	199.6		148.2
1983	24.4	132.6	41.1	709.7	2.09	219.7	59.1	132.0
1984	26.1	141.6	44.4	765.5	2.22	241.7	59.8	144.9
1985	27.3	148.7	48.0	827.2	2.53	265.7	60.5	159.2
1986	28.7	156.4	52.0	897.1	2.78	292.3	61.2	173.5
1987	30.2	164.5	56.6	975.1	3.05	321.5	62.0	186.3
1988	32.0	174.2	61.2	1055.7	3.36	353.6	62.7	203.6
1989	32.3	178.6	67.6	1164.9	3.70	389.2	63.5	204.1
1990	33.9	187.4	73.7	1271.2	4.06	428.0	64.2	216.8

TABLE 1.1-34

FUEL COSTS AS A PERCENTAGE OF TOTAL
OPERATING COSTS
1968-1984

Year	KG&E**	KCPL
1968	22.6	33.2
1969	24.8	45.6
1970	24.7	51.1
1971	25.6	53.6
1972	25.1	51.5
1973	27.5	50.7
1974	30.7	57.5
1975	39.8	54.0
1976	37.5	60.0
1977	45.2	67.6
1978	48.1	66.9*
1979		54.3
1980		70.2
1981		74.1
1982		74.7
1983		76.1
1984		75.8

*Outages caused this anomaly
**Missing data are not available

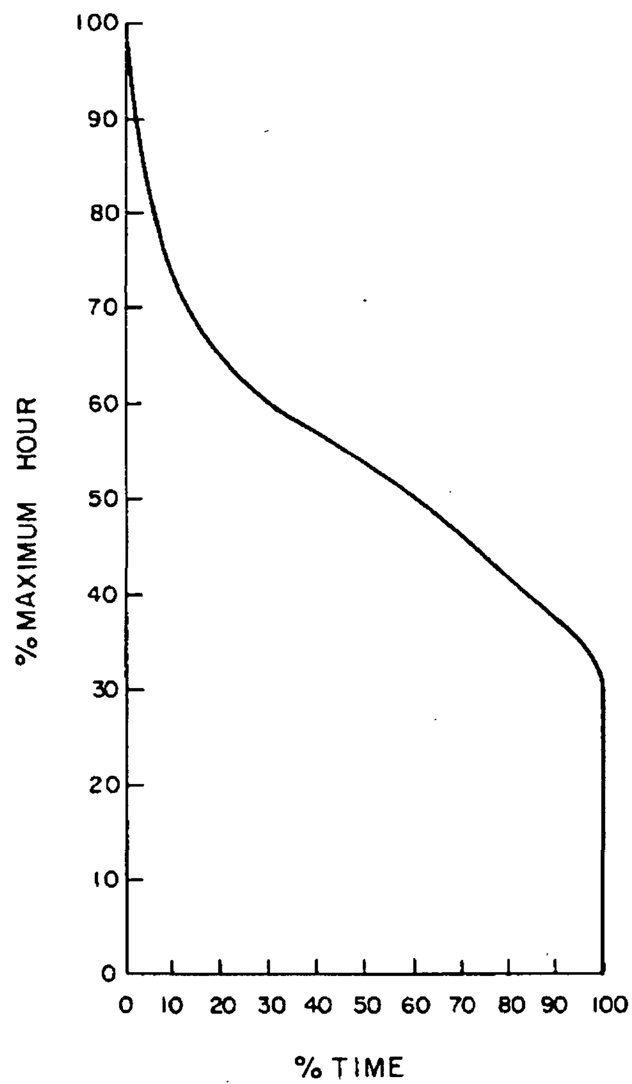


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-1

KG&E LOAD DURATION CURVE

1983

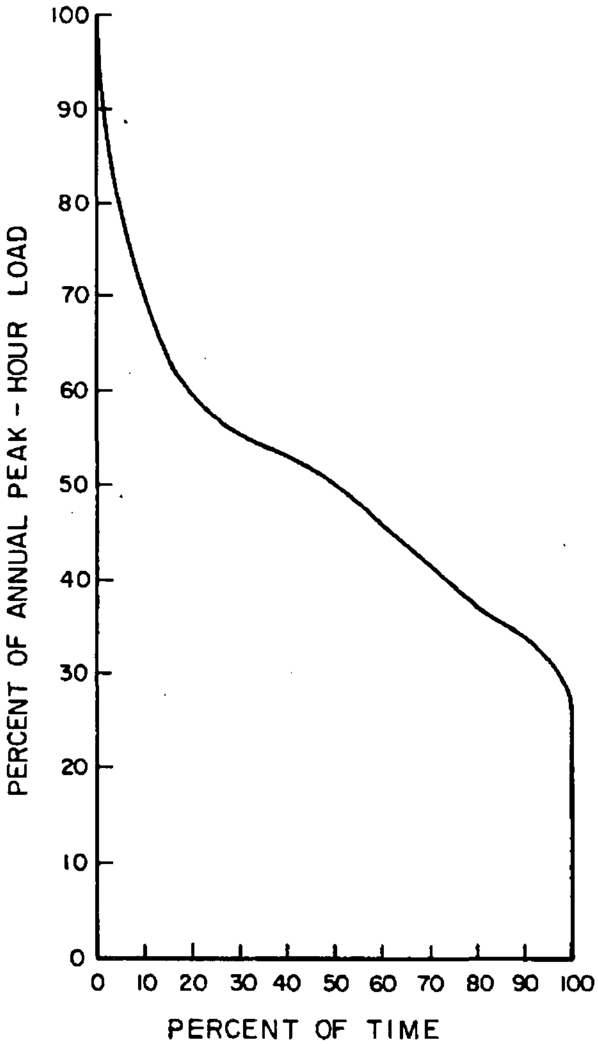


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-2

KG&E LOAD DURATION CURVE

1984

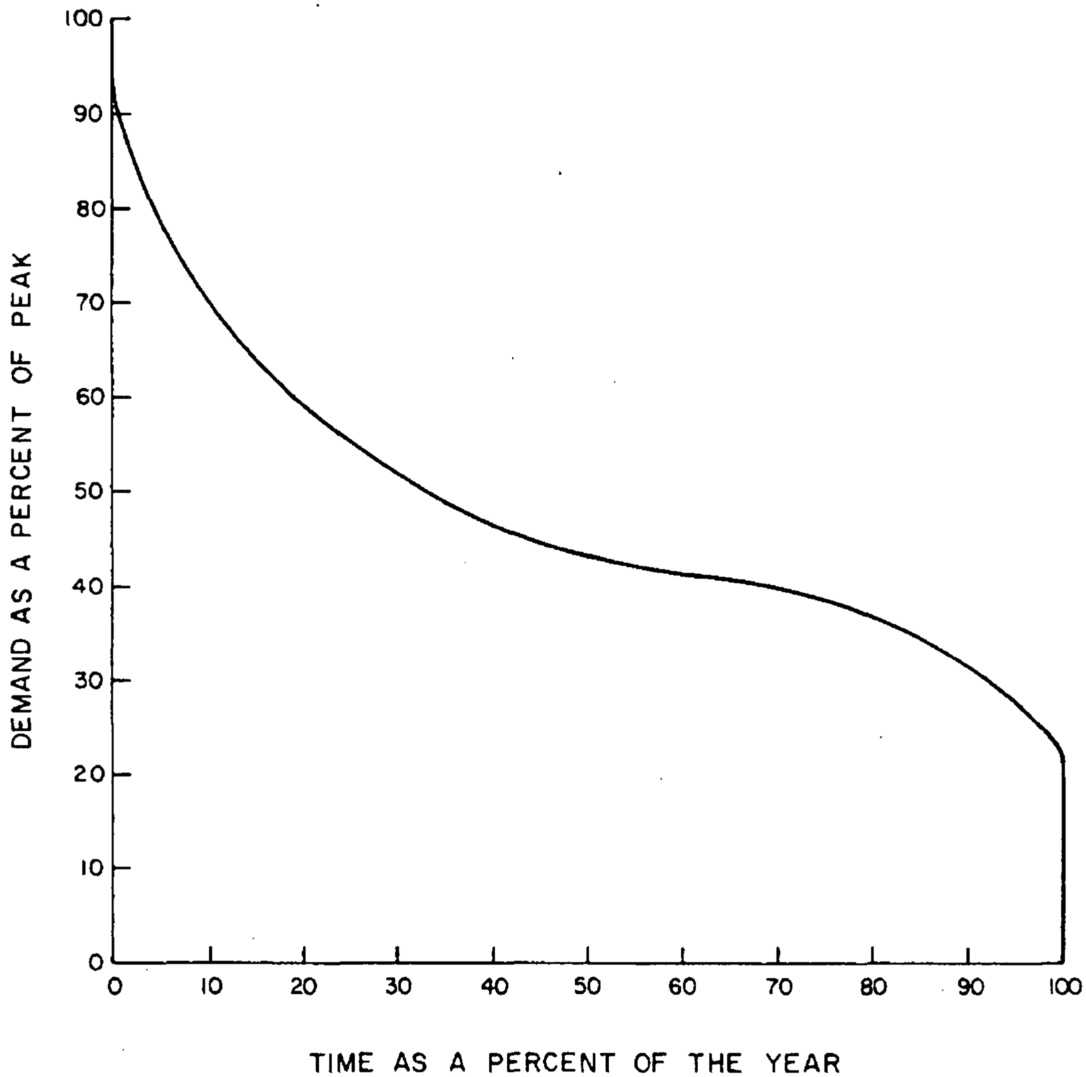


WOLF CREEK GENERATING STATION
UNIT NO. I
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-3

KCPL LOAD DURATION CURVE

1983-1984

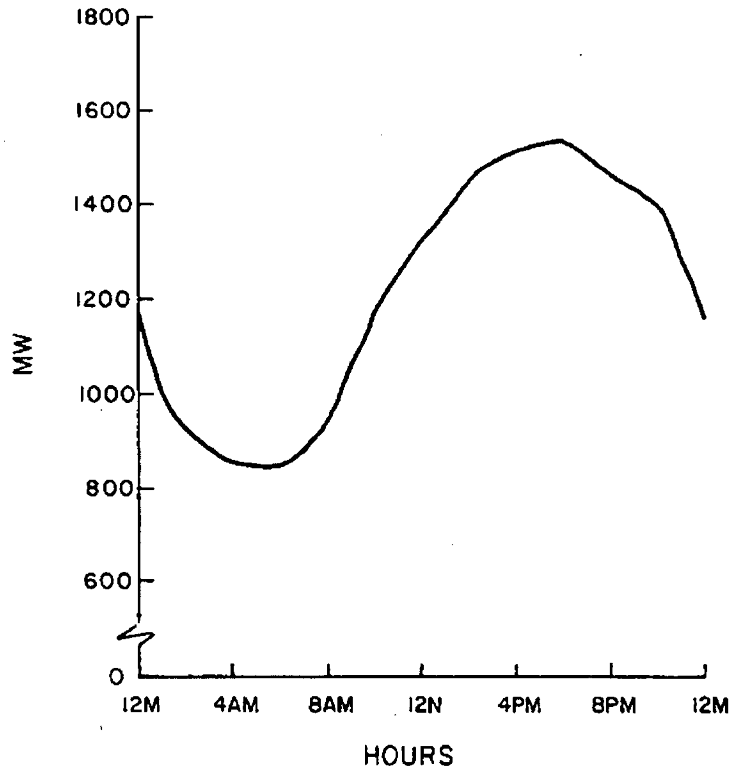


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-4

KEPCo LOAD DURATION CURVE

1983-1984

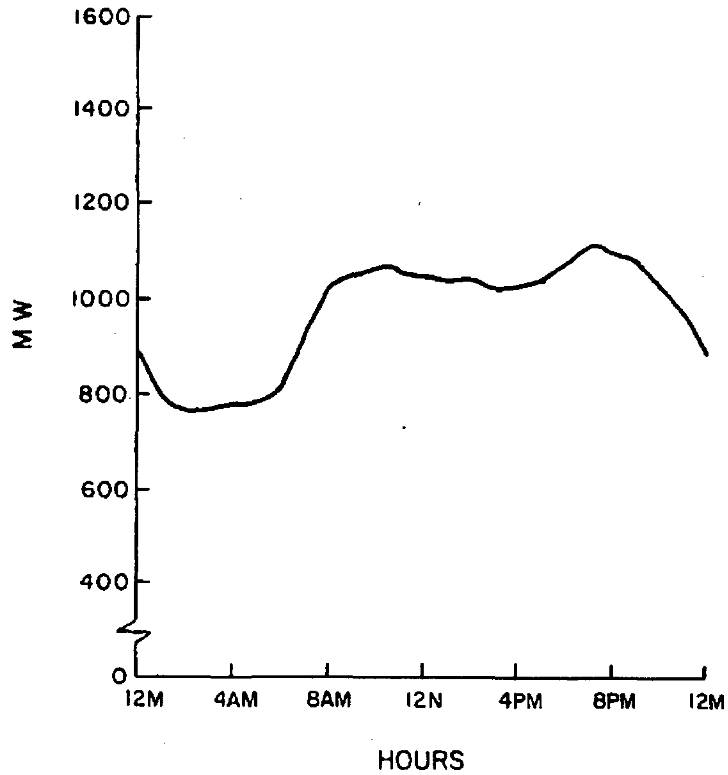


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-5

KG&E HOURLY LOAD CURVE

SUMMER PEAK DAY 1978

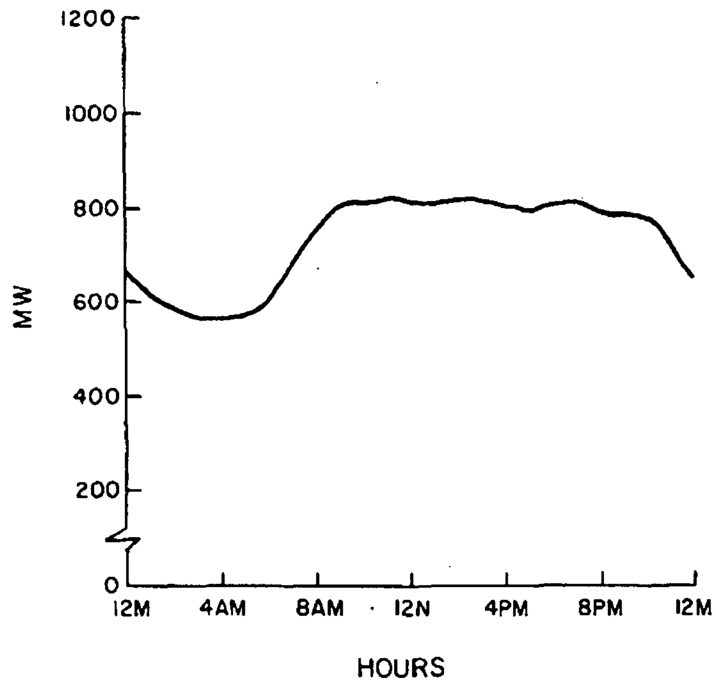


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-6

KG&E HOURLY LOAD CURVE

WINTER PEAK DAY 1979

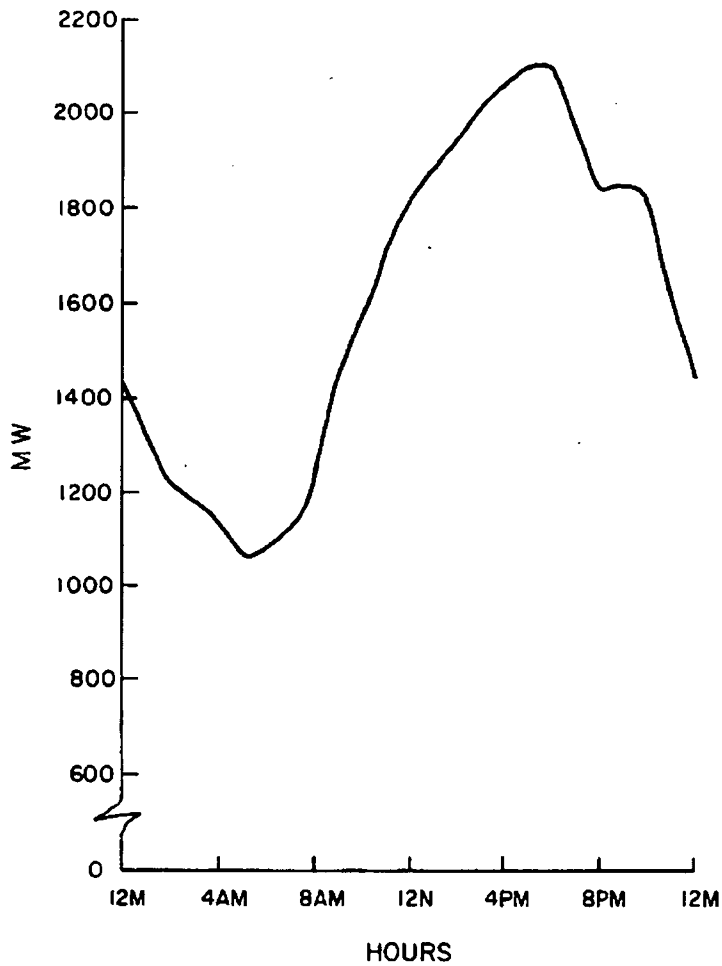


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-7

KG&E HOURLY LOAD CURVE

TYPICAL SPRING-FALL DAY

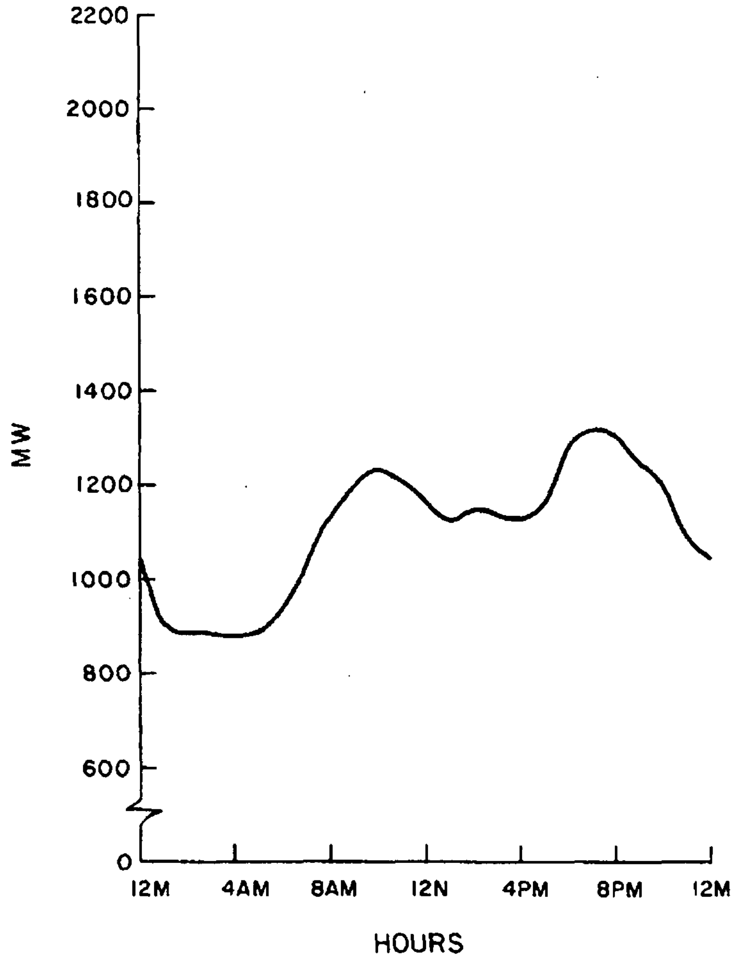


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-8

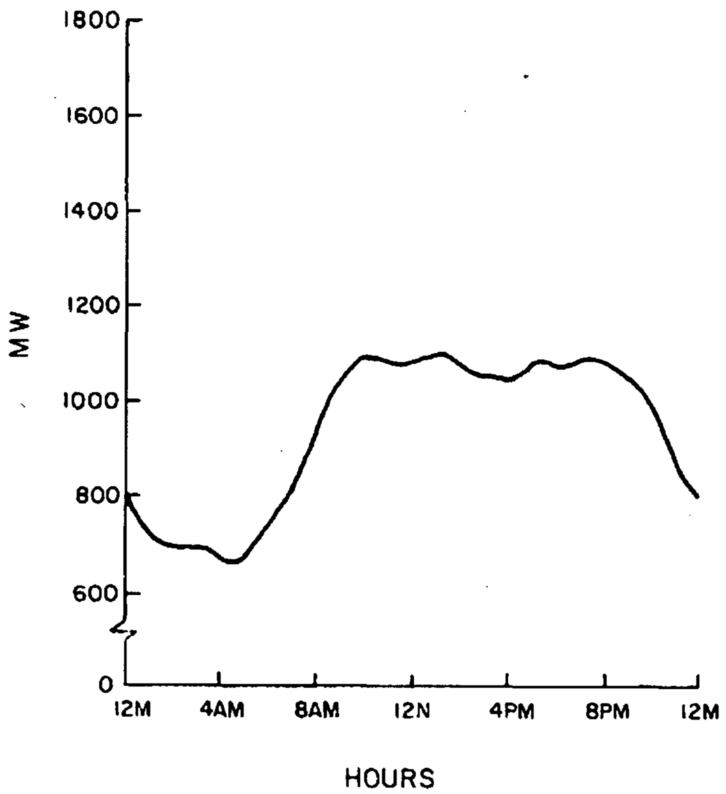
KCPL HOURLY LOAD CURVE

SUMMER PEAK DAY 1978



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-9
KCPL HOURLY LOAD CURVE
WINTER PEAK DAY 1979

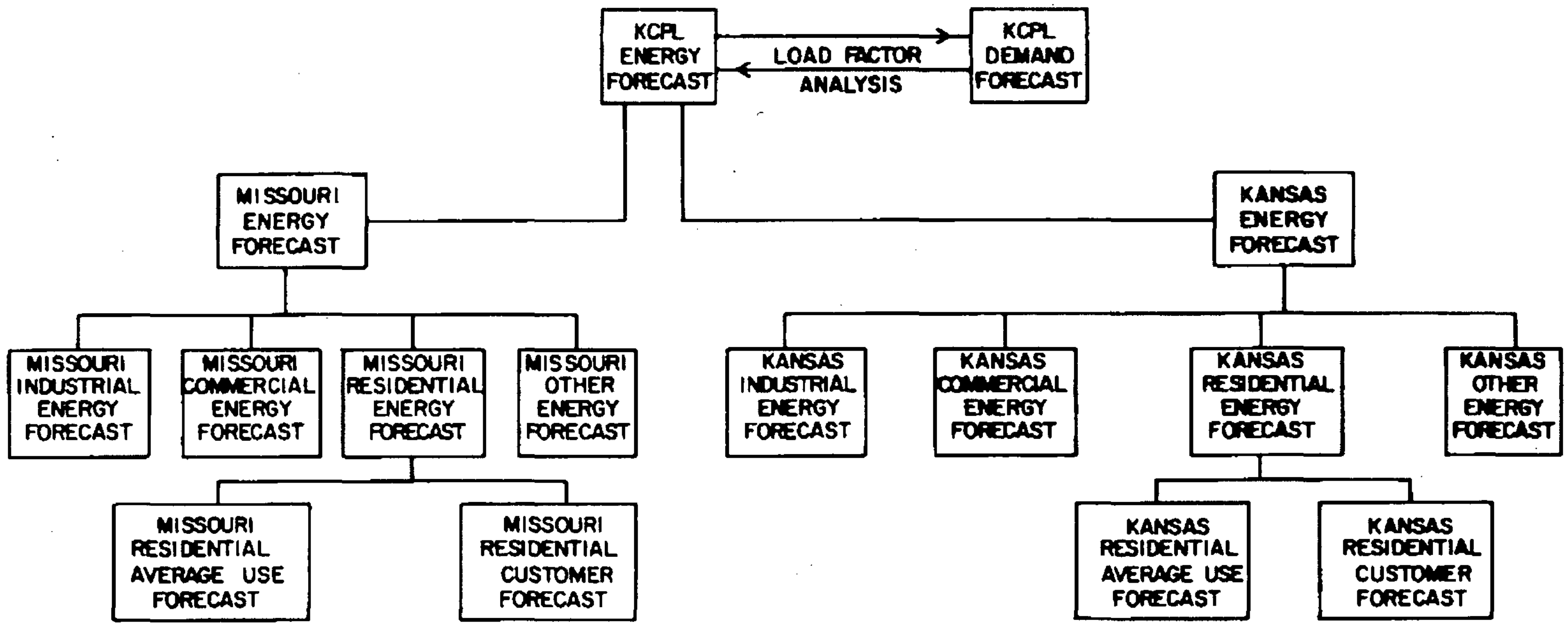


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-10

KCPL HOURLY LOAD CURVE

TYPICAL SPRING-FALL DAY



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 1.1-11

KCPL Econometric Model

Forecast Diagram

1.2 OTHER OBJECTIVES

There are no other objectives to be met by the operation of WCGS than the production of power and energy to be used in the service areas of the Applicants.

1.3 CONSEQUENCES OF DELAY

The consequences of delay will be serious for each of the Applicants in terms of declining margins, increasing fuel costs, consuming additional quantities of replacement fossil fuels, and incurring higher financing costs.

1.3.1 EFFECTS OF DELAY ON RESERVE MARGINS

The following table shows for KG&E and KCPL the reduced reserve margins that will exist with a one, two, or three year delay on WCGS:

RESERVE MARGINS IN PERCENT WITHOUT WCGS

Year	Length of Delay	KG&E	KCPL	MOKAN	SPP
1983	One year	18.3%	16.5%	14.5%	18.2%
1984	Two years	12.9	12.4	12.9	18.1
1985	Three years	15.5	8.5	14.8	17.2

With a one year delay, KG&E's margin would be within requirements. KCPL's would be below its internal requirement of 20 percent but within MOKAN's and SPP's requirements. MOKAN would fall below its margin requirement while SPP would be within its margin. However, both MOKAN and SPP are projecting capacity increases of over 30 percent between 1979 and 1983. It is likely that there will be delays for some of this planned capacity which means that the margins will be lower.

Though not listed, KEPCo would have no owned capacity because WCGS will represent its first block of owned capacity. KEPCo will sell 60 MW of its WCGS capacity to the Sunflower Electric Cooperative, but without WCGS the generation reserve margin for the Sunflower system will drop from -49 MW to -109 MW. Sunflower plans to construct a 280 MW coal-fired unit near Holcomb, Kansas, but construction on that plant has not begun, and it is improbable that the unit will be in operation in 1983. Though power might be available to KEPCo and Sunflower in the region or from adjacent regions the economic consequences would be severe since the cooperatives would have to make commitments to transmit power across the state and to purchase makeup power at relatively high cost.

A two year delay would bring both KG&E and KCPL below internal and pool requirements. Both companies would be required by MOKAN to pay capacity charges because of the reserve margin deficiencies.

The MOKAN margin would have declined further to 12.9 percent, and the projected margin for SPP would remain about the same. Of significance, though, are projected capacity increases of 37.5 percent by MOKAN and 40.0 percent by SPP in the period 1979-1984. With delays, the margins shown are likely to be even lower.

KEPCo would still have no reserve margin and would be forced to make arrangements for transmission of high cost makeup power. Sunflower's position would continue to deteriorate to a -124 MW margin if the fossil plant were not on line.

With a three year delay KG&E would have added capacity to bring its reserve margin within requirements, but KCPL's margin would have declined to 8.5 percent. The MOKAN reserve margin would be below requirement, but the projected margin for SPP would be within requirements. Again it is noted that MOKAN and SPP margins are based on increases in capacity between 1979 and 1985 of 45 percent for MOKAN and 47 percent for SPP. It is highly unlikely that all of this capacity will be installed on schedule.

KEPCo would still have no reserve margin and would have to make arrangements for purchase and transmission of high cost makeup power. By that time, it is assumed that Sunflower would have its new plant, but if not, it would have a reserve margin of -140 MW.

If no WCGS capacity were to be added, the effects would be the same as those for the delays except that the cooperatives would be better able to plan for long term commitments on power purchase and transmission, if both are available. It is unlikely that a new coal-fired plant could be planned and constructed so as to be in operation by 1983 to 1985. The option of purchasing capacity from neighboring utilities would probably not exist. Large blocks of power would not be available; other companies in the region are experiencing delays in bringing plants on line and in obtaining financing for new plants.

1.3.2 EFFECTS OF DELAY ON FUEL CONSUMPTION

There would be greater consumption of fossil fuels with substantially higher costs if there were a delay in the operation of WCGS. The following table summarizes the fuel consumption and costs per year, with cumulatives also given.

ADDITIONAL FUEL CONSUMPTION AND COSTS WITHOUT WCGS AND WITH INDICATED DELAYS

Fuel	Measure	1983 One Year Delay	1984 Two Year Delay	1984 Cumulative	1985 Three Year Delay	1985 Cumulative
			KG&E			
Coal	(000) Bbls	1,667	2,197	3,864	2,580	6,444
Oil	MMCF	10,507	12,262	22,769	14,754	37,523
Net Additional Fuel Cost (000)		$52,375	$73,927	$126,302	$96,859	$223,161
			KCPL			
Coal	(000) tons	1,407	1,420	2,827	1,380	4,207
Oil	(000) Bbls	574	525	1,099	607	1,076
Gas	MMCF	2,035	2,046	4,081	2,792	6,873
Net Additional Fuel Cost (000)		$42,993	$46,024	$89,967	$54,760	$143,777

As shown, large quantities of coal, oil and gas would be burned to replace the nuclear fuel. With a three year delay, there would be additional consumption of 4.2 million tons of coal, 7.5 million barrels of oil and about 44.4 billion cubic feet of gas by the two companies at a net additional cost of nearly $367 million. This does not include additional fuel burned by other utilities that would supply KEPCo.

In addition, KEPCo and probably the Sunflower Electric Cooperative would be paying high costs for make-up power and transmission.

If the WCGS capacity were not added, these rates of consumption and related costs would continue until additional capacity could be provided.

1.3.3 EFFECTS OF DELAY ON OTHER APPLICANT COSTS

If there were a delay in the WCGS operating date other large additional costs would be incurred by the Applicants. The largest of these would be that for interest during construction, or the allowance for funds used during construction (AFUDC). These costs for plant, fuel and associated transmission are estimated as follows:

ADDITIONAL AFUDC COSTS
IN MILLIONS OF DOLLARS

Period of Delay	Annual	Cumulative
One Year	$115	$115
Two Years	166	281
Three Years	184	465

Property taxes would also have to be paid, amounting to more than $9 million per year. Costs for maintaining the plant in a secure condition after the completion of construction would amount to several million dollars per year.

Total cumulative costs for each year of delay are estimated as follows:

COSTS INCURRED WITH WCGS DELAY

Period of Delay	Cumulative Costs Incurred In Millions Of Dollars
One Year	$127
Two Years	306
Three Years	503

The impact of additional costs of this magnitude upon the applicants would be very serious.

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CHAPTER 2.0 - THE SITE AND ENVIRONMENTAL INTERFACES

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CHAPTER 2.0

THE SITE AND ENVIRONMENTAL INTERFACES

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 SITE LOCATION AND DESCRIPTION

2.1.1.1 Specification of Location

The Wolf Creek Generating Station, Unit No. 1 (WCGS) is located in eastern Kansas approximately 75 miles southwest of Kansas City, 53 miles south of Topeka, and 100 miles east-northeast of Wichita, Kansas. The plant site is near the center of Coffey County in Hampden Township, 3.5 miles northeast of the city of Burlington and 3.6 miles east of the Neosho River and the main dam at John Redmond Reservoir. Figure 2.1-1 shows the location of the site in Kansas, and Figure 2.1-2 locates it in Coffey County.

The plant site is located in Township 21 South, Range 16 East of the Sixth Principal Meridian, and Townships 20 and 21 South, Range 15 East of the Sixth Principal Meridian. The reactor is located 4,235,500 meters north and 264,600 meters east within zone 15 at Universal Transverse Mercator Coordinates Latitude 38°14'20" North and Longitude 95°41'20" West. The WCGS is a Standardized Nuclear Unit Power Plant System (SNUPPS) plant, which locates the reactor centerline at hypothetical SNUPPS coordinates Latitude 100,000 North and Longitude 100,000 East. The Kansas State plane coordinates corresponding to these hypothetical coordinates are Latitude 584,670 North and Longitude 2,807,250 East.

2.1.1.2 Site Area

Of the 11,882 acres owned by the applicant on and near to the WCGS site, 9,818 acres are occupied by the site, and 1,976 acres lie outside of the site boundary. The acreage beyond the site boundary is leased as farmland and pastureland. The railroad right-of-way to the site boundary occupies about 148 acres, 88 acres of which are owned by the applicant. Figure 2.1-3 shows the lands owned by the applicant. The station property lines include both the land inside the site boundary and the leased land outside the boundary. Areas modified by construction of the plant include 135 acres for the station, 60 acres for the cooling lake dams and dikes, and 5,090 acres for the cooling lake at a normal elevation of 1,087 feet above mean sea level (MSL). Figure 2.1-4 shows the location and orientation of principal plant structures, and Figure 2.1-5 shows the layout for the cooling lake, dams, dikes, and spillways.

The plant exclusion area, shown on Figure 2.1-6, lies within the site boundary and encompasses approximately 1,118 acres, which are owned by the applicant. This area is traversed only by the access road to the plant.

There are no residential, commercial, or industrial structures within either the exclusion area or the plant site area. The effects of the Wolf Creek cooling lake are discussed in Section 2.8.

The transportation network in the site vicinity is shown on Figure 2.1-7. The main highway artery in the plant site area is U.S. Highway 75, which runs in a north-south direction about 0.25 mile west of the site boundary and 2.8 miles west of the reactor location at its closest point. The four other major roads within a 5-mile radius of the plant are the federal-aid secondary routes 10, 149, 153, and 1472. The nearest existing railroad to the site is the Missouri Pacific Railroad located 10.1 miles southeast of the site boundary. A spur connecting the site with this track was constructed to provide rail access to the site. Another railroad (Santa Fe Railroad) running in a north-south direction through the site property was abandoned in 1972. There is no commercial water traffic on the Neosho River or the John Redmond Reservoir.

2.1.1.3 Boundaries for Establishing Effluent Release Limits

The restricted area, which is used for establishing effluent release limits, enables the applicant to fulfill their obligations with respect to the requirements of 10 CFR Part 20. This area and the distances from the station vent stack to the boundary lines of the restricted area are shown on Figure 2.1-6. The restricted area boundary closest to the gaseous effluents release point is to the west at a distance of 1,250 feet.

2.1.2 POPULATION DISTRIBUTION

The current and projected populations within 50 miles of the Wolf Creek Generating Station site have previously been described in Section 2.2.1 of the Environmental Report - Construction Permit Stage [ER(CPS)]. Section 2.1.2 of the ER(OLS) presents revised population projections and updated information on transient population. Some of the information on methodology and populations of incorporated places, previously presented in the ER(CPS), has been repeated for continuity.

The population projections have been revised to reflect the most recent U.S. Bureau of the Census and State of Kansas projections, which have changed since the submittal of the ER(CPS). Information on transient population has also been updated to reflect the most recent data. As requested in the revised NRC guidelines (Revision 2), age distribution of the population has also been provided.

The updated information on population distribution is presented in revised text, tables, and figures in the format requested by Revision 2 to Regulatory Guide 4.2.

In general, east-central Kansas is predominantly a low-population density, rural, agricultural area. Table 2.1-1 presents the 1960 and 1970 populations of incorporated places (Figure 2.1-8) within 50 miles of the site. The populations of both the rural areas and the communities which serve the rural economy declined during the 1960 to 1970 decade; this decline has continued into the 1970s.

Population studies in support of this application were directed toward estimating the distribution of current (1970) population figures and estimating the projected population from 1980 to 2020 (by 10-year increments) within a 50-mile radius of the plant site. Data sources and methodology used for the studies are summarized in the following paragraphs.

The distributions of the current and projected populations were determined by first establishing a network of geographic sectors and then apportioning the available census data.

To establish the geographic sectors, the 50-mile-radius area (using the plant site as the center) was divided by superimposing concentric circles and radial lines over a base map. Within 5 miles of the plant site, the concentric circles were located at 1-mile radial increments; for the area from 10 to 50 miles of the site, the circles were located at increments of 10 miles. These concentric circles were then divided in 16, 22.5° segments, each centered on one of the

16 cardinal compass points. This rose format is illustrated on Figures 2.1-9 through 2.1-20.

The current population distribution within 50 miles of the site was based on 1970 census data (U.S. Bureau of Census, 1971). The population data for the area within 5 miles of the plant site were supplemented by a field survey in which each occupied house was located on a county map and the number of residents tallied. This detailed survey, which did not include the incorporated areas of Burlington and New Strawn (since actual populations of these towns were known), was conducted to provide an accurate distribution of population among the small sectors, ranging from 0.1 to 4.5 square miles, within 5 miles of the plant site. Beyond 5 miles, the sectors formed by the concentric circles and radial lines are large enough to include both inhabited and vacant areas, and thus an area-distribution method was used. With this method the populations of all Minor Civil Divisions (MCD) were allocated to sectors by area (U.S. Bureau of Census, 1971). Where 10 percent of an MCD was within a given sector, 10 percent of the census population was allocated to that sector. The sum of MCD population portions within a sector was presented as the sector total.

The population projections were based largely on federal census projections to 2020 for the nation, and state projections to 2000. These projections were stepped down from the national and state levels to the county level (U.S. Bureau of the Census, 1977 and 1978). In addition, 1975 county projections formulated by Dr. Cornelia Flora in 1975 were used (Flora, 1975).

The step-down technique (Greenberg and others, 1973) was applied in extending state projections past 1990 to obtain projections at the local level. This method involves reproportioning of state projections based on change in share of the state's overall population relative to the nation.

Also, as these projections offer a selection of fertility and migration rates, a conservative national fertility rate, of 2.1 children per woman through the year 2020, was assumed for these projections. (In 1978 the average monthly general fertility rate was 66.4 births per 1,000 women 15-44 years of age. This fertility rate is equivalent to about 2.0 children per woman completed fertility [National Center for Health Statistics, 1979, page 8]). Interstate migration similar to that observed by the state between 1965 and 1975 was chosen.

Since projections for specific Minor Civil Divisions (MCD) were lacking, historic trends were investigated, and the average percent change by decade from 1940 to 1970 was continued to 2020 for each MCD. County sums derived from these divisions were then reproportioned to county totals derived from the step-down procedure (Greenberg and others, 1973). Thus, if an area had grown in the past, it was assumed it would continue to grow. The MCD projections were allocated to various segments in the 0- to 50-mile area with the area-distribution method previously described.

In cases where new residential developments occurred within the 0- to 5-mile area and historic population trends were not reliable, projections were based on the number of planned home sites within each development. An occupancy factor of 2.9 people per dwelling (determined from a field survey and verified by the 1970 census data) was used to derive a total population for each new residential area. This approach provides a conservative or high population projection for these areas.

It is assumed that no permanent residents would live within 1 mile of the plant site or within the area occupied by the cooling lake beyond 1980.

2.1.2.1 Population Within 10 Miles

The total 1970 population within the 10-mile area was 4,059, which results in a density of 13 people per square mile and clearly depicts the area's rural nature (Table 2.1-2). Within 5 miles of the plant site, the 2,537 residents provide a density of 32 people per square mile. However, when Burlington with its population of 2,099 is excluded, the area within 5 miles of the plant site then has a density of six people per square mile.

The 2020 population projection for the area within 10 miles of the plant site indicates a decline in nearly all segments except in those which encompass Burlington and New Strawn. These communities are located principally in the 3- to 4- and 4- to 5-mile segments described in Table 2.1-2 and on Figure 2.1-8. However, the 2020 projection is not the maximum. As shown in Table 2.1-2, the 10-mile population increases very slowly from 4,059 in 1970 to 6,120 in 2000. After the year 2000 the 10-mile population declines to 5,370 in 2020. The increase and decline is related to the age-structure of the population and the out-migration history of the area. Figures 2.1-9 through 2.1-14 present the projected populations in the 0- to 10-mile area from 1970 to 2020.

The only incorporated communities within 10 miles of the plant site are at Burlington, 3.5 miles to the southwest, and New Strawn, 3 miles to the west-northwest of the plant site (Table 2.1-1).

Burlington had a 1970 population of 2,099, a January 1979 population of 2,511, and is expected to undergo only moderate growth by 2020.

New Strawn was created when the U.S. Army Corps of Engineers relocated Strawn (an unincorporated settlement) from the area to be inundated by the John Redmond Reservoir, and was incorporated in 1971 (Brown, 1979). The town did not appear in the 1970 U.S. Census. Therefore, in the absence of historic population trends, estimates for the future have been based on the number of planned lot sites.

New Strawn is currently growing, and has the capability to accommodate significant new residential development. Within New Strawn 668 home and trailer lots have been subdivided, with approximately 150 single family homes and 63 trailers presently occupied within the town (Jones, 1979; Boyce, 1979). Present growth in New Strawn is estimated at 12 to 15 single family homes per year (Jones, 1979).

Assuming development of an additional 30 single family residences and 22 trailers (remaining capacity in the Arrowhead Park Trailer Camp), the 1980 population of New Strawn could be as high as 800 residents (assuming about 2.9 people per dwelling unit). As New Strawn occupies parts of two of the geographic sectors, approximately 534 of these people would live in the west-northwest segment from 3 to 4 miles from the site, and 266 residents would live in the northwest segment from 3 to 4 miles from the site.

In addition to incorporated New Strawn, there are two adjacent developments, Remer's Point and Hillview, in an unincorporated area west of New Strawn. Presently, there are a total of 11 homes and 2 mobile homes in the two developments - 7 homes and 2 trailers in Hillview, and 4 homes in Remer's Point. It is estimated that there exists space for approximately 40 additional dwelling units within the two developments (Remer, 1979; Harris, 1979). Full development of these two areas would result in a total population of approximately 150 residents (assuming 2.9 persons per dwelling unit). However, this development is unlikely to occur until well after 1980 (Remer, 1979; Harris, 1979).

Of this potential total of 150 residents in Remer's Point and Hillview, 10 would locate in the west-northwest segment, 5 to 10 miles from the plant, and the remainder would locate in west-northwest segment, 4 to 5 miles from the site.

It should be noted that, as the historic growth trends for the region suggest decreased population growth for most communities, the above increased projections are therefore likely to be conservative or high estimates of future populations for these communities.

The midpoint of station operating life, rounded to the nearest census date, is 2000. The distribution for age categories 0 to 12, 12 to 18, and over 18 is shown in Table 2.1-3. The U.S. projected age distributon for 2000 was used because the 1970 age distribution for Coffey County did not differ significantly from the 1970 U.S. age distribution. Appendix D of Regulatory Guide 4.2 Revision 2, Preparation of Environmental Reports for Nuclear Power Stations, defines a "significant difference" as more than a 10 percent difference of the age distribution of the county in which the proposed station is to be located from the U.S. age distribution in the 1970 decennial census. The 10-percent difference criterion is to be applied to any of the three age groups. Table 2.1-3 shows the 1970 age distribution for the U.S., Coffey County (the county in which the plant is located), and the counties in which all or a portion are located within 50 miles of the plant. None of the age categories differ significantly from the 1970 U.S. age distribution. The year 2000 age distributions for 0 to 10 miles from the site and 10 to 50 miles are the same.

2.1.2.2 Population Between 10 and 50 Miles

Cities and towns within 10 to 50 miles of the plant site are shown on Figure 2.1-8 and their 1960 and 1970 census populations are listed in Table 2.1-1. Many of these incorporated places experienced a decline in population from 1960 to 1970.

Emporia, Kansas, with 23,327 residents in 1970 and 26,145 residents in 1978 is the largest city in the 10- to 50-mile region, while the next largest is Ottawa with 11,036 people in 1970 and 10,693 people in January 1978 (Knight, 1979). The majority of the incorporated places contain less than 1,000 people.

The population rose for the area from 10-to-50 miles is divided into 64 segments ranging in size from 59 to 177 square miles. The current and projected population distribution from 10 to 50 miles is listed in Table 2.1-4. The 1970 through 2020 population distributions are compared on Figures 2.1-15 through 2.1-20. The total cumulative 1970 population within the entire 50-mile area surrounding the site was 163,834 or about 21 persons per square mile.

In the region within 10 to 50 miles of the plant site, the projections clearly depict a decline in the rural areas with moderate growth occurring only in the vicinities of major cities and towns (Figure 2.1-8 and Table 2.1-1). A net population decline of 4 percent over the entire 0- to 50-mile area is projected for the 50-year period from 1970 to 2020.

The year 2000 age distribution for the 10 to 50 mile area around the site is shown in Table 2.1-3. The means by which this distribution was generated is discussed in Section 2.1.3.1.

2.1.2.3 Transient Population

Transient population within 10 miles of the site is low. Most seasonal or daily shifts in population are associated with public facilities such as the John Redmond Reservoir, schools, and parks.

Figure 2.1-21, Public Facilities and Institutions, illustrates the geographic location of the transient population centers within 5 miles. Tables 2.1-5 through 2.1-8 provide a description of the facilities shown on Figure 2.1-21. The Flint Hills National Wildlife Refuge (Table 2.1-8) is primarily outside the 10-mile study area.

By comparing the population statistics (enrollment and usage) on Tables 2.1-5 through 2.1-8 with the geographic locations (Figure 2.1-21), current transient concentrations can be identified in relation to the plant location. For future projections, there were no anticipated expansions to public facilities within 5 miles of the site. There is presently no commitment by the Applicants to public use of the WCGS cooling lake or surrounding land (see Section 2.8). If this commitment is made in the future, an increase in the transient population within 5 miles of the site would result.

One Federal-Aid Primary highway (FAP 75) and four Federal-Aid Secondary highways (FAS 10, FAS 149, FAS 153, and FAS 1472) occur within 5 miles of the site (Figure 2.1-21). Based on the 1978 annual average daily traffic (ADT) count for FAP 75 and the 1975 ADT counts for the secondary highways, the following ranges of traffic volumes were recorded within 5 miles of the site (Ijans, 1978):

Route	Orientation	Range of ADT (vehicles per day)
FAP 75	N-S	2810 - 3800
FAS 10	E-W	485 - 875
FAS 149	N-S	95 - 110
FAS 153	E-W	75 - 225
FAS 1472	E-W	90 - 125

The most important source of transient seasonal population in the general area is the recreational usage of John Redmond Reservoir. The conservation pool of John Redmond Reservoir extends 3.5 to 7.2 miles west of the site. The facilities that attract a transient population are boat launching ramps, fishing, picnic facilities, and campgrounds. The peak monthly usage was 79,400 during July 1978 (Duncan, 1979). The yearly visitation at John Redmond Dam and Reservoir averages about 380,000 (yearly change in visitation is largely dependent on weather conditions [Chester, 1979]). Actual 1972 visitation was reported to be 692,300 (Kansas Park and Resources Authority, and Oblinger-Smith Corporation, 1975, Table IX.1). The recreational season is year round, but the peak months are during the summer. Major sources of transient or seasonal populations, such as that experienced during recreational use of John Redmond Reservoir, have established visitor trends which can be utilized as a guide for future usage of these areas.

With the exception of visitation at Kansas reserviors and state parks, transient populations at distances of 5 to 50 miles are minimal due to the absence of major industrial facilities or recreational attractions.

The Pomona, Melvern, Toronto, and Fall River reservoirs and state parks are located within 50 miles of the site. The recreational facilities available at each of these reservoirs consist of boat launching ramps, picnic shelters, sanitary facilities, campgrounds and swimming beaches. Location and actual 1978 visitation for each of these reservoirs are given below (Herndon, 1979):

Reservoir and State Park	Location	1978 Visitation
Pomona	29 miles north	885,380
Melvern	19 miles north	896,054
Toronto	34 miles south-southwest	419,900
Fall River	45 miles south-southwest	433,500

The two largest cities within 50 miles are Emporia (28 miles west-northwest) and Ottawa (32.5 miles northeast). The 1978 populations of these cities, 26,145 and 10,693, respectively, reflect the absence of a large population-industrial source in the 16-county area surrounding the site. Transient population in the area is not expected to increase due to the projected population decline (4 percent, Section 2.1.2.2) in the next 50 years.

2.1.2.4 Low Population Zone

The low population zone (LPZ) is defined as the area within 2.5 miles (4,023 meters) from the reactor center as shown on Figures 2.1-6 and 2.1-21. The LPZ meets the requirements as stated in 10 CFR Part 100. The LPZ does not include Burlington, New Strawn, or Highway 75, nor does it contain any areas of heavy residential use.

The 1970 population of the 20-square mile area of the LPZ was 101 people. By 1980, the permanent resident population should be about 130 people. Table 2.1-9 presents the estimated distribution of population in 1970 and 1980 within the LPZ. All exit routes within the LPZ are presently unsurfaced two-lane county roads. Some of these roads may be impassable during periods of rainy weather except for tracked vehicles, four-wheel drive vehicles, and farm tractors. Detailed evacuation provisions will be addressed in the detailed emergency procedures (Section 13.3 of the Final Safety Analysis Report). Two improved access roads (one all-weather) will be constructed which will provide exit routes within the site property boundary and from the LPZ area.

There are no sources of transient population within the LPZ. [There is presently no commitment by the Applicants to public use of the cooling lake or surrounding land (Section 2.8)] With the exception of residential traffic, there is no transient population in the LPZ, neither during the working day nor seasonally. No data are available on the frequency of residential traffic within the LPZ. The roads are not major highways but are unsurfaced country roads which serve scattered residences. The railroad passing through the site area was abandoned, and the rails have been removed. There are no commercial facilities within 2.5 miles of the site.

2.1.2.5 Population Center

The population center or city closest to the site with a population greater than 25,000 persons, is Emporia, Kansas, 28 miles west-northwest of the site. In 1975 its population was estimated to be 26,145 persons (DeMott, 1979). The next city eligible for designation as a population center is Topeka, Kansas, 53 miles north of the site. Topeka's reported populations for 1970 and 1978 were 155,322 and 144,221 persons, respectively (Schlicher, 1979).

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2.1.2.6 Population Density

The site is located in a very low population density area. Within 50 miles of WCGS the range of density variation, from 6 persons per square mile to 62 persons per square mile, is very small. This low density indicates a relatively homogeneous rural population characteristic of an agricultural or ranching economy.

As shown on Figure 2.1-22 the projected population from 1980 to 2020 never exceeds 70 persons per square mile. Indeed the cumulative maximum density (62 persons per square mile) occurs in the year 2000 for the 0- to 5-mile distance. Thereafter the densities decline. Varying the fertility and migration assumptions does not influence the levels of population density significantly. Tables 2.1-10 and 2.1-11 show comparisons of population distributions for various fertility and migration patterns for 1980 and 2020, respectively. The most conservative projection (i.e. high) is the no migration, 2.7 children per woman fertility which results in a maximum density (66 persons per square mile).

2.1.3 USES OF ADJACENT LANDS AND WATER

Information on land and water use within the site environs was presented previously in Sections 2.2.2 and 2.2.3 of the Environmental Report - Construction Permit Stage [ER(CPS)]. Section 2.1.3 of the ER(OLS) updates some of the information previously presented, presents new information as requested in Revision 2 of the NRC guidelines, and also repeats some of the information from the ER(CPS) for continuity.

The revisions and new information include the following:

a. A summary of crop and livestock production within a 50-mile radius of the WCGS;

b. A summary of commercial and recreational fishing and hunting harvests within 50 miles;

c. Updated water rights and water use on the Neosho River downstream of the site;

d. Updated municipal ground-water use within 20 miles of the site;

e. New agriculture data for Coffey County;

f. Estimated distances from the reactor center to the nearest milk cow, milk goat, resident, and vegetable garden in each of the 16 sectors within 5 miles;

g. Updated well inventory within 5 miles; and

h. A field reconnaissance and review of recent aerial photos to determine recent developments or apparent changes in land use within 5 miles since 1973.

Inclusion of any data or discussion that were presented in the ER(CPS) is repeated herein only for the sake of continuity.

2.1.3.1 Land Use Within 50 Miles

2.1.3.1.1 General Description

The area within 50 miles of the plant site encompasses 7,854 square miles and all or portions of 21 counties (Figure 2.1-8). Farmland occupies approximately 89 percent of the 50-mile radius area (Table 2.1-12) and cropland, pasture and rangeland are the prevalent land use cover types. Urban or built-up lands occupy a very small percentage of this predominantly rural region. Farmland acreage has remained relatively stable in the region, decreasing by only 1.5 percent from 1969 to 1977. The statewide acreage of farmland decreased 1.4 percent during the same period (Kansas Crop and Livestock Reporting Service, 1978a; U.S. Bureau of the Census, 1977).

Presented below in Section 2.1.3.1.2 are the annual meat, milk and crop production estimates for the area within 50 miles of the WCGS. Unless stated otherwise these estimates are based on state and county data from the U.S. Bureau of the Census (1977) and the Kansas Crop and Livestock Reporting Service (1978a). When only a portion of a county was within the 50-mile radius area, it was assumed that agriculture production was distributed evenly throughout the county, and the total county estimates were reduced accordingly. Estimates are presented only for the total 50-mile radius area rather than for each 22-1/2 degree sector or annular segment because of the lack of more area-specific data.

2.1.3.1.2 Agriculture Activities

Cropland within 50 miles of the WCGS consists primarily of close grown field crops such as wheat, sorghum, soybeans and hay. Corn, oats and barley are less common in the region. Production of truck or row crops within 50 miles for canning purposes is negligible (Table 2.1-13).

Virtually all of the wheat sold in Kansas is used in food products for human consumption. Approximately 75 percent or more of the corn and sorghum raised for grain is used for livestock feed, the remainder is principally used for seed. Approximately 10 percent of the state soybean crop is used for human food products, approximately 40 percent for livestock feed, and approximately 50 percent is exported from the United States. Oats and barley are used primarily for livestock feed or seed (Kastens, 1979).

The estimated number of beef cows, milk cows and cattle on feed within 50 miles of the WCGS is presented in Table 2.1-14. Between 1973 and 1977, the annual beef production in Kansas averaged 403 pounds (183 kilograms) per head of cattle and calf on inventory (Kansas Crop and Livestock Reporting Service, 1978a). Using this state average, the total beef production in 1978 within 50 miles of the WCGS is estimated at 254 million pounds (115 million kilograms). Total milk production within 50 miles of the site is estimated to be 232 million pounds (102 million liters).

Typical annual feed consumption per dairy cow or beef cow in east-central Kansas is presented in Table 2.1-15. The average grazing season on native pasture is 6 months, from approximately April 20 to October 15. The grazing season is shorter on tame grass pastures of brome or fescue grass, lasting for 3-1/2 to 4-1/2 months. Native pasture grass in east-central Kansas generally yields one ton per acre (0.22 kilograms per square meter) per year and tame grass pasture generally yields two tons per acre (0.45 kilograms per square meter) (Bell, 1979). Estimated silage and forage production within 50 miles is presented in Table 2.1-13.

The estimated number of hogs and pigs within 50 miles of the WCGS in 1978 was approximately 249,000. Annual production in Kansas between 1973 and 1977 averaged approximately 367 pounds (167 kilograms) per head of hogs and pigs on inventory (Kansas Crop and Livestock Reporting Service, 1978a). Using this average, the total production in 1978 within 50 miles of the WCGS was estimated at 91.4 million pounds (41.5 million kilograms).

The raising of sheep and lambs is a relatively minor form of livestock production within 50 miles of the WCGS (Table 2.1-14). Annual production in Kansas between 1973 and 1977 averaged approximately 62 pounds (28 kilograms) per head of sheep and lamb on inventory (Kansas Crop and Livestock Reporting Service, 1978a). Using this average, the total production in 1978 within 50 miles was estimated at 797,000 pounds (362,000 kilograms).

The estimated number of chickens, excluding broilers, within 50 miles in 1977 was approximately 383,000 (Table 2.1-14). Annual production in Kansas in 1976 and 1977 averaged 0.80 birds per year per number on inventory (Kansas Crop and Livestock Reporting Service, 1978a). Using this average, the total production in 1977 within 50 miles was estimated at 305,000 chickens. Production data for broilers and other meat-type chickens were not available for 1977 but in 1969 and 1974 sales were 4.3 birds per year per number on inventory. The number of broilers and other meat-type chickens within 50 miles is approximately 10,300 (Table 2.1-14). Egg production within 50 miles in 1977 was estimated at 90 million.

The number of turkeys within 50 miles of WCGS is approximately 594 (Table 2.1-14). The most recent available annual comparisons of turkey production and inventory on farms was for the year 1974. In that year turkey production was 5.7 birds per number on inventory.

2.1.3.1.3 Hunting

The area within a 50-mile radius of the WCGS has a wide variety of game species. Species commonly sought by hunters include white-tailed deer, bobwhite quail, greater prairie chicken, ring-necked pheasant, gray and fox squirrel, eastern cottontail, mourning dove and a variety of ducks. The estimated annual average hunting harvest from 1973 to 1977 in the 50-mile radius area is presented in Table 2.1-16. See Section 6.1.4.2 for a description of the methods used to estimate the regional hunting harvest.

No data were available concerning the amount of game consumed locally. However, hunters residing outside the 50-mile radius area will likely hunt within the area and, therefore, only a portion of the harvest would be expected to be consumed locally.

Furbearers are also abundant in the region and species commonly taken by trappers include beaver, bobcat, muskrat, raccoon and coyote. Trapping harvest data are available only for large geographical regions within Kansas which precludes making a reliable harvest estimate for the area within 50 miles of the WCGS. Furbearers are seldom consumed by humans for food. The beaver, muskrat and raccoon are the only furbearing species that would likely be consumed as food and this consumption is probably less than 5 percent of the total harvest (Tiemann, 1979).

2.1.3.1.4 Other Uses

Land uses other than agriculture within 50 miles of the WCGS primarily occupy urban or built-up lands that include residential, commercial, industrial, and transportation uses. The locations of cities and towns in the region are shown on Figure 2.1-8.

2.1.3.2 Land Use Within 5 Miles

2.1.3.2.1 General Description

Land use within 5 miles of the WCGS and outside the site boundary is similar to that within 50 miles. The area is sparsely populated and characterized by the large percentage of agricultural land and rangeland (Figure 2.1-23). Based on 1979 aerial photos, the percentage of the area within 5 miles that is occupied by each land use type is listed below.

Rangeland	40%	Water Bodies	3%
Cropland	40%	Quarries	<1%
Woodland	9%	Cemetery	<1%
Built-up Area	5%		
Recreation Area	3%		

Presented below is a description of each land use type, along with livestock production, zoning, and land use trends within 5 miles of the site. Historic, scenic, cultural, and archeological features in the vicinity are discussed in Section 2.6.

2.1.3.2.2 Rangeland

Rangeland within 5 miles consists primarily of native and tame grass but mixed grass, brushland and managed pastures are also present. Cattle are the principal livestock using the rangeland as there are few sheep or horses in the area.

2.1.3.2.3 Cropland

Cropland within 5 miles of the WCGS consists primarily of wheat, corn, sorghum, soybeans and alfalfa. Minor acreages of clover, timothy and orchards are also present. Average yields per acre for crops within 5 miles could be expected to be similiar to county-wide data presented in Table 2.1-17.

Many of the residents within 5 miles of the site maintain vegetable gardens. The distance from the reactor to the nearest vegetable garden, greater than 500 square feet, for each 22-1/2 degree sector was noted during the fall of 1978 and is presented in Table 2.1-18.

2.1.3.2.4 Livestock, Dairy and Poultry Production

Beef cattle and hogs are the principal livestock raised near the site. Dairy production is minimal. Presented in Section 2.2.2.3 of the ER(CPS) are the locations and numbers of beef cattle, dairy cows and hogs within 5 miles of the site as of 1973.

The dairy cow nearest to the WCGS is approxmately 1.1 miles north. The milk from all cows nearest to the plant site in each 22-1/2 degree sector is consumed raw by the family members indicated in Table 2.1-18. Dairy herds account for the majority of the remaining milk cows within 5 miles. The dairy herds produce grades B and C milk, manufacturing grades, which are primarily sold to various milk buyers for production of butter, cheese, powder, ice cream and other frozen products. Manufacturing grade milk may also be sold to local families for liquid consumption or used on the farm where it is produced. Throughout Kansas in 1977, milk used or sold on the farms where it was produced averaged approximately 3 percent of total production, the remainder was sold to plants and dealers (Kansas Crop and Livestock Reporting Service, 1978b). None of the dairy herds produce grade A milk which can be sold commercially for liquid consumption (Bonewitz, 1979).

Egg production within 5 miles is limited to small family operations on individual farms. Egg production in Kansas is approximately 230 eggs per layer per year (Kansas Crop and Livestock Reporting Service, 1978c). The number and location of laying hens and broiler chickens within 5 miles is presented in Section 2.2.2.3 of the ER(CPS).

The number of sheep and miscellaneous livestock surveyed in 1973 within 5 miles of the plant site is also listed in the ER(CPS).

The numbers of livestock on farms are frequently changing due to marketings, purchases, births and deaths, therefore, the 1973 data presented in the ER(CPS) are subject to continous change. A reconnaissance of the 5-mile radius area in 1979, however, did not reveal any obvious significant changes in livestock practices outside the site boundary. Therefore, the 1973 survey is expected to be fairly represENTIVE of the livestock distribution outside the site boundary in 1979.

A survey was also conducted in 1978 to determine the distance from the reactor to the nearest milk cow, milk goat and meat animal. These distances are presented in Table 2.1-18.

2.1.3.2.5 Woodlands

The woodlands within 5 miles of the site consist predominately of deciduous hardwoods along the creek and river systems (Figure 2.1-23) but osage-orange also occurs in hedgerows and in scattered stands in upland fields. The total estimated area of woodland within 5 miles of the site is 4,690 acres. There is little apparent commercial utilization of the woodlands.

2.1.3.2.6 Built-Up Areas

Built-up areas occupy approximately 5 percent of the area within 5 miles of the WCGS. These areas include residential, commercial, industrial, and sewerage facilities; subdivisions; areas within city boundaries; a pipeline pumping facility; and land parcels within the site boundary that will be occupied by WCGS facilities. Outside of the WCGS site boundaries most built-up areas are concentrated in and around the towns of Burlington and New Strawn (Figure 2.1-23). Clustered and individual rural residences, isolated commercial establishments and transportation systems are not indicated on Figure 2.1-23. More detailed description of the land use of the built-up areas is provided in Section 2.1.2; further description of the WCGS site area is presented in Section 2.1.3.3.

The local road system and many of the nearby facilities and institutions are shown on Figure 2.1-21. U. S. Highway 75, 2.8 miles west, is the only major highway within 5 miles. The nearest existing railroad is the Missouri Pacific Railroad, located 9.5 miles southeast of the site. A spur from this line has been constructed to the site. Presently, the Applicants have no plans to make the spur available for use by others. The Santa Fe Railroad and right-of-way located 0.3 miles west of the plant site is abandoned.

2.1.3.2.7 Recreation Areas

The recreation area classification on Figure 2.1-23 includes city parks, the John Redmond Reservoir Recreation Area, and the Outdoor Laboratory for Environmental Education. For further information on nearby recreation areas and public facilities see Section 2.1.2.3.

2.1.3.2.8 Water Bodies

The surface waters mapped within 5 miles of the site include the John Redmond Reservoir, Mathias Lake and the Neosho River (Figure 2.1-23). Small farm ponds, oxbow lakes and small streams such as Wolf Creek and Long Creek are not indicated. Water use within 5 miles is described in Section 2.1.3.5.

2.1.3.2.9 Quarries

Most of the quarries indicated on Figure 2.1-23 have been abandoned. The only operating quarry within 5 miles of the site is owned by Nelson Quarry, Inc. It is located 3 miles south-southwest of the plant site. Total acreage of all quarries within 5 miles is approximately 160 acres.

2.1.3.2.10 Zoning

Indicated on Figure 2.1-24 are the zoning district boundaries of the Coffey County Zoning Resolution (Board of Commissioners of Coffey County, 1968) and the Burlington City Zoning Ordinance (Simon, 1976). There is no other type of zoning in the area. Most of the lands zoned by the city or county within 5 miles are designated as Agricultural District. The cooling lake for the WCGS will occupy approximately 700 to 800 acres of county zoned land and 2,200 to 2,300 acres of city zoned land. The remainder of the cooling lake area is not zoned. These zoned lands within the boundaries of the cooling lake are designated as Agricultural.

The Coffey County Commissioners passed a County Zoning Amendment in 1976 that granted the Applicants a conditional use zoning change that would include the electrical generating facility and its pertinent structures. The permitted uses within the Agricultural District of the City Zoning Ordinance specifically include power plants and all appurtenances necessary for their construction and operation, and public utility installations. Therefore, the WCGS is in accordance with the County Zoning Regulations and the City of Burlington Zoning Regulations.

Other specific permitted and conditional uses for the zoning districts within 5 miles of the plant site are discussed in the Coffey County Zoning Resolution (Board of Commissioners of Coffey County, 1968) and the Burlington City Zoning Ordinance (Simon, 1976).

2.1.3.2.11 Trends and Projected Land Use

The primary land use trend in Coffey County has been the continued decrease in the number of farms and increase in the average size of farms. The total land area in farms in Coffey County has changed little from 1969 to 1977 (Table 2.1-17).

Outside of the site boundary, no new land use trends have been identified within 5 miles of the WCGS that would disturb the rural agricultural characteristics present today. This projection is based on population forecasts (see Section 2.1.2) and trends observed over several years.

A 1979 field reconnaissance noted only minor new developments since 1973 within 5 miles of the WCGS, not including site construction activities. The more apparent changes in recent years have been an increase in the number of large rural homesites on nearby agricultural land. The residents often have a few farm animals and may cultivate large gardens but their primary source of income is expected to be from non-farm employment. New residential construction is also evident near the southwest and north boundaries of Burlington city limits.

A comparison of 1979 aerial photographs and the 1973 land use map (Figure 2.1-23) indicated the following approximate changes in land use types within 5 miles of the site:

Rangeland	-3,100 acres
Cropland	+1,850 acres
Woodland	- 130 acres
Built-up area	+1,360 acres
Quarries	+ 20 acres

The increased acreage of built-up area is primarily due to the new site facilities within the WCGS site boundaries.

Burlington, the county seat and rural service center for the county, should remain about the same size as today, though there should be some additional growth due to the plant. The recreational communities of New Strawn and the subdivisions of Hillview and Remer's Point should also undergo only moderate to no growth.

The existence of the John Redmond Reservoir has not encouraged a recreational building boom of second homes and retirement housing as many other reservoirs in the country have. This is because this lake was designed primarily as a flood-control facility, not a recreational lake. The reservoir level fluctuates greatly between periods of high water and conservation pool level. The reservoir is also rather shallow, being an inundated floodplain of the Neosho River. As a result, the shoreline frequently fluctuates. In addition, the U.S. Army Corps of Engineers owns the land around the reservoir.

2.1.3.3 Land Use Within The Site Area

2.1.3.3.1 General Description

A detailed site description is presented in Section 2.1.1.2. Included in that section and on Figures 2.1-3 through 2.1-7 are descriptions of the site boundaries, exclusion area, acreage owned by the Applicants, acreage modified for operation facilities, and nearby transportation routes. There are no commercial or industrial structures, parks, or scenic or natural designated dedicated areas within the site boundary. The only residential structures within the site boundary are located in the northwest sector; the nearest structure is located approximately 2.3 miles from the reactor site. Historic and archeological sites are described in Section 2.6. Transmission line rights-of-way off the site are discussed in Section 3.9.

2.1.3.3.2 Previous Land Use

Prior to the Applicants' purchase, the principal land use within the site boundary was for grazing livestock and crop production. In 1973, approximately 46 percent of the site area was rangeland, 38 percent was cropland, 11 percent was woodland and 3 percent was idle land. The remaining 2 percent was occupied by ponds, roads, gravel pits, railroad, rural residences, farm buildings, and cemetery [see Figure 2.1-7 of the ER(CPS)]. The new service roads, reactor site, dams and other facilities for plant operation have since displaced portions of this agricultural land. Further discussion of the land resources required for operation of the station and facilities is presented in Section 2.8.

2.1.3.3.3 Land Use Capabilities

A description of the soils on the site and their capabilities regarding agricultural potential, wildlife habitat and general construction characteristics are presented in Section 2.2.2.8 of the ER(CPS).

Since the ER(CPS) several of the soil units mapped on the site have been designated as prime farmland by the Soil Conservation Service (Swanson, 1979). These prime farmland soil types are listed below:

41B	- Bates loam, 1 to 4 percent slopes
41C	- Bates loam, 4 to 7 percent slopes
42B	- Dennis silt loam, 1 to 4 percent slopes
32	- Kenoma silt loam, 1 to 3 percent slopes
32B3	- Kenoma silt loam, 1 to 4 percent slopes, eroded
15	- Lanton silty clay loam. This is a new name; previously mapped as Oakwood silty clay loam.
16	- Leanna silt loam
21(23)	- Lula silt loam. This is a new designation; it includes Labette silt loams, 0 to 2 percent slopes that were mapped previously
18	- Osage silty clay loam.
14	- Osage silty clay
22B	- Summit silty clay loam, 1 to 4 percent slopes
12	- Verdigris silt loam. This has been changed to also include the Mason silt loam that was mapped previously
31	- Woodson silt loam

These prime farmland designations are subject to change prior to publishing the Coffey County Soil Survey, which is expected to be completed in 1981. There are no designated unique farmlands or farmlands of state or local significance in Coffey County (Swanson, 1979).

2.1.3.3.4 Projected Land Use and Visitors Center

A lake use study was conducted to determine the feasibility of allowing public use of the WCGS cooling lake for recreational purposes. Currently, there are no plans for public use of the cooling lake or lands within the site boundary adjacent to the cooling lake not needed during operation of the station and related facilities (see Section 2.8). At present the only area of the site which will be open for public use will be the visitor center. The location of the visitors center has not yet been finalized.

2.1.3.4 <u>Water Use Within 50 Miles</u>

2.1.3.4.1 Municipal, Industrial, Irrigation and Recreation Uses

This section discusses the regional ground-water use and the principal surface-water users of the Neosho River downstream of the WCGS site to the Kansas-Oklahoma state line (approximately 170 river miles). Regarding surface-water use, only users downstream of the plant discharge are described since these are most likely to be affected by plant effluent releases. Descriptions of the Neosho River and its major tributaries, streamflow gauging stations, major reservoirs and ground-water gradients are presented in Section 2.4. The effects of regional consumptive water use by the plant on water supplies are discussed in Sections 2.4, 3.3 and 5.7. Water and sewage treatment processes of the plant are discussed in Sections 3.6, 3.7, 5.3 and 5.4.

The water use estimates presented herein are based primarily on unpublished data which consisted primarily of estimated annual totals. Little information was available for monthly or seasonal variations, or for past and projected water use.

The principal water withdrawal from the Neosho River downstream of the site is for municipal use, followed by industrial, irrigation and recreational uses. Listed in Tables 2.1-19 and 2.1-20 are the major water users and dischargers on the Neosho River downstream of the site. The locations of the major water users are indicated on Figure 2.1-25. The City of LeRoy is the nearest municipal water user downstream of Wolf Creek (13.5 miles).

More detail regarding the incorporated municipal water supply systems downstream of the site is presented in Table 2.1-21. These municipal systems supply water for domestic, commercial, industrial and public-water requirements. Rural water districts (RWD) utilizing the Neosho River, either directly or indirectly, are also listed in Table 2.1-21.

The RWDs have been formed in those areas where ground-water resources are limited.

Municipal ground-water supplies within a 20-mile radius of the site are listed in Table 2.1-22; their locations are shown on Figure 2.1-26. Many rural residences rely on individual wells for domestic needs and livestock watering.

There is no commercial water traffic on either the Neosho River or on the John Redmond Reservoir.

2.1.3.4.2 Commercial and Recreational Fish Harvest

The principal fishing waters that are contiguous with the WCGS discharge and that may be influenced by the station effluents include the Neosho River downstream from the John Redmond Dam and tributary streams to the Neosho River. Within 50 miles of the plant site this includes approximately 100 anglable river miles of the Neosho River and approximately 24 tributaries with 240 stream miles of anglable waters. Fish cannot move upstream on the Neosho River past the John Redmond Dam. Therefore, fisheries upstream of the John Redmond Dam would not be influenced by station effluents. Although numerous city and county lakes, farm and ranch ponds, and other small lakes may also be considered contiguous with waters receiving station effluents (since their waters eventually flow into the Neosho River), they are not considered in the following discussion since many small dams block continuous flow during dry seasons and are also barriers to fish moving upstream.

Commercial Fishing - There is no commercial fishing nor any commercial fish farms in contiguous waters within 50 miles of the WCGS (Hartmann, 1979; Kansas Fish and Game Commission, 1977). Mussels, however, are commercially harvested from the Neosho River, but none of the catch is used for human consumption. The shells are exported for seeding pearls in clams. The most recent annual mussel harvest estimate was for the 1969-1970 season and included both the Neosho and Verdigris rivers; total harvest was 600,000 pounds (272 metric tons) and was valued at $21,000. The annual harvest for the three previous seasons was 32,000 pounds (14.5 metric tons) in 1966-1967, 24,000 pounds (10.9 metric tons) in 1967-1968, and 8,750 pounds (3.9 metric tons) in 1968-1969 (Hartmann, 1979).

Recreational Fishing - The Neosho River and many of its tributaries within 50 miles of the WCGS provide good sport-fishing, primarily for panfish and catfish. The species of fish caught by anglers in these waters are listed below (Ray, 1976):

channel catfish	bullheads	walleye
flathead catfish	largemouth bass	spotted bass
carp	white bass	paddlefish
white crappie	sunfish	blue catfish
freshwater drum	buffalo	

The principal fishing areas on the Neosho River are generally restricted to adjacent towns, road crossings, low water or overflow dams and reservoir tailwaters. The most popular areas within 100 river miles downstream of the John Redmond Dam are the John Redmond Dam stilling basin area and dams at the cities of Burlington, LeRoy, Neosho Falls, Iola, Humboldt, Erie and Chanute (Jirak, 1979; Ray, 1976).

Although recreational fish harvest estimates for the Neosho River and its tributaries are not available, angler utilization of these waters has been reported (Ray, 1976). The estimated angler use for the 100 miles of the Neosho River below the John Redmond Dam and for the 24 anglable tributaries is estimated to be approximately 54,000 man-days per year. The catch rate from these waters is expected to be similar to the regional lake harvest objective of approximately two fish per man-day, each weighing 1/2 pound (Brunson, 1979). Based on these estimates the annual harvest from these waters was determined to be approximately 54,000 pounds (24.5 metric tons).

No data were available concerning the amount of sport fish consumed locally. Fishermen residing beyond the 50-mile radius area from the WCGS will likely fish within the area and, therefore, only a portion of the harvest would be expected to be consumed locally.

2.1.3.5 Water Use Within 5 Miles

2.1.3.5.1 Municipal, Industrial, Irrigation and Recreation Uses

All surface water rights within 5 miles of the site, except for two, are located on the Neosho River upstream of the confluence with Wolf Creek. Of the two remaining water rights, one is located on Long Creek, in the adjacent watershed east of the site; the other water right is held by the Applicants for storage of natural flows on Wolf Creek. The water rights on the Neosho River between Wolf Creek and the John Redmond Dam are held for municipal, industrial, irrigation and recreation use. The municipal water rights are for the City of Burlington and Coffey County Rural Water Districts 2 and 3; the industrial water rights are held by the Applicants for use at the WCGS; several individuals hold water rights for irrigation use; and, the recreation water rights are held by the Kansas Fish and Game Commission.

The only National Pollution Discharge Elimination System (NPDES) discharger identified on the Neosho River between the John Redmond Dam and the Wolf Creek is the City of Burlington. The design discharge capacity for the City of Burlington is 0.32 million gallons per day (mgd). However, the actual discharge is reportedly 0.25 mgd (Waldo, 1979). The City of Burlington and the Applicants also have each been issued 404 permits by the U.S. Army Corps of Engineers for construction of water intake structures on the Neosho River above Wolf Creek (Houge, 1979). Related construction activities should have minor effects on the water quality near Wolf Creek if the permit stipulations are satisfied [for 404 permit stipulations see U.S. Army Corps of Engineers (1977)].

Recreational areas within a 5-mile radius that offer water-based activities are discussed in Section 2.1.2

Within a 5-mile radius of the WCGS, numerous individuals utilize ground water for domestic supplies and livestock watering. Local streams and farm ponds are also used for livestock watering. Figure 2.1-27 shows the location of individual wells, and Table 2.1-23 provides pertinent data on these wells. The regional and local hydraulic gradient of ground water and typical yields in the local aquifers are discussed in Section 2.4.

2.1.3.5.2 Recreational Fishing

The closest locations to the point of discharge downstream on Wolf Creek that are publicly accessible are several small road bridges across Wolf Creek. All of the lands adjacent to Wolf Creek downstream of the discharge are privately owned. The closest bridge is on Federal-Aid Secondary Highway 10, approximately one-half mile downstream of the main dam. The species of fish caught by anglers in Wolf Creek include channel catfish, white crappie and black bullhead. There are 3.0 miles of Wolf Creek that have angling potential and estimated fisherman use is 60 man-days per year (Ray, 1976).

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TABLE 2.1-1

POPULATION OF INCORPORATED
PLACES WITHIN 50 MILES OF THE SITE

	1960	1970	Percent Change	Location (miles from site)
Allen County				
Basset	67	62	- 7.5	27.7 SE
Elsmore	128	116	- 9.4	42.0 SE
Gas	342	438	28.1	28.3 SE
Humboldt	2,285	2,249	- 1.6	32.1 SSE
Iola	6,885	6,493	- 5.7	25.9 SE
La Harpe	529	509	- 3.8	29.6 SE
Mildred	60	42	-30.0	31.1 ESE
Moran	549	550	0.2	35.4 SE
Savonburg	131	109	-16.8	44.2 SE
Anderson County				
Colony	419	382	- 8.8	20.8 ESE
Garnett	3,034	3,169	4.4	23.3 E
Greeley	415	368	-11.3	31.8 ENE
Harris	36	41	13.9	13.7 NE
Kincaid	220	189	-14.1	30.5 ESE
Lone Elm	69	66	- 4.3	26.2 ESE
Westphalia	249	185	-25.7	10.6 ESE
Bourbon County				
Bronson	354	397	12.1	41.1 SE
Mapleton	127	112	-11.8	46.0 ESE
Uniontown	211	286	35.5	46.6 SE
Butler County				
(none)				
Chase County				
Cottonwood Falls	971	987	1.6	46.4 WNW
Matfield Green	95	77	-18.9	47.3 W
Strong City	659	545	-17.3	46.9 WNW

Source: U.S. Bureau of Census, 1971, Number of inhabitants - Kansas, U.S. census of population - 1970: U.S. Government Printing Office, Final Report PC (1)-A18.

TABLE 2.1-1 (continued) Sheet 2 of 4

	1960	1970	Percent Change	Location (miles from site)
Coffey County				
Burlington	2,113	2,099	- 0.7	3.5 SW
Gridley	321	328	2.2	14.2 SW
Lebo	498	589	18.3	14.5 NW
LeRoy	601	551	- 8.3	10.8 SSE
New Strawn*				3.0 NW
Waverly	381	510	33.9	11.1 NNE
Douglas County				
Baldwin City	1,877	2,520	34.3	45.8 NE
Elk County				
(none)				
Franklin County				
Lane	282	254	- 9.9	35.0 ENE
Ottawa	10,673	11,036	3.4	32.5 NE
Pomona	489	541	10.6	29.9 NNE
Princeton	174	159	- 8.6	27.4 NE
Rantoul	157	163	3.8	35.2 NE
Richmond	352	464	31.8	25.4 ENE
Wellsville	984	1,183	20.2	46.0 NE
Williamsburg	255	286	12.2	19.2 NE
Greenwood County				
Climax	81	64	-21.0	45.9 SW
Eureka	4,055	3,576	-11.8	42.9 SW
Fall River	226	191	-15.5	46.1 SSW
Hamilton	400	349	-12.8	31.3 SW
Madison	1,105	1,061	- 4.0	23.6 SW
Virgil	229	179	-21.8	24.2 SW
Johnson County				
(none)				

* New Strawn was incorporated in 1971.

TABLE 2.1-1 (continued)

	1960	1970	Percent Change	Location (miles from site)
Linn County				
Blue Mound	319	308	- 3.4	37.7 ESE
La Cygne	810	989	22.1	48.0 E
Mound City	601	714	8.0	47.6 E
Parker	181	255	40.9	37.5 E
Lyon County				
Admire	149	144	- 3.4	34.9 NW
Allen	205	175	-14.6	38.4 NW
Americus	300	441	47.0	35.7 WNW
Bushong	51	39	-23.5	41.5 NW
Emporia	18,190	22,327	28.2	28.0 WNW
Hartford	337	478	41.8	14.8 WNW
Neosho Rapids	178	234	31.5	17.2 WNW
Olpe	722	453	-37.3	25.5 W
Reading	249	247	- 0.8	23.6 NW
Miami County				
Fontana	138	160	15.9	47.0 ENE
Osawantomie	4,622	4,294	-71.1	42.8 ENE
Paola	4,784	4,622	- 3.4	48.2 ENE
Morris County				
Dunlap	134	102	-23.9	43.2 WNW
Neosho County				
Chanute	10,849	10,341	- 4.7	40.0 SSE
Earlton	104	102	- 1.9	45.6 SSE
Stark	96	124	29.2	47.5 SE
Osage County				
Burlingame	1,151	999	-13.2	35.7 NNW
Carbondale	664	1,041	56.8	39.0 N
Lyndon	953	958	0.5	24.6 N
Melvern	376	455	21.0	17.7 N
Olivet	116	64	-44.8	16.3 N
Osage City	2,213	2,600	17.5	27.0 N
Overbrook	509	748	47.0	37.4 N
Quenemo	434	429	- 1.2	24.8 NNE
Scranton	576	575	- 0.2	37.4 N

TABLE 2.1-1 (continued)

	1960	1970	Percent Change	Location (miles from site)
Shawnee County				
Auburn	-	261	-	46.2 N
Wabaunsee County				
Eskridge	519	589	13.5	48.3 NNW
Harveyville	204	279	36.8	32.4 NNW
Wilson County				
Altoona	490	475	- 3.1	48.8 S
Benedict	128	91	-28.9	41.5 S
Buffalo	422	321	-23.9	35.7 S
Coyville	133	93	-30.1	40.1 SSW
Fredonia	3,233	3,080	- 4.7	48.2 S
New Albany	104	59	-43.3	47.4 SSW
Woodson County				
Neosho Falls	222	184	-17.1	16.8 SSE
Toronto	524	431	-17.7	32.8 SSW
Yates Center	2,080	1,967	- 5.4	23.9 S

TABLE 2.1-2 Sheet 1 of 3

RESIDENT POPULATION DISTRIBUTION
BY SECTOR AND RADIAL DISTANCE UP TO 10 MILES*

		Radial Distance from Reactor (Miles)						
Sector	Year	0-1	1-2	2-3	3-4	4-5	5-10	10-Mile Total
N	1970	0	3	2	9	1	75	90
	1980	0	10	10	10	10	70	110
	1990	0	10	10	10	10	60	100
	2000	0	10	10	10	10	60	100
	2010	0	10	10	10	0	40	70
	2020	0	10	10	10	0	30	60
NNE	1970	0	1	1	5	18	147	172
	1980	0	10	10	10	20	150	200
	1990	0	10	10	10	20	140	190
	2000	0	10	10	10	20	140	190
	2010	0	10	10	10	10	110	150
	2020	0	0	0	10	10	90	110
NE	1970	0	1	4	11	6	74	96
	1980	0	10	10	10	10	70	110
	1990	0	10	10	10	10	70	110
	2000	0	10	10	10	10	60	100
	2010	0	0	10	10	10	50	80
	2020	0	0	10	10	10	40	70
ENE	1970	0	0	7	3	4	77	91
	1980	0	0	10	10	10	70	100
	1990	0	0	10	10	10	70	100
	2000	0	0	10	10	10	60	90
	2010	0	0	10	10	10	50	80
	2020	0	0	10	10	10	40	70
E	1970	0	3	1	1	1	61	67
	1980	0	10	10	10	10	50	90
	1990	0	10	10	10	10	50	90
	2000	0	10	10	10	10	40	80
	2010	0	10	0	0	0	30	40
	2020	0	10	0	0	0	20	30

* If the projected population is less than 10, the projections have been rounded upward. Thus, if there are 2 persons projected, the number has been rounded to 10.

TABLE 2.1-2 (continued) Sheet 2 of 3

Sector	Year	0-1	1-2	2-3	3-4	4-5	5-10	10-Mile Total
		Radial Distance from Reactor (Miles)						
ESE	1970	0	9	7	3	18	90	127
	1980	0	10	10	10	20	80	130
	1990	0	10	10	10	10	80	120
	2000	0	10	10	10	10	70	110
	2010	0	10	10	10	10	50	90
	2020	0	10	10	10	10	40	80
SE	1970	0	4	7	7	8	107	133
	1980	0	10	10	10	10	100	140
	1990	0	10	10	10	10	90	130
	2000	0	10	10	10	10	90	130
	2010	0	10	10	10	10	70	110
	2020	0	10	10	10	10	50	90
SSE	1970	2	7	7	1	9	260	286
	1980	0	0	0	10	10	250	270
	1990	0	0	0	10	10	250	270
	2000	0	0	0	0	10	240	250
	2010	0	0	0	0	10	200	210
	2020	0	0	0	0	10	150	160
S	1970	0	4	7	14	8	84	117
	1980	0	0	0	10	10	80	100
	1990	0	0	0	10	10	70	90
	2000	0	0	0	10	10	60	80
	2010	0	0	0	10	10	50	70
	2020	0	0	0	10	10	30	50
SSW	1970	0	0	0	0	7	89	96
	1980	0	0	0	0	10	90	100
	1990	0	0	0	0	10	80	90
	2000	0	0	0	0	10	80	90
	2010	0	0	0	0	10	60	70
	2020	0	0	0	0	10	50	60
SW	1970	2	0	6	652	1,431	211	2,302
	1980	0	0	10	710	1,560	220	2,500
	1990	0	0	10	790	1,730	230	2,760
	2000	0	0	10	860	1,880	230	2,980
	2010	0	0	10	780	1,700	200	2,690
	2020	0	0	10	690	1,500	170	2,370

TABLE 2.1-2 (continued) Sheet 3 of 3

Sector	Year	0-1	1-2	2-3	3-4	4-5	5-10	10-Mile Total
		Radial Distance from Reactor (Miles)						
WSW	1970	0	0	11	29	13	66	119
	1980	0	0	10	30	10	60	110
	1990	0	0	10	30	10	50	100
	2000	0	0	10	30	10	50	100
	2010	0	0	10	20	10	40	80
	2020	0	0	10	20	10	30	70
W	1970	1	0	13	1	0	43	58
	1980	0	0	10	10	0	40	60
	1990	0	0	10	10	0	30	50
	2000	0	0	10	10	0	30	50
	2010	0	0	10	10	0	20	40
	2020	0	0	10	10	0	10	30
WNW	1970	0	0	3	49	14	24	90
	1980	0	0	10	530	80	20	640
	1990	0	0	10	760	90	20	880
	2000	0	0	10	990	100	20	1,120
	2010	0	0	10	1,220	110	10	1,350
	2020	0	0	10	1,240	120	10	1,380
NW	1970	1	0	22	46	9	54	132
	1980	0	0	20	270	10	50	350
	1990	0	0	20	390	10	40	460
	2000	0	0	20	510	10	40	580
	2010	0	0	10	630	10	30	680
	2020	0	0	10	650	10	20	690
NNW	1970	0	0	13	5	5	60	83
	1980	0	0	10	10	10	50	80
	1990	0	0	10	10	10	50	80
	2000	0	0	10	10	10	40	70
	2010	0	0	10	10	10	30	60
	2020	0	0	10	10	10	20	50
Total	1970	6	32	111	836	1,552	1,522	4,059
	1980	0	60	140	1,650	1,790	1,450	5,090
	1990	0	60	140	2,080	1,960	1,380	5,620
	2000	0	60	140	2,490	2,120	1,310	6,120
	2010	0	50	120	2,740	1,920	1,040	5,870
	2020	0	40	110	2,690	1,730	800	5,370

TABLE 2.1-3

AGE DISTRIBUTIONS FOR THE SITE AREA FOR 1970 and 2000[a]

Age Category	1970 U.S. Population	Coffey County[b]	Counties Within 50 Miles Of Site[b]	2000 U.S. Population[c]
0 to 12	24%	19%	23%	19%
12 to 18	12%	10%	12%	9%
Over 18	64%	71%	65%	72%

[a] Year 2000 is the midpoint (rounded to the nearest census date) of the station operating life.

[b] 1970 U.S. Census of Population, General Population Characteristics, Kansas

[c] "Projections of the Population of the United States: 1977 to 2050", Population Estimates and Projections, Current Population Reports, Series P-25, No. 704: Bureau of the Census.

Note: The 0- to 10-mile 1970 distribution is represented by the "Coffey County" column, and the 10- to 50-mile 1970 distribution by the "Counties within 50 miles of the Site" column. The projected age distribution for 2000 for 0-to-10 miles and 10-to-50 miles is found in the "2000 U.S. Population" column.

TABLE 2.1-4 Sheet 1 of 3

RESIDENT POPULATION DISTRIBUTION
BY SECTOR AND RADIAL DISTANCE BETWEEN 10 AND 50 MILES

		Radial Distance from Reactor (Miles)					
Sector	Year	10-Mile Total	10-20	20-30	30-40	40-50	50-Mile Total
N	1970	90	612	2,006	2,280	11,298	16,286
	1980	110	550	1,990	2,370	13,700	18,720
	1990	100	510	2,030	2,550	16,900	22,090
	2000	100	460	2,000	2,680	20,100	25,340
	2010	70	360	1,720	2,480	23,100	27,730
	2020	60	270	1,440	2,260	26,100	30,130
NNE	1970	172	650	1,593	1,453	3,627	7,495
	1980	200	600	1,460	1,380	3,200	6,840
	1990	190	570	1,360	1,330	2,950	6,400
	2000	190	530	1,240	1,260	2,710	5,930
	2010	150	420	990	1,050	2,410	5,020
	2020	110	330	780	860	2,100	4,180
NE	1970	96	716	1,101	12,846	4,297	19,056
	1980	110	680	1,010	13,700	4,300	19,800
	1990	110	650	940	15,000	4,430	21,130
	2000	100	620	850	15,100	4,520	21,190
	2010	80	500	690	14,000	4,160	19,430
	2020	70	400	540	12,800	3,750	17,560
ENE	1970	91	477	1,449	2,248	9,120	13,385
	1980	100	390	1,310	2,110	10,100	14,010
	1990	100	330	1,210	2,000	11,400	15,040
	2000	90	270	1,100	1,880	12,700	16,040
	2010	80	190	890	1,540	12,000	14,700
	2020	70	140	710	1,230	11,100	13,250
E	1970	67	563	4,266	1,030	1,553	7,479
	1980	90	460	4,080	910	1,470	7,010
	1990	90	380	3,940	810	1,410	6,630
	2000	80	310	3,760	730	1,350	6,230
	2010	40	220	3,240	560	1,110	5,170
	2020	30	160	2,730	420	890	4,230
ESE	1970	127	466	562	1,212	1,532	3,899
	1980	130	380	460	1,020	1,400	3,390
	1990	120	310	370	870	1,290	2,960
	2000	110	250	300	740	1,190	2,590
	2010	90	180	210	550	960	1,990
	2020	80	130	150	400	750	1,510

TABLE 2.1-4 (continued) Sheet 2 of 3

Sector	Year	10-Mile Total	10-20	20-30	30-40	40-50	50-Mile Total
		Radial Distance from Reactor (Miles)					
SE	1970	133	305	7,525	2,433	1,779	12,175
	1980	140	250	7,460	2,290	1,550	11,690
	1990	130	210	7,450	2,180	1,370	11,340
	2000	130	170	7,370	2,060	1,190	10,920
	2010	110	120	6,450	1,720	930	9,330
	2020	90	80	5,510	1,410	700	7,790
SSE	1970	286	754	1,176	3,810	13,388	19,414
	1980	270	690	1,000	3,660	12,800	18,420
	1990	270	630	850	3,550	12,300	17,600
	2000	250	580	720	3,410	11,600	16,560
	2010	210	450	540	2,920	10,100	14,220
	2020	160	350	400	2,450	8,710	12,070
S	1970	117	152	2,798	986	4,367	8,420
	1980	100	120	2,600	840	4,520	8,180
	1990	90	100	2,430	720	4,730	8,070
	2000	80	80	2,240	620	4,930	7,950
	2010	70	60	1,860	460	4,360	6,810
	2020	50	40	1,500	340	3,770	5,700
SSW	1970	96	336	660	290	947	2,329
	1980	100	270	540	240	800	1,950
	1990	90	220	450	210	680	1,650
	2000	90	180	370	170	580	1,390
	2010	70	130	270	130	430	1,030
	2020	60	90	200	90	310	750
SW	1970	2,302	495	452	524	4,332	8,105
	1980	2,500	460	310	380	3,930	7,580
	1990	2,760	430	210	280	3,570	7,250
	2000	2,980	410	140	200	3,200	6,930
	2010	2,690	320	90	130	2,590	5,820
	2020	2,370	240	50	80	2,040	4,780
WSW	1970	119	418	986	868	260	2,651
	1980	110	360	740	650	180	2,040
	1990	100	320	560	480	130	1,590
	2000	100	280	410	350	90	1,230
	2010	80	210	280	230	60	860
	2020	70	150	180	150	40	590

TABLE 2.1-4 (continued) Sheet 3 of 3

Sector	Year	10-Mile Total	10-20	20-30	30-40	40-50	50-Mile Total
		Radial Distance from Reactor (Miles)					
W	1970	58	460	1,908	1,415	993	4,834
	1980	60	420	1,820	1,340	920	4,560
	1990	50	380	1,730	1,280	920	4,360
	2000	50	340	1,620	1,220	910	4,140
	2010	40	260	1,290	1,000	760	3,350
	2020	30	190	1,000	800	620	2,640
WNW	1970	90	415	19,119	6,382	1,491	27,497
	1980	640	390	23,200	7,470	1,360	33,060
	1990	880	370	28,200	8,800	1,320	39,570
	2000	1,120	350	33,800	10,300	1,260	46,830
	2010	1,350	280	34,300	10,200	1,030	47,160
	2020	1,380	220	33,900	9,870	810	46,180
NW	1970	132	851	783	1,056	828	3,650
	1980	350	880	730	970	720	3,650
	1990	460	910	670	900	650	3,590
	2000	580	930	620	820	580	3,530
	2010	680	800	480	640	440	3,040
	2020	690	670	360	480	330	2,530
NNW	1970	83	252	3,168	1,314	2,342	7,159
	1980	80	210	3,220	1,220	2,500	7,230
	1990	80	190	3,350	1,150	2,720	7,490
	2000	70	160	3,380	1,070	2,930	7,610
	2010	60	120	2,960	850	2,600	6,590
	2020	50	90	2,520	650	2,260	5,570
Total	1970	4,059	7,922	49,552	40,147	62,154	163,834
	1980	5,090	7,110	51,930	40,550	63,450	168,130
	1990	5,620	6,510	55,750	42,110	66,770	176,760
	2000	6,120	5,920	59,920	42,610	69,840	184,410
	2010	5,870	4,620	56,260	38,460	67,040	172,250
	2020	5,370	3,550	51,970	34,290	64,280	159,460

TABLE 2.1-5

SCHOOLS WITHIN 10 MILES OF THE SITE

School District	School	Enrollment	Staff	Grades Served	Location (miles from site)
244	Elementary School	305	15	K-4	4.3 SW
	Middle School	236	14	5-8	4.3 SW
	High School	231	18	9-12	4.3 SW
	Outdoor Laboratory for Environmental Education	Transient from enrollment listed above	Transient from staff listed above	All	4.3-5.7 WNW
Private	Honey Tree Preschool	24 4-year olds 10 3-year olds	1	Preschool	3.0 NW

Sources: Superintendent of Unified School District 244, 1979, Burlington, Kansas, personal communication.

Vajne, Mrs. J., 1979, Honey Tree Preschool, personal communication.

Yokum, T., 1979, Biology Instructor, Burlington High School, Burlington, Kansas, personal communication.

Note: For locations of these facilities, see Figure 2.1-21.

TABLE 2.1-6

HOSPITALS AND NURSING HOMES
WITHIN 10 MILES OF THE SITE

	Capacity (beds)	Staff	Planned Expansion	Location (miles from site)
Coffey County Hospital	26	80	None	3.7 SW
Golden Age Lodge	115	70	None	3.7 SW

Sources: Griffith, W., 1979, Administrator, Coffey County Hospital, Burlington, Kansas, personal interview (May 22).

Garrett, Mrs., 1979, Administrator, Golden Age Lodge of Burlington, Burlington, Kansas, personal communication.

<u>Note</u>: For location of these facilities, see Figure 2.1-21.

TABLE 2.1-7

CORRECTIONAL FACILITIES
WITHIN 10 MILES OF THE SITE

Facility	Maximum Capacity (prisoners)	Employees	Location (miles from site)
Coffey County Jail	19	7	4.2 SW

Source: Freeman, E., 1979, Sheriff, Coffey County, Kansas, personal communication.

Note: For location of this facility, see Figure 2.1-21.

TABLE 2.1-8

RECREATION FACILITIES WITHIN 10 MILES OF THE SITE

Location	Activities	Visitor Statistics	Location (miles from site)
Coffey County Fairgrounds	Baseball Football Tractor Pulling	100-150/game 500-600/game 1,700-2,000/contest	4.2 SW
Drake Park	Fishing Camping Picnicking	25-35	3.3 SW
Floral Park	Band Concerts General Use Picnicking	75	4.2 SW
Flint Hills National Wildlife Refuge	Warmwater Fishing Other Sightseeing	4,098/month 3,868/month 8,827/month 16,791/top peak month (June 1978)	6.8 - 20.8 NW
John Redmond Reservoir	Boating Fishing Picnicking	380,000/year	3.5 W
Katy Park	Tennis Baseball Swimming	 50-75/game 300 daily	4.6 SW
Pleasant Valley Tourist Farm	Campsites	8 permanent 5 maximum transient	3.2 WSW

TABLE 2.1-8 (continued)

Location	Activities	Visitor Statistics	Location (miles from site)
Rock Creek Country Club	Golf Dancing Billiards Dining	90-120 at one time	4.8 SW
Arrowhead Hills	Golf	85-90/day on summer weekend	3.5 NW

Sources: Bahr, J., 1973, Vice-President of Fair Association, Burlington, Kansas, written communication.

Boyce, E.M., 1979, Owner, Arrowhead Hills Golf Course, personal interview (May 23).

Chester, M., 1979, Project Manager, U.S. Army Corps of Engineers, John Redmond Reservoir, Kansas, personal communication.

Duncan, D., 1979, Project Headquarters, John Redmond Resevoir, U.S. Army Corps of Engineers, Tulsa, Oklahoma.

Hayen, B., 1973, Co-owner of Glassco, New Strawn, Kansas, written communication.

Helbert, J.R., 1973, Manager of the Rock Creek Country Club, Inc., written communication.

Likes, G., 1973, Owner of the Pleasant Valley Tourist Farm, Coffey County, Kansas, written communication.

Logan, M., 1973, City Clerk, Burlington, Kansas, written communication.

Long, M., 1979, Refuge Manager, Flint Hills National Wildlife Refuge, U.S. Fish & Wildlife Service, Hartford, Kansas.

Note: For locations of these facilities, see Figure 2.1-21.

TABLE 2.1-9 Sheet 1 of 2

POPULATION DISTRIBUTION WITHIN THE LOW POPULATION ZONE, 1970 and 1980

Sector	Year	0-1	1-2	2-2.5	Total
N	1970	0	3	0	3
	1980*	0	10	5	15
NNE	1970	0	1	0	1
	1980*	0	10	5	15
NE	1970	0	1	1	2
	1980*	0	10	5	15
ENE	1970	0	0	4	4
	1980*	0	0	5	15
E	1970	0	3	0	3
	1980*	0	10	5	15
ESE	1970	0	9	3	12
	1980*	0	10	5	15
SE	1970	0	4	7	11
	1980*	0	10	5	15
SSE	1970	2	7	6	15
	1980*	0	0	0	0
S	1970	0	4	4	8
	1980*	0	0	0	0
SSW	1970	0	0	0	0
	1980*	0	0	0	0
SW	1970	2	0	0	2
	1980*	0	0	5	5
WSW	1970	0	0	12	12
	1980*	0	0	5	5

*For the 2- to 2.5-mile area outside the cooling lake, the population was apportioned 1/2 in the LPZ and 1/2 out of the LPZ (Table 2.1-2).

TABLE 2.1-9 (continued) Sheet 2 of 2

Sector	Year	0-1	1-2	2-2.5	Total
W	1970	1	0	4	5
	1980*	0	0	5	5
WNW	1970	0	0	3	3
	1980*	0	0	5	5
NW	1970	1	0	15	16
	1980*	0	0	10	10
NNW	1970	0	0	4	4
	1980*	0	0	5	5
Grand	1970	6	32	63	101
Total	1980*	0	60	70	130

TABLE 2.1-10

COMPARISON OF POPULATION DENSITY DISTRIBUTIONS FOR 1980 FOR VARIOUS FERTILITY AND MIGRATION PATTERNS

Distance from Site	Cumulative Population Density (Persons per Square Mile)			
	2.1 Fertility[a] 1965 to 1975 Migration	2.1 Fertility[a] No Migration[c]	2.7 Fertility[b] 1965 to 1975 Migration	2.7 Fertility[b] No Migration[c]
0 - 1	0	0	0	0
0 - 2	10	10	10	10
0 - 3	10	10	10	10
0 - 4	38	38	38	39
0 - 5	47	48	48	49
0 - 10	16	16	16	16
0 - 20	10	10	10	10
0 - 30	23	23	23	23
0 - 40	21	21	21	21
0 - 50	21	22	22	22

[a] Replacement fertility.

[b] Growth fertility.

[c] The no-migration assumption means that continuing out-migration trends would cease.

TABLE 2.1-11

COMPARISON OF POPULATION DENSITY DISTRIBUTIONS
FOR 2020 FOR VARIOUS FERTILITY AND MIGRATION PATTERNS

Distance from Site	Cumulative Population Density (Persons per Square Mile)			
	2.1 Fertility[a] 1965 to 1975 Migration	2.1 Fertility[a] No Migration[c]	2.7 Fertility[b] 1965 to 1975 Migration	2.7 Fertility[b] No Migration[c]
0 - 1	0	0	0	0
0 - 2	5	5	5	6
0 - 3	7	7	7	8
0 - 4	21	21	24	26
0 - 5	57	59	63	66
0 - 10	15	16	17	18
0 - 20	7	7	8	8
0 - 30	22	22	25	27
0 - 40	19	20	23	24
0 - 50	20	21	24	26

[a]Replacement fertility.

[b]Growth fertility.

[c]The no-migration assumption means that continuing out-migration trends would cease.

TABLE 2.1-12

FARMS, LAND IN FARMS, AND LAND USE
WITHIN 50 MILES OF THE SITE

Land Use	Number*
Total Area	5,026,548
Approximate Water Area	8,900
All Farms	
All Farms	10,000 (total number)
Land in Farms	4,500,000
Average Size of Farm	440
Proportion in Farms	89%
Land in Farms According to Use	
Total Cropland	2,200,000
Harvested Cropland	1,500,000
Cropland Used Only for Pasture	530,000
Woodland, Including Woodland Pasture	170,000
Other Land, Including Other Pastureland	2,100,000
Irrigated Land	8,500

*All numbers in acres except where noted.

Sources: U.S. Bureau of the Census, 1977, 1974 census of agriculture: U.S. Government Printing Office, Washington, D.C., vol. 1, part 16, Kansas.

Kansas Crop and Livestock Reporting Service, 1978, 61st annual report and farm facts: Kansas State Board of Agriculture, Topeka.

TABLE 2.1-13

CROP PRODUCTION WITHIN 50 MILES OF THE SITE

Crop	Acres	U.S. Units: Yield Per Acre	U.S. Units: Quantity Harvested	Metric Equivalent: Yield (kg/m^2)	Metric Equivalent: Quantity Harvested (kg)
Wheat	377,000	27 bu.	10,300,000 bu.	0.18	280,000,000
Corn for Grain	99,000	83 bu.	8,220,000 bu.	0.52	209,000,000
Corn for Silage	35,300	12 tons	440,000 tons	2.79	399,000,000
Oats	39,500	46 bu.	1,830,000 bu.	0.17	26,500,000
Barley	3,500	39 bu.	138,000 bu.	0.21	3,010,000
Rye	286	20 bu.	5,700 bu.	0.13	145,000
Sorghum for Grain	459,000	64 bu.	29,400,000 bu.	0.40	747,000,000
Sorghum for Silage	27,100	13 tons	355,000 tons	2.93	322,000,000
Sorghum for Forage	7,970	3 tons	24,200 tons	0.68	21,900,000
Soybeans	369,000	26 bu.	9,770,000 bu.	0.18	266,000,000
Pasture	2,680,000	NA	NA	NA	NA
Alfalfa Hay	93,400	3 tons	266,000 tons	0.64	241,000,000
Other Hay	401,000	1.5 tons	610,000 tons	0.34	554,000,000
Other Field Seeds	17,700	123 lbs.	2,170,000 lbs.	0.01	986,000
Apples, Peaches	NA	NA	1,970,000 lbs.	NA	892,000
Irish Potatoes	85	85 cwt.	7,210 cwt.	0.95	327,000
Vegetables, Sweet Corn, Melons	178	NA	NA	NA	NA
Berries	24	NA	NA	NA	NA
Land in Orchards	854	NA	NA	NA	NA

Note: NA = Not Available

Sources: U.S. Bureau of the Census, 1977, 1974 census of agriculture: U.S. Government Printing Office, Washington, D.C., vol. 1, part 16, Kansas.

Kansas Crop and Livestock Reporting Service, 1978, 61st annual report and farm facts: Kansas State Board of Agriculture, Topeka.

TABLE 2.1-14

LIVESTOCK WITHIN 50 MILES OF THE SITE

Type Of Animal	Inventory (Number Of Animals)
All Cattle and Calves	630,000
Beef Cows	228,000
Milk Cows	21,000
Cattle on Feed	35,100
Hogs and Pigs	249,000
Sheep and Lambs	12,800
Chickens (excluding broilers)	383,000
Broilers and Other Meat-Type Chickens	10,300
Turkeys	594

Sources: U.S. Bureau of the Census, 1977, 1974 census of agriculture: U.S. Government Printing Office, Washington, D.C., vol. 1, part 16, Kansas.

Kansas Crop and Livestock Reporting Service, 1978, 61st annual report and farm facts: Kansas State Board of Agriculture, Topeka.

TABLE 2.1-15

FEED CONSUMPTION BY CATTLE
IN EAST-CENTRAL KANSAS

	Average Annual Consumption (Pounds Per Animal)			
	Feed Grains	Hay	Forage And Silage	Pasture
Beef Cows and Calves	450 - 600	2,000	4,000	7,000
Milk Cows	6,000	4,000	8,000	1,500 - 2,000
Cattle on Feed	2,500 - 3,000	250	250	--
Other Cattle	450 - 600	1,500	--	4,000 - 4,500

Source: Brazle, 1979, Livestock Specialist, Extension Services, Chanute, Kansas, personal communication (January 26).

TABLE 2.1-16

HUNTING HARVEST WITHIN 50 MILES

Game Species	Annual Harvest
Big Game	
White-Tailed Deer	560
Small Game	
Bobwhite	220,000
Ring-Necked Pheasant	65,000
Greater Prairie Chicken	2,400
Gray and Fox Squirrel	34,000
Eastern Cottontail	45,000
Mourning Dove	170,000
Waterfowl	
Mallard	3,400
Pintail	320
Green-Winged Teal	1,300
Blue-Winged Teal	900
Wigeon	301
Gadwall	690
Shoveler	130
Scaup	400
Ring-Necked Duck	160
Redhead	61
Canvasback	32
Wood Duck	250
Merganser	65
Coot	140
Other Ducks	83
Unknown Ducks	210
Canada Goose	210
White-fronted Goose	41
Snow Goose	320
Unknown Geese	5

Sources:

Sexon, K., 1979, Big Game Project Leader, Kansas Fish and Game Commission, Pratt, Kansas, personal communication (February 6).

Kraft, M.J., 1979, Waterfowl Project Leader, Kansas Fish and Game Commission, Pratt, Kansas, personal communication (January 26).

Montei, K., 1979, Head of Wildlife Research, Kansas Fish and Game Commission, Pratt, Kansas, personal communication (January 18).

Johnson, N.F., 1979, Furbearer Project Leader, Kansas Fish and Game Commission, Pratt, Kansas, personal communications (January).

TABLE 2.1-17 Sheet 1 of 4

AGRICULTURAL DATA FOR COFFEY COUNTY, KANSAS

	1977[(a)]	1974[(b)]	1969[(b)]
County Land Area (acres)	394,880[(b)]	394,880	394,880
Lands in Farms (acres)	373,000	383,983	379,025
Percent of Land Area in Farms	94.5	97.2	96.0
Number of Farms	734	797	873
Average Size of Farms (acres)	508	482	434
Average Value of Land and Buildings per Farm	NA[(c)]	$138,803	$67,277
Land in Farms According to Use			
Total Cropland (acres)	NA	208,166	210,014
Harvested Cropland (acres)	177,020	158,218	122,770
Cropland Used Only For Pasture or Grazing (acres)	NA	43,641	55,345
Other Cropland (acres)	NA	6,307	31,899
Woodland (acres)	NA	7,776	11,522
Other Land (acres)	NA	168,041	157,489
Irrigated Land (acres)	NA	468	189

[a]Kansas Crop and Livestock Reporting Service, 1978, 61st annual report and farm facts: Kansas State Board of Agriculture, Topeka.

[b]U.S. Bureau of the Census, 1977, 1974 census of agriculture: U.S. Government Printing Office, Washington, D.C., vol. 1, part 16, Kansas.

[c]NA = Not Available

TABLE 2.1-17 (continued)

	1977[a]	1974[b]	1969[b]
Crops Harvested			
Corn for Grain			
Farms Reporting	NA	166	331
Acres	8,700	8,358	11,409
Bushels	734,000	259,266	643,335
Corn for Silage or Green Chop			
Farms Reporting	NA	155	95
Acres	1,300	7,213	2,177
Tons (green)	15,600	41,764	24,507
Corn for Dry Fodder, Hogged or Grazed			
Farms Reporting	NA	14	15
Acres	NA	399	219
Sorghum for Grain			
Farms Reporting	NA	449	414
Acres	37,100	27,678	22,362
Bushels	2,565,200	987,760	1,150,115
Sorghum for Silage, Fodder, Hay			
Farms Reporting	NA	77	NA
Acres	4,100	1,733	2,681
Wheat for Grain			
Farms Reporting	NA	443	474
Acres	34,200	23,309	15,397
Bushels	896,000	592,683	419,657

TABLE 2.1-17 (continued)

	1977[a]	1974[b]	1969[b]
Soybeans for Beans			
Farms Reporting	NA	566	533
Acres	44,400	53,801	35,837
Bushels	1,095,000	877,136	790,808
Hay			
Farms Reporting	NA	547	553
Acres	48,500	39,295	33,383
Tons (dry)	84,400	46,017	62,569
Other Small Grains for Grain			
Farms Reporting	NA	71	39
Acres	200	876	731
Irish Potatoes			
Farms Reporting	NA	6	NA
Acres	NA	6	NA
Hundredweight	NA	202	NA
Sweet Potatoes			
Farms Reporting	NA	1	NA
Acres	NA	-	NA
Bushels	NA	2	NA
Vegetables, Sweet Corn, or Melons For Sale			
Farms Reporting	NA	1	-
Acres	NA	2	-
Land in Orchards			
Farms Reporting	NA	5	6
Acres	NA	37	14

TABLE 2.1-17 (continued)

	1977[a]	1974[b]	1969[b]
Berries For Sale			
Farms Reporting	NA	-	6
Acres	NA	-	2
Other Crops			
Farms Reporting	NA	16	NA
Acres	NA	480	628
<u>Livestock & Poultry</u>			
Cattle and Calves			
Farms Reporting	NA	609	661
Number	47,600	48,747	54,847
Hogs and Pigs			
Farms Reporting	NA	159	284
Number	13,100	11,741	20,409
Sheep and Lambs			
Farms Reporting	NA	13	36
Number	400	521	1,415
Chickens (3 months old or older)			
Farms Reporting	NA	113	196
Number	37,000	43,315	27,707
Broilers and Other Meat-Type Chickens			
Farms Reporting	NA	12	2
Number	NA	968	57

TABLE 2.1-18

DISTANCE TO NEAREST PLANT BOUNDARY, RESIDENCE, VEGETABLE GARDEN AND LIVESTOCK WITHIN 5 MILES

Sector	Distance From Reactor (Miles)						
	Nearest Plant Boundary	Nearest Residence	Nearest Vegetable Garden	Nearest Meat Animal	Nearest Dairy Cow	Nearest Dairy Goat	Milk Consumers
N	1.1	1.4	1.4	1.1	1.1	None	2 adults and 1 child (8 years old)
NNE	1.1	2.6	2.7	0.8	4.7	None	3 adults and 2 children (ages 3 and 5 years)
NE	1.3	1.8	1.8	0.8	None	None	
ENE	1.5	2.0	2.0	0.8	None	None	
E	1.2	1.8	1.8	1.2	1.8	None	4 adults and 4 children (ages 4-16 years)
ESE	1.2	1.6	1.6	1.2	1.7	None	2 adults
SE	1.2	1.4	1.4	1.2	3.6	None	2 adults
SSE	3.0	3.0	3.0	3.2	None	None	
S	3.3	3.5	3.5	3.3	None	None	
SSW	1.7	2.6	3.9	3.3	None	2.6	2 adults and 2 children (ages 10 and 12 years)
SW	1.5	2.1	2.1	1.6	3.6	4.4	Cow milk - 1 adult, Goat milk - 2 adults
WSW	1.5	2.4	2.4	1.5	4.7	None	Various local families
W	1.8	2.2	2.2	1.7	None	None	
WNW	2.1	2.9	2.9	2.1	None	None	
NW	2.6	2.3	2.3	2.2	None	None	
NNW	1.5	1.5	2.2	2.0	None	None	

Source: Field Investigation, Kansas Gas and Electric Company, 1978.

TABLE 2.1-19

WATER RIGHTS ON THE NEOSHO RIVER IN KANSAS DOWNSTREAM OF THE SITE

Application Number	Location of Diversion[(a)]	Map Key [(b)]	Approximate River Mile[(c)]	Owner	Source	Authorized Maximum Diversion Rate (gpm)	Authorized Maximum Annual Quantity (acre-feet)	Principal Use
6799-A	E/SE/NE 29-22-16	1	327	K. Crotts	Neosho River	1125	39	Irrigation
1526	SW/NW, SW/SW 4-23-16 SE/SE 5-23-16	2	324	M. Parmely	Neosho River	1300	79	Irrigation
4865	SW/NW, SW/SW 4-23-16 SE/SE 5-23-16	2	324	M. Parmely	Neosho River	2160	79	Irrigation
R Code 624	NE/NW 3-23-16	3	321	City of Leroy and vicinity	Neosho River	160	55	Municipal
3495	NE/NW 3-23-16	3	321	City of Leroy and vicinity	Neosho River	200	80	Municipal
10803	SW/SW 28-23-17 NW/NW/NW 33-23-17	4	306	Woodson Co. Rural Water District No. 1	Neosho River	100	81	Municipal
27403	SW/SW/SW 28-23-17	4	306	Woodson Co. Rural Water District No. 1	Neosho River	210	160	Municipal
3854	N/NE 11-24-17	5	301	F. Leis	Neosho River	1400	211	Irrigation
13055	SE/SE/NE, NE/NE/SE 12-24-17	6	300	K. Heinz	Neosho River	1000	233	Irrigation
15435	SE/SE/SW 7-24-18	7	298	E. Bergman	Neosho River	800	34	Irrigation

[a] Locations are specified by section division, section, township, and range.

[b] See Figure 2.1-25 for locations.

[c] Mouth of Wolf Creek is approximately at Neosho River Mile 334.5; the Kansas-Oklahoma state line is at river mile 164.

Source: Kansas State Board of Agriculture, 1979, Open file material: Division of Water Resources, Topeka, Kansas (March).

Application Number	Location of Diversion[a]	Map Key[b]	Approximate River Mile[c]	Owner	Source	Authorized Maximum Diversion Rate (gpm)	Authorized Maximum Annual Quantity (acre-feet)	Principal Use
30383	NE/SE/SE 28-24-18	8	292	J. McFadden	Neosho River	800	70	Irrigation
VR 621	SW/SW 27-24-18	8	292	City of Iola	Neosho River	2200	982	Municipal
17489	SW/SW/SW 27-24-18	8	292	City of Iola	Neosho River	3250	1596	Municipal
VR 624	NW/NE 34-24-18	9	291	Pet Milk Plant	Neosho River	450	301	Industrial
3137	SE/SW/SW/SW 34-24-18	10	290	C. Sutherland	Neosho River	1000	300	Irrigation
	NE/SE/SW/NE 33-24-18	10	290					
	NW/NW 3-25-18	11	289					
28706	NE/SW/SW 34-24-18	10	290	J. McFadden	Neosho River	800	134	Irrigation
30382	SE/NW/SW 9-25-18	12	287	J. McFadden	Neosho River	800	82	Irrigation
15417	NW/NE/NE 31-25-18	13	282	R. Lesh	Neosho River	2700	275	Irrigation
9685	NE/NE 5-26-18	14	281	R. Lesh	Neosho River	3000	414	Irrigation
15425	NE/NE/NE 5-26-18	14	281	R. Lesh	Neosho River	4500	475	Irrigation
VR 622	SE/SW/NW 4-26-18	15	280	City of Humboldt	Neosho River	1150	368	Municipal
3527	SE/SW 32-26-18	16	274	A. Nelson	Neosho River	500	112	Irrigation
VR 625	SW/SE 5-27-18	17	273	Ash Grove Lime & Portland Cement Co.	Neosho River	500	614	Industrial
16226	SW/SW/SE 5-27-18	17	273	Ash Grove Lime & Portland Cement Co.	Neosho River	4000	921	Industrial

TABLE 2.1-19 (continued)

Application Number	Location of Diversion[a]	Map Key[b]	Approximate River Mile[c]	Owner	Source	Authorized Maximum Diversion Rate (gpm)	Authorized Maximum Annual Quantity (acre-feet)	Principal Use
26943	SE/NW/SW 11-27-18	18	268	Texaco, Inc.	Neosho River	321	518	Industrial
7566	SE/NE/SE 15-27-18	19	267	K. Casper	Neosho River	600	100	Irrigation
	SW/SE/NE SW/NE/SE 22-27-18	20	266					
VR 621	SW/NE 22-27-18	20	266	City of Chanute	Neosho River	1200	1517	Municipal
8660	SE/SW/NE 22-27-18	20	266	City of Chanute	Neosho River	4200	2717	Municipal
2702	NW/SW/NE 2-28-18	21	262	L. Taylor	Neosho River	1000	186	Irrigation
25920	SW/SE/NW, SE/NW/SE 9-28-19	22	256	E. Smith	Neosho River	700	52	Irrigation
28487	W/E 27-28-19	23	249	R. Hudson	Neosho River	1500	128	Irrigation
28488	SW/SW 36-28-19	24	247	Y. Hudson	Neosho River	1700	140	Irrigation
VR 623	NE/NW/SW 5-29-20	25	243	City of Erie	Neosho River	500	246	Municipal
19515	NE 15-29-20 NW/NW/SE 15-29-20	26	239	Hy-Grade Construction & Materials, Inc.	Neosho River	1000	178	Industrial
19514	SW 23-29-20	27	234	Hy-Grade Construction & Materials, Inc.	Neosho River	2000	1193	Irrigation
	SW 24-29-20	28	233					
	NW 25-29-20	28	232					
	NE 25-29-20	28	232					

Application Number	Location of Diversion[a]	Map Key[b]	Approximate River Mile[c]	Owner	Source	Authorized Maximum Diversion Rate (gpm)	Authorized Maximum Annual Quantity (acre-feet)	Principal Use
VR 624	NW/SW/SW 24-29-20	28	233	City of St. Paul	Neosho River	150	46	Municipal
23942	SW/SW 24-29-20	28	233	City of St. Paul	Neosho River	300	156	Municipal
8359	S/S 19-29-21	29	232	Kansas Fish & Game Commission	Neosho River	13464	3000	Recreation
29030	SW/NE/NW, NW/SW/SW, NE/SW/NW, NW/NW/SW 8-30-21	30	217	W. Goley	Alluvial Well	614	363	Irrigation
30279	SW/NE/NW, NE/SW/NW, NW/NW/SW, NW/SW/SW 8-30-21	30	217	W. Goley	Neosho River	3000	551	Irrigation
VR 622	NW 24-30-20	31	214	City of Parsons	Neosho River	6300	2306	Municipal
29739	NE/SE/NW 20-30-21	31	214	D. Goodeyon	Neosho River	1000	45	Irrigation
18139	SE/NE/NE 5-31-21 SW/SW/NW 4-31-21	32	209	Jarbse-Lackey Feed Lots, Inc.	Neosho River	2000	215 110	Irrigation Industrial
11562	SW/SW/NW 4-31-21 SE/NE/NE 5-31-21	32	209	W. Charles	Neosho River	400	313	Industrial
25860	SE/SW/NE 8-31-21 SE/NE/NW, SE/NW/SW 9-31-21	34 33 35	207 208 206	W. Brunenn	Neosho River	1500	156	Irrigation

TABLE 2.1-19 (continued)

Application Number	Location of Diversion[a]	Map Key[b]	Approximate River Mile[c]	Owner	Source	Authorized Maximum Diversion Rate (gpm)	Authorized Maximum Annual Quantity (acre-feet)	Principal Use
VR 628	SW/SE 28-31-21 NW/NE 33-31-21	36	200	Kansas Ordinance Plant	Neosho River	2225	869	Industrial
VR 627	SE 33-31-21	37	199	Kansas Gas & Electric	Neosho River	10,000	651	Industrial
3646	SE 33-31-21	37	199	Kansas Gas & Electric	Neosho River	2600	2080	Industrial
8432	SE 33-31-21	37	199	Kansas Gas & Electric	Neosho River	14890	2026	Industrial
19526	SE/SW/NE, SN/NE/SE, 4-32-21 NW 9-32-21	38 39	198 197	C. Sprague	Neosho River	1000	163	Irrigation
19498	NE/SE 9-32-21	39	197	C. Sprague	Neosho River	1000	198	Irrigation
30,155	NW/NE/SE 4-32-21 NE/SE/NE 9-32-21 NW/NW/NW 10-32-21	38 39 39	198 197 197	R. Spriggs	Neosho River	1500	360	Irrigation
29,746	SW/SW/SE 22-32-21 SW/NW/NE 27-32-21	40	193	J. Sprague	Neosho River	1500	285	Irrigation
29,952	NE/NE/NE 15-33-21 NW/SW/SW 10-33-21	41	187	P. Sinclair	Neosho River	1500	340	Irrigation
VR 623	16-33-21	41	187	City of Oswego	Neosho River	600	261	Municipal
25,003	SE/NE/NE 16-33-21	41	187	City of Oswego	Neosho River	800	635	Municipal
VR 624	35-34-21	42	170	City of Chetopa	Neosho River	300	190	Municipal

TABLE 2.1-20

NEOSHO RIVER DISCHARGERS* IN KANSAS
DOWNSTREAM OF THE SITE

Facility	Design Discharge (mgd)	Actual Discharge (mgd)
City of LeRoy	0.10	0.04
City of Iola	1.63	0.6-0.7
City of Humboldt	0.325	0.25
City of Chetopa	0.2	0.2
City of Chanute	1.46	2.0

*National Pollution Discharge Elimination System (NPDES)

Source: Waldo, D.F., 1979, Water Pollution Control Section, Kansas State Department of Health and Environment, Topeka, Kansas, personal communication.

TABLE 2.1-21

MUNICIPALITIES AND RURAL WATER DISTRICTS (RWD) IN KANSAS
UTILIZING THE NEOSHO RIVER DOWNSTREAM OF THE SITE

City or Rural Water District	1976-1977 Population Served	1976-1977 Annual Water Use (acre-feet)	2000 Estimated Population Served	2000 Annual Projected Water Water Use (acre-feet)	Source of Water
Coffey County					
LeRoy	653	47.6	992	93.1	Neosho River
Anderson County					
RWD #5	1,205	135.0	*	*	City of Iola, Allen Co.
Kincaid	350	28.0	*	*	RWD #5
RWD #5 to Allen Co.	240	18.1	240	22.0	City of Iola, Allen Co.
RWD #5 to Coffey Co.	55	6.2	58	7.7	City of Iola, Allen Co.
RWD #5 to Franklin Co.	90	10.6	*	*	City of Iola, Allen Co.
Woodson County					
RWD #1	360	21.9	462	34.8	Neosho River
RWD #1 to Allen Co.	200	15.1	200	18.3	Neosho River
Allen County					
Humboldt	2,444	472.7	2,610	511.8	Neosho River
Iola	6,968	1,197.9	7,500	1,309.8	Neosho River
Bassett	32	8.0	28	7.0	City of Iola
Gas City	522	73.7	580	89.4	City of Iola
LaHarpe	621	87.7	670	104.9	City of Iola
RWD #1	26	3.7	22	3.2	City of Iola
RWD #2	42	7.0	38	6.3	City of Iola
RWD #3	60	5.3	64	5.7	City of Iola
RWD #4	28	5.9	24	5.3	City of Iola
RWD #5	20	8.8	18	8.0	City of Iola
RWD #6	54	6.9	50	6.4	City of Iola
RWD #7	152	17.8	145	16.9	City of Iola
RWD #8	180	27.7	352	32.4	City of Iola
RWD #9	34	4.3	38	4.8	City of Humboldt
RWD #10	84	11.7	164	36.2	City of Humboldt

*Present population and water use greater than year 2000; use present values for delivery.

Source: Flickenger, G., 1979, Associate Engineer, Kansas Water Resources Board, Topeka, Kansas, personal communication (March 9).

TABLE 2.1-21 (continued)

City or Rural Water District	1976-1977 Population Served	1976-1977 Annual Water Use (acre-feet)	2000 Estimated Population Served	2000 Annual Projected Water Water Use (acre-feet)	Source of Water
Neosho County					
Chanute	10,400	1,309.1	12,526	2,011.0	Neosho River
Erie	1,425	172.0	1,787	469.6	Neosho River
St. Paul	713	92.1	921	110.5	Neosho River
RWD #3	107	12.3	115	12.5	City of Erie
RWD #4	340	30.5	360	32.5	City of Erie
RWD #7	620	67.5	700	76.8	City of Chanute
RWD #8	196	26.6	231	108.7	City of St. Paul
RWD #9	182	26.1	274	43.0	City of Chanute
RWD #7 to Allen Co.	19	2.0	25	2.7	City of Chanute
Chanute to Petrolia (Allen Co.)	83	18.8	100	22.7	City of Chanute
Labette County					
Chetopa	1,663	168.9	1,997	233.3	Neosho River
Oswego	2,167	456.2	2,250	437.7	Neosho River
Parsons	12,344	2,151.4	16,654	2,345.1	Neosoh River Standby and Imperial Reservoir
RWD #1	220	11.0	400	20.0	City of Oswego
RWD #2	105	5.2	200	10.7	City of Parsons
RWD #4	141	15.4	170	21.5	City of Oswego
RWD #7	186	13.1	230	18.4	Neosho RWD #4
RWD #8	700	73.7	900	94.7	Labette RWD #2

WCGS-ER(OLS)

TABLE 2.1-22

MUNICIPAL GROUND-WATER SUPPLIES
WITHIN 20 MILES OF THE SITE

Location[a]	Approx[b] Elev.	Well Depth (feet)	Well Diameter (inches)	Screen Interval (feet)	Static[c] Water Level (feet)	Pumping[d] Water Level (feet)	Aquifer	Test Yield (gpm)
Waverly #1	1100	280	6	170-190 200-230	950	935	Tonganoxie	20
Waverly #2	1100	260	6	165-195 255-265	970	945	Tonganoxie	22
Waverly #3	1100	228	6	199-205	NA	NA	Tonganoxie	10
Waverly #4	1100	270	6	142-192 263-268	958	943	Tonganoxie	20
Waverly #5	1100	300	6	NA	938	NA	Tonganoxie	16
Williamsburg #1	1280	190	6	NA	1158	NA	Tonganoxie	10
Williamsburg #2	1280	190	6	NA	1164	NA	Tonganoxie	10
Williamsburg #3	1280	210	6	NA	NA	NA	Tonganoxie	18
Williamsburg #4	1280	300	6	NA	NA	NA	Tonganoxie	18
New Strawn[e]	1010	32	24	NA	998	NA	Alluvium	30
Melvern #1	1015	168	6	50-100	906	NA	Tonganoxie	13
Melvern #2	1015	160	6	NA	NA	NA	Tonganoxie	6
Melvern #3	1015	94	6	46-71 74-94	NA	NA	Tonganoxie	20
Melvern #4	1015	97	6	47-97	NA	NA	Tonganoxie	30
Melvern #5	1015	80	6	50-80	NA	NA	Tonganoxie	14
Melvern #6	1015	179	NA	NA	NA	NA	Tonganoxie	10
Hartford #1	1036	30	NA	NA	1004	NA	Alluvium	NA

[a] Locations of municipalities shown on Figure 2.1-26.

[b] Approximate elevations in feet above MSL of wells taken from U.S. Geological Survey Topographic Maps.

[c] Static water level shown as elevation above mean sea level.

[d] Pumping water level shown as elevation above mean sea level.

[e] Well for New Strawn located in alluvium of Neosho River about 1/2 mile downstream from John Redmond Dam (see Reischick below).

Sources: Kansas Water Resources Board, 1973: Open-file Material.

Gettinger, L., 1979, Records, Kansas State Board of Agriculture, Division of Water Resources, Topeka, Kansas, written communication (August 24).

Reischick, L., 1973, Farmer's Home Administration, Burlington, Kansas; written communication (September).

TABLE 2.1-23

WELL INVENTORY WITHIN 5 MILES OF THE SITE

Location[a]	Well Depth (feet)	Approx. Land Surface Elev. (feet, MSL)	Depth to Water Level (feet)	Approx. Elev. of Water Level (feet, MSL)	Type of Well	Estimated Pumpage Rate (gpd)	Name of Owner or Tenant[d]	Remarks
A1	18	1144	Above Ground Surface (AGS)	1144	Dug	250	Bennett	RWD[c]
A2	30	1164	8	1156	Dug	0	Salava	RWD
A4	NA[(b)]	NA	NA	NA	NA	0	Phillips	Well to be sealed
A14	30	1076	2	1074	Dug	360	Clapp	None
A17	35	1100	3	1007	Dug	70	Abbey	Well to be sealed
A18	30	1100	8	1092	Dug	530	Anderson	Well to be sealed
A19	2	1096	NA	NA	Dug	NA	Anderson	None
A20	18	1112	6	1106	Dug	50	Anderson	RWD
A22	14	1140	AGS	1140	Dug	0	Anderson	None
A23	NA	1090	NA	NA	NA	230	Williams	RWD
A23	NA	1093	NA	NA	NA	NA	Williams	Well to be sealed
A23	10	1089	NA	NA	NA	NA	Garrepp/ Corden	Well to be sealed
A24	NA	1099	NA	NA	NA	NA	Anderson	Well to be sealed

[a]Locations shown on Figure 2.1-27.

[b]NA indicates data Not Available.

[c]Indicates property serviced by Rural Water District No. 3.

[d]Owner or tenant at time of 1973 survey. KG&E presently owns or controls all wells within the site boundary.

Source: Based on field investigation, Dames & Moore, 1973 and 1979.

TABLE 2.1-23 (continued)

Location[a]	Well Depth (feet)	Approx. Land Surface Elev. (feet, MSL)	Depth to Water Level (feet)	Approx. Elev. of Water Level (feet, MSL)	Type of Well	Estimated Pumpage Rate (gpd)	Name of Owner or Tenant[d]	Remarks
B2	30	1123	5	1118	Dug	500	Wayne	RWD
B4	40	1091	8	1083	Dug	310	French	RWD
B8	20	1091	5	1086	Dug	75	Hess	RWD
B11	35	1080	15	1065	Dug	220	Hess	None
B12	16	NA	NA	NA	Dug	NA	NA	RWD
B12	42	1132	15	1117	Dug	410	Mallon	None
B13	33	NA	NA	NA	Dug	100	Crouch	RWD
B14	18	1081	AGS	1081	Dug	NA	NA	RWD
B14	22	1083	35	1070	Dug	NA	NA	None
B14	22	1080	5	1075	Dug	830	Huffman	None
B15	25	1062	9	1053	Dug	100	Crouch	RWD
B16	27	1087	2	1085	Dug	840	Allen	RWD
B19	13	NA	2.5	NA	Dug	NA	NA	RWD
B19	31	1113	2.5	1110	Dug	200	Skillman	None
C1	25	1097	3	1094	Dug	350	Houser	Well to be sealed
C2	NA	1101	15	1086	NA	630	Levering	RWD
C4	NA	NA	NA	NA	NA	340	Woods	RWD
C5	43	1085	11	1074	Dug	NA	NA	Well to be sealed
C5	12	1088	7	1081	Dug	500	Woods	Well to be sealed
C7	15	1075	2	1073	Dug	0	Skillman	Well to be sealed
C8	30	NA	Dry	NA	Drilled	0	Anderson	RWD

WCGS-ER(OLS)

Location[a]	Well Depth (feet)	Approx. Land Surface Elev. (feet, MSL)	Depth to Water Level (feet)	Approx. Elev. of Water Level (feet, MSL)	Type of Well	Estimated Pumpage Rate (gpd)	Name of Owner or Tenant[d]	Remarks
C9	20	1065	AGS	1065	Dug	0	Griffin	RWD
C10	20	1058	7.5	1050	Dug	410	Rhoads	RWD
C11	40	1030	10	1020	Dug	410	Nelson	None
C17	NA	1084	10	1074	Drilled	0	Hunter	Well has been sealed
C18	75	1080	4	1076	Dug	700	Robinett	Well to be sealed
C20	22	1090	18	1072	Dug	550	Applicant	RWD
C21	22	1040	5	1035	Dug	210	Robinett	None
C23	10	1030	10	1020	Dug	230	Reinker	RWD
C24	36	1022	10	1012	Dug	660	Decker	None
C25	12	1020	10	1010	Dug	5400	Likes	None
C26	31	NA	NA	NA	Drilled	210	Allen	None
C27	30	1040	15	1025	Dug	200	Cranford	None
C28	30	1040	10	1030	Dug	320	Zscheile	None
C29	30	1020	10	1010	Dug	290	Decker	None
C30	31	1041	9	1032	Dug	390	Hess	None
C31	24	1044	13	1031	Drilled	210	Birkbeck	None
C32	31	1039	4	1035	Drilled	2630	Birkbeck	None
C33	30	1040	9	1031	Dug	110	Rife	None
C34	15	1031	5	1026	Dug	410	Thompson	None
C35	NA	1031	NA	1026	NA	100	Traymick	None
C36	33	1034	10	1024	Drilled	210	Mays	None
C37	28	1031	5	1026	Drilled	210	White	None

TABLE 2.1-23 (continued)

Location[a]	Well Depth (feet)	Approx. Land Surface Elev. (feet, MSL)	Depth to Water Level (feet)	Approx. Elev. of Water Level (feet, MSL)	Type of Well	Estimated Pumpage Rate (gpd)	Name of Owner or Tenant[d]	Remarks
C38	NA	NA	NA	NA	NA	100	Hair	CITY[e]
C39	27	1020	6	1014	Dug	240	Shepherd	CITY
C41	NA	NA	NA	NA	NA	210	Deitrich	CITY
C42	25	NA	NA	NA	Dug	3400	Keith	None
C43	NA	1040	10	1030	Dug	400	Rieschick	None
C44	40	1040	10	1030	Drilled	400	Tice	None
C45	20	NA	NA	NA	Dug	390	Freeman	None
C49	23	1020	4	1016	Dug	310	Barrett	None
C50	20	1031	4	1027	Dug	75	Myers	None
C51	20	1017	3	1014	Dug	100	Hess	None
C54	NA	NA	NA	NA	NA	100	Glemore	None
C55	30	1033	8	1025	Drilled	580	Bryan	CITY
C56	30	1030	10	1020	Drilled	630	Paxson	CITY
C57	NA	NA	NA	NA	NA	0	Birk	RWD
C58	NA	NA	NA	NA	Drilled	200	Thompson	CITY
C59	30	1032	15	1017	Drilled	210	Cochran	CITY
C60	30	1033	8	1025	Drilled	410	Bolton	CITY
C61	40	1032	5	1027	Dug	430	Harson	None
C61	30	1032	8	1024	Drilled	NA	Harson	None
C64	21	1032	7	1025	Drilled	110	Vasey	None
C65	25	1030	15	1015	Dug	290	Caldwell	CITY
C70	30	1020	31	1017	Dug	1110	Hayes	RWD

[e]Indicates property serviced by City of Burlington water supply.

Location[a]	Well Depth (feet)	Approx. Land Surface Elev. (feet, MSL)	Depth to Water Level (feet)	Approx. Elev. of Water Level (feet, MSL)	Type of Well	Estimated Pumpage Rate (gpd)	Name of Owner or Tenant[a]	Remarks
C71	22	1010	5	1005	Drilled	440	Williams	None
C72	10	1013	1	1012	Dug	1370	Smart	None
C73	9	1075	NA	NA	Dug	NA	Winn	None
C73	28	1074	NA	NA	Dug	NA	Winn	None
C74	27	1087	NA	NA	NA	NA	Williams	None
C74	23	1087	NA	NA	NA	NA	NA	None
C75	10	1066	NA	NA	NA	NA	Woods	None
C76	1	1083	NA	NA	NA	NA	NA	None
C77	9	1056	NA	NA	Dug	NA	Anderson	None
C77	16	1056	NA	NA	NA	NA	Anderson	None
C77	NA	1060	NA	NA	NA	NA	Anderson	None
D1	100	1110	5	1105	Dug	380	Nielson	RWD
D1	14	NA	NA	NA	NA	NA	NA	NA
D2	30	1115	5	1100	Dug	220	Bon	RWD
D2	NA	NA	NA	NA	NA	NA	NA	NA
D3	30	1070	6	1064	Dug	150	Miller	None
D3	NA	NA	NA	NA	NA	NA	NA	NA
D4	20	1075	4	1070	Dug	10	Wuerfele	None
D5	40	1060	11	1049	Dug	440	Iseman	None
D5	25	NA	11	NA	NA	NA	NA	None
D6	20	1060	12	1048	Dug	310	Wuerfele	None
D7	16	1115	4	1111	Dug	250	Tracy	None
D8	16	1111	6	1105	Dug	470	Tragar	RWD

Location[a]	Well Depth (feet)	Approx. Land Surface Elev. (feet, MSL)	Depth to Water Level (feet)	Approx. Elev. of Water Level (feet, MSL)	Type of Well	Estimated Pumpage Rate (gpd)	Name of Owner or Tenant[b]	Remarks
D9	NA	1114	14	1100	NA	650	Hermon	None
D10	23	1105	4	1101	Dug	560	Cordell	RWD
D11	16	1043	2	1091	Dug	230	Johnson	Well to be sealed
D11	25	1088	4	1084	Dug	NA	Johnson	Well to be sealed
D12	12	1049	3	1046	Dug	160	Kellerman	Well to be sealed
D12	20	1048	7	1042	Dug	NA	Kellerman	Well to be sealed
D13	NA	1103	7	1096	Dug	650	Taylor	None
D14	26	1102	8	1094	Dug	630	Baldwin	RWD
D15	22	1070	10	1060	Dug	1820	Gifford	None
D16	20	1090	5	NA	Dug	1060	Kennard	None
D16	35	1090	5	1085	Dug	NA	Kennard	None
D17	18	1050	1	1049	Dug	1160	Salava	None
D17	10	1050	1	1049	Dug	NA	Salava	None
D19	50	NA	NA	NA	Dug	710	Yound	None
D20	180	1068	10	1058	Drilled	6400	Herr	None
D21	30	1090	5	1085	Dug	900	Bouse	None
D21	30	1095	3	1092	Dug	NA	Bouse	None
D21	30	1070	3	1067	Dug	NA	Bouse	None
D22	30	1100	AGS	1100	Dug	1410	Anderson	RWD
D23	22	1045	AGS	1045	Dug	430	Dalby	None
D24	24	1058	8	1050	Dug	630	Allen	None

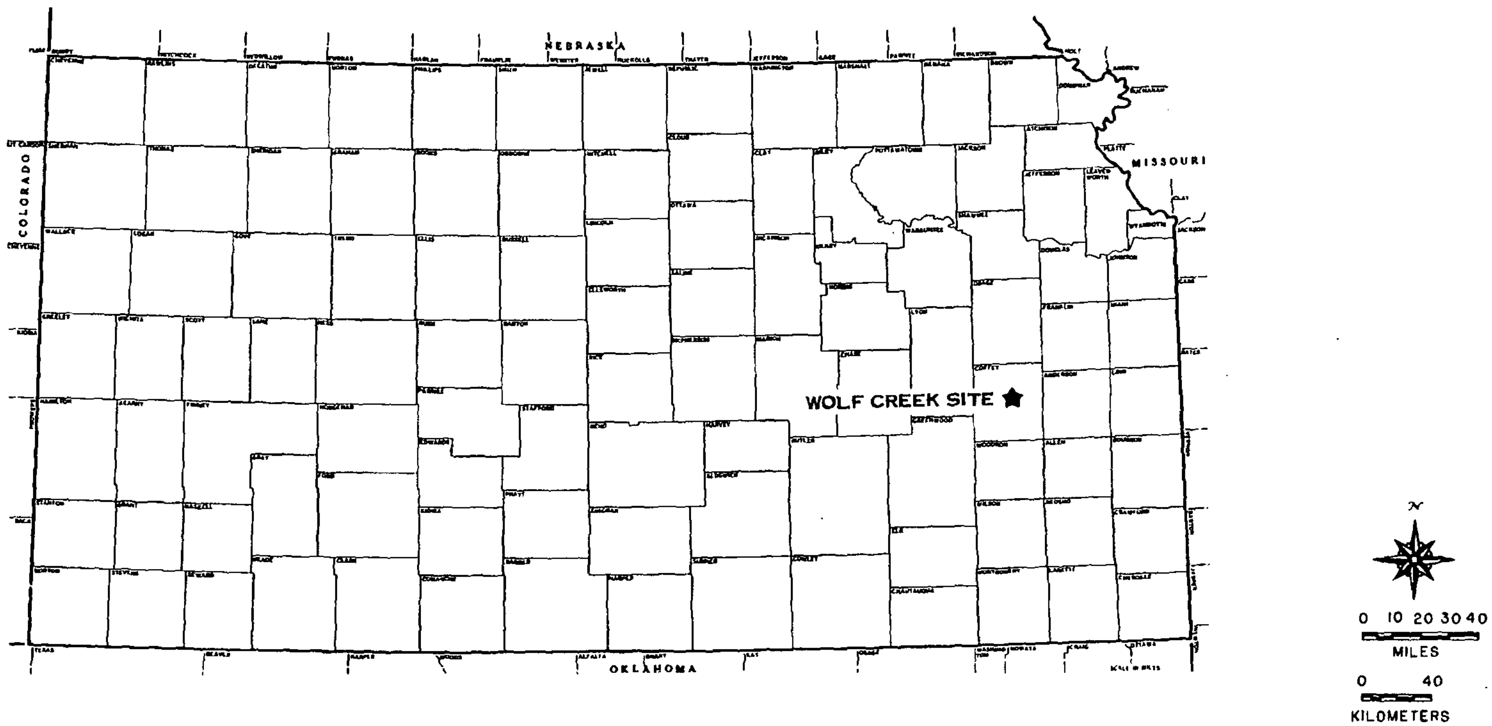
Location[a]	Well Depth (feet)	Approx. Land Surface Elev. (feet, MSL)	Depth to Water Level (feet)	Approx. Elev. of Water Level (feet, MSL)	Type of Well	Estimated Pumpage Rate (gpd)	Name of Owner or Tenant[a]	Remarks
D24	18	1050	2	1050	Dug	NA	Allen	None
D25	30	1100	4	1096	Dug	1860	Hess	Well to be sealed
D25	10	1095	AGS	1095	Dug	NA	Hess	Well to be sealed
D26	25	1104	5	1099	Dug	230	Bemis	None
D27	30	1114	7	1107	Dug	150	McReynolds	None
D28	19	1110	4	1106	Dug	150	Hess	RWD
D29	40	1071	1	1070	Dug	0	Hildebrand	Well to be sealed
D32	40	1063	NA	NA	Dug	300	Hamman	Well has been sealed
D33	42	1062	6	1057	Drilled	220	Snider	Well has been sealed
D33	30	1060	10	1050	Dug	NA	Snider	Well has been sealed
D34	30	1040	15	1025	Dug	325	Salava	Well has been sealed
D34	30	NA	NA	NA	Dug	NA	Salava	Well has been sealed
D35	NA	NA	NA	NA	NA	100	Wynn	Well to be sealed
D36	28	1030	AGS	1030	Dug	640	Riffenbark	Well has been sealed
D36	28	1030	AGS	1030	Dug	NA	Riffenbark	Well has been sealed
D37	25	1035	AGS	1035	Dug	470	Danford	Well to be sealed
D38	26	1063	3	1060	Dug	470	Iseman	Well to be sealed

TABLE 2.1-23 (continued)

Location[a]	Well Depth (feet)	Approx. Land Surface Elev. (feet, MSL)	Depth to Water Level (feet)	Approx. Elev. of Water Level (feet, MSL)	Type of Well	Estimated Pumpage Rate (gpd)	Name of Owner or Tenant[b]	Remarks
D39	38	1062	6	1056	Dug	540	Hess	Well to be sealed
D39	24	1057	3	1054	Dug	NA	Hess	None
D41	30	1083	5	1078	Dug	560	Martens	None
D42	30	1085	5	1080	Dug	190	Wuerfele	None
D43	22	1038	AGS	1038	Dug	1243	Crooks	None
D43	25	1034	AGS	1034	Dug	NA	Crooks	None
D44	22	1041	AGS	1041	Dug	80	Applicant	None
D45	30	NA	NA	NA	Dug	300	Ballew	None
D46	30	1042	AGS	1042	Dug	310	Lichlyter	None
D47	35	1040	4	1086	Dug	430	Rayl	RWD
D47	25	1040	5	1035	Dug	NA	Rayl	None
D48	26	1062	9	1053	Dug	620	Alexander	None
D49	20	1050	8	1042	Dug	900	Finical	RWD
D50	16	1063	3	1060	Dug	440	Combs	None
D51	25	1040	3	1037	Dug	340	Giesy	None
D52	18	1022	AGS	1022	Dug	390	Spencer	None
D53	20	1036	AGS	1036	Dug	290	Hess	None
D54	15	1040	10	1030	Dug	170	Wynn	None
D55	28	1078	14	1064	Dug	170	Taylor	None
D56	16	1088	3	1085	Dug	280	Hutson	Well to be sealed
D57	14	1054	AGS	1054	Dug	250	Vincent	Well to be sealed

Location[a]	Well Depth (feet)	Approx. Land Surface Elev. (feet, MSL)	Depth to Water Level (feet)	Approx. Elev. of Water Level (feet, MSL)	Type of Well	Estimated Pumpage Rate (gpd)	Name of Owner or Tenant[d]	Remarks
D58	70	1032	6	1026	Dug	360	Bull	Well to be sealed
D58	16	1044	NA	NA	Dug	NA	NA	Well to be sealed
D58	45	1032	NA	NA	Dug	NA	NA	Well to be sealed
D59	17	1019	6	1013	Dug	110	Morris	Well to be sealed
D60	8	1046	NA	NA	Dug	NA	NA	Well to be sealed
D61	28	1028	6	1022	Dug	1650	Levering	Well to be sealed
D61	28	1018	6	1011	Dug	NA	Levering	Well to be sealed
D61	140	1033	19	1014	Drilled	NA	Levering	Well to be sealed
D62	29	1018	7	1012	Dug	320	Delong	None
D63	32	1055	4	1051	Dug	110	Delong	Well to be sealed
D64	NA	NA	NA	NA	NA	100	Gooch	None
D65	18	1018	AGS	1018	Dug	210	Green	None
D65	21	1018	AGS	1018	Drilled	NA	Green	None
D66	104	1052	8	1044	Dug	2030	Werber	None
D66	27	1015	3	1012	Dug	NA	Werber	None
D67	20	1012	15	997	Dug	410	Gum	None
D68	18	1020	11	1009	Dug	470	Saueressig	None

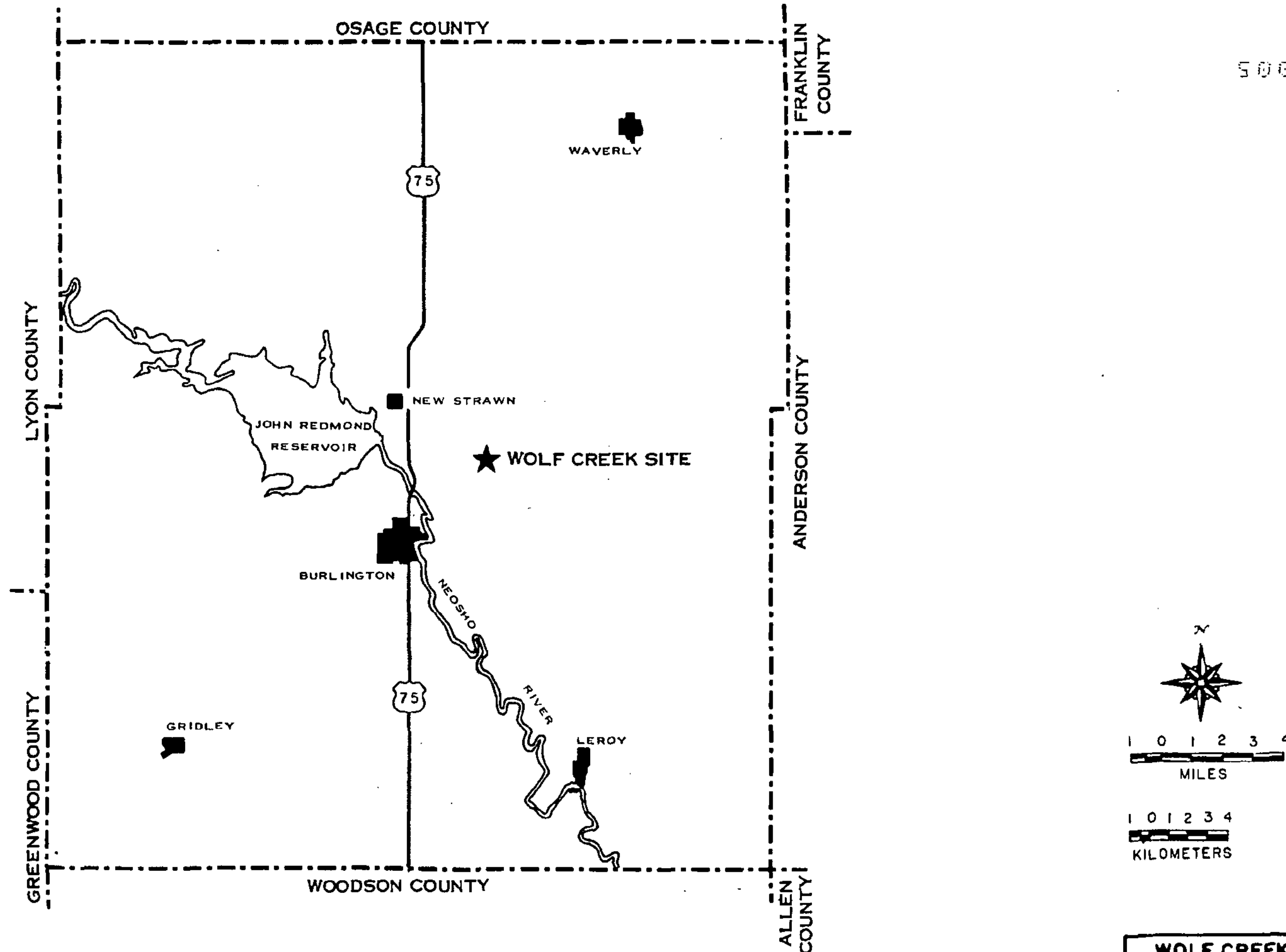
Location[a]	Well Depth (feet)	Approx. Land Surface Elev. (feet, MSL)	Depth to Water Level (feet)	Approx. Elev. of Water Level (feet, MSL)	Type of Well	Estimated Pumpage Rate (gpd)	Name of Owner or Tenant[d]	Remarks
D69	40	1026	NA	NA	Dug	560	Means	None
D70	32	1035	10	1025	Dug	660	Robinson	None
D71	25	1040	AGS	1040	Dug	800	Engel	None
D72	32	1040	4	1036	Dug	510	Reed	None
D73	NA	1080	NA	NA	NA	NA	NA	None
D74	41	1070	NA	NA	NA	NA	NA	None
D75	NA	1070	NA	NA	NA	NA	NA	None
D76	19	1042	NA	NA	Dug	NA	Hamman	None
D77	13.5	1075	NA	NA	NA	NA	Reinker	None
D78	25	1094	NA	NA	NA	NA	Paxton	None
D78	9	1094	NA	NA	Dug	NA	Paxton	None
D79	25	1085	NA	NA	NA	NA	Ellen	None
D80	16	1093	NA	NA	NA	NA	Mooris	None
D81	12	1085	NA	NA	NA	NA	Reinker	None
D82	25	1085	NA	NA	NA	NA	Martens	None
D82	5	1083	NA	NA	Dug	NA	Martens	None
D83	20	1061	NA	NA	NA	NA	Snyder	None
D83	7	1061	NA	NA	NA	NA	Snyder	None
D84	19	1060	NA	NA	NA	NA	Hess	None
D85	10	1080	NA	NA	Dug	NA	NA	Cistern
E2	32	1009	NA	NA	Drilled	510	Williams	None



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-1

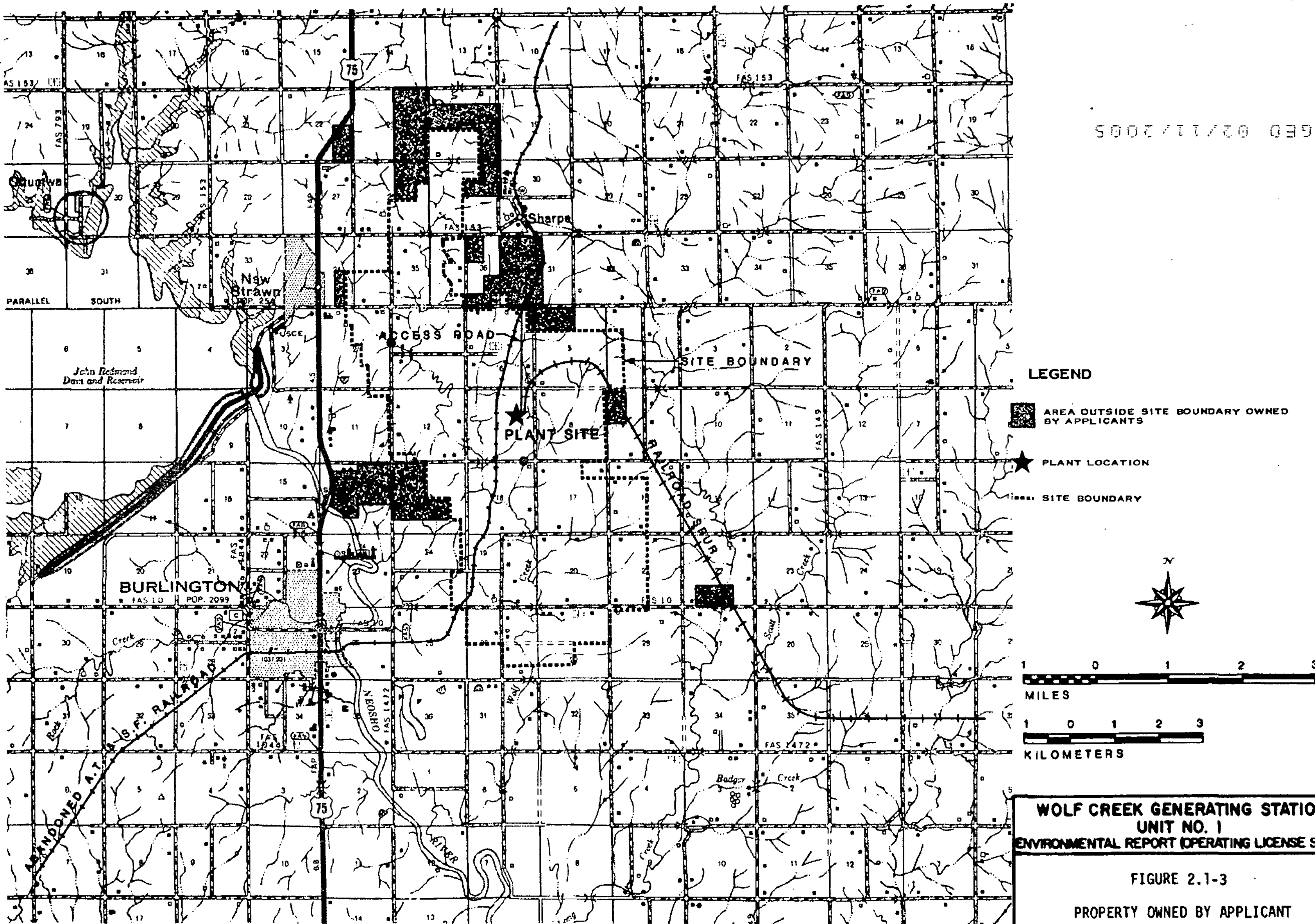
LOCATION OF SITE WITHIN
THE STATE OF KANSAS



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-2

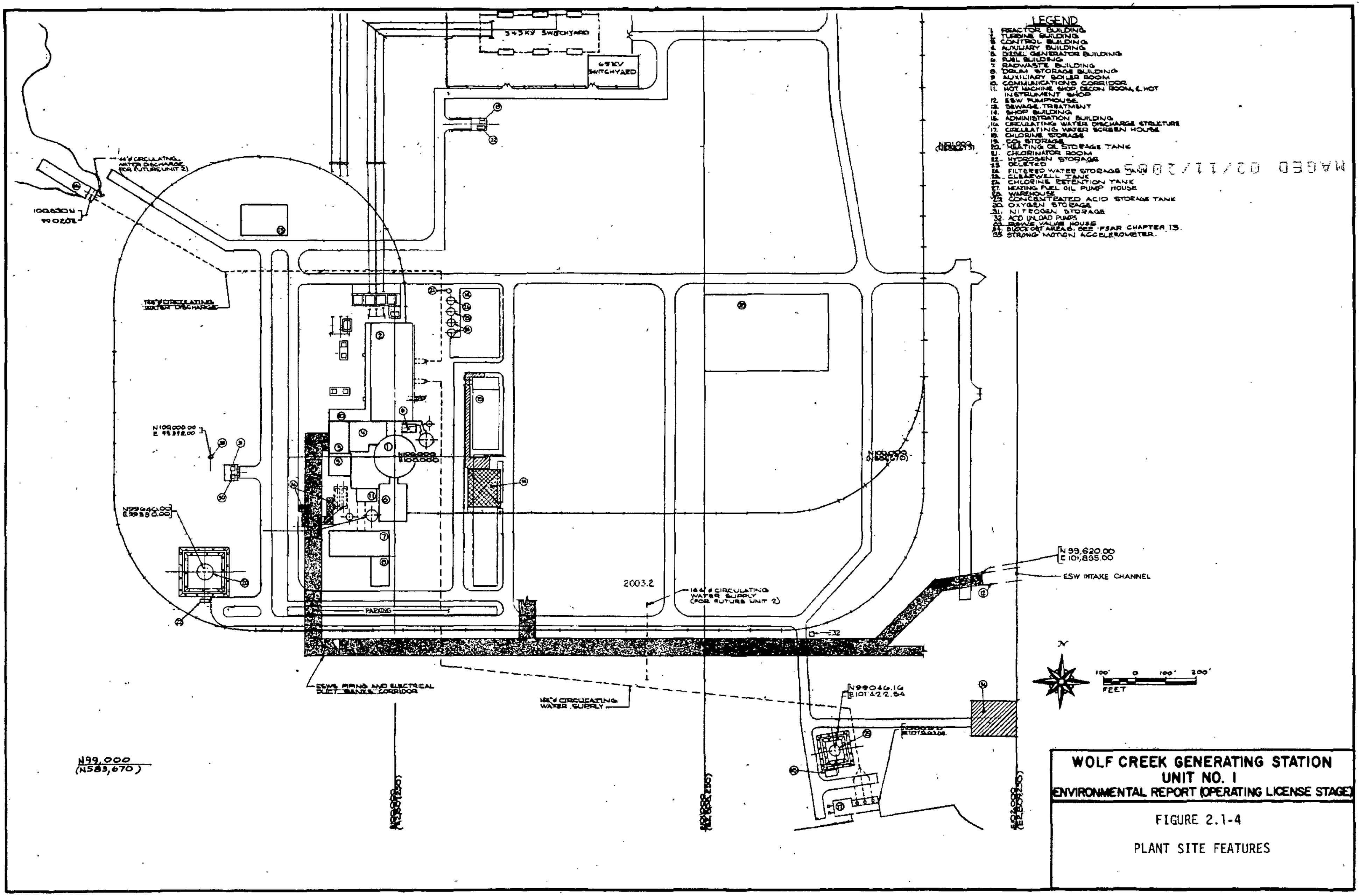
LOCATION OF SITE
WITHIN COFFEY COUNTY



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-3

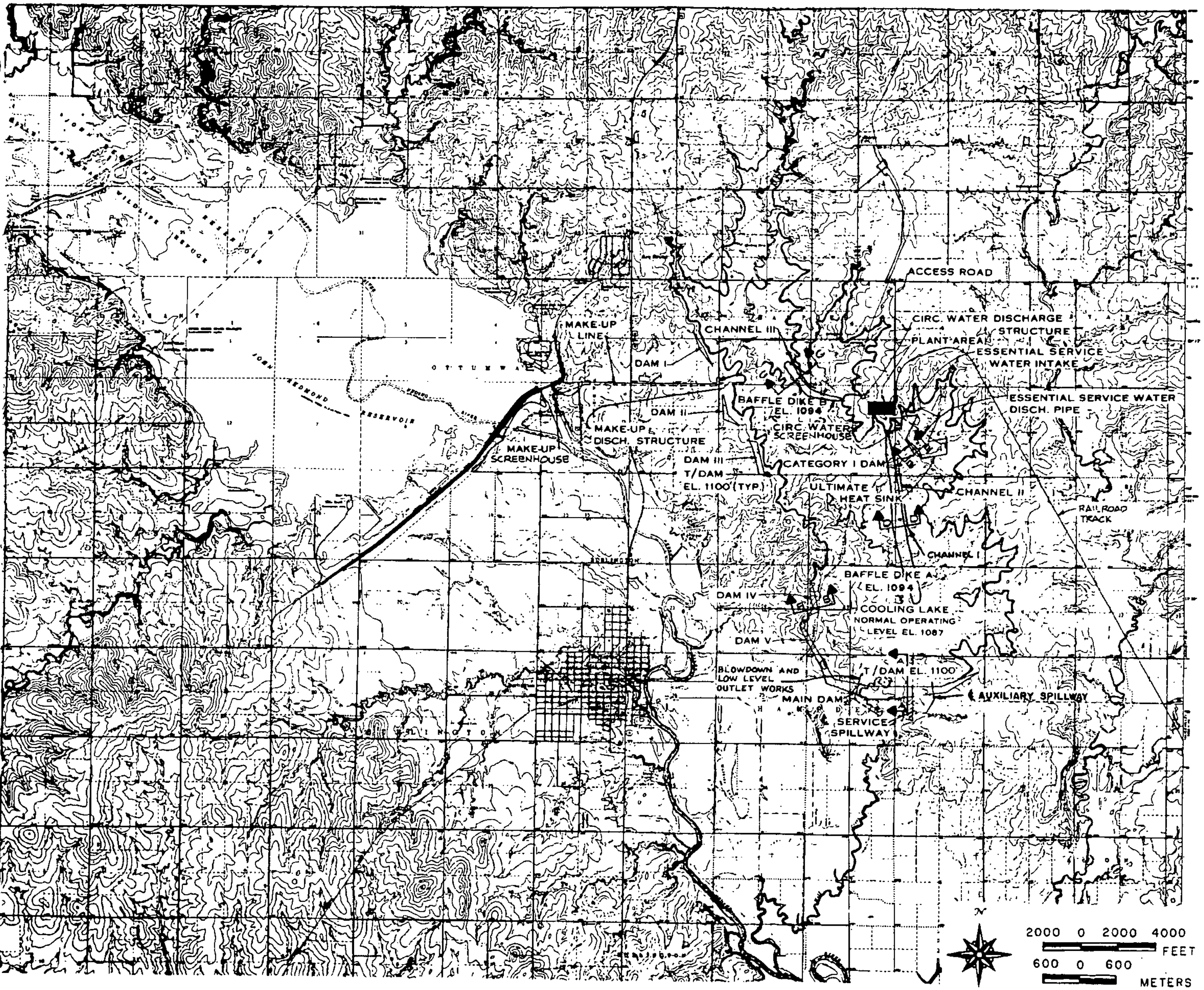
PROPERTY OWNED BY APPLICANT

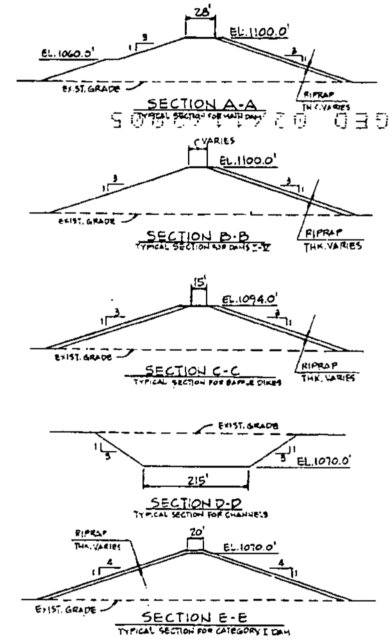


WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-4

PLANT SITE FEATURES



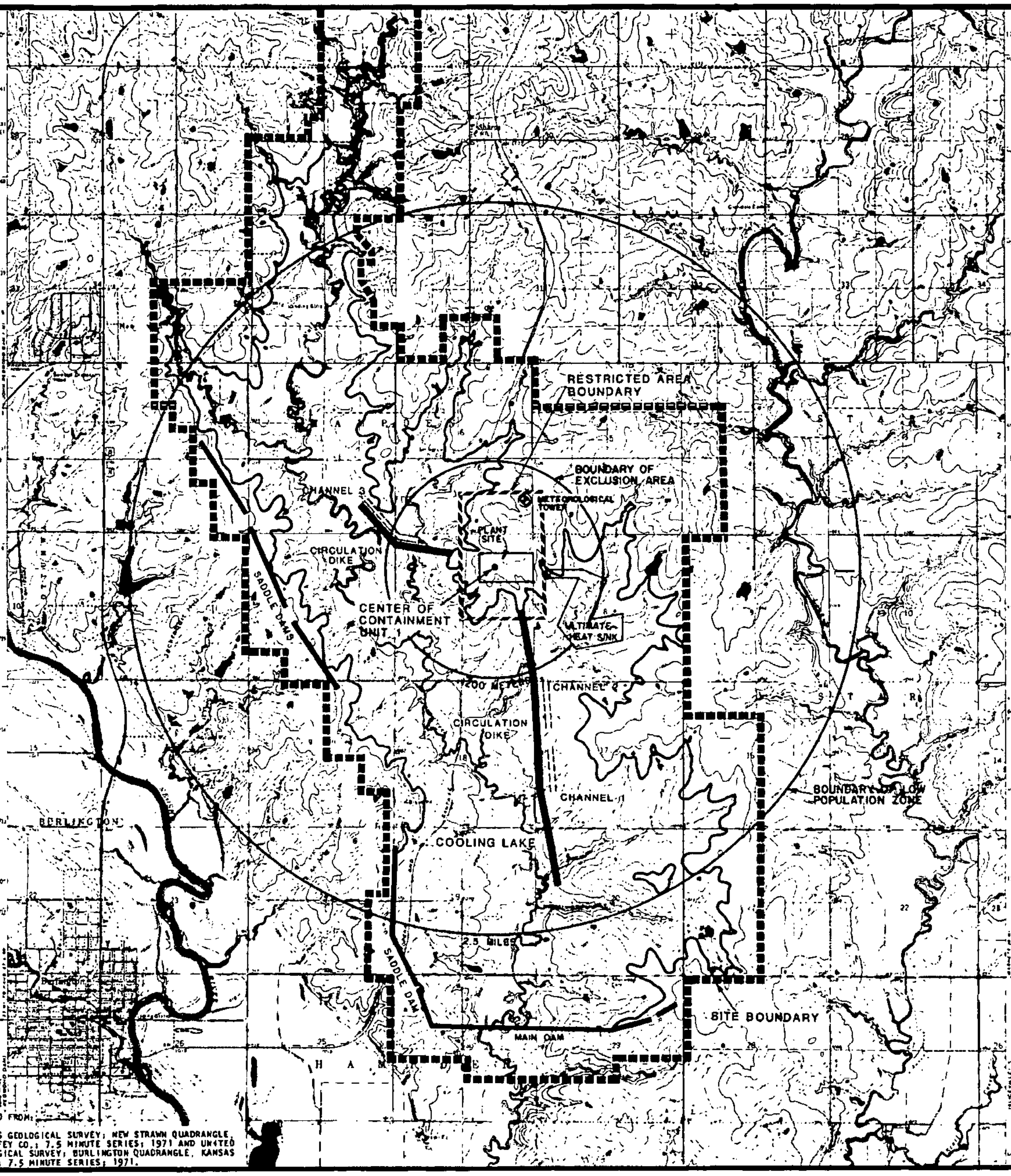


ITEM	APPROX. LENGTH	WIDTH	SIDE SLOPE
MAIN DAM	12260'	28'	3:1
DAM I	1740'	12'	3:1
DAM II	3020'	12'	3:1
DAM III	2450'	12'	3:1
DAM IV	2470'	20'	3:1
DAM V	445'	12'	3:1
BAFFLE DIKE 'A'	10410'	15'	3:1
BAFFLE DIKE 'B'	4570'	15'	3:1
CHANNEL #1	4800'	215'	3:1
CHANNEL #2	3230'	215'	3:1
CHANNEL #3	4700'	215'	3:1
CATEGORY I DAM	1500'	20'	4:1

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-5

LAYOUT OF DAMS, DIKES, SPILLWAYS, AND OUTLET WORKS



BASE MAP MODIFIED FROM:
UNITED STATES GEOLOGICAL SURVEY; NEW STRAWN QUADRANGLE, KANSAS - COFFEY CO.; 7.5 MINUTE SERIES; 1971 AND UNITED STATED GEOLOGICAL SURVEY; BURLINGTON QUADRANGLE, KANSAS - COFFEY CO.; 7.5 MINUTE SERIES; 1971.

NOTE

CENTER OF UNIT 1 CONTAINMENT IS LOCATED THE FOLLOWING DISTANCES FROM THE RESTRICTED AREA BOUNDARY:

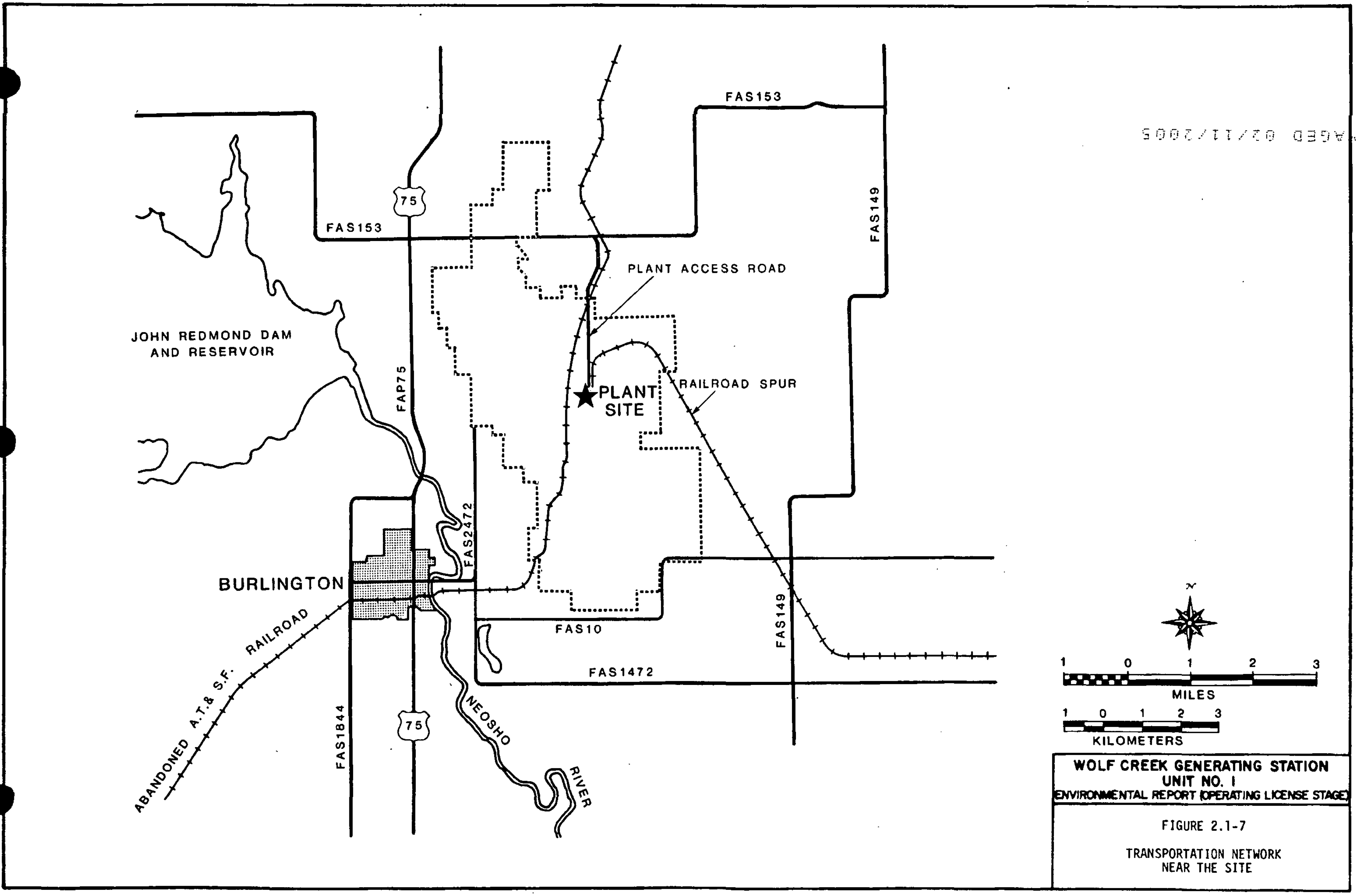
NORTH BOUNDARY – 2830 FEET
EAST BOUNDARY – 1750 FEET
SOUTH BOUNDARY – 1670 FEET
WEST BOUNDARY – 1250 FEET

1 0 1
MILES

1 0 1
KILOMETERS

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

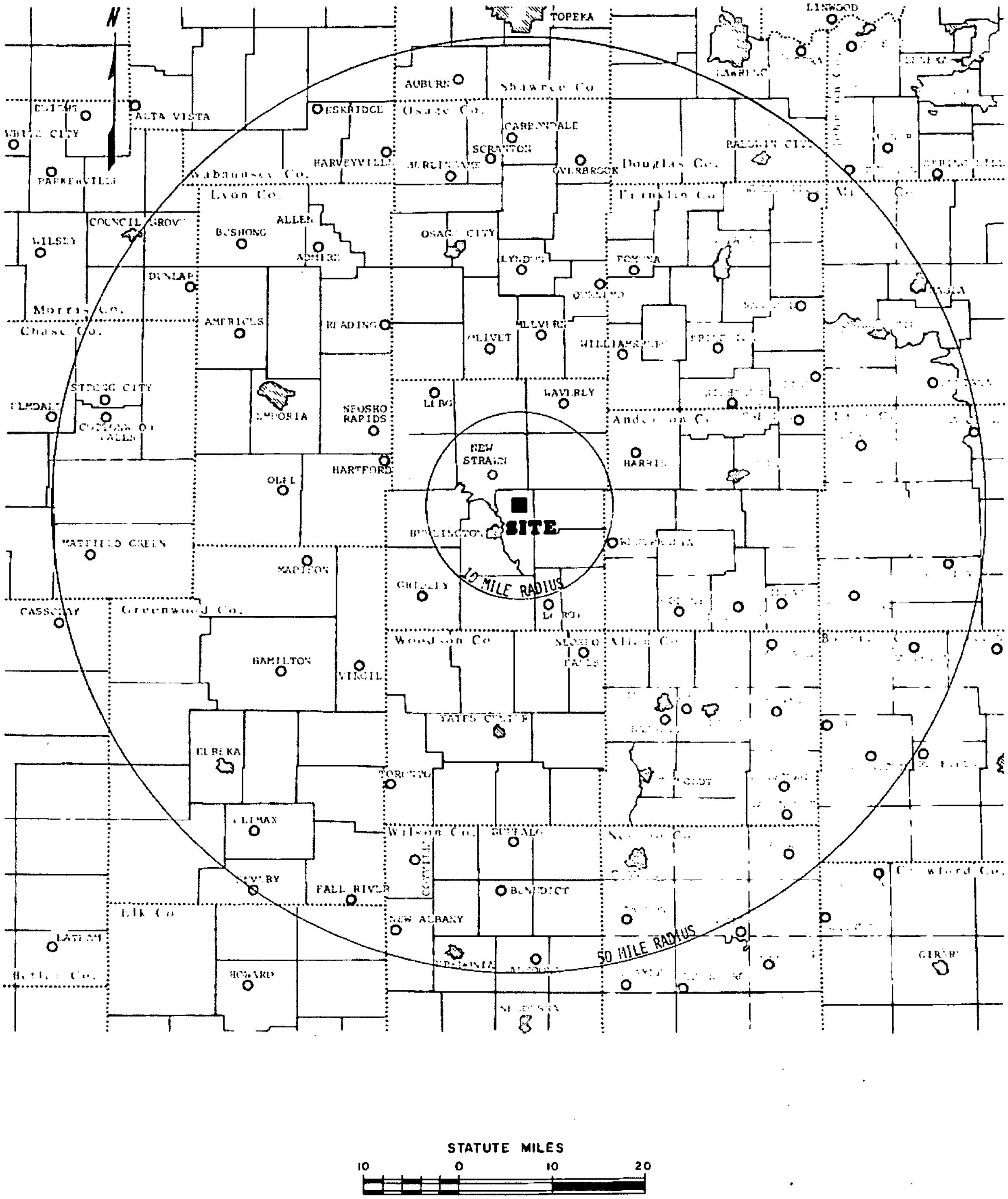
FIGURE 2.1-6
SITE FEATURES



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-7

TRANSPORTATION NETWORK
NEAR THE SITE

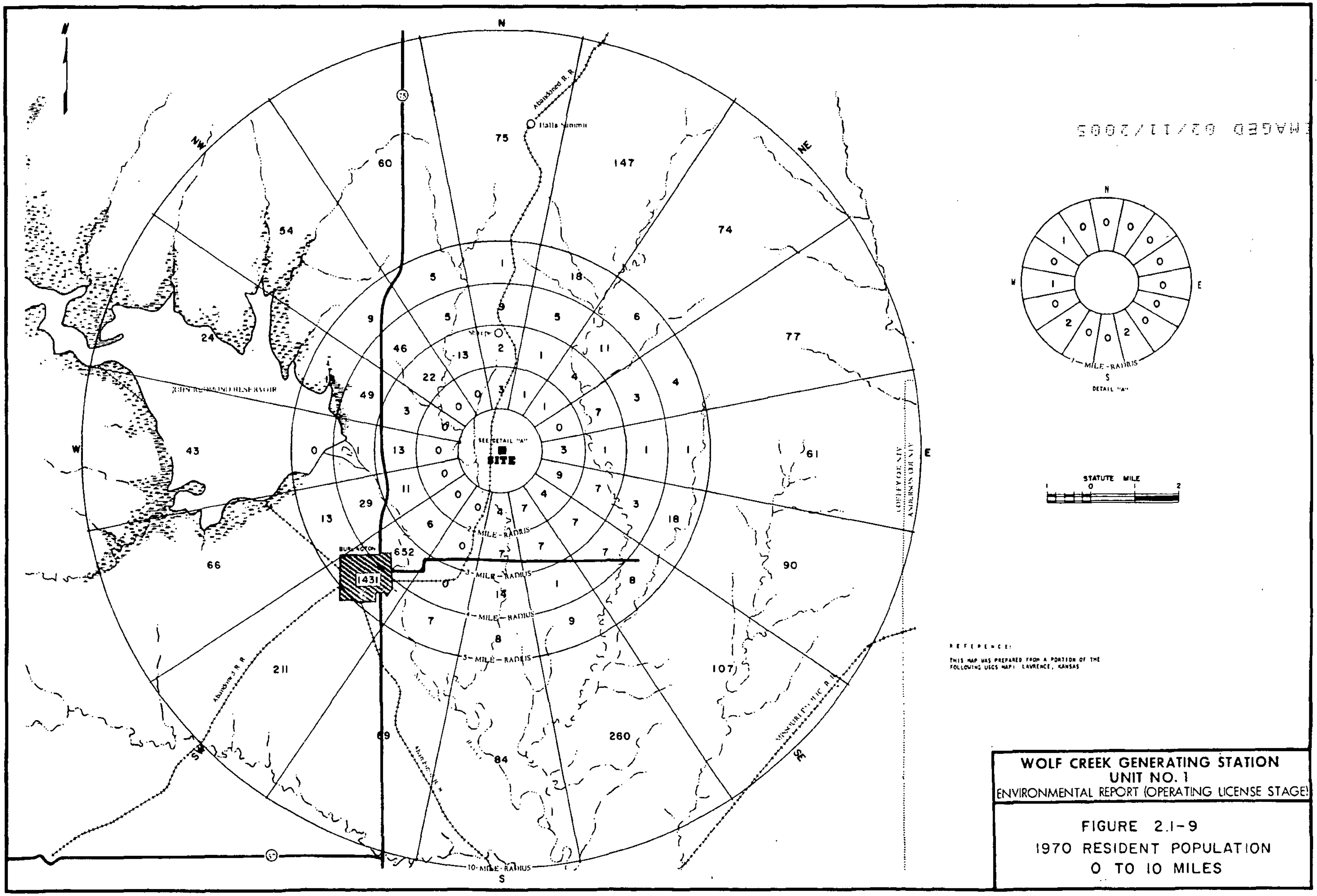


REFERENCE:

BUREAU OF CENSUS, CIVIL DIVISION
MAP OF KANSAS, 1970

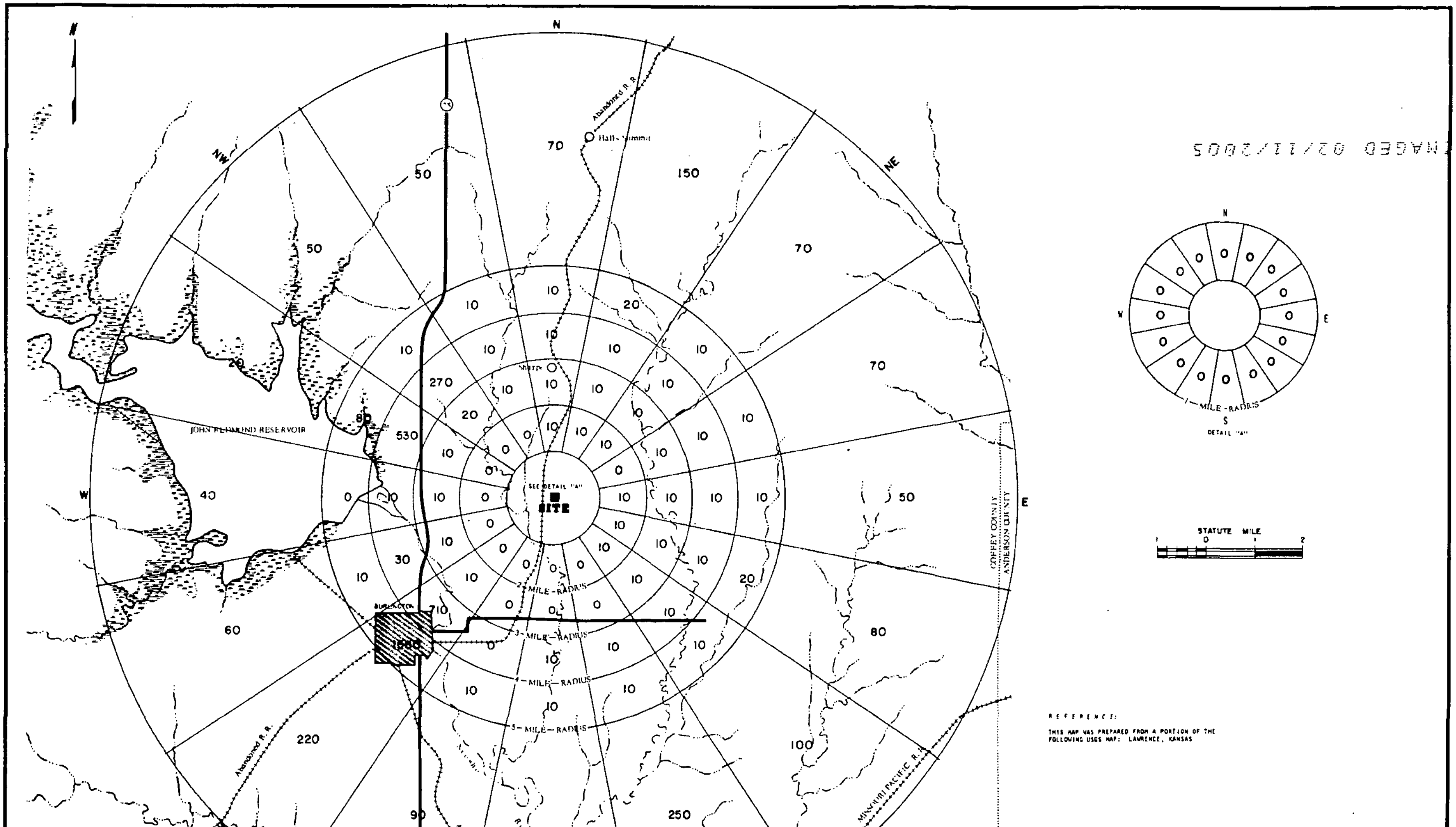
WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-8
CITIES & TOWNS
WITHIN 50 MILES OF THE SITE



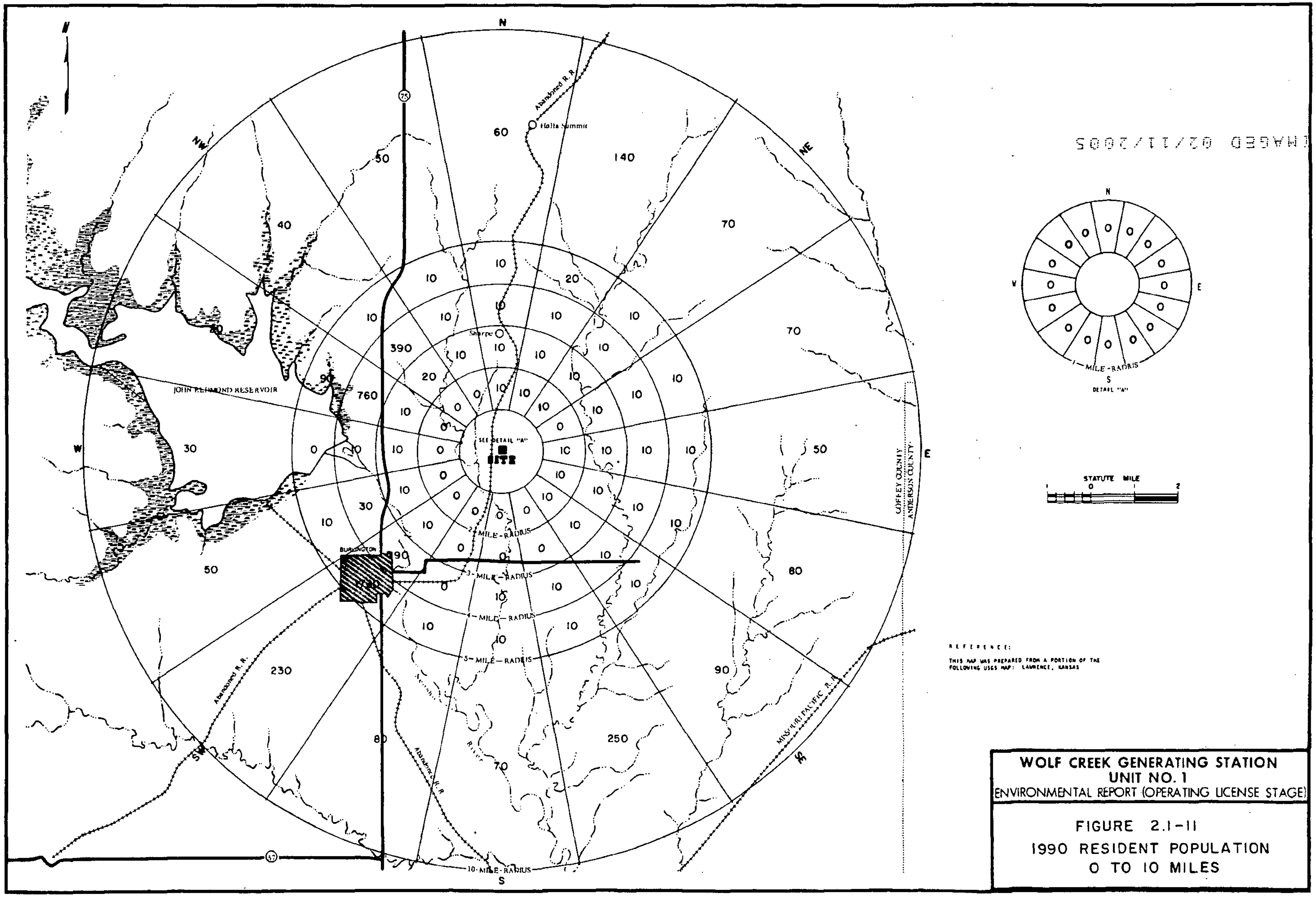
WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-9
1970 RESIDENT POPULATION
0 TO 10 MILES



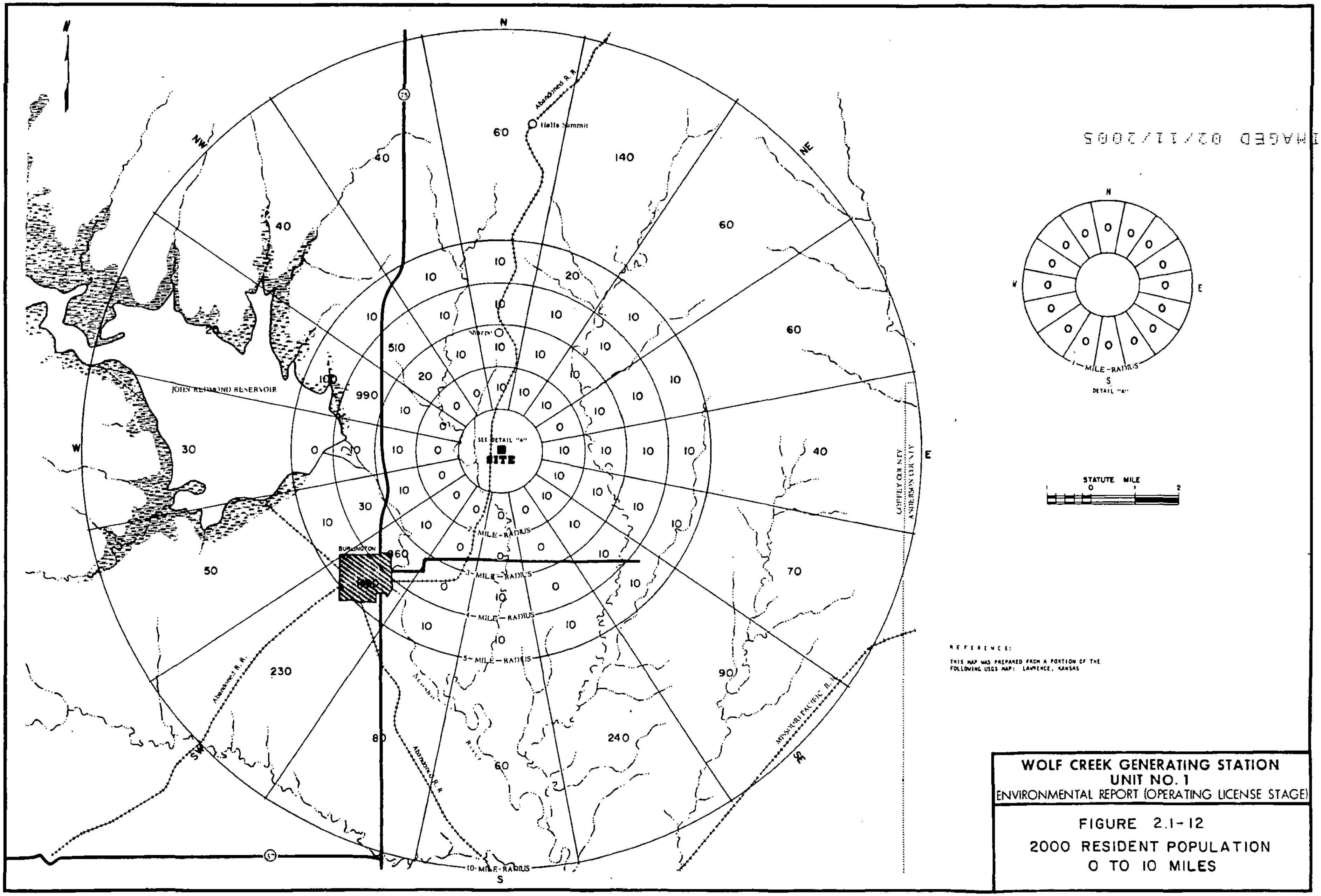
WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-10
1980 RESIDENT POPULATION
0 TO 10 MILES



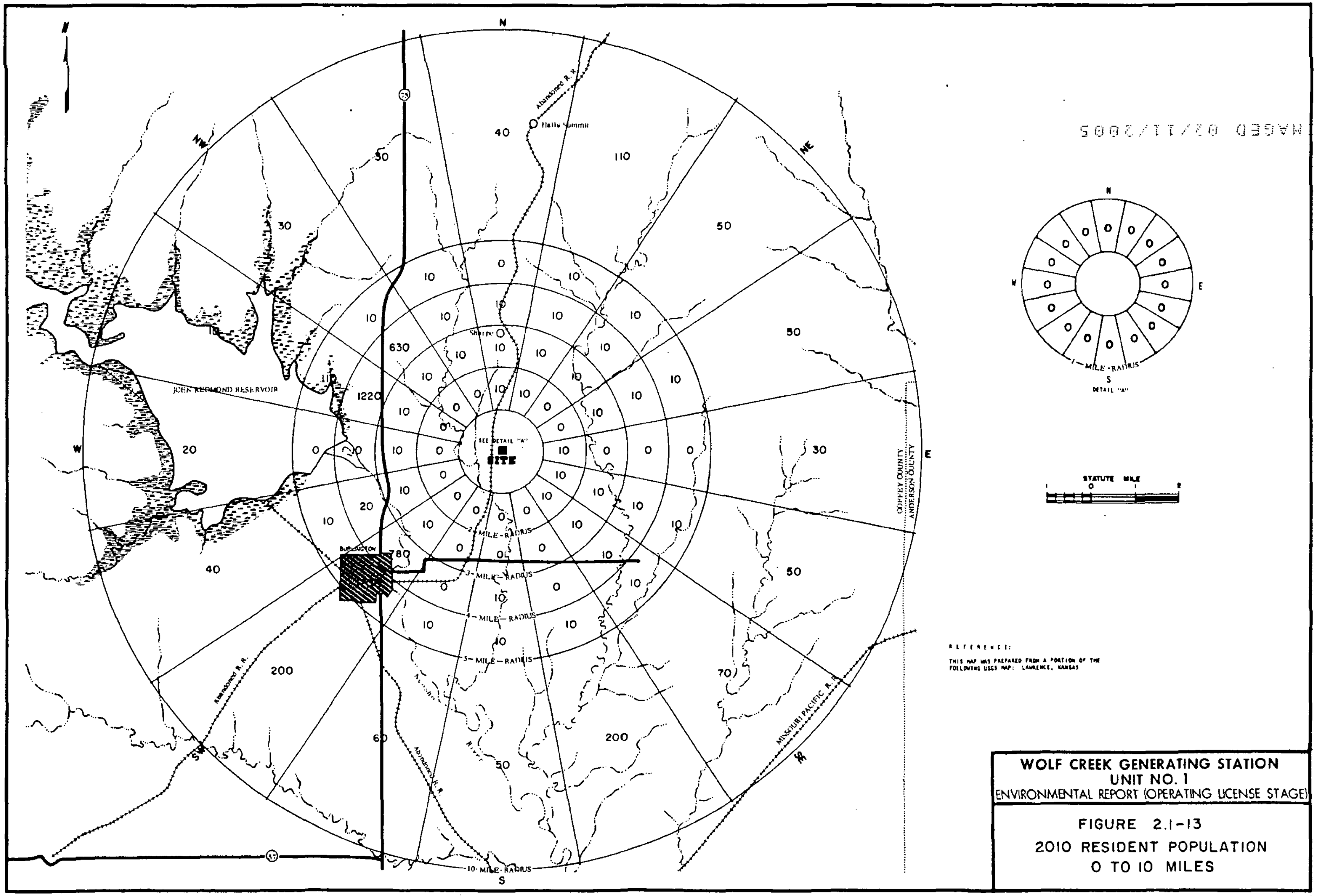
WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-11
1990 RESIDENT POPULATION
0 TO 10 MILES



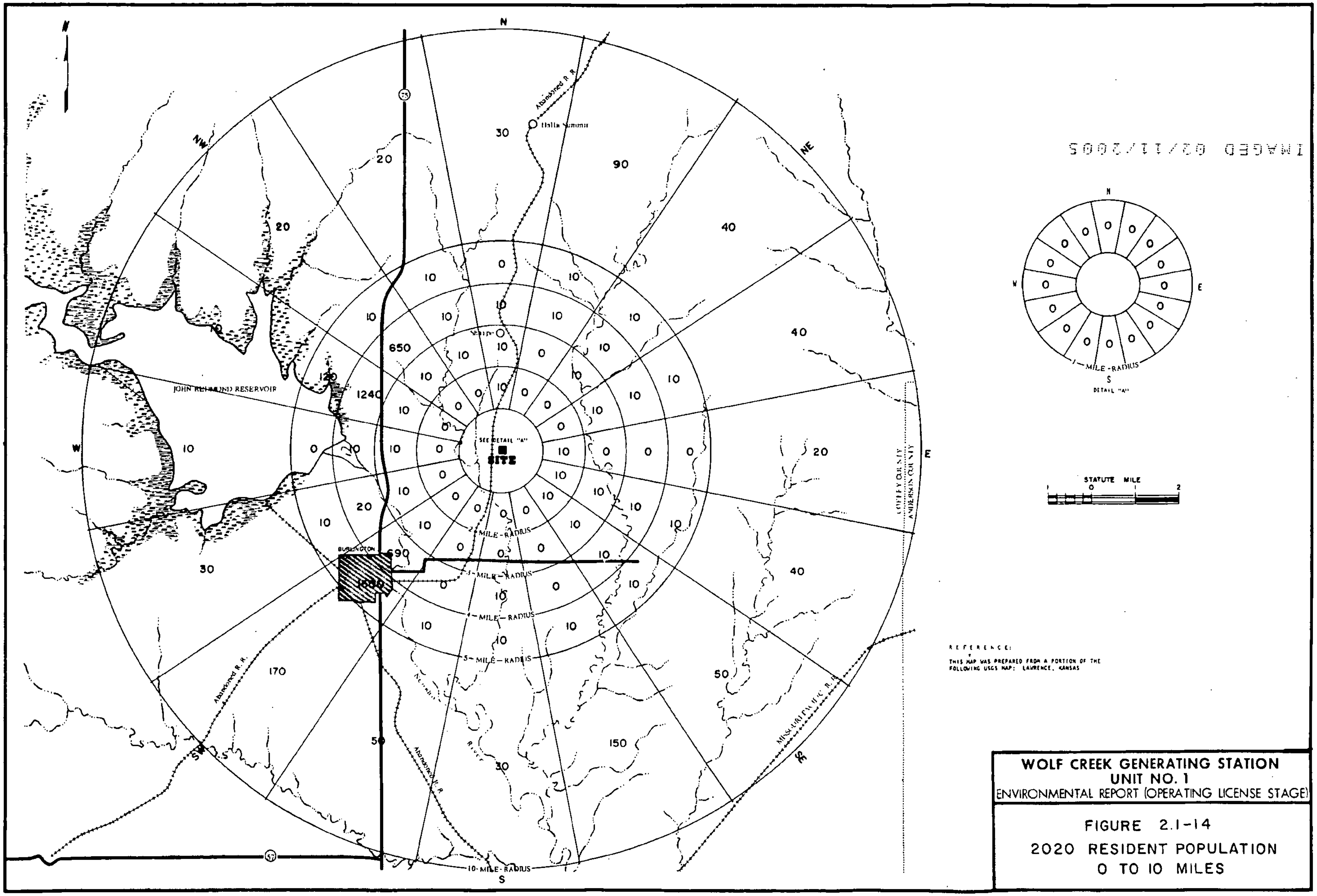
WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-12
2000 RESIDENT POPULATION
0 TO 10 MILES



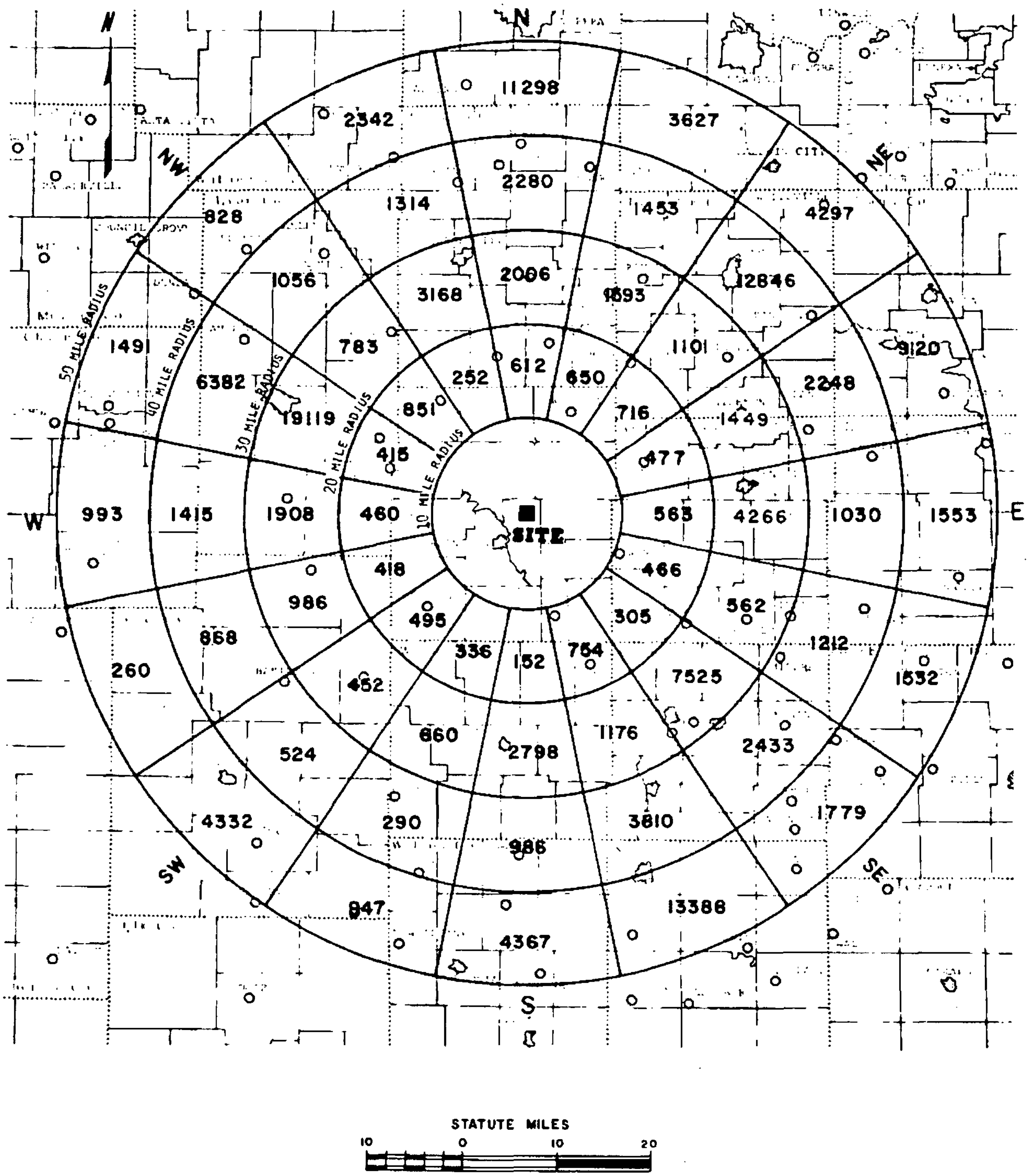
WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-13
2010 RESIDENT POPULATION
0 TO 10 MILES



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-14
2020 RESIDENT POPULATION
0 TO 10 MILES

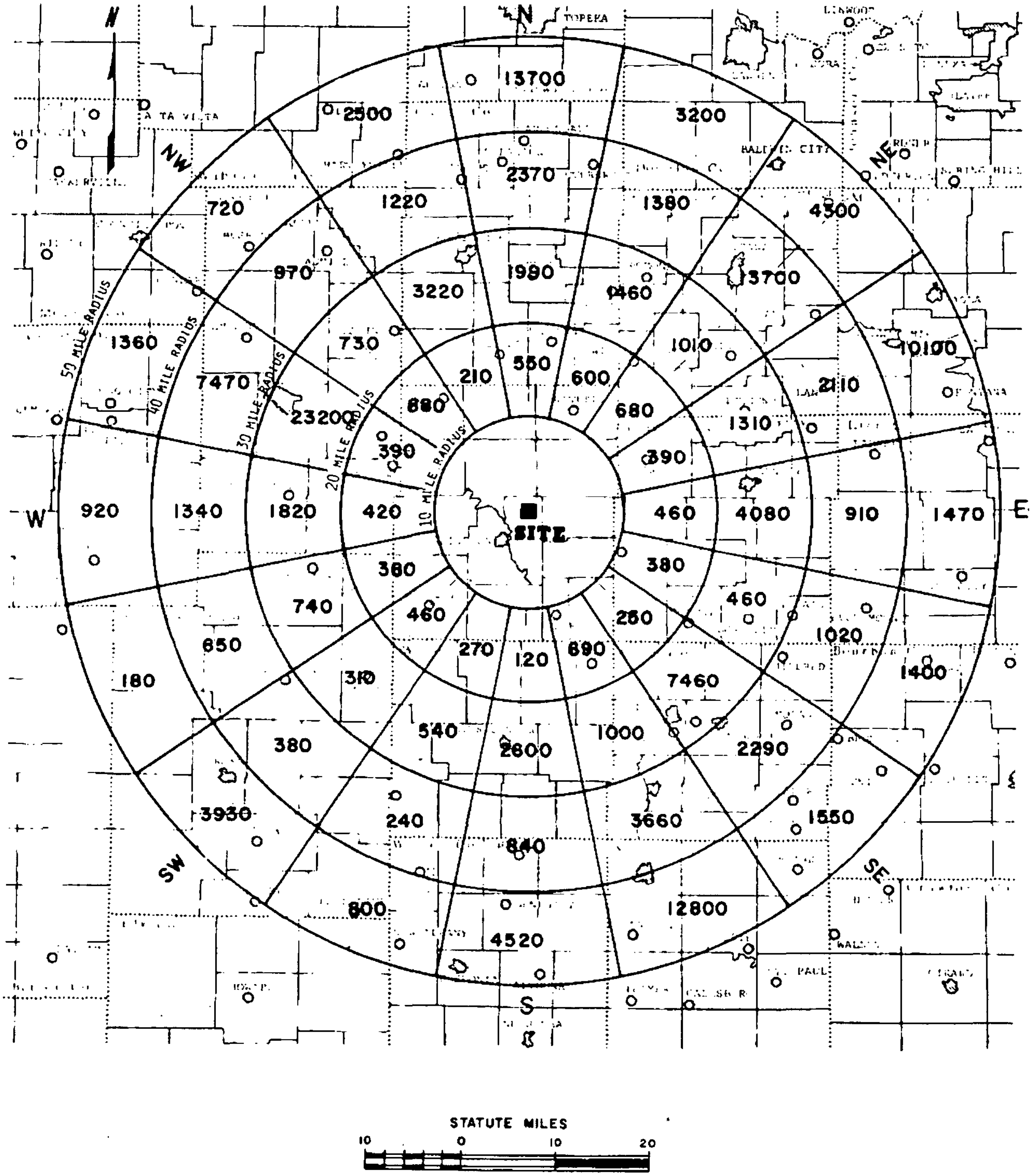


REFERENCE:

BUREAU OF CENSUS, CIVIL DIVISION MAP OF KANSAS, 1970

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

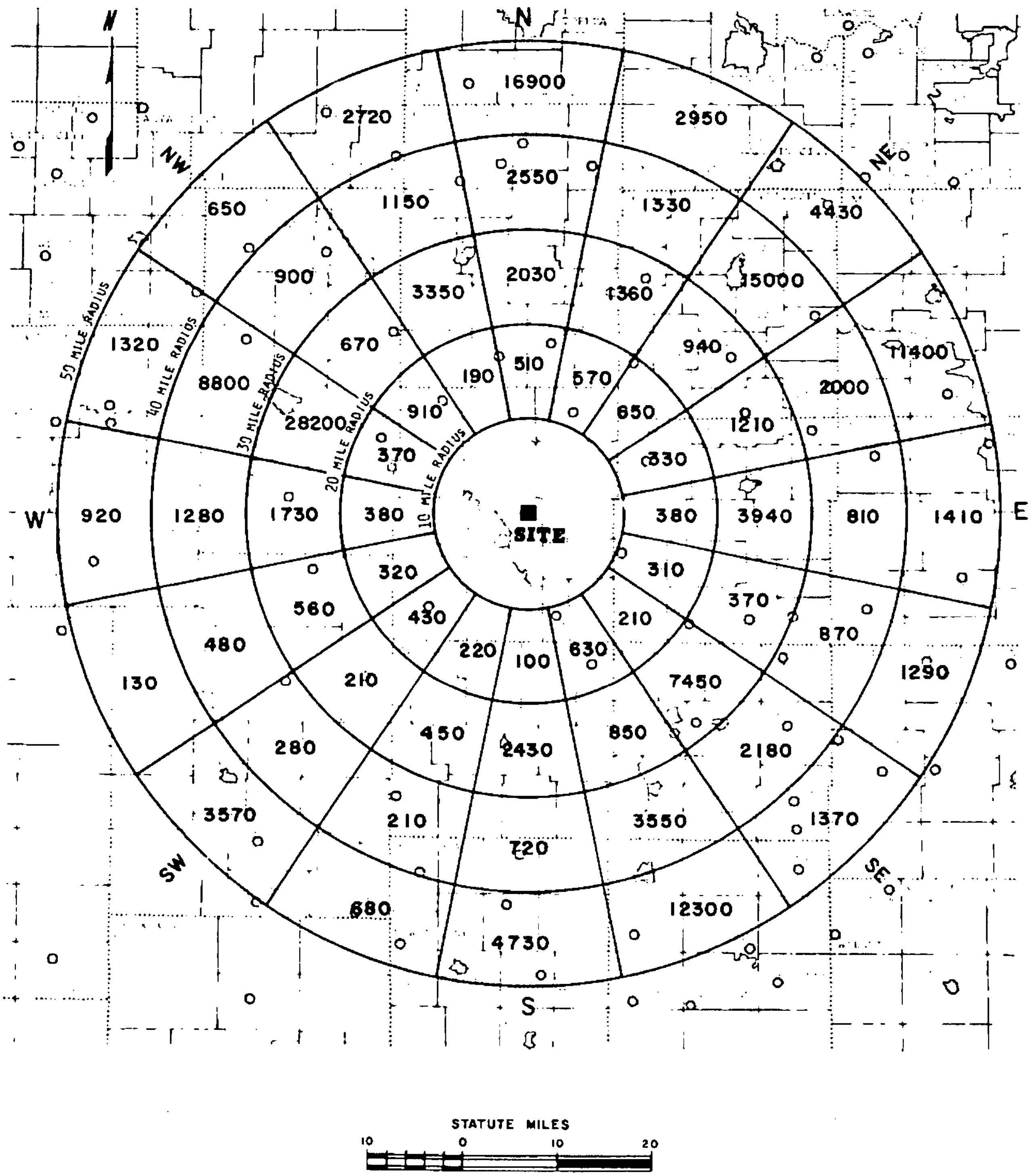
FIGURE 2.1-15
1970 RESIDENT POPULATION
10 TO 50 MILES



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-16
1980 RESIDENT POPULATION
10 TO 50 MILES

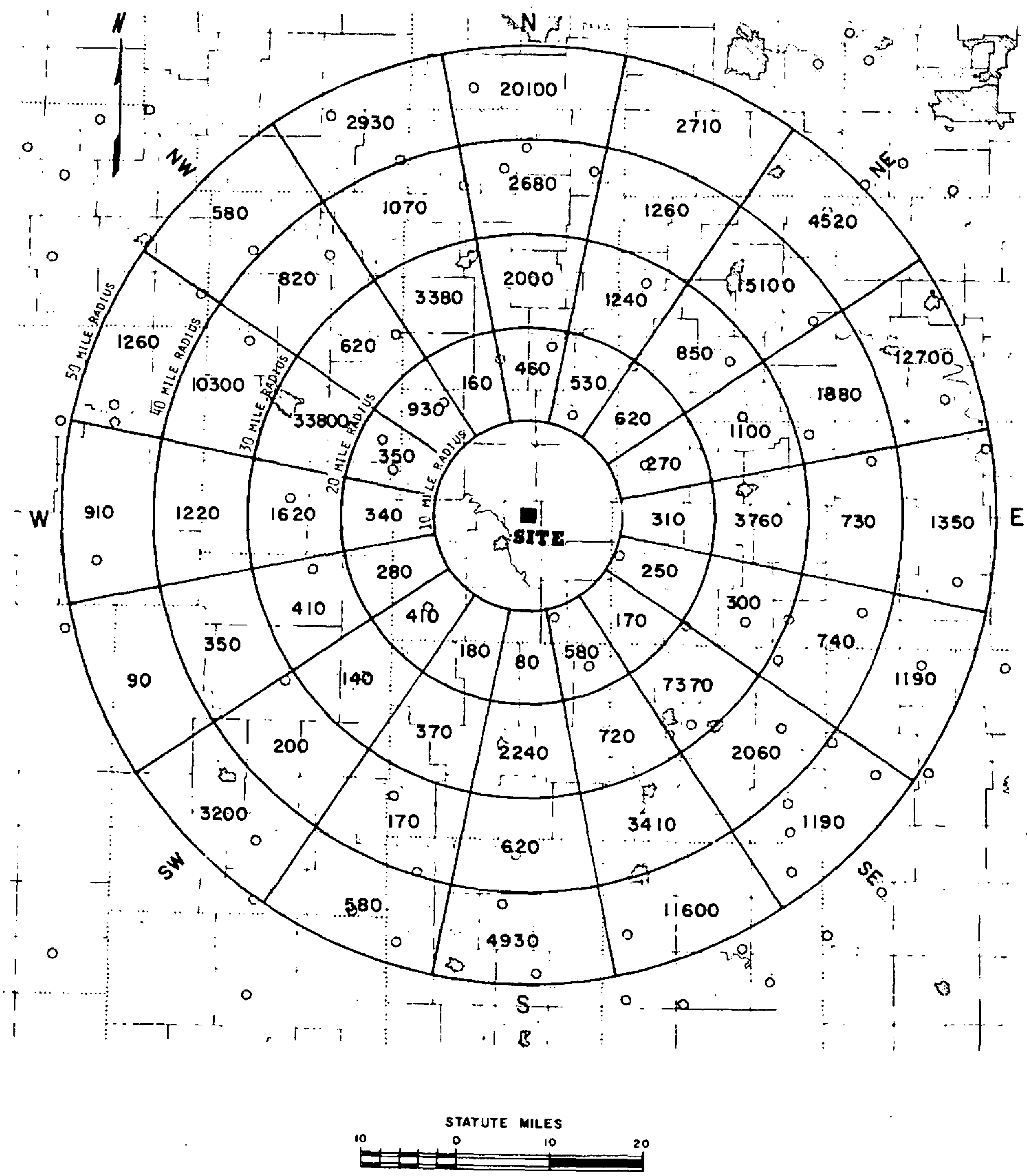
REFERENCE.
BUREAU OF CENSUS, CIVIL DIVISION MAP OF KANSAS, 1970



REFERENCE:
BUREAU OF CENSUS, CIVIL DIVISION
MAP OF KANSAS, 1970

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-17
1990 RESIDENT POPULATION
10 TO 50 MILES

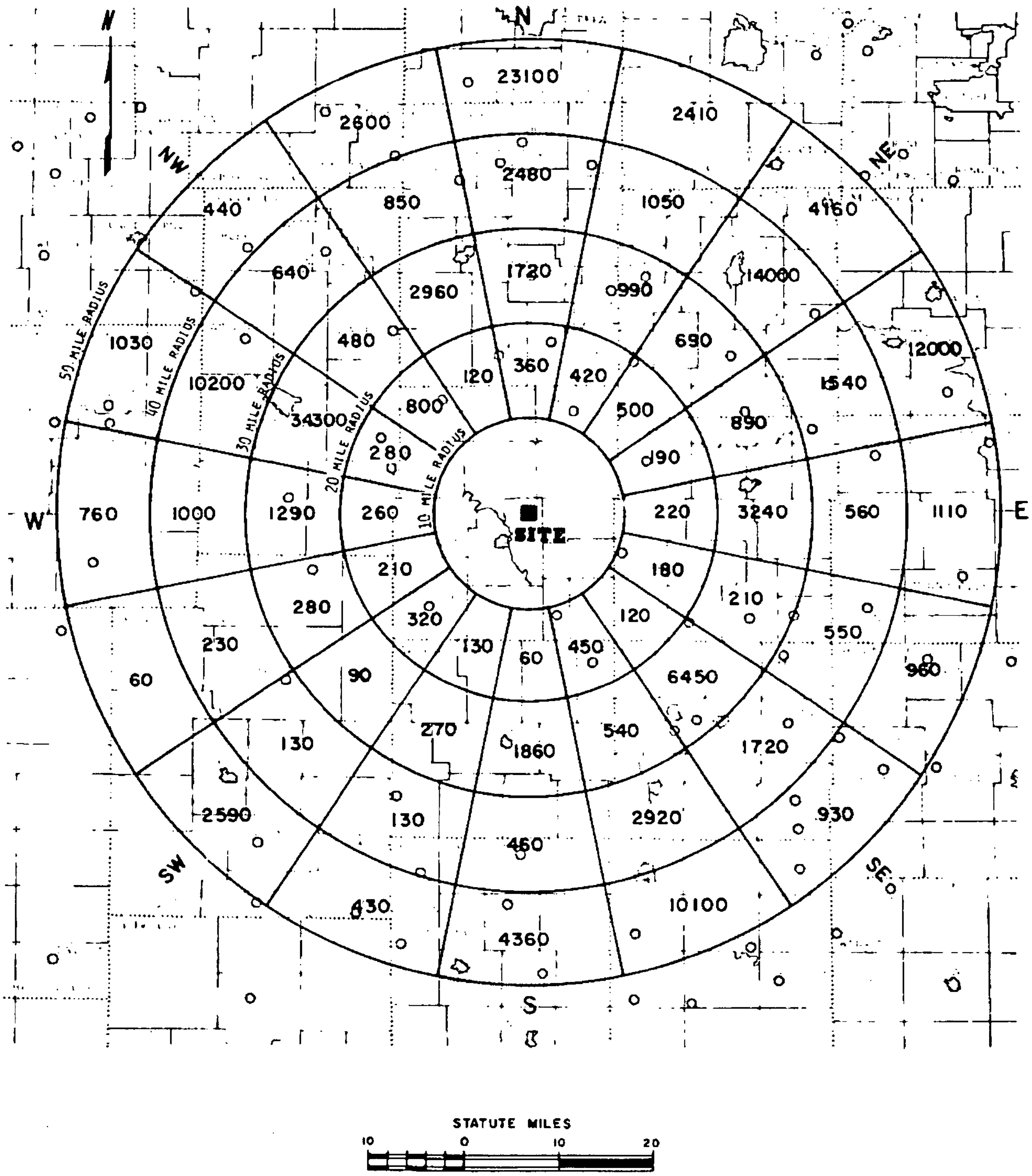


REFERENCE:

BUREAU OF CENSUS, CIVIL DIVISION MAP OF KANSAS, 1970

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-18
2000 RESIDENT POPULATION
10 TO 50 MILES

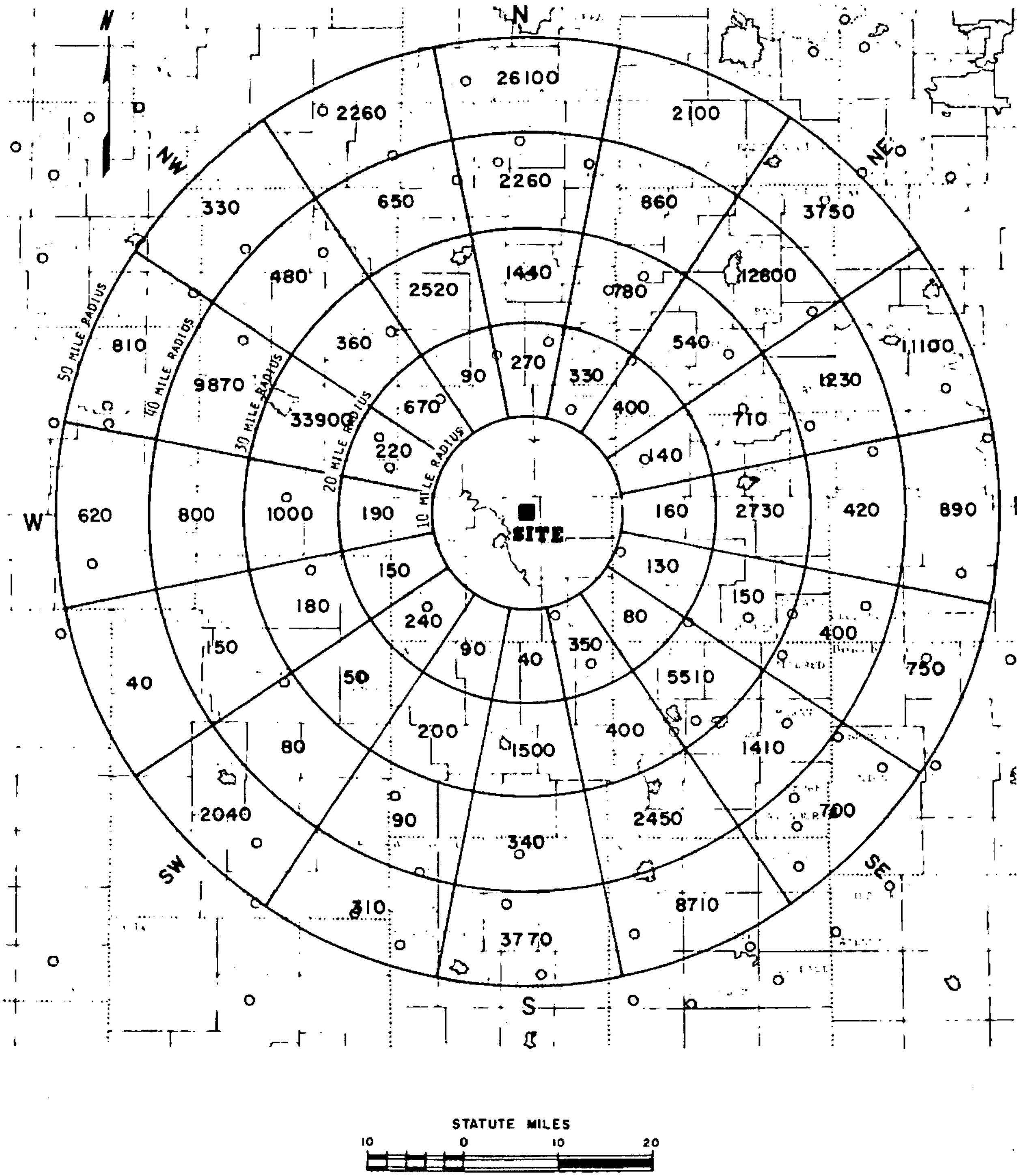


REFERENCE:

BUREAU OF CENSUS, CIVIL DIV
MAP OF KANSAS, 1970

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-19
2010 RESIDENT POPULATION
10 TO 50 MILES

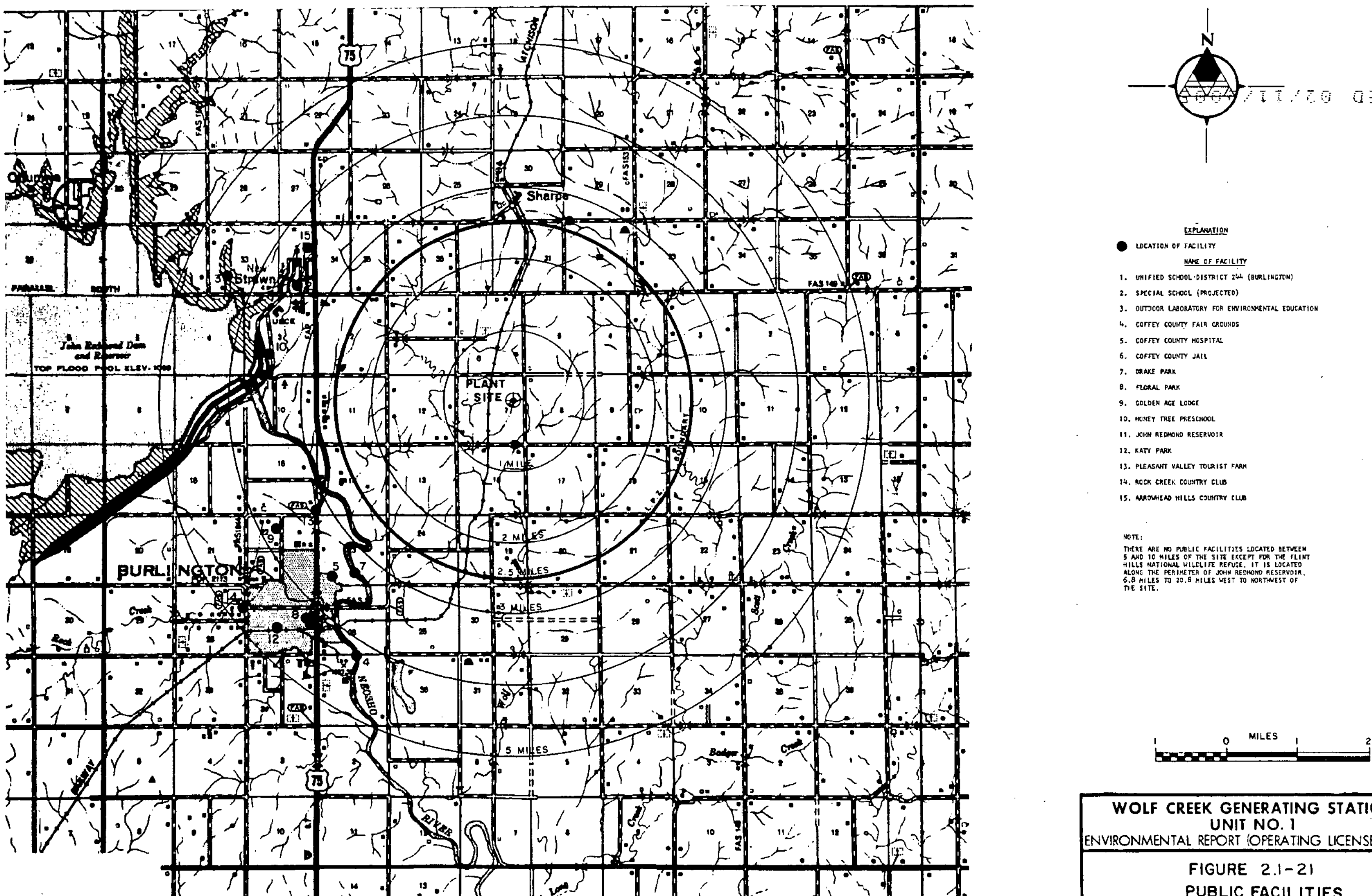


REFERENCE.

BUREAU OF CENSUS, CIVIL DIVISION
MAP OF KANSAS, 1970

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-20
2020 RESIDENT POPULATION
10 TO 50 MILES



EXPLANATION

● LOCATION OF FACILITY

NAME OF FACILITY

1. UNIFIED SCHOOL DISTRICT 244 (BURLINGTON)
2. SPECIAL SCHOOL (PROJECTED)
3. OUTDOOR LABORATORY FOR ENVIRONMENTAL EDUCATION
4. COFFEY COUNTY FAIR GROUNDS
5. COFFEY COUNTY HOSPITAL
6. COFFEY COUNTY JAIL
7. DRAKE PARK
8. FLORAL PARK
9. GOLDEN AGE LODGE
10. HONEY TREE PRESCHOOL
11. JOHN REDMOND RESERVOIR
12. KATY PARK
13. PLEASANT VALLEY TOURIST FARM
14. ROCK CREEK COUNTRY CLUB
15. ARROWHEAD HILLS COUNTRY CLUB

NOTE:

THERE ARE NO PUBLIC FACILITIES LOCATED BETWEEN 5 AND 10 MILES OF THE SITE EXCEPT FOR THE FLINT HILLS NATIONAL WILDLIFE REFUGE. IT IS LOCATED ALONG THE PERIMETER OF JOHN REDMOND RESERVOIR, 6.8 MILES TO 20.8 MILES WEST TO NORTHWEST OF THE SITE.

WOLF CREEK GENERATING STATION
UNIT NO. 1
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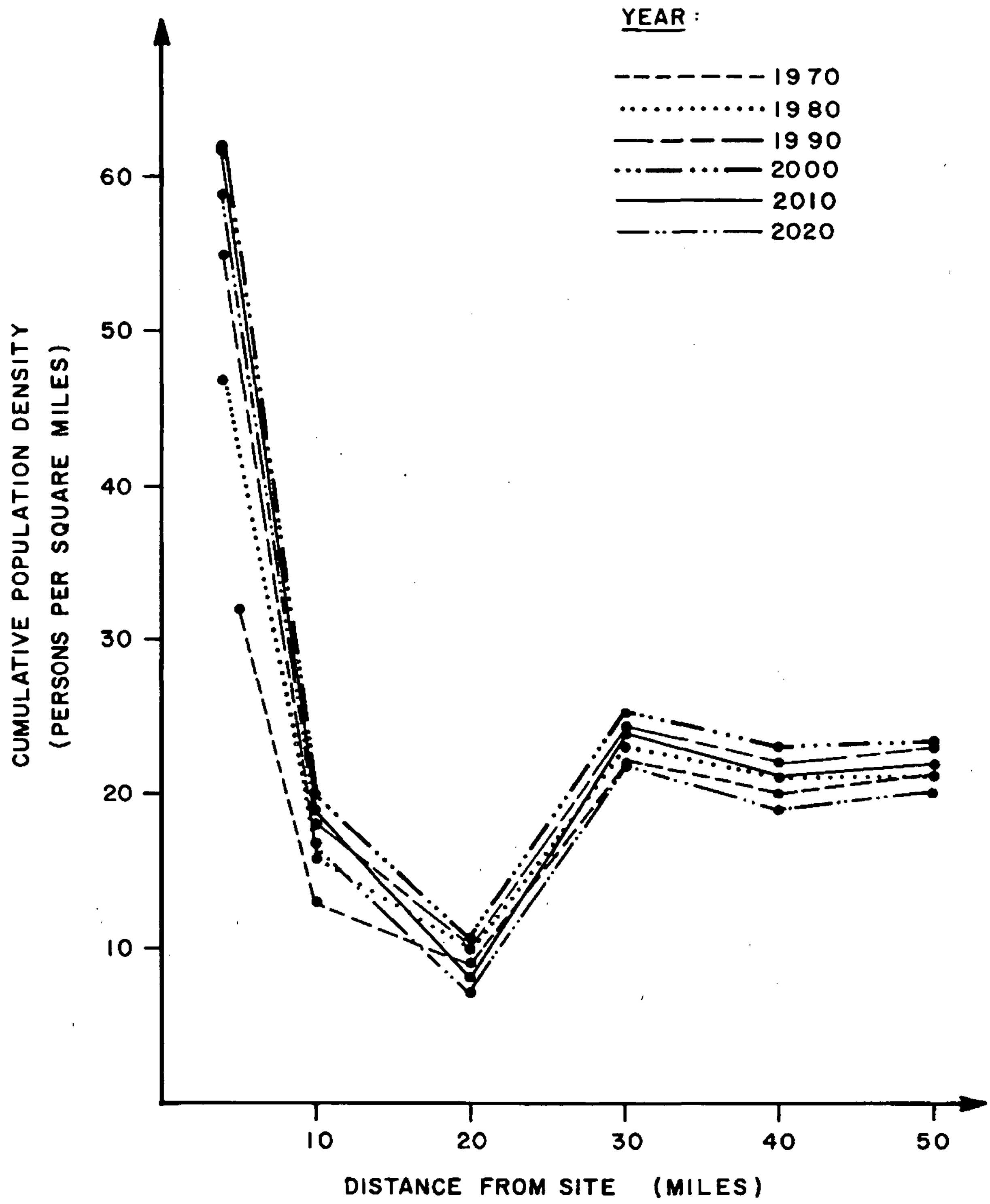
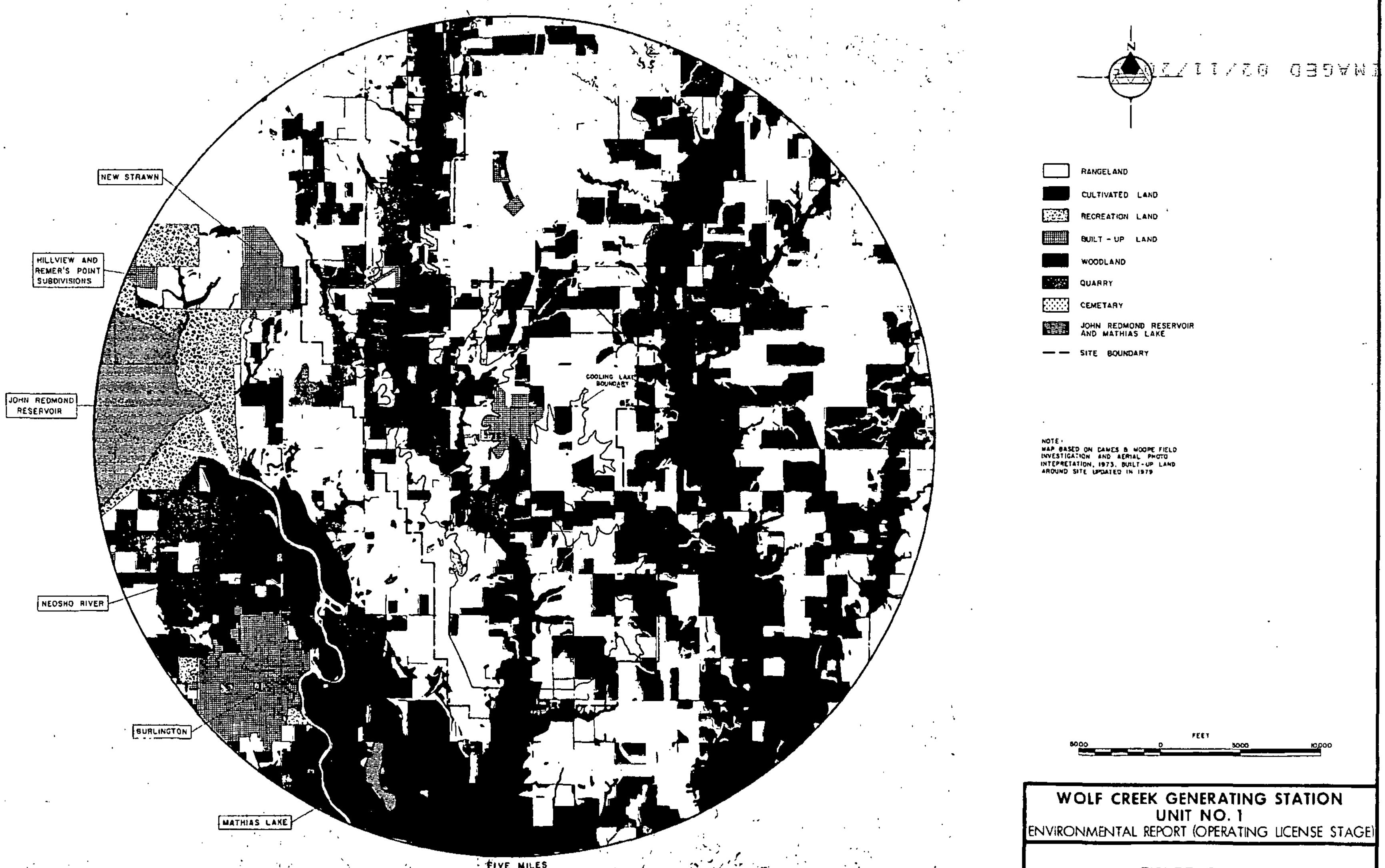
FIGURE 2.1-21
PUBLIC FACILITIES AND INSTITUTIONS WITHIN 5 MILES OF THE SITE



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

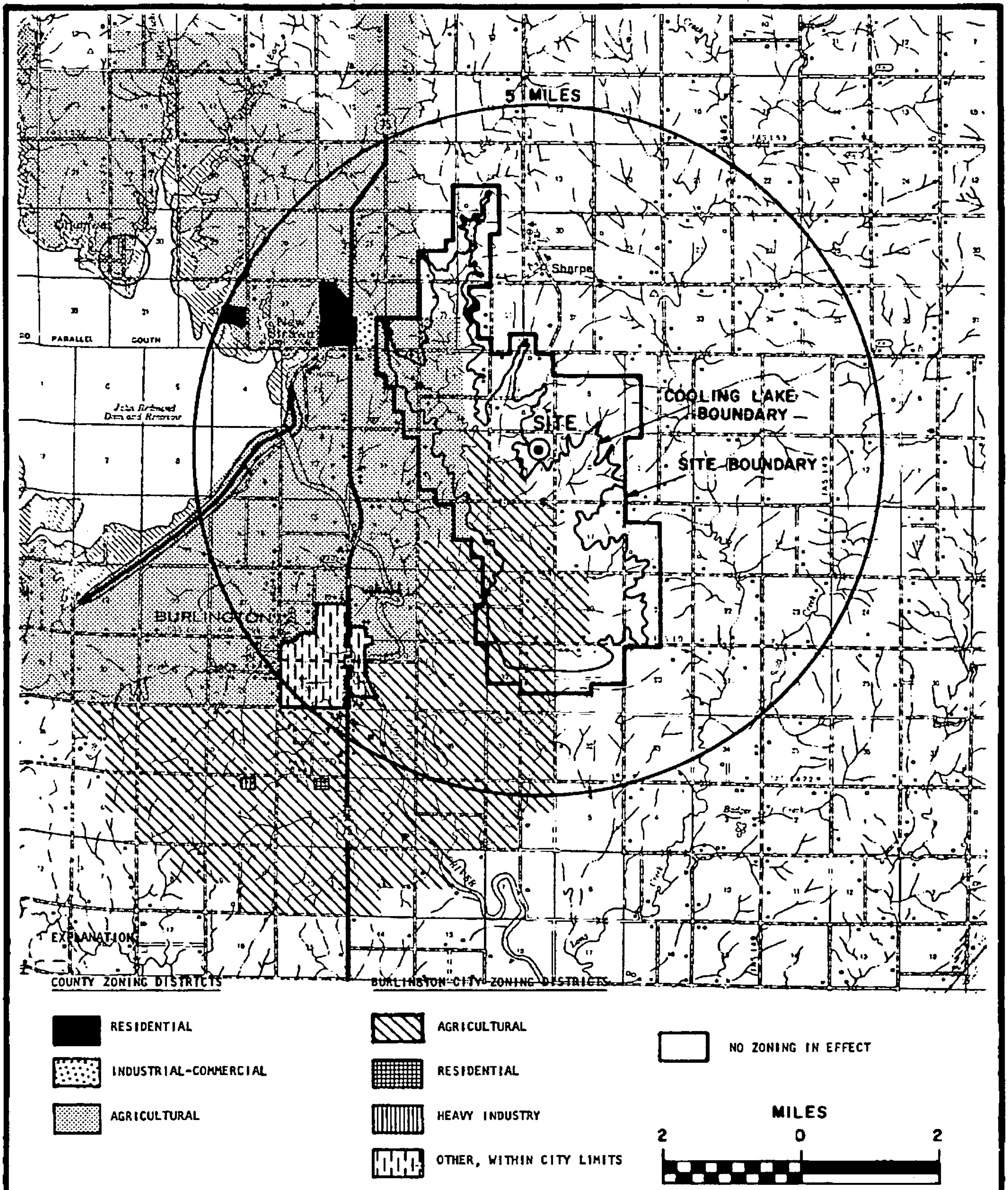
FIGURE 2.1-22
CUMULATIVE POPULATION DENSITY, 1970 TO 2020, WITHIN 50 MILES OF THE SITE



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-23

LAND USE WITHIN 5 MILES



SOURCE

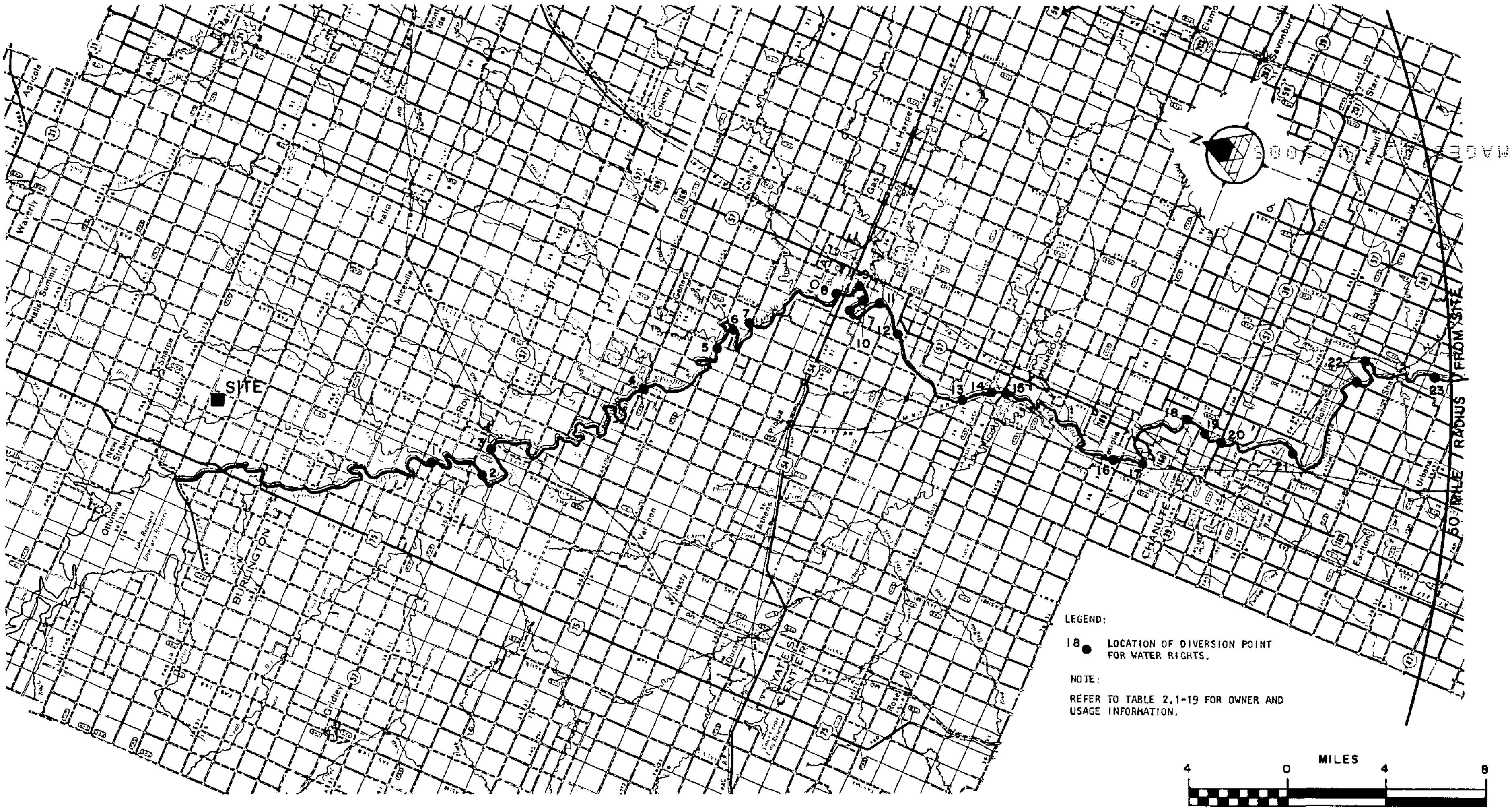
BOARD OF COMMISSIONERS OF COFFEY COUNTY, 1968, COFFEY COUNTY ZONING RESOLUTION (JANUARY 29), BURLINGTON, KANSAS.
SIMON, S.S., 1976, ZONING ORDINANCE FOR THE CITY OF BURLINGTON, KANSAS.

BASE MAP MODIFIED FROM GENERAL HIGHWAY MAP, COFFEY COUNTY, KANSAS, STATE, STATE HIGHWAY COMMIS ION OF KANSAS, 1969.

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-24

ZONING WITHIN 5 MILES



SOURCE:

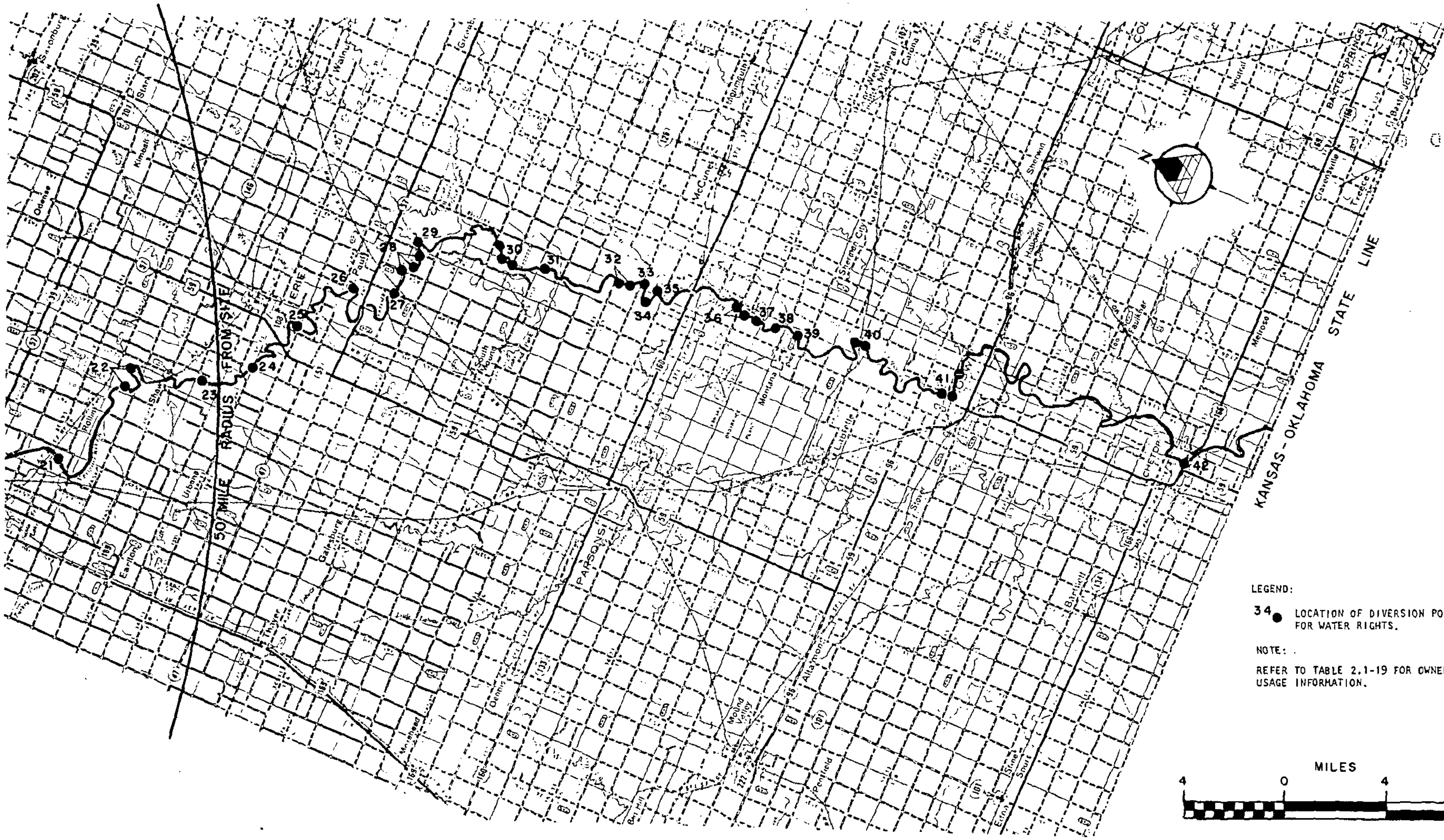
STATE BOARD OF AGRICULTURE, 1979, OPEN FILE MATERIAL.
DIVISION OF WATER RESOURCES, TOPEKA, KANSAS (MARCH)

REFERENCE:

BASE MAP FROM STATE HIGHWAY COMMISSION OF KANSAS, GENERAL HIGHWAY MAP OF COFFEY COUNTY, 1974; WOODSON COUNTY, 1971; ANDERSON COUNTY, 1969; ALLEN COUNTY, 1969; AND NEOSHO COUNTY, 1969.

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-25
WATER WITHDRAWAL POINTS ON THE NEOSHO RIVER IN KANSAS DOWNSTREAM OF THE SITE
SHEET 1 OF 2



LEGEND:

34● LOCATION OF DIVERSION POINT FOR WATER RIGHTS.

NOTE:

REFER TO TABLE 2.1-19 FOR OWNER AND USAGE INFORMATION.

MILES

4 0 4 8

SOURCE:

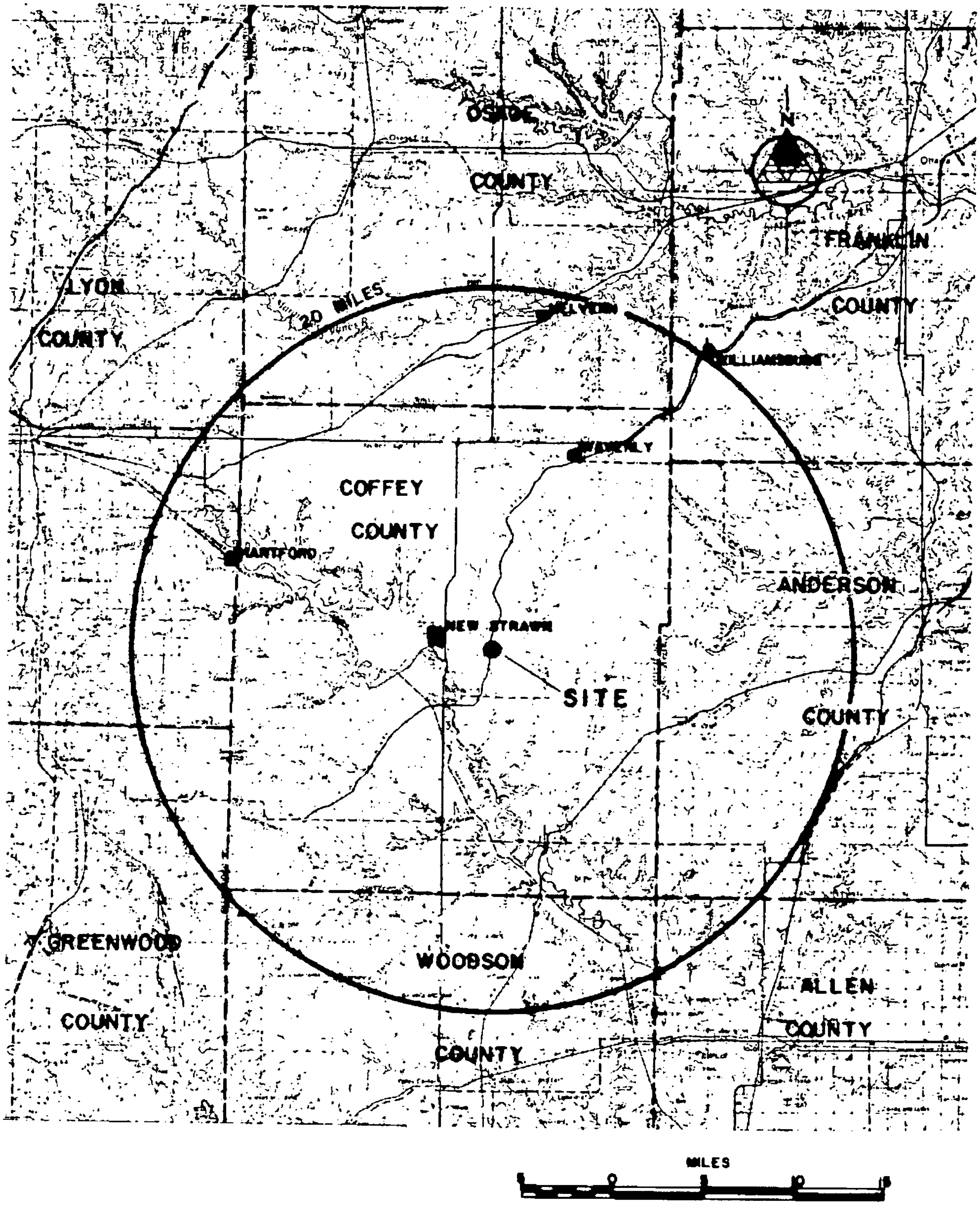
STATE BOARD OF AGRICULTURE, 1979, OPEN FILE MATERIAL. DIVISION OF WATER RESOURCES, TOPEKA, KANSAS (MARCH)

REFERENCE:

BASE MAP FROM STATE HIGHWAY COMMISSION OF KANSAS, GENERAL HIGHWAY MAP OF NEOSHO COUNTY, 1969; CRAWFORD COUNTY, 1975; LABETTE COUNTY, 1970; AND CHEROKEE COUNTY, 1975.

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-25
WATER WITHDRAWAL POINTS
ON THE NEOSHO RIVER IN KANSAS
DOWNSTREAM OF THE SITE
SHEET 2 OF 2



NOTE:

MAP INDENTIFIES MUNICIPALITIES SERVED BY ONE OR MORE WELLS. SEE TABLE 2.1-22 FOR WELL INFORMATION.

REFERENCE:

BASED ON U.S.G.S. TOPOGRAPHIC QUADRANGLES:
HUTCHINSON, KANSAS - 1955
JOPLIN, MISSOURI; KANSAS - 1954
LAWRENCE, KANSAS; MISSOURI - 1956
WICHITA, KANSAS - 1955

WOLF CREEK GENERATING STATION
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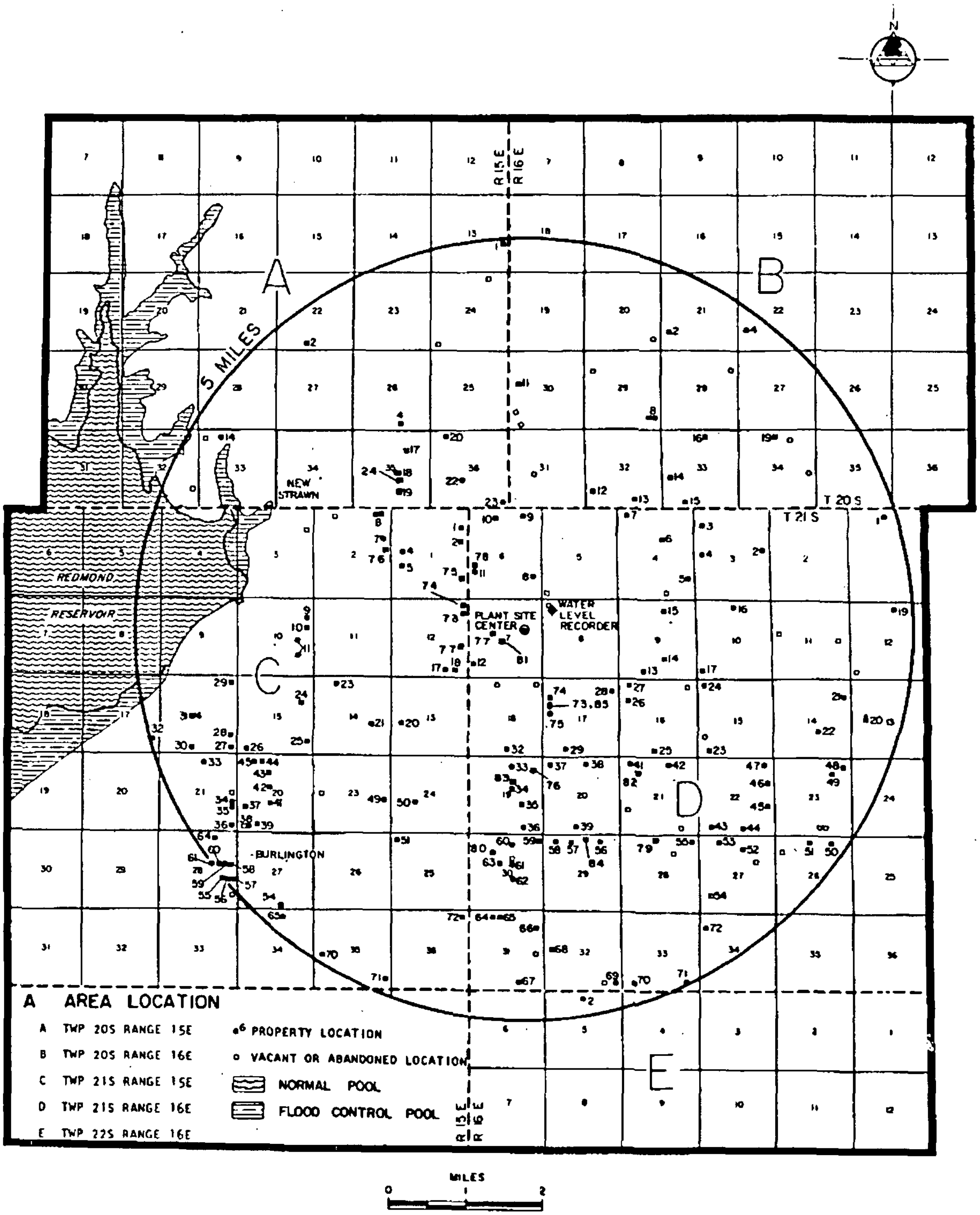
FIGURE 2.1-26

MUNICIPAL GROUND-WATER SUPPLIES WITHIN 20 MILES OF THE SITE



NOTE:

REFER TO TABLE 2.1-23 FOR OWNER AND WELL DATA.

REFERENCE:

GENERAL HIGHWAY MAP OF COFFEY COUNTY, KANSAS; PREPARED BY THE KANSAS STATE HIGHWAY DEPARTMENT.

WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.1-27

WELL INVENTORY WITHIN 5 MILES

2.2 ECOLOGY

2.2.1 TERRESTRIAL ECOLOGY

Information presented in this section supplements material provided in Section 2.7.2 of the ER(CPS). Annual preoperational monitoring has been conducted since completion of the baseline survey and the results were presented in annual reports to the Applicants (Industrial BIO-TEST Laboratories, Inc., 1975; Nalco Environmental Sciences, 1976, 1977, 1978; Hazleton Environmental Sciences, 1979).

The preoperational monitoring program was designed to provide environmental data that could be compared to baseline information. Additional community types and locations were sampled since the ER(CPS), and revisions recommended by the NRC in the FES(CPS) were incorporated into the program in 1976. Specific objectives of the terrestrial ecology environmental program were identified in the ER(CPS) and modified as listed below:

a. To identify existing plant communities in the vicinity of the site and to make qualitative and quantitative descriptions of selected plant communities.

b. To determine the relationships between floodplain intracommunity phytosociological variances and intracommunity environmental gradients.

c. To identify migrant and/or resident populations of mammals, birds, reptiles, amphibians, and terrestrial invertebrates in the vicinity of the site.

d. To determine the general distribution and interrelationships of existing wildlife populations and to assess their utilization of existing habitats.

e. To determine existing effects of natural and man-induced factors of animal and plant communities.

f. To provide a basis for comparison with subsequent environmental surveys.

g. To assess the impact of the proposed action on animal and plant communities in the site area.

2.2.1.1 Vegetation

2.2.1.1.1 Environmental Stresses

Natural and man-induced environmental stresses that are present in the Burlington, Kansas vicinity were addressed in Section 2.7.2.3.1.2 of the ER(CPS).

2.2.1.1.2 Site Community Types

The vegetation in the Wolf Creek area is characterized by four distinct community types: (a) lowland woods, (b) native prairie, (c) open pasture, and (d) mixed shrub-grass pasture. Annual-dominated mudflat is a minor community type that is primarily restricted in occurrence to the periphery of John Redmond Reservoir. Extensive quantitative analyses were made of each community type and the important vegetation components of each are discussed below.

A photogenetic list of all species encountered during community vegetation surveys conducted from 1973 to 1978 is presented in Table 2.2-1. For each species listed, community type occurrence and an index of relative community importance are indicated.

Lowland Woods: Lowland woods communities were surveyed at five locations (Communities 1, 1A, 1B, 1C, and 8) during the baseline and preoperational monitoring programs (Figure 2.2-1). Descriptions of the individual sites and quantitative vegetation data summaries are available in Section 2.7 of the ER(CPS) and the annual monitoring reports. A variety of topographic and moisture conditions were represented by the sampling plots, and although the dominant species varied from plot to plot and from stand to stand, the overall composition was similar.

Hackberry (*Celtis occidentalis*) was dominant or codominant at all sites; common associates were black walnut (*Juglans nigra*), American elm (*Ulmus americana*), white bitternut hickory (*Carya cordiformis*), silver maple (*Acer saccharinum*), bur oak (*Quercus macrocarpa*), green ash (*Fraxinus pennsylvanica*), and Kentucky coffee tree (*Gymnocladus dioica*). Hackberry was the only species that was well represented in the understory at all locations.

A gradient analysis was performed using phytosociological data from the north floodplain woods (Location 1) and south floodplain woods (Location 8) in 1976 and 1977 to relate variance in the vegetation to the flood susceptibility prior to construction of the cooling lake (Nalco Environmental Sciences, 1977, 1978). This analysis showed a distinct gradient of moderate ecological amplitude in the south floodplain woods and a more subtle gradient in the north floodplain woods. Inspection of tree species distribution in relation to the flooding gradient of the lowland woods showed that silver maple, American elm, green ash, and sycamore (*Platanus occidentalis*) were more common on the frequently inundated sites, whereas hackberry, red bud (*Cercis canadensis*), Kentucky coffee tree, and the hickories (*Carya* spp.) and oaks (*Quercus* spp.) occurred on higher, well-drained sites.

Coralberry (Symphoricarpos orbiculatus), poison ivy (Rhus radicans), Missouri gooseberry (Ribes missouriense), hackberry, and elms (Ulmus spp.) were dominant shrub stratum components. Poison ivy and green ash occurred on the most frequently flooded sites, and coralberry and gooseberry occurred on well-drained sites. In 1978, shrub stratum flood susceptibility indices were developed to detect the effects of changes in flooding intensity resulting from cooling lake operation on community vegetation (Hazleton Environmental Sciences, 1979). The baseline shrub stratum flood susceptibility indices ranged from 8.14 to 8.84 for the north floodplain woods and from 6.19 to 6.60 for the south floodplain woods (Table 2.2-2). These data indicated that shrubs in the south floodplain woods are more flood-tolerant than in the north floodplain woods.

Frequent ground layer species from lowland woods sites included spreading chervil (Chaerophyllum procumbens), wood nettle (Laportea canadensis), Virginia wild rye (Elymus virginicus), clearweed (Pilea pumila), and fescue (Festuca obtusa), all typical floodplain species.

Three years of monitoring arboreal productivity at Locations 1 and 8 yielded productivity estimates ranging from 8629-13825 kg/ha per year and 13694-17668 kg/ha per year, respectively. At both locations, the low value of the range represents data from the relatively-dry 1978 growing season.

Abandoned railroad right-of-way: Bluestem prairie has been sampled in an abandoned railroad right-of-way at two locations. Composition and structure of this habitat have been described in Section 2.7 of the ER(CPS) and in the annual environmental monitoring reports.

During the course of the study, composition of the north floodplain woods, south floodplain woods, and the abandoned railroad right-of-way communities has been similar with only minor changes in the order of relative species importance. Under relatively stable environmental conditions, community change takes place relatively slowly in mature, wooded communities; relatively high similarity indices were calculated for both the north and south floodplain woods (Table 2.2-3). Composition differences reflected in the moderate to relatively low similarity indices for the abandoned railroad right-of-way community generally involved the addition or deletion of low frequency species. The lowest index (1978/1974) was due to transects being located near railroad ballast where disturbed conditions existed.

Open Pasture Community: This community type is addressed in Section 2.7 of the ER(CPS).

Mixed Shrub-Grass Pasture: This community type is addressed in Section 2.7 of the ER(CPS).

Mudflat Communities: Two mudflat communities were sampled on the flood control bench of John Redmond Reservoir. Generally, vegetation was poorly developed during early stages of the growing season and reached maximum development in late summer (Tables 2.2-4 and 2.2-5). The communities were dominated by annual species including fall panic grass (*Panicum dichotomiflorum*), fescue (*Festuca paradoxa*), amaranth (*Amaranthus* sp.), rough sumpweed (*Iva ciliata*), flower of an hour (*Hybiscus trionum*), common cocklebur (*Xanthium strumarium*), smartweeds (*Polygonum lapathifolium* and *P. pensylvanicam*), barnyard grass (*Echinochloa crusgali*) and members of the sedge family (Cyperaceae). Community composition varied from year to year in response to duration and depth of community inundation. Mudflats that were exposed early in the growing season had a much greater proportion of dry-site annuals such as sunflower (*Helianthus annuus*), horse nettle (*Solenum carolinense*) and sweetclover (*Melilotus* spp.), whereas sites that were shallowly inundated for long periods of time developed low-diversity graminoid stands dominated by barnyard grass. The composition of the mudflat communities was similar to that of annually inundated, inland, freshwater flats and basins described by Shaw and Fredine (1956). Average community ground layer ranged from 17 percent in June of 1978 to 64 percent in September 1978. Water levels and frequency of inundation contributed to community differences between the wet and dry mudflat communities.

2.2.1.2 Wildlife

2.2.1.2.1 Mammals

2.2.1.2.1.1 Small Mammals

During the baseline study and subsequent monitoring, 10 species of small mammals were captured in the study area (Table 2.2-6). The capture rate during the 8647 total trapnight effort averaged 7.88 animals per 100 trapnights.

Floodplain Woods: This community was sampled from 1973 through 1975 (Table 2.2-7). Five species of small mammals were reported in the ER(CPS), Section 2.7.2.3.2.2. No new species were captured in subsequent monitoring through 1975 although there were annual fluctuations in occurrence and abundance. The white-footed mouse (*Peromyscus leucopus*) was the most common species captured in all years.

North Floodplain Woods: The north floodplain woods community is structurally similar to the floodplain woods community and was sampled from 1976 through 1978 (Table 2.2-7). The white-footed mouse was captured during all three years of monitoring.

Shorttail shrews (Blarina brevicauda) were captured in 1976 and 1978. The opossum (Didelphis virginiana) and woodland vole (Microtus pinetorum) were trapped only in 1978.

Open Pasture: A total of six species were found in the open pasture community during sampling from 1973 through 1975 (Table 2.2-7). Two species, including the plains harvest mouse (Reithrodontomys montanus) and deer mouse (Peromyscus maniculatus), were captured in 1973. In 1974, the shorttail shrew, least shrew (Cryptotis parva), deer mouse, hispid cotton rat (Sigmodon hispidus) and prairie vole (Microtus ochrogaster) were caught. No small mammals were captured in 1975.

Mixed Shrub-Grass: Four species of small mammals were caught in this community between 1973 and 1975 (Table 2.2-7). The plains harvest mouse and hispid cotton rat were captured in 1973. In 1974, the deer mouse and white-footed mouse were caught; in 1975 only the white-footed mouse was captured.

Abandoned Railroad Right-of-Way: The abandoned railroad right-of-way was sampled throughout the series of baseline and monitoring studies between 1973 and 1978 (Table 2.2-7). Five species of small mammals were reported in the ER(CPS), Section 2.7.2.3.2.2. Two additional species, the white-footed mouse and prairie vole, were captured during subsequent monitoring studies.

Mudflat: The results of mammal trapping on mudflat communities at John Redmond Reservoir have been discussed by Nalco Environmental Sciences (1977). Small mammal populations were relatively high and the deer mouse and house mouse (Mus musculus) were the most abundant species. Flooded areas were rapidly colonized by small mammals when waters receded.

The floodplain woods, sampled fron 1973 to 1975, and the similar north floodplain woods, sampled from 1976 to 1978, had the highest small mammal capture rates. Rates ranged from 5.85 animals/100 trapnights in 1973 to 33.25 animals/100 trapnights in 1976. The lowest rates occurred in different communities, depending on the year. Generally, the open pasture and mixed shrub-grass communities had low capture levels in the years they were sampled. The abandoned railroad right-of-way was variable, having the second lowest trap success in 1975 but the highest in 1978.

Data collected during the 1973 baseline study were not directly comparable to those collected during subsequent monitoring studies due to sampling differences and community relocation. Similarly, there were additional changes made during the 1974 study regarding locations and sampling schedules that made comparisons between portions of the 1974 and subsequent monitoring studies invalid. However, comparisons between more recent studies are feasible.

The seasonal trend of white-footed mouse densities in the north floodplain woods during 1978 was opposite that observed in the 1975-77 studies (Table 2.2-8), with estimated densities lower in June (23.0/ha) than in September (38.0/ha). Density in June 1978 was similar to densities of June 1975 and 1977, but lower than 1976 (34.0/ha). September 1978 density estimates were the highest recorded of all sample years.

Based on sample data from 1973 to 1978, hispid cotton rat densities fluctuated from year to year. Estimated densities were relatively high in 1974, 1976, and 1978 but low in 1975, and no cotton rats were captured in 1977.

A comparison of estimated mammal densities in each community showed that higher densities occurred in 1978 compared to 1977. The only year in which densities were higher than 1978 was 1976 when there were about 7 percent more animals. The number of species (9) captured during 1978 was higher than in any previous year.

2.2.1.2.1.2 Observations of Other Mammals

In addition to those mammals that were trapped, signs of observations of nine other mammalian species were recorded during the baseline and monitoring studies. These mammals included the eastern mole (Scalopus aquaticus), eastern cottontail (Sylvilagus floridanus), eastern fox squirrel (Sciurus niger), coyote (Canis latrans), raccoon (Procyon lotor), badger (Taxidea taxus), striped skunk (Mephitis mephitis), bobcat (Felis rufus), and white-tailed deer (Odocoileus virginianus). Mammalian species that were not sighted but whose distribution probably encompasses central Coffey County are presented in Table 2.2-9.

2.2.1.2.2 Birds

The area surrounding WCGS offers a variety of habitats for both resident and migratory avian populations. Eighty species of birds were reported in the ER(CPS), Section 2.7.2.3.3.1. Sixty-two additional species were recorded during the 1974-78 monitoring studies. Of the total of 142 species, 57 were classified as summer residents, 17 as winter residents, 41 as permanent residents, and 27 as migrants (Table 2.2-10). Residency status of individual species was based on field observations during the study and published ornithological records (Kortright 1942; Peterson 1947; Clarke et al. 1958; Johnson 1965; Robbins et al., 1966). The natural occurrence of fauna in Kansas is dependent on many diverse environmental factors. The seasonal classification for each avian species may vary within a given region depending upon nesting needs, food availability, weather, and other environmental components.

Eastern Meadowlark (*Sturnella magna*), Red-winged Blackbird (*Agelaius phoeniceus*), House Sparrow (*Passer domesticus*), Common Grackle (*Quiscalus quiscula*), and Mourning Dove (*Zenaida macroura*) were the most frequently sighted permanent residents. Although generally less abundant than permanent residents, summer residents commonly observed included the Eastern Kingbird (*Tyrannus tyrannus*), Barn Swallow (*Hirundo rustica*), and Dickcissel (*Spiza americana*). Descriptions of habitat preference of the more common and important phylogentic groups found in the vicinity of WCGS are discussed in Section 2.7.2.3.3.2 of the ER(CPS).

Data collected prior to November 1974 in the floodplain woods community represented a different location and direct comparisons are not valid; however, comparisons are possible for the north floodplain woods studied after November 1974 and for all data collected in the abandoned railroad right-of-way community (Table 2.2-11).

The avian community characteristics, including number of species, number of birds observed per hour, and species diversity, varied in both communities among years. In general, species richness and diversity were higher during migratory periods and summer breeding. The lowest numbers usually occurred in mid-winter (January). Variation between years may be due to factors such as weather, habitat quality, parasites, and disease. No long term trends are indicated by the observed fluctuations in the two communities.

Data from avian censuses made on the wildlife survey route between May 1973 and January 1979 also indicates fluctuations between years and seasons (Table 2.2-12).

2.2.1.2.3 Upland Game Species

Three mammalian and three avian upland game species have been reported near WCGS; life history information on these species was reported in Sections 2.7.2.3.2.2 and 2.7.2.3.3.2 of the ER(CPS).

The white-tailed deer was observed during baseline studies and has been recorded during all monitoring studies. Deer were occasionally noted along the wildlife survey route, and signs of deer were noted frequently in the lowland woods community. The interspersion of wooded and agricultural habitats bordering creeks in the area provides good deer habitat.

Fox squirrels were commonly observed in wooded habitats of the site and midwinter time-area counts indicated that squirrels were relatively abundant on the site (ER(CPS), Nalco Environmental Sciences, 1976, 1977). Results of the time-area counts did not indicate any trends in fox squirrel populations near the site.

Eastern cottontails were sighted in all cover types during surveys; however, brushy and edge habitats appeared to be preferred. Census data collected along the wildlife survey route indicated that cottontail populations have fluctuated during the study periods. Population indices were high in 1973, 1976, and 1978 and lower in 1974, 1975, and 1977 (Table 2.2-13). Cottontail population changes noted near WCGS were probably related to natural fluctuations.

Avian upland game species noted included Mourning Dove, Bobwhite, and Greater Prairie Chicken (Tympanuchus cupido). The Greater Prairie Chicken was noted only in 1978 (Hazleton Environmental Sciences, 1979). A single individual was observed on the wildlife survey route. Mourning Doves were commonly observed on the site, but no noticeable trends in dove populations have been recorded.

Bobwhite also occur commonly near WCGS and have been observed in most habitats. The mixture of wooded, transitional, and open field habitats provides suitable cover and food for this species. The highest number of Bobwhite heard calling along the 20-mile wildlife survey route in June occurred in 1973 when an average of 57 birds were heard calling on the census route (Table 2.2-13). Counts since then have been variable with a low in 1977 of only 15 Bobwhite. Yearly trends in call count data from WCGS can be compared to rural mail carrier counts tabulated by the Kansas Fish and Game Commission. The July 1972-1978 rural mail carrier counts for Coffey County indicated a gradual decline in the Bobwhite population between 1972 and 1975, an increase in 1976, a decrease in 1977, and another increase in 1978 (Kansas Fish and Game Comm., Pratt, Kansas, personal communication). Similar trends are indicated in data collected near the WCGS. Fluctuations in Bobwhite populations may be a response to various factors (e.g., hunting pressure, weather, habitat quality, parasites, and disease), and the population declines noted near WCGS appear to be correlated with naturally occurring events causing similar fluctuations throughout Coffey County and southeast Kansas.

2.2.1.2.4 Amphibians and Reptiles

Twenty-four species of amphibians and reptiles were recorded in the vicinity of the WCGS site (Table 2.2-14). This compares with a total of 37 species recorded by Clarke (1958) in an ecological study of reptiles and amphibians in Osage County, Kansas. This east central county borders Coffey County on the North and both are a part of the Osage Plains.

Three species of turtles were reported in ER(CPS), Section 2.7.2.3.4. Five additional species were found during the subsequent monitoring program. These included the snapping turtle (*Chelydra serpentina*), map turtle (*Graptemys geographica*), false map turtle (*G. pseudogeographica*), western painted turtle (*Chrysemys picta belli*), and western spiny softshell (*Trionyx spiniferus hartwegi*).

Although Clark (1958) has recorded five lizards for Osage County, only two species were recorded near WCGS. The slender glass lizard (*Ophisaurus attenuatus*) was found during the baseline study (ER(CPS), Section 2.7.2.3.4) and the six-lined race-runner (*Cnemidophorous s. sexlineatus*) was seen during monitoring studies.

Five snake species, including the red-sided garter snake (*Thamnophis sirtalis parietalis*), yellow-bellied racer (*Coluber constrictor*), black rat snake (*Elaphe o. obsoleta*), bullsnake (*Pituophis melanoleucus sayi*), and western massasauga (*Sistrurus catenatus tergeminus*) were observed.

The American toad (*Bufo americanus*) and Woodhouse's toad (*Bufo w. woodhousei*) were common in the WCGS area. The Great Plains toad (*Bufo cognatus*) was observed during most years of the monitoring program.

The plains leopard frog (*Rana blairi*) and bullfrog (*Rana catesbeiana*) were observed throughout the baseline and monitoring studies. The crawfish frog (*Rana areolata*) is considered threatened in Kansas and was seen only during the 1976 monitoring study.

2.2.1.2.5 Terrestrial Arthropods

Terrestrial arthropods collected near WCGS during sampling in 1973 are discussed in Section 2.7.2.3.5 of the ER(CPS).

2.2.1.2.6 Rare and Endangered Species

All plant and animal species recorded in the study area were checked against the official list of threatened and endangered species for the United States (U. S. Department of Interior, 1978) and the lists of rare, endangered and extirpated species in Kansas (Platt, 1973; Platt et al., 1973).

Bobcat tracks were observed in the north floodplain woods in 1977. The bobcat is considered rare in Kansas, but not nationally. It occurs statewide but sightings are infrequent.

The federally endangered Bald Eagle was observed near the site in 1976 and 1977 and eagles winter in the area. Construction of the WCGS cooling lake will create habitat favorable for wintering eagle utilization. After filling of the lake, eagle use of the site should increase.

No herptile species listed as rare or endangered by the U. S. Department of Interior were observed near the WCGS site during the baseline or monitoring studies. The crawfish frog, observed in 1976, was not recorded in 1977 or 1978. This species is considered threatened in Kansas (Platt et al., 1973) and appears susceptible to flooding and alterations in the water table.

2.2.2 AQUATIC ECOLOGY

Information presented in this section is provided to supplement material addressed in Section 2.7 of the ER(CPS). Annual preoperational monitoring has been conducted since completion of the baseline study and the results were presented in annual reports to the Applicants (Industrial BIO-TEST Laboratories, Inc., 1975; Nalco Environmental Sciences, 1976, 1977, 1978; Hazleton Environmental Sciences, 1979). Seasonal and year-to-year variations in the composition, abundance, distribution, species diversity, and productivity of existing biotic communities in Wolf Creek, John Redmond Reservoir and the Neosho River were documented and related to natural environmental factors and to construction activities associated with WCGS.

2.2.2.1 Phytoplankton

Phytoplankton collected in Wolf Creek and the Neosho River from 1973 to 1978 consisted of over 300 taxa which represented more than 100 genera within eight algal divisions. Diatoms (*Bacillariophyta*) accounted for approximately one-half and green algae (*Chlorophyta*) about one-fourth of all taxa encountered. The remaining taxa were variously distributed among yellow-brown algae (*Chrysophyta*), blue-green algae (*Cyanophyta*), euglenoids (*Euglenophyta*), cryptomonads (*Cryptophyta*), chloromonads (*Chloromonadophyta*), and dinoflagellates (*Pyrrophyta*).

John Redmond Reservoir - Neosho River: Centric diatoms were usually the dominant phytoplankton group collected at Locations 1, 10, and 4 during the 6-year study period (Table 2.2-15). Large populations of centric diatoms are normally associated with open-water areas of lakes and reservoirs, although a number of rapidly-reproducing, small centric taxa can maintain appreciable populations in riverine habitats provided current velocity and water turbidity are not excessive (Lack et al., 1978). It is doubtful that significant production of centric diatoms or other euplanktonic taxa occurred in the 10 mile stretch of the Neosho River between Locations 1 and 4 due to the short travel time 4 hours) under conditions of average to high flows (>500 cfs). Most planktonic algae collected at Locations 10 and 4 may therefore be regarded as having originated in John Redmond Reservoir.

Dominant centric taxa in the John Redmond Reservoir-Neosho River system from 1973 to 1978 included Stephanodiscus astraea, S. hantzschii, S. minutus, Cyclotella atomus, C. meneghiniana, and Thalassiosira pseudonana (Nalco Environmental Sciences, 1978; Hazleton Environmental Sciences, 1979). The abundance of these and other euplanktonic taxa at Neosho River Locations 1, 10, and 4 reflected the discharge of phytoplankton from John Redmond Reservoir. The frequent occurrence of benthic pennate diatoms in the tailwaters (Location 1) is indicative of a shallow river-reservoir system in which substrate-associated taxa originating in the parent river or reservoir are easily swept into the water column by wave and reservoir currents. Frequent increases of pennate diatoms at Locations 10 and 4 are reflective of further sloughing of periphytic diatoms from substrates downstream of Location 1. The most common pennate diatom taxa during all studies were species of Nitzschia and Navicula. Species within these genera are normally members of periphytic (substrate) communities and occur only incidentally in the euplankton.

Diatoms did not exhibit a uniform seasonal pattern of abundance in John Redmond Reservoir or the Neosho River. Maximum annual populations generally occurred in spring and summer but in 1974 a winter diatom maximum was evident. A pronounced spring diatom maximum that characterizes many temperate lakes (Hutchinson, 1967) was recorded only in 1975. One or more secondary population peaks occurring before or after seasonal maximum densities were also characteristic of the annual cycles of river and reservoir diatom populations from 1973 through 1978 (Nalco Environmental Sciences, 1977, 1978; Hazleton Environmental Sciences, 1979).

Green algae together with cryptomonads were the second most abundant algal divisions in the reservoir and the Neosho River during all studies (Table 2.2-15). Maximum densities of Chlorophyta generally coincided with the cooler seasons of each year. Densities of this group are typically highest in spring or early fall (Hutchinson, 1967). Major Neosho River taxa included Dictyosphaerium, Ankistrodesmus, Oocystis, Chlamydomonas, Crucigenia, and Tetrastrum.

Cryptomonads exhibited a seasonal distributional pattern similar to that of green algae, being abundant in fall, winter, and spring with peak densities occurring in fall and winter. Although cryptomonads may be common throughout the year, peak annual densities have been frequently observed in spring, fall, and winter in other bodies of water (Birge and Juday, 1922; Applegate et al., 1973; Staker, 1974). Major cryptomonad taxa in the Neosho River were Cryptomonas, Rhodomonas, and Chroomonas.

Blue-green algae were usually insignificant constituents of the reservoir tailwater and river phytoplankton communities.

Aphanizomenon, *Microcystis*, and *Anabaena*, species that frequently become abundant in the summer plankton of eutrophic prairie lakes, were rarely observed in John Redmond Reservoir or the Neosho River. High turbidity and rapid water exchange rates may have prevented the development of these forms since nutrient concentrations were sufficient to support dense blooms of these nuisance algae (Section 2.4.3). *Merismopedia tenuissima*, a very small colonial taxon, was the only common blue-green species consistently collected during summer and early fall in the Neosho River.

Other algal divisions that were occasionally important included chloromonads (*Gonyostomum*) in July and October and euglenoids (*Euglena*) and chrysophytes (*Chrysochromulina*) in December 1978.

Both mean annual phytoplankton density and chlorophyll *a* concentration in John Redmond Reservoir and tailwaters (Location 1) from 1974 to 1978 were inversely correlated with annual precipitation (r = -0.78 and -0.98, respectively). High rainfall may reduce reservoir phytoplankton populations by: (1) increasing water turbidity, producing rapid decreases in reservoir water temperature, and diluting reservoir phytoplankton through stormwater runoff; and (2) necessitating higher reservoir water releases with resultant decreases in reservoir water retention time.

Comparison between mean annual retention time and phytoplankton abundance and chlorophyll *a* concentration indicated a moderate positive correlation (r = 0.42) for plankton density and virtually no correlation of chlorophyll *a* (r - 0.19). Margalef (1975) in a study of Spanish reservoirs was able to show only a weak positive correlation between retention time, chlorophyll concentration, and primary productivity.

Phytoplankton productivity at Location 1 from 1974 to 1978 showed a weak, negative correlation (r = -0.34) with annual rainfall and a positive correlation (r = 0.62) with reservoir water retention time. Mean annual phytoplankton density, chlorophyll *a* concentration, and primary productivity at downstream Locations 10 and 4 were generally lower relative to Location 1, whereas during 1976, a year of low annual precipitation and river flow, all the measured parameters were moderately higher at downstream locations compared to Location 1 (Tables 2.2-16 to 2.2-18).

With few exceptions, species diversity indices were generally similar between Neosho River Locations 1, 10, and 4 during all studies (Table 2.2-19). Diversities in the Neosho River were highest in summer and fall during the 1978 study. Maximum diversities were noted during the spring in 1974 and 1975, whereas in 1976 and 1977 species diversities were highest in late fall (Table 2.2-19).

Wolf Creek: Flow in Wolf Creek after 1974 was intermittent. Most phytoplankton samples from 1975 to 1978 were collected from stagnant pools at each creek location. Whereas centric diatoms were the predominant algal group in the Neosho River, pennate diatoms and flagellated algae, particularly cryptomonads (Cryptomonas) and euglenoids (Euglena and Trachelomonas), were frequently more common in Wolf Creek (Table 2.2-20). Other algal groups that were seasonally abundant included centric diatoms (Stephanodiscus and Cyclotella), green algae, and on rare occasions, blue-green algae (Oscillatoria). Seasonal and spatial patterns generally were not apparent in the distribution of major algal groups in Wolf Creek, although centric diatoms as a group were frequently dominant from summer to early winter and chrysophytes were most prevalent from late fall to early spring (Table 2.2-20). Considerable interlocation variability has been observed in the phytoplankton population structure of Wolf Creek during all studies. This variability has been attributed to sampling isolated shallow pools each of which represented a distinct habitat with its own physicochemical characteristics (Nalco Environmental Sciences, 1977).

Species diversity in Wolf Creek was similar among locations from 1975 through 1976 and moderately higher at Location 5 than at upstream locations in 1974 and 1977. During 1978 diversity was highest at upstream Location 7 and lowest at downstream Location 3. Diversity at all locations in 1978 was highest in June, a seasonal pattern that was also noted in 1975 and 1976 (Table 2.2-19).

Annual mean phytoplankton density, chlorophyll a concentration, and primary productivity in Wolf Creek from 1974 to 1978 were inversely correlated with annual precipitation ($r = -0.73$, -0.71, and -0.71, respectively). These comparisons indicated that the amount and pattern of yearly rainfall represented major controlling factors that govern the structure of creek phytoplankton communities.

The presence and persistence of pools of standing water during years of low rainfall were prime requirements for the development of large populations of euplanktonic algae in Wolf Creek.

2.2.2.2 Periphyton

Studies since the baseline program expanded the list of algae identified from periphyton samples to include 237 taxa representing 62 genera (Table 2.2-21). Eighty-three taxa were considered dominant because they composed 10 percent or more of total periphyton abundance or biovolume at least once (Table 2.2-22). Nitzschia sp. and Oscillatoria sp. were often dominant in both the Neosho River and Wolf Creek. The diatoms Navicula tripunctata v. schizonemoides and Stephanodiscus sp.

and filamentous green algae *Cladophora* sp. and *Stigeoclonium* sp. were frequently dominant only in the Neosho River. Taxa commonly dominant only in Wolf Creek included the diatoms *Diploneis* sp., *Gomphonema* sp., *Gyrosigma* sp., *Navicula symmetrica*, *Navicula* sp., *Nitzschia dissipata*, and *Surirella ovata* and a filamentous blue-green alga *Phormidium* sp. Except during 1974 periphyton was generally more abundant in the Neosho River than in Wolf Creek (Figures 2.2-2 and 2.2-3).

Hydrological conditions have been the major environmental factor affecting periphytic algal growth and sample collection during monitoring studies conducted near WCGS since 1973. Intermittent flow in Wolf Creek and variable discharges from John Redmond Reservoir into the Neosho River have either eliminated periphyton or prevented sampling for approximately one-third of the scheduled collections. Reduced sample collections from each water system have limited the scope of discussion on periphyton near WCGS.

2.2.2.3 Zooplankton

John Redmond Reservoir - Neosho River: Annual zooplankton densities in John Redmond Reservoir and tailwaters (Location 1) ranged from 150,815 organisms/m^3 in 1974 to 454,594 organisms/m^3 in 1976. Rotifers represented 68 percent, copepods 24 percent, and cladocerans about 8 percent of total zooplankton at Location 1 from 1973 to 1978 (Table 2.2-23).

Highest zooplankton densities in John Redmond Reservoir and tailwaters during the annual cycle occurred in February (5-year mean: 1,112,488 organisms/m^3) and lowest densities were present in July and December (137,230 and 121,345 organisms/m^3, respectively) (Table 2.2-24). Large February zooplankton populations were due to extremely high rotifer densities (mainly *Keratella* and *Polyarthra*) at Location 1 during late winter. Relatively low December reservoir populations may have been indicative of normal seasonal declines in reservoir populations, whereas low July densities may have been caused by the temporary depletion of reservoir zooplankton resulting from unusually late reservoir water releases (Nalco Environmental Sciences, 1978).

Sixty-four zooplankton taxa including 16 Copepoda, 22 Cladocera, 26 Rotifera were collected in John Redmond Reservoir and tailwaters (Location 1) from 1973 to 1978 (Table 2.2-23). Limnetic zooplankton species were predominant in all samples and comprised about 99 percent of total zooplankton densities and 53 percent of the total number of taxa collected at Location 1. Low densities of littoral zooplankton species in reservoir discharges are typical, particularly in impoundments which lack stable littoral habitats (Cowell, 1967, 1970).

Copepod nauplii, cyclopoid copepodites, Bosmina longirostris, and the rotifer genera Keratella, Polyarthra, Synchaeta, Brachionus, and Hexarthra were the most abundant zooplankton taxa collected at Location 1 and comprised over 90 percent of total zooplankton from 1973 to 1978 (Table 2.2-23).

The seasonal succession of major zooplankton taxa at Location 1 was generally similar from year to year. Keratella and Polyarthra were most abundant in later winter; nauplii, cyclopoid copepodites, Bosmina, Daphnia parvula during spring, and Brachionus, Hexarthra, Moina, Diaphanosoma, and Diaptomus siciloides during summer and early fall (Table 2.2-24).

Annual reservoir zooplankton populations from 1973 to 1978 were characterized by progressive increases in the annual densities of cyclopoid copepodites, Cyclops vernalis, Bosmina longirostris and by concurrent declines in annual densities of Daphnia spp. and Ceriodaphnia lacustris. Densities of Ceriodaphnia declined sharply from $2483/m^3$ in 1974 to $103/m^3$ in 1975 and continued to decrease during succeeding years to $17/m^3$ in 1978. Daphnia densities declined progressively from $14413/m^3$ in 1973 to $1859/m^3$ in 1978 (Hazleton Environmental Sciences, 1979).

Mean annual zooplankton densities in John Redmond Reservoir appeared to be influenced by reservoir water retention time and amount of annual precipitation. Microcrustacean densities were directly related to length of retention time ($r = 0.89$), whereas rotifer populations appeared to be less affected by changes in reservoir water retention ($r = 0.22$). In general, reproduction rates of rotifers are greater than those of the larger microcrustaceans. Rotifer turnover rate (rate of population renewal) may be as short as 4 to 5 days in spring and early summer (Ruttner-Kolisko, 1974). Reservoir rotifer populations showed a strong inverse relationship to the amount of annual precipitation ($r = -0.79$), whereas microcrustacean communities were generally indifferent ($r = 0.17$) to yearly variations in annual rainfall. Heavy rainfalls increased reservoir water turbidity and water releases which may have reduced existing algal standing crops in John Redmond Reservoir. Since algae are the primary food of rotifers, any appreciable reduction of this food source as a result of hydrological or biological factors can produce rapid decreases in rotifer populations. Due to their high population turnover rates, rotifers respond quicker to detrimental or favorable environmental changes than microcrustaceans (Gannon and Stemberger, 1978). The results obtained from 1974 to 1978 indicate that annual reservoir zooplankton populations can be expected to be lowest when annual precipitation and reservoir water discharges are high. Conversely, highest annual reservoir zooplankton densities may be realized during years when yearly rainfall and water discharges are relatively low.

Zooplankton studies conducted in the Neosho River since 1973 have established that most (>95 percent) of the zooplankton present near the confluence of Wolf Creek had originated in John Redmond Reservoir. Comparison of zooplankton densities at Location 1 to those at Location 10 and 4 indicated that zooplankton abundance at the latter locations was directly related to the volume of reservoir water releases ($r = 0.76$). When reservoir discharges were high (1000-6950 cfs) nearly 54 percent of the crustacean zooplankton density at Location 1 still remained at Locations 10 and 4, whereas during periods of low reservoir water releases (50-500 cfs) zooplankton densities at downstream locations were sharply reduced to about 1 percent of those at Location 1 (Hazleton Environmental Sciences, 1979). This relationship did not hold for the winter months (December and February) when zooplankton densities at Locations 10 and 4 were apparently independent of the volume of river flow ($r = 0.03$). The rapid decline of reservoir and lake zooplankton upon entering receiving rivers is a common phenomenon (Chandler, 1937; Ward, 1975; Armitage and Capper, 1976). Losses of zooplankton in these water systems have been related to the mechanical destruction of plankton by water turbulence and suspended particles of sand and silt. During relatively low river flows plankton may also be filtered out by periphytic growth and aufwuchs growing on the riverbed.

During high flows (>1000 cfs) in the Neosho River, losses of zooplankton appeared relatively small at downstream locations. This was due to the short travel time (<3 hours) for reservoir plankton between Location 1 and Locations 10 and 4 during high flows. The detrimental effects on pelagic zooplankton were more pronounced during relatively low river flows when the combined effects of water turbulence and turbidity together with the refiltering action of periphytic growth produced dramatic decreases in zooplankton densities at Locations 10 and 4. Moreover, reduced river flow may have allowed dead and moribund zooplankton to settle rapidly to the riverbed, whereas high river flows often carry these nonviable organisms for considerable distances downstream. On the average (6-year mean) the larger microcrustaceans are eliminated more rapidly than the smaller rotifers (Table 2.2-23). The persistence of reservoir zooplankton at Locations 10 and 4 during winter under conditions of minimal river flows (50 to 75 cfs) may have been related to the scarcity of periphytic growth and to a decrease of water turbidity in the Neosho River during December and February (Hazleton Environmental Sciences, 1979).

Wolf Creek: Following the collection of baseline data presented in the ER(CPS), virtually all zooplankton samples were collected from a series of isolated, stagnant pools in which zooplankton were generally abundant having developed under favorable, essentially lentic, conditions (Nalco Environmental Sciences, 1978). Large populations of zooplankton usually persisted within these pools unless: (1) the pools were dry; (2) water quality in the pools had deteriorated under ice cover during winter; or (3) flow had resumed in the creek and currents carried most of the pool zooplankton downstream into the Neosho River.

Annual zooplankton densities in Wolf Creek from 1974 to 1978 were inversely related to annual precipitation ($r = -0.66$). Minimum zooplankton densities (15600 organisms/m^3) occurred in 1974 when annual precipitation in the Wolf Creek watershed amounted to 78.6 cm. Maximum annual populations were present in 1976 (829,746 organisms/m^3) when annual rainfall had decreased to 34.1 cm. This relationship is not unexpected since the development of large populations of zooplankton is dependent on the absence of streamflow and the formation and persistence of pools of standing water. These favorable circumstances generally prevailed in Wolf Creek from 1975 through 1978 under conditions of reduced annual rainfall (28.2 to 67.4 cm).

Maximum seasonal densities (735,790 organisms/m^3) of zooplankton in Wolf Creek occurred in August (5-year mean), whereas minimum annual populations (24575 organisms/m^3) were present in December. The abundance of littoral microcrustaceans, mainly harpacticoid copepods, *Chydorus sphaericus* and other chydorids, coincided with the cooler portions of each year when water temperatures were less than 20 C (Table 2.2-25). *Tropocyclops prasinus mexicanus*, a small copepod species not common to John Redmond Reservoir or the Neosho River, attained maximum seasonal densities (30218/m^3) during August in Wolf Creek.

A comprehensive species list and a tabulation of relative densities of zooplankton taxa collected in Wolf Creek from 1973 to 1978 are presented in Table 2.2-23. The same limnetic zooplankton taxa were common to both the Redmond Reservoir - Neosho River system and Wolf Creek. In general, most major limnetic forms in John Redmond Reservoir were less abundant in Wolf Creek, particularly *Moina* spp., *Diaptomus siciloides*, *Diaphanosoma*, and *Hexarthra*. Some limnetic species such as *Tropocyclops*, *Diaptomus pallidus*, and *Filinia* were more common in Wolf Creek (Table 2.2-22). The zooplankton population structure of Wolf Creek differed from that of the John Redmond Reservoir - Neosho River system primarily in the greater species richness and densities of littoral zooplankton taxa present in Wolf Creek. Fifty-three littoral species were collected in Wolf Creek from 1973 to 1978 versus 30 in John Redmond Reservoir (Location 1) and 41 in the Neosho River (Locations 10 and 4). Densities of littoral taxa in Wolf Creek comprised over 4 percent of total zooplankton collected in the creek over a 6-year period. This represented nearly five times the densities in John Redmond Reservoir and three times the number collected in the Neosho River.

Comparisons of zooplankton densities and species composition at Neosho River Locations 10 and 4 with those at Location 5 in Wolf Creek during periods of flow did not indicate any impact of Wolf Creek on zooplankton populations at Location 4. The only appreciable impact would probably occur during brief periods of stormwater runoff when Wolf Creek water input would dilute zooplankton populations at Location 4 and subject transient reservoir zooplankton in the Neosho River to further stress through added sediment load from the Wolf Creek watershed.

2.2.2.4 Aquatic Macroinvertebrates

John Redmond Reservoir: The benthic macroinvertebrate community of John Redmond Reservoir was addressed in the ER(CPS), Section 2.7.1.7. The benthic fauna in the reservoir was studied through 1975 and the dominant taxa included *Limnodrilus*, *Coelotanypus*, *Chironomus*, *Procladius*, *Tanypus*, *Chaoborus punctipennis*, and *Hexagenia limbata*. Macroinvertebrate data collected in 1974 and 1975 were similar to that reported in the ER(CPS) and by Funk (1973).

John Redmond Reservoir Tailwater: The drifting macroinvertebrate assemblage below John Redmond Reservoir was dominated by representatives of the Hydridae, Chironomidae, and Hydropsychidae. Annual mean drift densities were 839 organisms/100 m^3 in 1976, 712/100 m^3 in 1977, and 3036/100 m^3 in 1978 (Table 2.2-26). High densities of hydroids (*Hydra*) were primarily responsible for the substantial increase in 1978.

Chironomidae were the most diverse group in the drift with *Cricotopus*, *Procladius*, and *Polypedilum* being the dominant taxa collected during the 1976-78 study period. The high density of *Cricotopus*, which comprised the majority of drifting chironomids, was partially due to its association with periphytic algae which is common below the dam. Mundie (1956) reported that *Cricotopus* frequently is found in association with periphytic algae. The presence of *Procladius*, a common benthic taxon in John Redmond Reservoir, in the tailwater drift suggests that they had been discharged from the reservoir. Davies (1976) reported that certain species of chironomids, such as *Procladius*, normally migrate from the lake substrate into the water column to feed or recolonize and therefore become susceptible to discharge currents.

The Hydropsychidae assemblage demonstrated seasonal variation with the highest densities usually recorded during the winter and summer (Table 2.2-26). *Potamyia* and *Cheumatopsyche* were the most abundant identifiable hydropsychids, with early instar hydropsychids being numerically dominant. Winter drift of hydrospychids may be related to the inability of the early instars to firmly attach to the substrate (Fremling, 1960), whereas high summer densities are related to the increased susceptibility of pupae to drift during emergence.

Chaoborus punctipennis was a principal component of the spring, summer, and fall drift collections. *Chaoborus* normally occupies a lake or still water habitat (La Row, 1968). The abundance of *Chaoborus* in the tailwaters was related to the volume of reservoir discharges (Hazleton Environmental Sciences, 1979).

Diel drift data showed few consistent trends (Hazleton Environmental Sciences, 1979). Overall, the densities of Hydridae were greater in the daylight samples, whereas hydropsychids and *Chaoborus* were more abundant at night. Hydropsychidae densities were greatest in the May, June, and July night samples, which may be related to emergence patterns. *Chaoborus* made up a large part of the nocturnal drift in April, May, July, and August. No other taxa exhibited consistent diel trends.

Neosho River: Benthic densities in the Neosho River (Locations 10 and 4) generally were high in late winter and spring, decreased in early summer, progressively increased in late summer and early fall and decreased in early winter (Table 2.2-27). Benthic densities in 1973 to 1978 ranged from 38 to 35504 organisms/m^2. Species diversity indices were indicative of good water quality. Dominant taxa included representatives of the Trichoptera, Chironomidae, Plecoptera, Tubificidae, Ephemeroptera, and Naididae.

Potamyia and *Cheumatopsyche* were the most abundant identifiable hydropsychids (Trichoptera) but early instar hydropsychids were more frequently encountered. The density of hydropsychids at Location 10 generally displayed normal seasonal variation of low winter abundance, increased densities during the spring and summer, and decreased abundance during the fall (Table 2.2-27). This seasonal cycle is related to adult emergence and egg hatching activities. Habitat requirements are also important in this cycle. Hydropsychidae require a solid silt-free substrate and current to develop large populations (Dodds and Hisaw, 1925; Fremling, 1960). The rocky riffle at Location 10 provided a better habitat than the gravel bar at Location 4 where hydropsychid populations were lower.

Chironomidae were the most diverse and the second most abundant taxa encountered in the benthic samples. Chironomid densities ranged from 9 to 29286 organisms/m^2 from 1973 to 1978. The most abundant taxa included *Polypedilum*, *Pseudochironomus*, *Stictochironomus*, *Cryptochironomus*, *Crocotopus*, *Chironomus*, and *Dicrotendipes*. Chironomids in the Neosho River demonstrated a typical seasonal pattern of low abundance in spring and early summer following adult emergence, increased densities in late summer and fall when eggs hatch, and declines in winter when recruitment was minimal (Table 2.2-27). Exceptions to this trend were occasionally recorded in February and December when high densities were encountered.

Tubificidae (mainly Branchiura sowerbyi and immatures), Plecoptera (Neoperla), and Ephemeroptera (Stenonema) were common throughout the study but their densities exhibited no seasonal pattern. Naididae were uncommon except during cooler periods of the year when they could be found in algal mats.

Wolf Creek: Ponar samples collected in Wolf Creek primarily contained Chironomidae and Oligochaeta, although other macroinvertebrate taxa (Sphaeriidae, Naididae, and Simuliidae) occasionally contributed substantially to the benthic fauna (Table 2.2-28). Densities varied widely, ranging from 57 to 5679 organisms/m^2 (Table 2.2-28). Fluctuations in the composition of dominant taxa represented normal seasonal cycles and demonstrated the ability of macroinvertebrates to adapt to pool environments during periods of low or zero flow. Most of the macroinvertebrates found in Wolf Creek have short life cycles and are tolerant of crowding and low dissolved oxygen concentrations, which occurs with droughts and ice cover.

Oligochaeta were represented by Naididae and Tubificidae. Naidids (primarily Dero and Nais) were generally a minor constituent in the benthos of the creek; however, they occasionally occurred in high density at Locations 7 and 2 (Table 2.2-28). Tubificidae were generally the most abundant group of benthic macroinvertebrates present in Wolf Creek with immatures without capilliform chaetae numerically dominant. The presence of immatures during all sampling dates is indicative of a reproducing population. The majority of identifiable mature tubificids were Branchiura sowerbyi, Limnodrilus hoffmeisteri, and L. cervix. The presence of Branchiura and Limnodrilus indicates an organically enriched habitat.

Chrionomids were the second most abundant benthic group and the most diverse group of macroinvertebrates collected in the creek. Most of the midge taxa collected were tolerant of the variable hydrological conditions that affect Wolf Creek. The chironomid taxa have varied seasonally as well as yearly since 1973. Hydrobaenus, Chironomus, Polypedilum, and Procladius have been abundant during the six-year study period. Chironomid densities did not show a distinct annual trend; however, chironomids were most abundant in the sediments with peak densities recorded in the summer, early fall and winter.

Other taxa sporadically dominated the fauna of Wolf Creek. Simuliidae exhibited a seasonal variation during some collections in spring and winter (Table 2.2-28). Dramatic seasonal changes in simuliid populations have been reported by Peterson (1959) and Hynes (1970). Sphaeriidae were abundant during all seasons of the year; however, densities decreased in 1977 and 1978. This decline in density was attributed to drought conditions in 1976 when Wolf Creek was either dry or pooled (Nalco Environmental Sciences, 1977). Apparently, the lack of flow,

low oxygen level, and normal winter kill decreased the sphaeriid population.

2.2.2.5 Fish

Adult, juvenile, and larval fish were sampled in the tailwaters of John Redmond Reservoir to provide data on potential impingement and entrainment losses at the make-up water screenhouse. Additional sampling upstream and downstream of the confluence of Wolf Creek and the Neosho River was conducted to monitor potential construction effects and to provide additional baseline data. The occurrence of fishes in Wolf Creek has been monitored since 1973 to: (1) establish seasonal and spatial distribution, (2) to monitor construction effects, and (3) to establish the value of Wolf Creek as a spawning and/or nursery area.

Monitoring of the fish community in the Neosho River and Wolf Creek has yielded 46 species representing 12 families (Table 2.2-29). Species not reported in the ER(CPS) include longnose gar, rosyface shiner, redfin shiner, sand shiner, slim minnow, blue sucker, bigmouth buffalo, black buffalo, yellow bullhead, stonecat, Neosho madtom, mosquitofish, brook silversides, longear sunfish, slenderhead darter, and bluntnose darter. These species individually comprised less than 2 percent and collectively 4 percent of the total catch (Table 2.2-30). Fishes recorded in the study area since the monitoring was initiated in 1973 included all species except black crappie encountered by Cross and Braasch (1968) in a 1967 survey of the Neosho River and tributaries. Collections since 1973 also yielded six species (rosyface shiner, river carpsucker, blue sucker, Neosho madtom, orangethroat darter and log perch) that were not encountered in 1967 but were reported in a 1952 survey (Cross and Braasch, 1968).

Two species classified as rare in Kansas (Platt et al., 1973; U. S. Fish and Wildlife Service, 1979) were collected in the Neosho River. Blue suckers were collected from the reservoir tailwaters and the downstream locations in chutes or riffles with rock or rubble bottoms. Blue suckers can apparently tolerate high turbidity (which occurs in the Neosho River) when there is sufficient current to prevent siltation (Pfleiger, 1975). All blue suckers collected were longer than 500 mm which suggests that either reproduction is not occurring in the study area or the habitat sampled was not utilized by young-of-the-year or juvenile blue suckers (Hazleton Environmental Sciences, 1979). Cross and Braasch (1968) collected both young and adult blue suckers in the Neosho River during a 1967 survey.

The Neosho madtom was the other rare species that was encountered in the Neosho River. It was taken consistently since

1976 from a riffle (Location 11) below the confluence of Wolf Creek. In additon, Neosho madtoms were collected from shallow gravel bars upstream of Wolf Creek (Location 10) in 1977 and 1978 and further downstream (Location 4) in 1978. The preferred habitat of this species consists of riffles and sloping gravel bars in strong current (Cross, 1967). The availability of suitable habitat is the major factor limiting the abundance of the Neosho madtom. Both of these rare species apparently occur only in the mainstream of the river since they have not been reported from the tributaries.

Rare or threatened fishes were not encountered in Wolf Creek. Bluntnose darters, which have been classified as rare in Kansas (Platt et al., 1973), were taken in low numbers (Table 2.2-31); this species is not presently included on the rare and endangered species lists (Kansas Fish and Game Comm., 1978; U. S. Fish and Wildlife Service, 1979). All other species collected from Wolf Creek are widely distributed in the Arkansas River Basin, which includes the Neosho River, and are not unique to the Wolf Creek drainage.

Fish communities in the Neosho River and Wolf Creek differ as a result of the water sources of the two systems and because of differences in flow characteristics. Stormwater runoff is the primary water source for Wolf Creek with limited groundwater input, while discharges from John Redmond Reservoir account for most of the flow in the Neosho River (Section 2.4.1.2). Seining data indicated that the fish community in the Neosho River is influenced by releases from John Redmond Reservoir (Table 2.2-32). Approximately 22 percent of the total seine catch in the river consisted of species that are abundant in John Redmond Reservoir. Groen and Schroeder (1978) reported that walleye are readily lost from Kansas reservoirs during periods of peak discharge and it can be assumed that other species are also lost. Catch data in 1977 and 1978 following high discharges indicate that fish are lost from the reservoir (Nalco Environmental Sciences, 1978; Hazleton Environmental Sciences, 1979).

Major differences existed between the river and creek in the relative abundance of gizzard shad, orangespotted sunfish, and game fish. Gizzard shad accounted for 19.1 percent of the total seine catch in the Neosho River while comprising only 2.8 percent in Wolf Creek, whereas orangespotted sunfish made up 17.1 percent of the creek catch versus 0.4 percent in the river (Tables 2.2-31 and 2.2-32). Gizzard shad only used the creek when flows were sufficient to allow movement from the river (Nalco Environmental Sciences, 1978). The utilization of Wolf Creek as a nursery and/or spawning area by other species that are more common in the river also occurred when flows were adequate to allow movement into Wolf Creek. The Neosho River throughout the study area supports a good sport fishery for channel catfish and flathead catfish. In addition, a fair sport fishery exists in the tailwaters of John Redmond Reservoir for white crappie and white bass. Wolf Creek does not provide a sport fishery since only juveniles of game species have been taken at the lower reaches of the creek.

The fish community in Wolf Creek was influenced greatly by low or intermittent flows during the 1976-78 study period. Reduced flows contributed to substantial fish kills during the winter in 1976-77 and 1977-78 (Nalco Environmental Sciences, 1978; Hazleton Environmental Sciences, 1979). The more abundant species generally recovered following low water conditions (Table 2.2-31). Red shiners and orangespotted sunfish remained abundant throughout the 1973-78 study period which was attributed to the hardiness of both species. In addition, orangespotted sunfish may have been transported to the creek when farm ponds overflowed during heavy rainfalls.

Electroshocking data collected in 1977 and 1978 indicated that releases from John Redmond Reservoir influenced the tailwaters fish community and that spatial differences in species composition and abundance existed between the location in the tailwaters and those near the confluence with Wolf Creek (Locations 4 and 10) (Tables 2.2-33 and 2.2-34). Appreciable spatial differences were noted for gizzard shad, river carpsucker, bigmouth buffalo, channel catfish, white bass, green sunfish, and white crappie which were collected more frequently in the tailwaters than at the downstream locations. In general, spatial variations were attributed to habitat differences among locations. Also, the Burlington City Dam, located downstream of John Redmond Reservoir Dam, probably restricts fish movements.

Age determinations of representative individuals of selected game species have been made each year since 1973. Sufficient data were obtained to provide valid information on growth rates of white bass, white crappie, and freshwater drum (Hazleton Environmental Sciences, 1979). Both freshwater drum and white crappie had considerable overlap in length distribution between adjacent age classes which was attributed to mixing with fish from upstream reservoirs, extended spawning season, and to collection of scale samples over the entire growing season. In comparison to growth rates of fish from other water systems in the midwest, growth of white bass in the Neosho River was below average whereas the growth of white crappie was above average. Freshwater drum inhabiting the study area were long lived as over 32 percent of the drum aged were 5 years or older. In general the growth rate of freshwater drum was average during the first 3 years of life and slower in succeeding years when compared to fish in other midwest water systems.

Food habits for six game species (channel catfish, flathead catfish, white bass, spotted bass, white crappie, and freshwater drum) were determined. Fish was the major food item in the diet of channel catfish, flathead catfish, white bass, and white crappie and of secondary importance for spotted bass and freshwater drum. Gizzard shad accounted for over 60 percent by volume of fish which occurred as food items while centrachids, white bass, cyprinids and catostomids occurred sporadically. Approximately 25 percent of the fish examined were digested beyond recognition. Crayfish and aquatic insects were also important food items for game species in the Neosho River. Crayfish was the most abundant food item consumed by spotted bass and was of lesser importance in the diet of channel catfish, flathead catfish, and freshwater drum. Aquatic insects were the primary food item of freshwater drum and of secondary importance for white crappie and channel catfish. Zooplankton and algae were of secondary importance in the diet of white crappie and channel catfish, respectively. Bryozoa, plant fragments, and terrestrial insects were consumed but were not important in the diet of the species analyzed.

Biweekly ichthyoplankton samples were collected April through July from 1976 through 1978 to determine the period of occurrence, species composition, and density of fish larvae in the drift in the tailwaters of John Redmond Reservoir. This study was initiated to provide data on fish larvae and eggs that will be entrained during operation of the make-up water screenhouse (Section 5.1.2). Larval fish were present in the drift during all months sampled except April 1976 (Table 2.2-35). Annual peak larval densities occurred during June of 1976 and 1978 and May 1977. Species composition of the drift was similar during each year with gizzard shad representing 90.5 percent of all larval fish collected. In addition, minnows and suckers comprised 7.5 percent of the larval fish. Game fish represented only 1.4 percent of the total larval fish collected. The low abundance of game fish larvae in the drift suggests that spawning characteristics of most game species in John Redmond Reservoir and the Neosho River reduce the likelihood that their larvae enter the drift.

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TABLE 2.2-1

PHYLOGENTIC LISTING OF PLANT SPECIES SAMPLED NEAR WCGS, 1973-78

Scientific Name	Common Name	Lowland Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub and Grass Pasture	Wet Mudflat	Dry Mudflat
	Community Type:	Index of Relative Community Abundance[a]					
Coniferae							
Cupressaceae	Cypress Family						
Juniperus virginiana L.	Eastern redcedar				I		
Graminales							
Gramineae	Grass Family						
Bromus tectorum L.	Downy chess		I	A-D	I		
Bromus inermis Leyss.	Smooth brome		I	A-D			
Bromus japonicus Thunb.	Japanese brome		C	A-D	A-D		
Festuca elatior L.	Meadow fescue	I					
Festuca obtusa Biehler	Fescue	C					
Festuca paradoxa Desv.	Fescue					I	A-D
Poa compressa L.	Canada bluegrass		I	D	I		
Poa pratensis L.	Kentucky bluegrass		C	I-C	I		
Eragrostis pilosa (L.) Beauv.	Love grass					I	
Eragrostis spectabilis (Pursh) Steud.	Purple lovegrass		I	I			
Triodia flava (L.) Smyth.	Purple top			I	I		
Elymus canadensis L.	Canada wild rye		I				
Elymus virginicus L.	Virginia wild rye	D	C				
Hordeum pusillum Nutt.	Little barley		I	C	I-C		
Koeleria cristata (L.) Pers.	Prairie junegrass		I				
Agrostis hyemalis (Walt.) BSP	Red top		I				
Cinna arundinacea L.	Wood reed	I					
Muhlenbergia sp. L.	Muhly	I		I			
Muhlenbergia schreberi Gmel.	Nimble will			I	C		
Sporobolus asper (Michx.) Kunth.	Tall dropseed		I	I	I		
Sporobolus neglectus Nash.	Dropseed				I		
Sporobolus heterolepis Gray	Prairie dropseed		I				
Aristida oligantha Michx.	Three-awn		I				
Leptochloa filiformis (Lam.) Beauv.	Leptochloa					I	C
Leptochloa fascicularis (Lam.) Gray	Leptochloa					C	
Bouteloua curtipendula (Michx.) Torr.	Side-oats grama				I		
Phalaris caroliniana Walt.	Maygrass		I				
Phalaris arundinacea L.	Reed canary grass			I			
Leersia virginica Willd.	White grass	I			I		
Digitaria sanguinalis (L.) Scope	Crab grass			I	I		
Paspalum ciliatifolium Michx.	Paspalum			C	I-C		
Panicum sp. L.	Panic grass		C	C	C		
Panicum capillare L.	Witch grass				I		
Panicum dichotomiflorum Michx.	Fall panic grass					D	A-D
Panicum praecocius Hitch & Chase	Panic grass		I				

TABLE 2.2-1 (Sheet 2)

Scientific Name	Common Name	Lowland Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub and Grass Pasture	Wet Mudflat	Dry Mudflat
	Community Type:						
		Index of Relative Community Abundance					
Liliaceae (continued)							
Smilacina racemosa (L.) Desf.	False Solomon's seal	I	I-C				
Polygonatum biflorum (Walt.) Ell.	Solomon's seal	I					
Smilax hispida Muhl.	Greenbrier	A					
Smilax rotundifolia L.	Greenbrier	I					
Salicales							
Salicaceae	Willow Family						
Populus deltoides Marsh.	Cottonwood	I					A-D
Salix nigra L.	Black willow	I					I
Juglandales							
Juglandaceae	Walnut Family						
Juglans nigra L.	Black walnut	A					
Carya cordiformis (Wang.) K. Koch.	Bitternut hickory	A					
Carya laciniosa (Michx. f.) Loud	Shellbark hickory	C					
Fagales							
Fagaceae	Beech Family						
Quercus macrocarpa Michx.	Bur oak	D					
Quercus borealis Michx. f.	Red oak	I					
Quercus palustris Muenchh.	Pin oak						
Quercus shumardii Buckl.	Shumard's oak	A					
Urticales							
Ulmaceae	Elm Family						
Ulmus sp. L	Elm				A		
Ulmus americana L.	American elm	A					
Ulmus rubra Muhl.	Slippery elm	C					
Celtis occidentalis L.	Hackberry	D					
Moraceae	Mulberry Family						
Maclura pomifera (Raf.) Schneid.	Osage-orange	I					
Morus rubra L.	Red mulberry	C					I
Urticaceae	Nettle Family						
Urtica dioica L.	Stinging nettle	C					
Laportea canadensis (L.) Wedd.	Wood-nettle	D					
Pilea pumila (L.) Gray	Clearweed	C	I				
Parietaria pensylvanica Muhl.	Pellitory	C	I				
Boehmaria cylindrica (L.) Sw.	False nettle	I					

TABLE 2.2-1 (Sheet 3)

Scientific Name	Common Name	Lowland Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub and Grass Pasture	Wet Mudflat	Dry Mudflat
	Community Type:	Index of Relative Community Abundance					
Polygonales							
Polygonaceae	Smartweed Family						
Rumex acetosella L.	Red sorrel			I			
Rumex crispus L.	Curly dock			I			
Polygonum sp. L.	Polygonum	I					
Polygonum lapathifolium L.	Smartweed					A	I
Polygonum pensylvanicum L.	Pennsylvania smartweed					D	
Polygonum punctatum Ell.	Dotted smartweed	I					
Polygonum persicaria L.	Lady's thumb					C	C
Polygonum virginianum L.	Smartweed	C					
Polygonum scandens	False buckwheat	I					
Caryophyllales							
Chenopodiaceae	Goosefoot Family						
Chenopodium sp. L.	Goosefoot	I					
Chenopodium album L.	Lamb's quarters	I					I
Chenopodium hybridum L.	Mapleleaf goosefoot	I					
Chenopodium leptophyllum Aellen	Goosefoot						I
Amaranthaceae	Amaranth Family						
Amaranthus sp. L.	Amaranth					C	
Amaranthus tamariscinus (Nutt.) Wood	Water hemp						I-C
Amaranthus retroflexus L.	Redroot						I
Aizoaceae	Carpetweed Family						
Mollugo verticillata	Carpetweed						I
Portulacaceae	Purslane Family						
Portulaca oleracea L.	Purslane					I	
Claytonia virginica L.	Spring beauty	I	I				
Caryophyllaceae	Pink Family						
Stellaria sp. L.	Chickweed			I			
Cerastium vulgatum L.	Mouse-ear chickweed		I	A	C		
Silene antirrhiana L.	Sleepy catchfly			I			
Silene stellata (L.) Ait. f.	Starry campion	I					
Ranales							
Ranunculaceae	Crowfoot Family						
Ranunculus sp. L.	Buttercup	I			I		
Ranunculus abortivus L.	Small-flowered crowfoot	C					

TABLE 2.2-1 (Sheet 4)

Scientific Name	Common Name	Lowland Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub and Grass Pasture	Wet Mudflat	Dry Mudflat
	Community Type:						
		Index of Relative Community Abundance					
Ranunculaceae (continued)							
Delphinium virescens Nutt.	Prairie larkspur	I					
Thalictrum sp. L.	Meadow rue	I					
Thalictrum polygamum Muhl.	Meadow rue	I					
Clematis sp. L.	Clematis	I					
Menispermaceae	Moonseed Family						
Menispermum canadense L.	Canada moonseed	C					
Papaverales							
Cruciferae	Mustard Family						
Lepidium sp. L.	Peppergrass						
Lepidium virginicum	Peppergrass			I	I		
Draba reptans (Lam.) Fern.	Draba			I			
Arabis shortii (Fern.) Gl.	Rock cress	I					
Arabis canadensis L.	Sickle-pod	I					
Rorippa islandica (Oeder) Borbas	Marsh cress				I-C		
Rosales							
Saxifragaceae	Saxifrage Family						
Ribes missouriense Nutt.	Missouri gooseberry	A					
Platanaceae	Plane-Tree Family						
Platanus occidentalis L.	Sycamore	C					
Rosaceae	Rose Family						
Fragaria virginiana Duchesne	Virginia strawberry		I	I	A-D		
Geum sp. L.	Avens				I		
Geum vernum (Raf.) T. & G.	Spring avens	C					
Geum canadense Jacq.	White avens	C		I			
Rubus allegheniensis Porter	Common blackberry			I			
Agrimonia sp. L.	Agrimony		I				
Rosa carolina L.	Carolina rose		I		C		
Prunus sp. L.	Cherry		I				
Prunus serotina Ehrh.	Black cherry	I	I				
Crataegus sp. L.	Hawthorn	I					
Mimosaceae	Mimosa Family						
Desmanthus illinoensis Willd.	Illinois bundleflower		I				
Caesalpiniaceae							
Cercis canadensis L.	Redbud	A					
Gleditsia triacanthos L.	Honey-locust	C		I	I		
Gymnocladus dioica (L.) K. Koch	Kentucky coffee-tree	C					

TABLE 2.2-1 (Sheet 5)

Scientific Name	Common Name	Lowland Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub and Grass Pasture	Wet Mudflat	Dry Mudflat
	Community Type:						
		Index of Relative Community Abundance					
Fabaceae	Bean Family						
Baptisia leucophaea Nutt.	Wild indigo		I	I	I		
Trifolium sp. L.	Clover			I	I		
Trifolium repens L.	White clover				C		
Melilotus officinalis (L.) Desr.	Yellow sweetclover		I				
Psoralea esculenta Pursh.	Prairie turnip		I				
Psoralea tenuiflora Pursh.	Scurfpea		I				
Petalostemum sp. Michx.	Prairie-clover		I				
Petalostemum candidum (Willd.) Michx.	White prairie-clover		I				
Lespedeza stipulacea Mixim.	Korean lespedeza			C	D		I
Strophostyles leiosperma (T. & G.) Piper	Wild bean				I		
Strophostyles helveola (L.) Ell.	Wild bean			I			
Desmodium sp. Desv.	Tick-trefoil				I		
Geraniales							
Oxalidaceae	Wood-sorrel Family						
Oxalis sp. L.	Wood-sorrel			I	I		
Oxalis stricta L.	Yellow wood-sorrel			A			
Oxalis violacea L.	Violet wood-sorrel		C-A				
Geraniaceae	Geranium Family						
Geranium carolinianum L.	Crane's-bill		I				
Euphorbiaceae	Spurge Family						
Croton capitatus Michx.	Croton		I		I		
Acalypha gracilens Gray	Three-seeded mercury		C	C	I-C		
Euphorbia serpens HBK	Spurge					I	
Euphorbia preslii Guss	Nodding spurge					I	
Euphorbia glyptosperma Engelm.	Spurge						I
Euphorbia maculata L.	Wartweed					I	
Euphorbia humistrata Engelm.	Spurge					C	
Euphorbia corollata L.	Flowering spurge		C				
Euphorbia heterophylla L.	Fire-on-the-mountain	I					
Euphorbia marginata Pursh.	Snow-on-the-mountain						I
Sapindales							
Anacardiaceae	Cashew Family						
Rhus radicans L.	Poison ivy	A		I	I		
Rhus glabra L.	Smooth sumac				C-A		
Celastraceae	Staff-tree Family						
Euonymus atropurpureus Jacq.	Wahoo	C					

TABLE 2.2-1 (Sheet 6)

Scientific Name	Common Name	Lowland Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub and Grass Pasture	Wet Mudflat	Dry Mudflat
	Community Type:						
		Index of Relative Community Abundance					
Aceraceae	Maple Family						
Acer saccharinum L.	Silver maple	D					
Acer negundo L.	Boxelder	I					
Hippocastanaceae	Horse-chestnut Family						
Aesculus glabra Willd.	Ohio buckeye	I					
Balsaminaceae	Touch-me-Not Family						
Impatiens biflora Walt.	Jewelweed	I					
Rhamnales							
Vitaceae	Grape Family						
Vitis sp. L.	Grape	C	I				
Vitis aestivalis Michx.	Summer grape	I					
Parthenocissus quinquefolia (L.) Planch.	Virginia creeper	A					
Malvales							
Malvaceae	Mallow Family						
Sida spinosa L.	Sida					I	
Hibiscus trionum L.	Flower of an hour					C	I-C
Abutilon theophrasti Medic.	Velvetleaf					I	
Parietales							
Hypericaceae	St. John's wort Family						
Hypericum punctatum Lam.				I			
Violaceae	Violet Family						
Viola sp. L.	Violet	I					
Viola papilionacea Pursh.	Common blue violet	A					
Viola pedatifida G. Don.	Prairie violet		I	I			
Viola eriocarpa Schw.	Smooth yellow violet	A					
Cactales							
Cactaceae	Cactus Family						
Opuntia compressa (Salisb.) Macbr.	Prickly pear				I		
Myrtales							
Onagraceae	Evening Primrose Family						
Oenothera biennis L.	Common evening primrose		I				
Guara biennis L.	Biennial gaura						
Circaea quadrisulcata (Maxim.) Franch & Sav.	Enchanter's nightshade	I					

TABLE 2.2-1 (Sheet 7)

Scientific Name	Common Name	Lowland Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub and Grass Pasture	Wet Mudflat	Dry Mudflat
	Community Type:	Index of Relative Community Abundance					
Umbellales							
Umbelliferae	Parsley Family						
<u>Sanicula gregaria</u> Bickn.	Black snakeroot	D					
<u>Cryptotaenia canadensis</u> (L.) DC.	Honewort	I					
<u>Osmorhiza</u> sp. Raf.	Sweet cicely	I					
<u>Chaerophyllum procumbens</u> (L.) Crantz	Spreading chervil	D	I				
<u>Pastinaca sativa</u> L.	Wild parsnip		I				
<u>Eryngium yuccifolium</u> Michx.	Rattlesnake-master		I				
Cornaceae	Dogwood Family						
<u>Cornus</u> sp. L.	Dogwood	I	I		I		
Ebenales							
Ebenaceae	Ebony Family						
<u>Diospyros virginiana</u> L.	Persimon	I					
Primulales							
Primulaceae	Primrose Family						
<u>Lysimachia quadrifolia</u> L.	Whorled loosestrife	I					
Gentianales							
Oleaceae	Olive Family						
<u>Fraxinus pennsylvanica</u> Marsh.	Green ash	A			I		
Apocynaceae	Dogbane Family						
Apocynum sp. L.	Dogbane				I		
<u>Apocynum cannabinum</u> L.	Indian hemp		I	I	I	I-C	I
Asclepiadaceae	Milkweed Family						
<u>Asclepias syriaca</u> L.	Common milkweed		I				
<u>Asclepias viridis</u> Walt.	Spider milkweed		I				
<u>Asclepias sullivantii</u> Engelm.	Sullivant's milkweed			I			
<u>Ascelpias variegata</u> L.	White milkweed			I	I		
Polemoniales							
Convolvulaceae	Morning-glory Family						
<u>Ipomoea lacunosa</u> L.	Morning-glory					I	
<u>Convolvulus</u> sp. L.	Bindweed	I					
<u>Convolvulus sepium</u> L.	Hedge bindweed	I	I			I	I-C
Polemoniaceae	Phlox Family						
<u>Phlox divaricata</u> L.	Phlox	C					

Table 2.2-1 (Sheet 8)

Scientific Name	Common Name	Lowland Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub and Grass Pasture	Wet Mudflat	Dry Mudflat
	Community Type:	Index of Relative Community Abundance					
Hydrophyllaceae	Waterleaf Family						
Ellisia nyctelea L.	Nyctelea	C					
Boraginaceae	Borage Family						
Myosotis sp. L.	Forget-me-not		I				
Myosotis verna Nutt.	Forget-me-not		I	I			
Verbenaceae	Vervain Family						
Verbena sp. L.	Vervain	I					
Verbena canadensis (L.) Britt.	Large-flowered verbena		I				
Labiatae	Mint Family						
Prunella vulgaris L.	Self-heal			I	I		
Scutellaria parvula Michx.	Skullcap		I				
Lamium album L.	White dead nettle		I				
Salvia reflexa Hornem.	Sage		I				
Salvia pitcheri L.	Pitcher's sage		I				
Pycnanthemum flexuosum (Walt.) Bsp.	Mountain mint		C	C-A			
Lycopus americanus Muhl.	American bugle-weed			I			
Stachys tenuifolia Willd.	Hedge nettle	I					
Solanaceae	Nightshade Family						
Physalis sp. L.	Ground-cherry		I				
Solanum carolinense L.	Horse-nettle		I	I	I	I	C
Phrymaceae	Lopseed Family						
Phryma leptostachya L.	Lopseed	I					
Scrophulariaceae	Figwort Family						
Penstemon tubaeflorus Nutt.	Penstemon		I				
Veronica serpyllifolia L.	Speedwell				I		
Veronica peregrina L.	Speedwell				I		
Veronica officinalis L.	Speedwell			I			
Acanthaceae	Acanthus Family						
Ruellia strepens L.	Ruellia	C					
Plantaginales							
Plantaginaceae	Plantain Family						
Plantago virginica L.	White dwarf plantain		I	C	C		
Plantago rugelii Decne.	Rugel's plantain				I		
Plantago major L.	Common plantain			I			
Plantago lanceolata L.	English plantain			I			
Plantago aristata Michx.	Buckhorn plantain			I			

TABLE 2.2-1 (Sheet 9)

Scientific Name	Common Name	Lowland Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub and Grass Pasture	Wet Mudflat	Dry Mudflat
	Community Type:						
		Index of Relative Community Abundance					
Rubiales							
Rubiaceae	Madder Family						
Galium aparine L.	Cleavers	D	I				
Caprifoliaceae	Honeysuckle Family						
Sambucus canadensis L.	Common elder	I					
Symphoricarpos orbiculatus Moench	Coralberry	D		C	C-D		
Cucurbitales							
Cucurbitacea	Gourd Family						
Sicyos angulata L.	Bur-cucumber	I					
Campanulales							
Campanulaceae	Harebell Family						
Campanula americana L.	Tall bellflower	I-C					
Triodanis perfoliata (L.) Nieuwl.	Venus' looking glass		I				
Triodanis leptocarpa (Nutt.) Nieuwl.	Venus' looking glass		I				
Lobeliaceae	Lobelia Family						
Lobelia spicatata Lam.	Lobelia		I				
Asterales	Composite Family						
Compositae							
Helianthus annuus L.	Sunflower						C-D
Helianthus petiolaris Nutt.	Common sunflower						I
Helianthus laetiflorus Pers.	Sunflower		I-C				
Helianthus maximiliani Schrader	Maximilian sunflower		I				
Verbesina alternifolia (L.) Britt.	Wingstem	A					
Ratibida columnifera (Nutt.) Woot & Standle.	Prairie coneflower		I				
Bidens polylepis Blake	Beggar-ticks		I				
Bidens tripartita L.	Beggar-ticks	I					
Bidens frondosa L.	Begger-ticks	I					
Silphium perfoliatum L.	Cup plant	I					
Iva ciliata Willd.	Rough sumpweed			I	I	C	C
Ambrosia trifida L.	Giant ragweed	C					
Ambrosia artemisiifolia L.	Common ragweed			A	A		
Ambrosia bidentata Michx.	Ragweed			I	C		
Ambrosia psilostachya Dc.	Western ragweed			A-D			
Xanthium strumarium L.	Common cocklebur			I		A	A
Achillea millefolium L.	Yarrow		C	I	I-C		
Chrysanthemum leucanthemum	Ox-eye daisy				I		
Artemisia ludoviciana Nutt.	Louisiana				I		

TABLE 2.2-1 (Sheet 10)

Scientific Name	Common Name	Lowland Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub and Grass Pasture	Wet Mudflat	Dry Mudflat
	Community Type:	Index of Relative Community Abundance[a]					
Compositae (continued)							
Solidago sp. L.	Goldenrod		I				
Solidago candensis L.	Canada goldenrod			I			
Solidago rugosa Mill.	Rough-leaved goldenrod			I			
Solidago graminifolia (L.) Salisb.	Narrowleaf goldenrod		I-C	C-A	C-A		
Gutierezia dracunculoides (DC.) Blake	Broomweed				C-A		
Aster sp. L.	Wild aster				I-C		
Aster ericoides L.	Heath aster		I-C	I	I		
Erigeron strigosus Muhl.	Rough fleabane		I	I-C	I		
Conyza canadensis (L.) Crong.	Horseweed		I				
Gnaphalium purpureum L.	Everlasting				I		
Antennaria neglecta Greene	Field pussytoes			I	I		
Eupatorium purpureum L.	Joe-pye weed	I					
Eupatorium rugosum Houtt.	White snakeroot	I			I		
Eupatorium serotinum L.	Thoroughwort			C	C		
Liatris pycnostachya Michx.	Blazing star		I				
Liatris punctata Hook	Blazing star		I	I			
Vernonia fasciculata Michx.	Ironweed				C		
Vernonia baldwini Torr.	Ironweed		I	I	C		
Cirsium arvense (L.) Scop.	Canada thistle		I	I			
Prenanthes sp. L.	White lettuce	I					
Taraxacum officinale Weber	Dandelion				I		
Latuca sp. L.	Prickly lettuce	I					
Latuca serriola L.	Prickly lettuce	I					I
Latuca biennis (Moench) Fern.	Tall lettuce	I					

[a] D = community dominant; A = abundant; C = common; I = relatively infrequent.

TABLE 2.2-2

SHRUB STRATUM FLOOD SUSCEPTIBILITY INDEX
OF THE NORTH AND SOUTH FLOODPLAIN WOODS
NEAR WCGS, 1975-78

Location/Years	Flood Susceptibility Index
North floodplain woods:	
1975	8.14
1976	8.46
1977	8.84
1978	8.71
Average	8.54
South floodplain woods:	
1976	6.54
1977	6.60
1978	6.19
Average	6.44

TABLE 2.2-3

YEAR-TO-DATA COMPARISONS EXPRESSED AS PERCENT SIMILARITY FOR THREE PLANT COMMUNITIES NEAR WCGS

Community/Stratum	Years Compared	Similarity (%)
North floodplain woods		
Shrub stratum:	1978/1977	89
	1978/1976	90
	1978/1975	84
Ground layer:	1978/1977	76
	1978/1976	67
	1978/1975	61
Abandoned railroad right-of-way		
Ground layer:	1978/1977	60
	1978/1976	46
	1978/1975	47
	1978/1974	31
South floodplain woods		
Shrub stratum:	1978/1977	80
	1978/1976	84
Ground layer:	1978/1977	79
	1978/1976	79

TABLE 2.2-4

FREQUENCY OF SPECIES IN THE GROUND LAYER AND AVERAGE GROUND LAYER COVER ON A DRY MUDFLAT (COMMUNITY 10) ON JOHN REDMOND RESERVOIR, BURLINGTON, KANSAS, JUNE AND SEPTEMBER 1978

Species	June		September	
	Frequency	Relative Frequency	Frequency	Relative Frequency
Gramineae	88.0	23.4		
Polygonum sp.	68.0	18.1		
Cyperaceae	52.0	13.8	32.0	7.5
Rorippa islandica	40.0	10.6		
Xanthium strumarium	36.0	9.5	52.0	12.3
Amaranthus retroflexus	28.0	7.4		
Juncus interior	20.0	5.3		
Ambrosia artemisiifolia	20.0	5.3	4.0	0.9
Bidens tripartita	8.0	2.1	8.0	1.9
Hibiscus trionum	4.0	1.1	12.0	2.8
Rumex crispus	4.0	1.1	4.0	0.9
Draba reptans	4.0	1.1		
Melilotus officinalis	4.0	1.1		
Echinochloa crusgalli			68.0	16.0
Panicum dichotomiflorum			52.0	12.3
Polygonum lapathifolium			44.0	10.4
Polygonum pensylvanicum			40.0	9.4
Festuca paradoxa			28.0	6.6
Amaranthus sp.			24.0	5.7
Eragrostis spectablis			16.0	3.8
Euphorbia serpens			16.0	3.8
Setaria glauca			8.0	1.9
Euphorbia glyptosperma			8.0	1.9
Iva ciliata			4.0	0.9
Verbena sp.			4.0	0.9
Average Community Ground Layer		46%	64%	

TABLE 2.2-5

FREQUENCY OF SPECIES IN THE GROUND LAYER AND AVERAGE GROUND LAYER COVER ON A WET MUDFLAT (COMMUNITY 9) ON JOHN REDMOND RESERVOIR, BURLINGTON, KANSAS, JUNE AND SEPTEMBER 1978

Species	June		September	
	Frequency	Relative Frequency	Frequency	Relative Frequency
Gramineae	80.0	40.8		
Polygonum sp.	52.0	26.5		
Amaranthus retroflexus	20.0	10.2		
Iva ciliata	8.0	4.1	24.0	6.8
Convolvulus sp.	8.0	4.1		
Hibiscus trionum	8.0	4.1	24.0	6.8
Xanthium strumarium	4.0	2.0	16.0	4.5
Cyperaceae	4.0	2.0	4.0	1.1
Helianthus annuus	4.0	2.0		
Ambrosia trifida	4.0	2.0		
Oxalis sp.	4.0	2.0		
Panicum dichotomiflorum			84.0	23.9
Festuca paradoxa			72.0	20.5
Amaranthus sp.			40.0	11.4
Euphorbia serpens			24.0	6.8
Convolvulus sepium			12.0	3.4
Polygonum lapathifolium			12.0	3.4
Polygonum pensylvanicum			12.0	3.4
Leptochloa filiformis			8.0	2.3
Solanum carolinense			4.0	1.1
Apocynum cannabinum			4.0	1.1
Lespedeza stipulacea			4.0	1.1
Leptochloa fasicularis			4.0	1.1
Echinochloa crusgalli			4.0	1.1
Average Community Ground Layer		17%	48%	

TABLE 2.2-6

SMALL MAMMAL SPECIES CAPTURED NEAR THE WCGS SITE

Scientific Name	Common Name
Didelphis virginiana	Opossum
Blarina brevicauda	Short-tailed shrew
Cryptotis parva	Least shrew
Reithrodontomys montanus	Plains harvest mouse
Peromyscus maniculatus	Deer mouse
Peromyscus leucopus	White-footed mouse
Sigmodon hispidus	Hispid cotton rat
Microtus ochrogaster	Prairie vole
Microtus pinetorum	Woodland vole
Mus musculus	House mouse

TABLE 2.2-7

NUMBER OF SMALL MAMMALS CAPTURED PER 100 TRAPNIGHTS IN FIVE COMMUNITIES NEAR WCGS, 1973-78

Community/Year	Species									
	Opossum	Short-tailed Shrew	Least Shrew	Plains Harvest Mouse	Deer Mouse	White-footed Mouse	Hispid Cotton Rat	Prairie Vole	Woodland Vole	House Mouse
Floodplain woods										
1973	-	0.27	-	-	0.43	4.87	-	0.14	-	0.14
1974	-	1.78	-	-	-	14.22	-	0.22	-	-
1975	-	-	-	-	-	9.43	-	-	-	-
North floodplain woods										
1976	-	4.75	-	-	-	28.50	-	-	-	-
1977	-	15.72	-	-	-	-	-	-	-	-
1978	0.50	1.00	-	-	-	11.75	-	-	0.25	-
Open pasture										
1973	-	-	-	0.38	0.12	-	-	-	-	-
1974	-	0.22	0.22	-	2.44	-	0.22	1.11	-	-
1975	-	-	-	-	-	-	-	-	-	-
Mixed shrub-grass										
1973	-	-	-	0.43	-	-	0.43	-	-	-
1974	-	-	-	-	0.44	0.67	-	-	-	-
1975	-	-	-	-	-	0.86	-	-	-	-
Abandoned railroad right-of-way										
1973	-	0.12	-	1.00	0.38	-	2.12	-	-	0.12
1974	-	0.44	-	-	0.44	-	4.20	-	-	-
1975	-	-	-	-	-	-	0.57	-	-	-
1976	-	1.25	-	-	2.25	0.50	13.00	1.50	-	-
1977	-	-	-	-	2.00	0.25	-	-	-	-
1978	-	0.50	-	-	4.75	0.75	7.50	0.75	-	-

TABLE 2.2-8

SUMMARY OF SMALL MAMMAL DENSITIES (No./ha) IN TWO COMMUNITIES NEAR WCGS, 1974-78

Location/Species	1974 Jun	1974 Sep	1975 Jun	1975 Sep	1976 Jun	1976 Sep	1977 Jun	1977 Sep	1978 Jun	1978 Sep
North floodplain woods										
Didelphus virginiana	NS[a]	NS	-[b]	-	-	-	-	-	.03[c]	-
Blarina brevicauda	NS	NS	-	-	1.5	14.6	-	-	1.5[c]	1.5[c]
Peromyscus leucopus	NS	NS	23.0	7.0	34.0	25.0	25.0	17.0	23.0	38.0
Microtus pinetorum	NS	NS	-	-	-	-	-	-	-	1.6[c]
Abandoned railroad right-of-way										
Blarina brevicauda	0.7[c]	-	-	-	0.4[c]	1.3	-	-	1.3[c]	-
Microtus ochrogaster	-	-	-	-	7.5	1.3[c]	-	-	-	2.5
Peromyscus maniculatus	-	-	-	-	0.7	2.9	2.9	0.7[c]	11.4	6.4
Peromyscus leucopus	-	-	-	-	-	0.9	0.9[c]	-	-	1.8
Sigmodon hispidus	13.0	2.0	-	0.5	16.0	23.0	-	-	20.0	11.0

[a]Not sampled.
[b]None captured.
[c]Insufficient data; derived from the actual number of animals captured.

TABLE 2.2-9

SPECIES LIST AND RELATIVE OCCURRENCE OF MAMMALS NOT OBSERVED DURING THE STUDY, RECOGNIZED AS INHABITING COFFEY COUNTY, KANSAS.

Scientific Name	Common Name	Relative Occurrence[a]		
		Abundant	Common	Infrequent
Myotis lucifugus	Little brown myotis			X
Lasionycteris noctivagans	Silver-haired bat			X
Pipistrellus subflavus	Eastern pipistrel			X
Eptesicus fuscus	Big brown bat		X	
Lasiurus borealis	Red bat		X	
Lasiurus cinereus	Hoary bat			X
Nycticeius humeralis	Evening bat			X
Tadarida brasiliensis	Mexican freetail bat			X
Mustela frentata	Longtail weasel			X
Mustela vison	Mink			X
Spilogale putorius	Spotted skunk			X
Vulpes fulva	Red fox			X
Urocyon cinereoargenteus	Gray fox			X
Marmota monax	Woodchuck		X	
Citellus tridecemlineatus	Thirteen-lined ground squirrel		X	
Citellus franklini	Franklin ground squirrel			X
Tamias striatus	Eastern chipmunk			X
Sciurus carolinensis	Eastern gray squirrel			X
Glaucomys volans	Southern flying squirrel			X
Geomys bursarius	Plains pocket gopher		X	
Castor canadensis	Beaver			X
Reithrodontomys fulvescens	Fulvous harvest mouse			X
Onychomys leucogaster	Northern grasshopper mouse			X
Neotoma floridana	Eastern woodrat			X
Synaptomys cooperi	Southern bog lemming			X
Ondatra zibethica	Muskrat		X	
Rattus norvegicus	Norway rat		X	
Zapus hudsonicus	Meadow jumping mouse			X
Lepus californicus	Blacktail jackrabbit			X

[a]Follows Cockrum (1952) and Clark et al. (1958).

TABLE 2.2-10

AVIAN SPECIES OBSERVED NEAR WCGS, 1973-78

Scientific Name	Common Name	Residency Status[a]
Pelecanus erythrorhynchos	White Pelican	M
Phalacrocorax auritus	Double-crested Cormorant	S
Ardea herodias	Great Blue Heron	S
Butorides striatus	Green Heron	S
Botaurus lentiginosus	American Bittern	S
Branta canadensis	Canada Goose	W
Anser albifrons	White-fronted Goose	M
Chen caerulescens	Snow Goose	M
Anas platyrhynchos	Mallard	P
Anas acuta	Pintail	P
Anas discors	Blue-winged Teal	M
Anas crecca	Green-winged Teal	M
Anas americana	American Wigeon	M
Aix sponsa	Wood Duck	S
Mergus merganser	Common Merganser	W
Mergus serrator	Red-breasted Merganser	M
Carthartes aura	Turkey Vulture	S
Accipiter striatus	Sharp-shinned Hawk	P
Buteo jamaicensis	Red-tailed Hawk	P
Buteo platypterus	Broad-winged Hawk	S
Buteo swainsoni	Swainson's Hawk	S
Buteo lagopus	Rough-legged Hawk	W
Haliaeetus leucocephalus	Bald Eagle	W
Circus cyaneus	Marsh Hawk	W
Falco mexicanus	Prairie Falcon	W
Falco columbarius	Merlin	W
Falco sparverius	American Kestrel	P
Colinus virginianus	Bobwhite	P
Tympanuchus cupido	Greater Prairie Chicken	P
Fulica americana	American Coot	S
Charadrius vociferus	Killdeer	S
Capella gallinago	Common Snipe	S
Bartramia longicauda	Upland Sandpiper	S
Actitis macularia	Spotted Sandpiper	S
Tringa melanoleucus	Greater Yellowlegs	M
Tringa flavipes	Lesser Yellowlegs	M
Larus delawarensis	Ring-billed Gull	M
Larus pipixcan	Franklin's Gull	M
Chlidonias niger	Black Tern	M
Columba livia	Rock Dove	P
Zenaida macroura	Mourning Dove	P
Coccyzus erythropthalmus	Yellow-billed Cuckoo	S
Bubo virginianus	Great Horned Owl	P
Strix varia	Barred Owl	P

TABLE 2.2-10 (Sheet 2)

Scientific Name	Common Name	Residency Status
Asio otus	Long-eared Owl	P
Chordeiles minor	Common Nighthawk	S
Chaetura pelagica	Chimney Swift	S
Archilochus colubris	Ruby-throated Hummingbird	S
Colaptes auratus	Common Flicker	P
Dryocopus pileatus	Pileated Woodpecker	P
Melanerpes carolinus	Red-bellied Woodpecker	P
Melanerpes erythrocephalus	Red-headed Woodecker	P
Picoides villosus	Hairy Woodpecker	P
Picoides pubescens	Downy Woodpecker	P
Tyrannus tyrannus	Eastern Kingbird	S
Tyrannus verticalis	Western Kingbird	S
Muscivora forficata	Scissor-tailed Flycatcher	S
Myiarchus crinitus	Great Crested Flycatcher	S
Sayornis phoebe	Eastern Phoebe	S
Empidonax minimus	Least Flycatcher	S
Contopus virens	Eastern Wood Pewee	S
Eremophila alpestris	Horned Lark	P
Iridoprocne bicolor	Tree Swallow	S
Stelgidopteryx ruficollis	Rough-winged Swallow	S
Hirundo rustica	Barn Swallow	S
Petrochelidon pyrrhonata	Cliff Swallow	S
Progne subis	Purple Martin	S
Cyanocitta cristata	Blue Jay	P
Corvus brachyrhynchos	Common Crow	P
Parus atricapillus	Black-capped Chickadee	P
Parus carolinensis	Carolina Chickadee	P
Parus bicolor	Tufted Titmouse	P
Sitta carolinensis	White-breasted Nuthatch	P
Certhia familiaris	Brown Creeper	W
Troglodytes aedon	House Wren	S
Troglodytes troglodytes	Winter Wren	W
Thryothorus ludovicianus	Carolina Wren	P
Mimus polyglottos	Mockingbird	P
Dumetella carolinensis	Gray Catbird	S
Toxostoma rufum	Brown Thrasher	S
Turdus migratorius	American Robin	S
Hylocichla mustelina	Wood Thrush	S
Catharus fuscescens	Veery	S
Sialia sialis	Eastern Bluebird	S
Polioptila caerulea	Blue-gray Gnatcatcher	S
Regulus satrapa	Golden-crowned Kinglet	W
Regulus calendula	Ruby-crowned Kinglet	M
Lanius excubitor	Northern Shrike	W

TABLE 2.2-10 (Sheet 3)

Scientific Name	Common Name	Residency Status
Lanius ludovicianus	Loggerhead Shrike	P
Sturnus vulgaris	Starling	P
Vireo bellii	Bell's Vireo	S
Vireo flavifrons	Yellow-throated Vireo	S
Vireo solitarius	Solitary Vireo	M
Vireo olivaceus	Red-eyed Vireo	S
Vireo gilvus	Warbling Vireo	S
Mniotilta varia	Black-and-white Warbler	S
Vermivora ruficapilla	Nashville Warbler	M
Parula americana	Northern Parula	S
Dendroica petechia	Yellow Warbler	S
Dendroica coronata	Yellow-rumped Warbler	M
Dendroica cerulea	Cerulean Warbler	S
Dendroica fusca	Blackburnian Warbler	M
Dendroica castanea	Bay-breasted Warbler	M
Seiurus aurocapillus	Ovenbird	S
Oporornis formosus	Kentucky Warbler	S
Geothlypis trichas	Common Yellowthroat	S
Wilsonia pusilla	Wilson's Warbler	M
Setophaga ruticilla	American Redstart	S
Passer domesticus	House Sparrow	P
Dolichonyx oryzivorus	Bobolink	M
Sturnella magna	Eastern Meadowlark	P
Sturnella neglecta	Western Meadowlark	P
Agelaius phoeniceus	Red-winged Blackbird	P
Icterus spurius	Orchard Oriole	S
Icterus galbula	Northern Oriole	S
Euphagus cyanocephalus	Brewer's Blackbird	W
Quiscalus quiscula	Common Grackle	P
Molothrus ater	Brown-headed Cowbird	P
Piranga rubra	Summer Tanager	S
Cardinalis cardinalis	Cardinal	P
Pheucticus ludovicianus	Rose-breasted Grosbeak	M
Passerina cyanea	Indigo Bunting	S
Spiza americana	Dickcissel	S
Carpodacus purpureus	Purple Finch	W
Carduelis pinus	Pine Siskin	W
Carduelis tristis	American Goldfinch	P
Pipilo erythrophthalmus	Rufous-sided Towhee	P
Passerculus sandwichensis	Savannah Sparrow	M
Ammodramus savannarum	Grasshopper Sparrow	S
Pooecetes gramineus	Vesper Sparrow	S
Chondestes grammacus	Lark Sparrow	P
Junco hyemalis	Dark-eyed Junco	W

TABLE 2.2-10 (Sheet 4)

Scientific Name	Common Name	Residency Status
Spizella arborea	Tree Sparrow	W
Spizella passerina	Chipping Sparrow	S
Spizella pusilla	Field Sparrow	P
Zonotrichia querula	Harris' Sparrow	M
Zonotrichia leucophrys	White-crowned Sparrow	M
Zonotrichia albicollis	White-throated Sparrow	M
Paserella iliaca	Fox Sparrow	M
Melospiza lincolnii	Lincoln's Sparrow	M
Melospiza melodia	Song Sparrow	P
Calcarius lapponicus	Lapland Longspur	W

[a]M = migrant; S = summer resident; W = winter resident; and P = permanent resident.

TABLE 2.2-11

NUMBER OF SPECIES, BIRDS PER HOUR, AND SPECIES DIVERSITY OF AVIFAUNA RECORDED IN TWO COMMUNITIES NEAR WCGS MAY 1974 - JANUARY 1979

	Month				
Variable	May	Jun	Sep	Nov	Jan
North floodplain woods					
Number of species					
1974	18	12	12	9	10
1975	23	9	11	11	20
1976	26	20	15	17	14
1977	16	18	16	12	12
1978	15	16	10	15	10
Birds per hour					
1974	37.3	22.7	26.0	18.7	17.3
1975	72.6	8.0	15.7	39.2	97.9
1976	58.0	110.8	71.9	441.3	143.3
1977	48.0	90.0	68.0	60.0	51.9
1978	40.0	67.0	21.5	89.5	52.0
Species diversity					
1974	2.63	2.35	2.30	1.89	1.96
1975	2.74	2.11	2.09	2.21	2.67
1976	2.91	2.56	2.32	0.98	2.25
1977	2.57	2.45	2.35	2.33	2.21
1978	2.39	2.35	2.16	2.36	1.93
Abandoned railroad right-of-way					
Number of species					
1974	21	17	13	15	12
1975	14	11	3	5	15
1976	14	19	17	10	2
1977	13	16	14	12	12
1978	19	13	17	12	9
Birds per hour					
1974	69.6	63.3	239.0	176.0	274.0
1975	68.7	29.6	11.4	82.4	157.8
1976	75.0	122.0	88.7	139.0	7.5
1977	82.8	76.3	84.8	56.5	141.0
1978	49.4	60.9	136.8	426.1	43.0

TABLE 2.2-11 (SHEET 2)

Variable	Month May	Jun	Sep	Nov	Jan
Species diversity					
1974	2.66	2.62	1.53	1.98	1.47
1975	2.13	2.14	1.01	0.85	1.81
1976	2.20	2.45	2.16	1.50	0.45
1977	2.20	2.22	1.65	2.04	1.82
1978	2.49	2.20	2.03	1.54	1.60

TABLE 2.2-12

NUMBER OF AVIAN SPECIES AND INDIVIDUALS OBSERVED ALONG THE 20-MILE WILDLIFE SURVEY ROUTE NEAR WCGS SITE, MAY 1973 - JANUARY 1979

Variable	Month				
	May	Jun	Sep	Nov	Jan
Number of species					
1973	37	a	27	37	a
1974	42	45	43	35	31
1975	45	41	42	34	33
1976	55	55	46	40	26
1977	50	53	34	52	35
1978	50	48	35	40	23[b]
Number of individuals					
1973	471	a	530	1806	a
1974	837	955	1288	2104	5218
1975	1452	1065	678	2568	2242
1976	1146	1198	768	1618	530[b]
1977	931	788	388	2905	1712
1978	1792	2247	550	2692	1063[b]

[a]Not censused.
[b]Partial census, several miles not included.

TABLE 2.2-13

EASTERN COTTONTAIL AND BOBWHITE POPULATION INDICES
COMPILED ALONG THE 20-MILE WILDLIFE SURVEY ROUTE NEAR WCGS,
JUNE 1973-1978

	Population Indices	
Year	Eastern Cottontail No. observed/mi.	Bobwhite No. calling/20 mi.
1973	0.35	57
1974	0.20	39
1975	0.05	18
1976	0.40	28
1977	0.20	15
1978	0.32	27

TABLE 2.2-14

AMPHIBIANS AND REPTILES OBSERVED IN THE VICINITY OF THE WCGS SITE

Scientific Name	Common Name
Chelydra serpentina	Snapping Turtle
Terrapene o. ornata	Ornate box turtle
Graptemys geographica	Map turtle
Graptemys kohni	Mississippi map turtle
Graptemys pseudogeographica	False map turtle
Chrysemys scripta elegans	Red-eared turtle
Chrysemys picta belli	Western painted turtle
Trionyx spiniferus hartwegi	Western spiny softshell
Cnemidophorus s. sexlineatus	Six-lined racerunner
Ophisaurus attenuatus	Slender glass lizzard
Thamnophis sirtalis parietalis	Red-sided garter snake
Coluber constrictor	Yellow-bellied racer
Elaphe o. obsoleta	Black rat snake
Pituophis melanoleucus sayi	Bullsnake
Sistrurus catenatus tergeminus	Western massasauga
Bufo americanus	American toad
Bufo w. woodhousei	Woodhouse's toad
Bufo cognatus	Great Plains toad
Acris crepitans blanchardi	Blanchard's cricket frog
Hyla chrysoscelis	Gray treefrog
Pseudacris triseriata	Western chorus frog
Rana catesbeiana	Bullfrog
Rana blairi	Plains leopard frog
Rana areolata	Crawfish frog

TABLE 2.2-15

MAJOR ALGAL GROUPS COMPRISING A MINIMUM OF 10 PERCENT OF THE DENSITY OF PHYTOPLANKTON COLLECTED IN THE NEOSHO RIVER, 1973-78

Date	Neosho River		
	1[a]	10	4
1973			
27 March	Centric diatoms (65)[b] Chrysophytes (25) Pennate diatoms (18)	-[c]	Centric diatoms (51) Green algae (26) Pennate diatoms (12)
12 April	Centric diatoms (70) Chrysophytes (13) Pennate diatoms (10)	-	Centric diatoms (63) Pennate diatoms (14) Green algae (11)
12 June	Centric diatoms (85)	-	Centric diatoms (88)
11 September	Centric diatoms (79) Blue-green algae (11)	-	Centric diatoms (59) Pennate diatoms (16) Blue-green algae (16)
12 December	Centric diatoms (45) Chrysophytes (22) Pennate diatoms (21)	-	Centric diatoms (58) Chrysophytes (18) Pennate diatoms (17)
1974			
27 March	Centric diatoms (91)	Centric diatoms (89)	Centric diatoms (89)
11 June	Centric diatoms (65) Green algae (21)	Centric diatoms (59) Pennate diatoms (14) Green algae (12)	Centric diatoms (53) Pennate diatoms (20) Green algae (20)
10 September	Cryptomonads (37) Centric diatoms (33) Blue-green algae (14)	Cryptomonads (46) Centric diatoms (33)	Cryptomonads (52) Centric diatoms (27) Blue-green algae (12)
10 December	Centric diatoms (76)	Centric diatoms (81)	Centric diatoms (81)

TABLE 2.2-15 (Sheet 2)

Date	Neosho River 1[a]		Neosho River 10		Neosho River 4	
1975						
16 April	Centric diatoms	(92)	Centric diatoms	(92)	Centric diatoms	(91)
10 June	Cryptomonads	(41)	Centric diatoms	(30)	Pennate diatoms	(75)
	Green algae	(34)	Pennate diatoms	(27)	Centric diatoms	(17)
	Pennate diatoms	(23)	Cryptomonads	(21)		
	Centric diatoms	(18)	Green algae	(18)		
9 September	Centric diatoms	(60)	Centric diatoms	(41)	Centric diatoms	(40)
	Cryptomonads	(16)	Cryptomonads	(31)	Cryptomonads	(35)
	Green algae	(13)	Blue-green algae	(15)	Blue-green algae	(14)
3 December	Centric diatoms	(49)	Centric diatoms	(34)	Cryptomonads	(37)
	Cryptomonads	(28)	Cryptomonads	(33)	Centric diatoms	(30)
	Green algae	(18)	Green algae	(24)	Green algae	(22)
1976						
25 February	Centric diatoms	(94)	Centric diatoms	(81)	Centric diatoms	(83)
6 April	Centric diatoms	(71)	Centric diatoms	(66)	Centric diatoms	(60)
	Green algae	(18)	Pennate diatoms	(20)	Green algae	(18)
					Pennate diatoms	(13)
3 May	Centric diatoms	(88)	-		-	
15 June	Centric diatoms	(87)	Centric diatoms	(88)	Centric diatoms	(85)
12 July	Centric diatoms	(71)	-		-	
	Pennate diatoms	(18)				

TABLE 2.2-15 (Sheet 3)

Date	Neosho River 1[a]		10		4	
1976 (continued)						
10 August	Centric diatoms	(73)	Centric diatoms	(70)	Centric diatoms	(63)
	Pennate diatoms	(22)	Green algae	(16)	Pennate diatoms	(18)
					Green algae	(17)
5 October	Pennate diatoms	(55)	Pennate diatoms	(47)	Euglenoids	(35)
	Centric diatoms	(42)	Centric diatoms	(30)	Green algae	(27)
			Green algae	(19)	Centric diatoms	(22)
					Pennate diatoms	(15)
14 December	Centric diatoms	(62)	Centric diatoms	(51)	Centric diatoms	(50)
	Green algae	(11)	Pennate diatoms	(14)	Green algae	(18)
			Cryptomonads	(10)	Cryptomonads	(17)
					Pennate diatoms	(14)
1977						
22 February	Centric diatoms	(66)	Centric diatoms	(62)	Centric diatoms	(53)
	Cryptomonads	(17)	Green algae	(14)	Green algae	(20)
	Green algae	(11)	Pennate diatoms	(13)	Pennate diatoms	(11)
			Cryptomonads	(11)	Cryptomonads	(11)
5 April	Centric diatoms	(77)	Centric diatoms	(58)	Centric diatoms	(53)
	Green algae	(15)	Green algae	(22)	Green algae	(23)
					Pennate diatoms	(13)
2 May	Centric diatoms	(84)	-		-	
	Green algae	(11)				
9 June	Centric diatoms	(78)	Centric diatoms	(49)	Centric diatoms	(73)
	Pennate diatoms	(14)	Pennate diatoms	(30)		
			Green algae	(11)		

TABLE 2.2-15 (Sheet 4)

Date	Neosho River 1[a]	10	4
1977 (continued)			
11 July	Centric diatoms (62) Pennate diatoms (13)	-	-
9 August	Centric diatoms (77) Pennate diatoms (15)	Centric diatoms (81) Pennate diatoms (13)	Centric diatoms (72) Pennate diatoms (20)
4 October	Centric diatoms (68) Pennate diatoms (14) Blue-green algae (13)	Centric diatoms (60) Pennate diatoms (18) Blue-green algae (15)	Centric diatoms (67) Pennate diatoms (15) Blue-green algae (14)
13 December	Centric diatoms (46) Cryptomonads (23) Green algae (15)	Centric diatoms (66) Pennate diatoms (13) Chloromonads (11)	Centric diatoms (58) Green algae (16) Chloromonads (14) Pennate diatoms (11)
1978			
22 February	Centric diatoms (62) Blue-green algae (13) Green algae (24)	Centric diatoms (72) Green algae (14) Blue-green algae (8)	Centric diatoms (68) Green algae (19) Blue-green algae (10)
25 April	Centric diatoms (59) Green algae (19) Pennate diatoms (10)	Centric diatoms (56) Green algae (20) Pennate diatoms (16)	Centric diatoms (51) Green algae (21) Pennate diatoms (19)
22 May	Centric diatoms (77) Green algae (16)	-	-
27 June	Centric diatoms (88)	Centric diatoms (84)	Centric diatoms (84)
19 July	Centric diatoms (68) Blue-green algae (12)	-	-

TABLE 2.2-15 (Sheet 5)

Date	Neosho River 1[a]		Neosho River 10		Neosho River 4	
1978 (continued)						
29 August	Centric diatoms	(77)	Centric diatoms	(79)	Centric diatoms	(74)
	Green algae	(12)			Green algae	(11)
10 October	Centric diatoms	(49)	Centric diatoms	(40)	Centric diatoms	(51)
	Cryptomonads	(21)	Cryptomonads	(24)	Green algae	(20)
	Green algae	(18)	Green algae	(22)	Cryptomonads	(16)
			Pennate diatoms	(11)		
12 December	Centric diatoms	(40)	Chrysophytes	(42)	Chrysophytes	(68)
	Chrysophytes	(21)	Green algae	(24)	Green algae	(15)
	Cryptomonads	(19)	Centric diatoms	(19)	Centric diatoms	(10)
	Green algae	(15)				

[a]Location 1 was in John Redmond Reservoir prior to 1976.
[b]Percent of total phytoplankton.
[c]Samples not collected.

TABLE 2.2-16

MEAN DENSITY (UNITS/ml) OF PHYTOPLANKTON IN SAMPLES COLLECTED, 1973-78

Date		Neosho River 1[a]	10	4	X̄	Wolf Creek 7	2	3	5	X̄
27 March	1973	309	-[b]	364	337	-	272	230	-	251
12 June		3,893	-	3,279	3,586	-	753	998	-	876
11 September		1,761	-	3,611	2,686	-	5,397	1,083	-	3,240
12 December		1,434	-	1,133	1,284	-	51	46	-	49
X̄		1,849	-	2,097	1,973	-	1,618	589	-	1,104
27 March	1974	4,401	4,694	3,674	4,256	-	615	928	736	760
11 June		1,183	431	362	659	-	526	1,193	722	814
10 September		1,555	2,498	1,937	1,997	-	5,229	1,883	1,438	2,850
10 December		9,879	7,490	8,521	8,630	-	1,074	3,661	498	1,744
X̄		4,255	3,778	3,624	3,886	-	1,861	1,916	849	1,542
16 April	1975	16,627	14,126	17,791	16,181	2,193	2,113	4,537	3,819	3,166
10 June		1,946	1,270	1,506	1,574	1,203	2,164	2,196	3,056	2,155
9 September		12,604	9,486	10,571	10,887	2,871	3,908	12,405	11,465	7,662
3 December		7,827	4,638	4,994	5,820	3,669	509	3,345	510	2,008
X̄		9,751	7,380	8,716	8,616	2,484	2,174	5,621	4,713	3,748
25 February	1976	31,437	42,501	43,799	39,246	173,954	6,484	962	2,021	45,855
6 April		5,655	7,636	7,641	6,977	5,136	3,905	5,182	1,686	3,977
3 May		8,137	-	-	8,137	-	-	-	-	-
15 June		8,721	7,440	7,572	7,911	1,364	2,968	5,012	8,299	4,411
12 July		6,537	-	-	6,537	-	-	-	-	-
10 August		3,549	10,138	22,695	12,127	2,778	10,234	7,289	4,594	6,224
5 October		8,360	3,398	5,420	5,726	2,941	9,994	-	-	6,468
14 December		3,076	1,588	701	1,788	-	-	-	-	-
X̄		9,434	12,117	14,638	12,063	37,235	6,717	4,611	4,150	14,156
22 February	1977	8,534	9,426	9,536	9,165	2,613	-	1,219	-	1,916
5 April		8,325	11,240	8,927	9,497	698	-	5,380	-	3,039
2 May		14,474	-	-	14,474	-	-	-	-	-
9 June		2,455	873	1,105	1,478	307	-	6,280	4,389	3,659

TABLE 2.2-16 (Sheet 2)

Date		Neosho River				Wolf Creek				
		1[a]	10	4	X̄	7	2	3	5	X̄
1977 (continued)										
11 July		962	-	-	962	-	-	-	-	-
9 August		14,189	11,053	7,118	10,787	2,367	-	1,737	13,352	5,819
4 October		2,514	2,395	1,692	2,200	1,570	-	1,508	439	1,172
13 December		1,885	1,595	1,532	1,671	349	-	1,403	921	891
X̄		6,667	6,097	4,985	5,991	1,317	-	2,921	4,775	2,783
22 February	1978	6,793	10,051	8,961	8,602	2,202	-	1,001	522	1,242
25 April		1,319	1,240	1,312	1,290	1,841	-	2,808	1,631	2,093
22 May		10,214	-	-	10,214	-	-	-	-	-
27 June		9,954	7,148	7,501	8,201	2,168	-	4,338	5,780	4,095
19 July		12,089	-	-	12,089	-	-	-	-	-
29 August		9,733	9,885	9,372	9,663	43,636	-	-	-	43,636
10 October		13,150	6,104	5,162	8,139	10,102	-	8,539	-	9,320
12 December		5,720	1,974	2,844	3,513	5,571	-	2,486	2,799	3,619
X̄		8,622	6,067	5,859	6,849	10,920	-	3,834	2,683	5,812

[a]Location 1 was in John Redmond Reservoir prior to 1976.
[b]Samples not collected.

TABLE 2.2-17

MEAN CARBON FIXATION RATE (mg C/m^3 per hr) FROM PHYTOPLANKTON SAMPLES COLLECTED, 1973-78

Sampling Date		Neosho River				Wolf Creek				
		1[a]	10	4	X̄	7	2	3	5	X̄
12 April	1973	3.51	-[b]	3.96	3.74	-	6.57	2.99	-	4.78
12 June		29.61	-	22.34	25.98	-	8.33	22.11	-	15.22
11 September		28.00	-	35.06	31.53	-	45.39	51.71	-	48.55
12 December		5.45	-	5.21	5.33	-	0.39	0.25	-	0.32
X̄		16.64	-	16.64	16.64	-	15.17	19.27	-	17.22
27 March	1974	18.29	17.45	18.90	18.21	-	7.31	11.60	14.85	11.25
11 June		15.57	0.15	11.40	9.04	-	2.32	1.40	2.10	1.94
10 September		7.30	5.62	5.94	6.29	-	47.89	14.51	10.16	24.19
10 December		24.83	22.92	22.92	23.56	-	4.05	5.72	2.55	4.11
X̄		16.50	11.54	14.79	14.28	-	15.39	8.31	7.42	10.37
16 April	1975	90.90	125.98	130.65	115.84	11.03	12.33	33.82	27.72	21.23
10 June		14.24	6.87	2.54	7.88	5.15	3.33	2.36	1.61	3.11
9 September		44.26	36.82	24.66	35.25	9.23	14.69	-	93.34	39.09
3 December		32.18	10.39	10.38	17.65	25.49	0.36	7.09	2.50	8.86
X̄		45.40	45.02	42.06	44.16	12.73	7.68	14.42	31.29	16.67
25 February	1976	21.66	20.35	20.82	20.94	36.36	11.08	5.78	1.79	13.75
6 April		58.82	62.25	64.23	61.77	13.90	15.10	43.58	11.50	21.02
3 May		21.11	-	-	21.11	-	-	-	-	-
15 June		45.79	45.97	41.07	44.28	3.59	26.34	32.82	36.98	24.93
12 July		71.12	-	-	71.12	-	-	-	-	-
10 August		26.23	80.69	95.59	67.50	43.86	61.47	53.81	26.89	46.51
5 October		41.58	46.35	79.01	55.65	20.83	8.74	-	-	14.79
14 December		21.39	5.27	4.84	10.50	-	-	-	-	-
X̄		38.46	43.48	50.93	43.71	23.71	24.55	34.00	19.29	25.25
22 February	1977	67.42	69.00	77.00	71.14	54.69	-	25.71	-	40.20
5 April		55.25	45.02	45.32	48.53	3.12	-	47.85	-	25.49
2 May		68.18	-	-	68.18	-	-	-	-	-

TABLE 2.2-17 (Sheet 2)

Sampling Date		Neosho River 1[a]	10	4	$\bar{X}$	Wolf Creek 7	2	3	5	$\bar{X}$
1977 (continued)										
9 June		5.30	5.75	7.04	6.03	2.06	-	42.04	49.55	31.22
11 July		4.09	-	-	4.09	-	-	-	-	-
9 August		34.28	33.34	45.35	37.66	50.05	-	16.98	42.60	36.54
4 October		15.09	13.30	13.22	13.87	18.06	-	11.46	3.95	11.16
13 December		15.42	14.47	13.99	14.63	6.87	-	9.91	3.16	6.65
$\bar{X}$		33.13	30.15	33.65	32.39	22.48	-	25.66	24.82	24.26
22 February	1978	6.71	8.08	6.56	7.12	1.90	-	0.54	0.91	1.12
25 April		6.51	4.90	5.76	5.72	-	-	4.36	4.78	4.57
22 May		0.74	-	-	0.74	-	-	-	-	-
27 June		25.80	24.54	30.52	26.95	10.46	-	23.37	28.68	20.84
19 July		100.67	-	-	100.67	-	-	-	-	-
29 August		28.24	45.14	51.68	41.69	148.68	-	-	-	148.68
10 October		26.64	13.45	17.66	19.25	25.11	-	42.66	-	33.88
12 December		12.19	1.55	2.58	5.44	16.89	-	33.48	9.20	19.86
$\bar{X}$		25.94	16.28	19.13	20.45	40.60	-	20.88	10.89	24.12

[a]Location 1 was in John Redmond Reservoir prior to 1976.
[b]Samples not collected.

TABLE 2.2-18

MEAN CHLOROPHYLL a CONCENTRATION (mg chl a/m^3) FROM PHYTOPLANKTON SAMPLES COLLECTED, 1973-78

Sampling Date		Neosho River 1[a]	10	4	$\bar{X}$	Wolf Creek 7	2	3	5	$\bar{X}$
12 April	1973	1.58	-[b]	1.93	1.78	-	4.63	2.49	-	3.56
12 June		8.13	-	2.23	5.18	-	1.01	1.44	-	1.23
11 September		13.41	-	19.75	16.58	-	5.75	4.67	-	5.21
12 December		3.57	-	3.13	3.35	-	0.28	0.39	-	0.34
$\bar{X}$		6.67	-	6.76	6.72	-	2.92	2.25	-	2.59
27 March	1974	8.77	6.57	7.54	7.63	-	5.40	9.00	9.04	7.81
11 June		0.70	0.77	0.80	0.76	-	0.74	2.14	1.74	1.54
10 September		4.14	1.83	0.80	2.26	-	10.63	3.54	3.30	5.82
10 December		10.50	9.17	9.00	9.56	-	2.07	3.17	2.68	2.64
$\bar{X}$		6.03	4.59	4.54	5.05	-	4.71	4.46	4.19	4.45
16 April	1975	34.97	33.33	34.00	34.10	2.59	6.30	14.20	12.43	8.88
10 June		3.67	1.84	2.27	2.59	2.00	2.07	2.43	2.54	2.26
9 September		10.97	10.34	6.70	9.34	3.57	6.17	10.07	30.00	12.45
3 December		21.67	6.57	7.87	12.04	9.27	1.75	10.50	3.29	6.20
$\bar{X}$		17.82	13.02	12.71	14.52	4.36	4.07	9.30	12.07	7.45
25 February	1976	38.67	11.67	17.33	22.56	51.67	4.63	1.46	1.63	14.85
6 April		18.33	15.37	16.63	16.78	7.57	3.30	5.80	3.93	5.15
3 May		6.67	-	-	6.67	-	-	-	-	-
15 June		16.00	14.23	12.77	14.33	2.37	7.93	10.90	27.00	12.05
12 July		11.43	-	-	11.43	-	-	-	-	-
10 August		7.27	16.00	16.00	13.09	13.57	12.10	14.67	6.67	11.75
5 October		7.17	9.73	19.73	12.21	7.90	5.37	-	-	6.64
14 December		6.33	2.99	2.53	3.95	-	-	-	-	-
$\bar{X}$		22.74	11.67	14.17	16.85	16.62	6.67	6.57	9.81	10.11
22 February	1977	12.27	12.43	11.60	12.10	16.37	-	5.30	-	10.84
5 April		21.33	14.53	14.33	16.73	13.67	-	17.00	-	15.34
2 May		13.37	-	-	13.37	-	-	-	-	-

WCGS-ER(OLS)

Sampling Date	Neosho River 1[a]	Neosho River 10	Neosho River 4	Neosho River $\bar{X}$	Wolf Creek 7	Wolf Creek 2	Wolf Creek 3	Wolf Creek 5	Wolf Creek $\bar{X}$
1977 (continued)									
9 June	1.53	1.47	1.53	1.51	0.68	-	12.83	17.93	10.48
11 July	1.77	-	-	1.77	-	-	-	-	-
9 August	35.90	28.54	43.25	35.90	28.11	-	12.30	35.03	19.45
4 October	8.54	6.32	5.26	6.71	12.65	-	7.73	3.82	8.07
13 December	8.20	7.61	7.96	7.92	4.79	-	6.49	3.13	4.80
$\bar{X}$	12.86	11.82	13.99	12.89	12.72	-	9.89	14.98	12.22
22 February 1978	35.04	29.85	28.98	31.29	5.94	-	2.70	4.36	4.33
25 April	12.00	10.33	9.54	10.62	4.40	-	8.66	6.49	6.52
22 May	38.62	-	-	38.62	-	-	-	-	-
27 June	30.11	21.29	23.42	24.94	11.20	-	24.94	31.63	22.59
19 July	41.97	-	-	41.97	-	-	-	-	-
29 August	24.63	20.68	27.98	24.43	34.98	-	-	-	34.98
10 October	37.41	14.86	14.56	22.28	47.14	-	42.88	-	45.01
12 December	20.07	2.95	2.15	8.39	35.28	-	8.56	9.05	17.63
$\bar{X}$	29.98	16.66	17.78	21.47	23.16	-	17.55	12.88	17.86

[a]Location 1 was in John Redmond Reservoir prior to 1976.
[b]Samples not collected.

TABLE 2.2-19

DIVERSITY[a] OF PHYTOPLANKTON COLLECTED, 1974-78

Sampling Date		Neosho River				Wolf Creek				
		1[b]	10	4	$\bar{X}$	7	2	3	5	$\bar{X}$
27 March	1974	2.01	0.91	1.94	1.62	–[c]	2.47	2.31	2.20	2.33
11 June		2.63	2.31	2.37	2.44	–	2.13	1.98	1.85	1.99
10 September		2.47	2.20	1.94	2.20	–	1.36	2.16	2.38	1.97
10 December		2.05	2.04	2.11	2.07	–	0.81	0.55	1.96	1.11
$\bar{X}$		2.29	1.87	2.09	2.08	–	1.69	1.75	2.10	1.85
16 April	1975	1.78	1.52	1.65	1.65	2.78	2.78	1.88	2.19	2.41
10 June		2.56	3.07	3.06	2.90	3.24	3.37	3.24	2.96	3.20
9 September		2.67	2.39	2.42	2.49	2.63	2.68	2.56	3.19	2.78
3 December		2.32	2.51	2.57	2.47	1.79	2.33	2.00	2.36	2.12
$\bar{X}$		2.33	2.37	2.43	2.38	2.61	2.79	2.42	2.68	2.63
25 February	1976	1.39	2.03	2.00	1.81	1.83	2.47	2.43	2.22	2.24
6 April		2.27	2.47	2.56	2.43	2.56	2.01	1.39	2.86	2.21
3 May		1.91	–	–	1.91	–	–	–	–	–
15 June		2.32	2.19	2.45	2.32	2.67	3.20	2.66	3.13	2.92
12 July		2.17	–	–	2.17	–	–	–	–	–
10 August		2.33	1.89	1.94	2.05	2.63	2.17	2.72	2.37	2.47
5 October		2.02	2.92	2.09	2.34	2.69	2.61	–	–	2.65
14 December		2.39	3.07	2.98	2.81	–	–	–	–	–
$\bar{X}$		2.10	2.43	2.34	2.27	2.48	2.49	2.30	2.65	2.48
22 February	1977	2.42	2.37	2.55	2.45	0.88	–	0.41	–	0.65
5 April		2.02	2.65	2.88	2.52	1.28	–	1.92	–	1.60
2 May		1.34	–	–	1.34	–	–	–	–	–

TABLE 2.2-19 (Sheet 2)

Sampling Date		Neosho River 1[b]	10	4	$\bar{X}$	Wolf Creek 7	2	3	5	$\bar{X}$
1977 (continued)										
9 June		2.19	2.56	1.95	2.23	1.47	-	1.85	1.55	1.62
11 July		2.67	-	-	2.67	-	-	-	-	-
9 August		2.48	2.32	2.53	2.44	3.33	-	2.55	2.32	3.07
4 October		2.65	2.61	2.57	2.61	3.06	-	2.37	3.09	2.84
13 December		3.00	2.77	2.91	2.89	1.69	-	2.45	2.77	2.30
$\bar{X}$		2.35	2.55	2.57	2.48	1.95	-	1.93	2.43	2.06
22 February	1978	1.14	1.02	1.05	1.07	1.81	-	1.45	1.56	1.61
25 April		2.38	2.29	2.50	2.39	1.94	-	1.68	1.88	1.83
22 May		2.07	-	-	2.07	-	-	-	-	-
27 June		2.21	2.09	2.31	2.20	3.41	-	3.17	2.73	3.10
19 July		2.55	-	-	2.55	-	-	-	-	-
29 August		2.38	2.30	2.46	2.38	0.69	-	-	-	0.69
10 October		2.72	3.16	3.11	3.00	2.54	-	0.52	-	1.53
12 December		2.55	2.61	1.91	2.36	2.29	-	1.68	1.59	1.85
$\bar{X}$		2.25	2.24	2.22	2.24	2.11	-	1.70	1.94	1.92

[a]Shannon (1948).
[b]Location 1 was in John Redmond Reservoir prior to 1976.
[c]Samples not collected.

TABLE 2.2-20

MAJOR ALGAL GROUPS COMPRISING A MINIMUM OF 10 PERCENT OF THE DENSITY OF PHYTOPLANKTON COLLECTED IN WOLF CREEK, 1973-78

	Wolf Creek			
	7	2	3	5
1973				
27 March	–[a]	Pennate diatoms (83)[b]	Pennate diatoms (90)	–
12 April	–	Green algae (49) Pennate diatoms (40)	Pennate diatoms (79)	–
12 June	–	Pennate diatoms (78) Centric diatoms (16)	Pennate diatoms (69) Centric diatoms (21)	–
11 September	–	Centric diatoms (49) Pennate diatoms (46)	Pennate diatoms (73) Cryptomonads (12)	–
12 December	–	Pennate diatoms (55) Centric diatoms (18) Cryptomonads (18)	Pennate diatoms (44) Centric diatoms (12) Green algae (11)	–
1974				
27 March	–	Pennate diatoms (83)	Pennate diatoms (78)	Pennate diatoms (77)
11 June	–	Pennate diatoms (83)	Pennate diatoms (85) Green algae (11)	Pennate diatoms (95)
10 September	–	Cryptomonads (87)	Cryptomonads (64) Pennate diatoms (15) Centric diatoms (13)	Cryptomonads (61) Pennate diatoms (16)
10 December	–	Cryptomonads (87)	Cryptomonads (91)	Cryptomonads (52) Pennate diatoms (30)
1975				
16 April	Cryptomonads (27) Green algae (20) Centric diatoms (19) Pennate diatoms (15) Chrysophytes (15)	Cryptomonads (45) Pennate diatoms (24) Green algae (15)	Cryptomonads (69) Pennate diatoms (18)	Cryptomonads (57) Pennate diatoms (21) Green algae (12)

TABLE 2.2-20 (Sheet 2)

	Wolf Creek			
	7	2	3	5
<u>1975</u> (continued)				
10 June	Pennate diatoms (50) Cryptomonads (27) Green algae (15)	Pennate diatoms (75)	Pennate diatoms (85)	Pennate diatoms (86)
9 September	Pennate diatoms (61) Cryptomonads (25)	Cryptomonads (49) Pennate diatoms (24) Chrysophytes (12) Green algae (12)	Cryptomonads (34) Green algae (26) Chrysophytes (21) Pennate diatoms (15)	Cryptomonads (37) Pennate diatoms (23) Centric diatoms (15) Green algae (11) Euglenoids (11)
3 December	Green algae (46) Cryptomonads (28) Pennate diatoms (14)	Pennate diatoms (75) Centric diatoms (12) Green algae (12)	Cryptomonads (38) Green algae (37) Pennate diatoms (12) Euglenoids (12)	Euglenoids (58) Green algae (19) Pennate diatoms (11)
<u>1976</u>				
25 February	Cryptomonads (51) Green algae (31) Chrysophytes (11)	Pennate diatoms (41) Chrysophytes (41) Green algae (14)	Cryptomonads (29) Blue-green algae (19) Pennate diatoms (18) Green algae (17)	Pennate diatoms (50) Green algae (24) Crysophytes (13)
6 April	Pennate diatoms (68) Centric diatoms (26)	Chrysophytes (51) Pennate diatoms (31) Cryptomonads (16)	Chrysophytes (80) Pennate diatoms (12)	Pennate diatoms (51) Cryptomorads (26) Blue-green algae (12)
3 May	-	-	-	-
15 June	Green algae (85) Pennate diatoms (12)	Pennate diatoms (71) Centric diatoms (11)	Pennate diatoms (97)	Pennate diatoms (58) Centric diatoms (38)
12 July	-	-	-	-
10 August	Centric diatoms (34) Cryptomonads (29) Pennate diatoms (23)	Pennate diatoms (74) Centric diatoms (25)	Pennate diatoms (46) Centric diatoms (40)	Centric diatoms (59) Pennate diatoms (39)
5 October	Pennate diatoms (77) Centric diatoms (13)	Pennate diatoms (96)	-	-
14 December	-	-	-	-

TABLE 2.2-20 (Sheet 3)

	Wolf Creek			
	7	2	3	5
1977				
22 February	Dinoflagellates (56) Chrysophytes (40)	-	Chrysophytes (92)	-
5 April	Cryptomonads (46) Chrysophytes (35) Pennate diatoms (16)	-	Pennate diatoms (38) Chrysophytes (35) Cryptomonads (12)	-
2 May	-	-	-	-
9 June	Pennate diatoms (58) Cryptomonads (34)	-	Pennate diatoms (49) Cryptomonads (35)	Cryptomonads (60) Chrysophytes (18) Pennate diatoms (11)
11 July	-	-	-	-
9 August	Pennate diatoms (45) Euglenoids (26) Centric diatoms (17)	-	Centric diatoms (51) Cryptomonads (25) Pennate diatoms (18)	Centric diatoms (81) Pennate diatoms (16)
4 October	Cryptomonads (28) Pennate diatoms (26) Euglenoids (22) Chrysophytes (21) Centric diatoms (18)	-	Cryptomonads (47) Centric diatoms (26) Pennate diatoms (23)	Centric diatoms (36) Pennate diatoms (36) Cryptomonads (23)
13 December	Cryptomonads (38) Green algae (32) Pennate diatoms (26)	-	Pennate diatoms (55) Cryptomonads (21) Centric diatoms (20)	Pennate diatoms (65) Centric diatoms (17)
1978				
22 February	Pennate diatoms (20) Chrysophytes (51) Green algae (25)	-	Chrysophytes (56) Green algae (34)	Chrysophytes (60) Green algae (14) Pennate diatoms (10) Cryptomonads (10)
25 April	Green algae (60) Cryptomonads (27)	-	Centric diatoms (47) Green algae (26) Cryptomonads (20)	Green algae (42) Cryptomonads (29) Centric diatoms (19)

TABLE 2.2-20 (Sheet 4)

	Wolf Creek							
	7		2	3		5		
1978 (continued)								
22 May	-		-	-		-	
27 June	Pennate diatoms	(29)	-	Centric diatoms	(41)	Centric diatoms	(45)
	Cryptomonads	(23)		Pennate diatoms	(20)	Green algae	(31)
	Euglenoids	(20)		Green algae	(21)	Pennate diatoms	(10)
	Centric diatoms	(12)		Cryptomonads	(10)	Cryptomonads	(10)
	Green algae	(11)					
19 July	-		-	-		-	
29 August	Blue-green algae	(92)	-	-		-	
10 October	Cryptomonads	(30)	-	Cryptomonads	(88)	-	
	Green algae	(30)					
	Centric diatoms	(12)					
	Chrysophytes	(11)					
12 December	Englenoids	(66)	-	Cryptomonads	(67)	Chrysophytes	(40)
	Chrysophytes	(13)		Chrysophytes	(16)	Cryptomonads	(34)
	Cryptomonads	(12)		Green algae	(13)	Green algae	(17)

[a]Samples not collected.
[b]Percent of total phytoplankton.

TABLE 2.2-21

PERIPHYTIC ALGAL TAXA COLLECTED FROM NATURAL SUBSTRATES, 1973-78

BACILLARIOPHYTA (Diatoms)
Achnanthes spp.
A. deflexa Reimer
A. lanceolata Brebisson
A. lanceolata v. rostrata Hustedt
A. linearis W. Smith
A. linearis f. curta H. L. Smith
A. microcephala Kuetzing
A. minutissima Kuetzing
Amphipleura pellucida Kuetzing
Amphora spp.
A. normani Rabenhorst
A. ovalis v. pediculus Kuetzing
A. perpusilla Grunow
A. veneta Kuetzing
Asterionella formosa Hassall
Bacillaria paradoxa Gmelin
Biddulphia laevis Ehrenberg
Caloneis spp.
C. bacillum (Grunow) Mereschowsky
C. bacillum v. lancettula (Schulz) Hustedt
C. clevei Cleve
C. lewisii Patrick
C. ventricosa (Ehrenberg) Meister
C. ventricosa v. minuta (Grunow) Patrick
C. ventricosa v. subundulata (Grunow) Patrick
C. ventricosa v. truncatula (Grunow) Meister
Camplyodiscus clypens Ehrenberg
Cocconeis diminuta Pantocsek
C. pediculus Ehrenberg
C. placentula Ehrenberg
C. placentula v. euglypta (Ehrenberg) Cleve
Cyclotella spp.
C. atomus Hustedt
C. meneghiniana Kuetzing
C. stelligera Cleve U. Grunow
Cymatopleura elliptica f. spiralis (Chase) Boyer
C. solea (Brebisson) W. Smith
Cymbella spp.
C. affinis Kuetzing
C. minuta Hilse ex Rabenhorst
C. prostrata (Berkley) Cleve
C. sinuta Gregory
C. triangulum Ehrenberg
C. tumida (Brebisson) V. Heurck
C. turgida (Gregory) Cleve
C. ventricosa Kuetzing
Denticula elegans Kuetzing
Diatoma tenue v. elongatum Lyngbye
D. vulgare Bory
Diploneis spp.
D. puella (Schumann) Cleve
D. pseudovalis Hustedt
Eunotia curvata (Kuetzing) Lagerstedt
Fragilaria spp.
F. capucina v. lanceolata Grunow
F. construens (Ehrenberg) Grunow
F. construens v. subsalina Hustedt
F. crotonensis Kitton
F. vaucheriae (Kuetzing) Petersen
F. virescens Ralfs
Frustulia vulgaris Thwaites
Gomphonema spp.
G. angustatum (Kuetzing) Rabenhorst
G. angustatum v. producta Grunow
G. bohemicum Reichelt et Fricke
G. gracile Ehrenberg
G. intricatum Kuetzing
G. lanceolatum Ehrenberg
G. lanceolatum v. insignis (Gregory) Cleve
G. longiceps Ehrenberg
G. olivaceum (Lyngbye) Kuetzing
G. parvulum Kuetzing
G. parvulum v. micropus (Kuetzing) Cleve
G. subclavatum Grunow
Melosira spp.
M. distans (Ehrenberg) Kuetzing
M. granulata (Ehrenberg) Ralfs
M. varians C. A. Agardh
Meridion circulare Agardh
M. circulare v. constictum (Ralfs) Van Heurck
Microsiphona (Skeletonema) potamos Weber
Navicula spp.
N. accomoda Hustedt
N. atomus (Naegeli) Grunow
N. auriculata Hustedt
N. bacillum Ehrenberg
N. biconica Patrick
N. capitata Ehrenberg
N. capitata v. hungarica (Grunow) Ross
N. cincta (Ehrenberg) Ralfs
N. cryptocephala Kuetzing
N. cryptocephala v. veneta (Kuetzing) Grunow
N. cuspidata Kuetzing
N. decussis Ostrup
N. gracilis Ehrenberg
N. graciloides A. Mayer
N. grimmei Krasske
N. heufleri Grunow
N. lanceolata (Agardh) Kuetzing
N. luzonensis Hustedt
N. menisculus Schumann
N. minima Grunow
N. mutica Kuetzing
N. mutica v. tropica Hustedt
N. mutica v. undulata (Hilse) Grunow
N. pelliculosa (Brebisson) Hilse
N. pupula Kuetzing
N. pupula v. capitata Hustedt
N. pupula v. rectangularis (Gregory) Grunow
N. radiosa Kuetzing
N. radiosa v. tenella (Brebisson) Grunow
N. rhynchocephala Kuetzing
N. salinarum v. intermedia (Grunow) Cleve
N. secreta v. apiculata Patrick
N. seminulum Grunow
N. symmetrica Patrick
N. tenera Hustedt
N. tripunctata (O. F. Muller) Bory
N. tripunctata v. schizonemoides (Van Heurck) Patrick
N. tuscula f. minor (Ehrenberg) Grunow
N. viridula (Kuetzing) Kuetzing emend. Van Heurck
N. viridula v. rostellata (Kuetzing) Cleve
Neidium affine v. amphirhynchus (Ehrenberg) Cleve
Nitzschia spp.
N. acicularis W. Smith
N. acuta Hustedt
N. amphibia Grunow
N. apiculata Grunow
N. capitellata Hustedt
N. closterium (Ehrenberg) W. Smith
N. constricta v. subconstricta Grunow
N. dissipata (Kuetzing) Grunow
N. elliptica Hustedt
N. filiformis (W. Smith) Hustedt
N. fonticola Grunow
N. frustulum v. perpusilla (Rabenhorst) Grunow
N. frustulum v. subsalina Hustedt
N. hungarica Grunow
N. ignorata Krasske
N. kutzingiana Hilse
N. linearis W. Smith
N. longissima (Brebisson) Ralfs
N. lorenziana Grunow
N. lorenziana v. substillis Grunow
N. microcephala Grunow
N. palea (Kuetzing) W. Smith
N. paleacea Grunow
N. scalaris (Ehrenberg) W. Smith
N. subhybrida Hustedt

TABLE 2.2-21 (Sheet 2)

Gyrosigma spp.
G. kutzingii (Grunow) Cleve
G. nodiferum (Grunow) Reimer
G. scalproides (Rabenhorst) Cleve

Opephora martyi Heribaud
Pinnularia spp.
Pleurosigma spp.
Rhoicosphenia curvata (Kuetzing) Grunow
Rhopalodia spp.
R. gibba (Ehrenberg) O. Muller
R. gibba v. *ventricosa* (Ehrenberg) Grunow
R. gibberula (Ehrenberg) O. Muller
Stauroneis anceps f. *gracilis* (Ehrenberg) Cleve
S. anceps f. *linearis* (Ehrenberg) Hustedt
S. Smithii Grunow
Stephanodiscus spp.
S. astraea (Ehrenberg) Grunow
S. hantzschii Grunow
S. invisitatus John & Hellerman
S. niagarae (Ehrenberg) Grunow
Surirella spp.
S. angusta Kuetzing
S. ovata Kuetzing
S. spiralis Kuetzing
Syndra spp.
S. acus Kuetzing
S. delicatissima W. Smith
S. minuscula Grunow
S. pulchella Ralfs ex Kuetzing
S. rumpens Kuetzing
S. rumpens v. *familiaris* Kuetzing
S. rumpens v. *meneghiniana* Grunow
S. socia Wallace
S. ulna (Nitzsch) Ehrenberg
S. ulna v. *oxyrhynchus* Kuetzing
S. ulna v. *ramesi* (Heribaud) Hustedt
Tabellaria flocculosa (Roth) Kuetzing

CHLOROPHYTA (Green Algae)
Ankistrodesmus falcatus (Corda) Ralfs
Characium sp.
Chlamydomonas snowii Printz
Cladaphora spp.
C. glomerata (L.) Kuetzing
Closterium spp.
Cosmarium spp.
N. subtilis Kuetzing
N. tryblionella Hantzsch
N. tryblionella v. *debilis* (Arnott) A. Mayer
N. tryblionella v. *levidensis* (W. Smith) Grunow
N. trybionella v. *victoriae* Grunow
N. vermicularis (Kuetzing) Grunow
Crucigenia rectangularis (A. Bruan) Gay
Desmococcus spp.
Entocladia spp.
Oedogonium spp.
Scenedesmus spp.
S. dimorphus (Turpin) Kuetzing
S. longispina Chodat
Schroederia setigera (Schroed.) Lemmermann
Spriogyra spp.
Stigeoclonium spp.
S. nanum Kuetzing
Ulothrix spp.
Zygnema spp.
unidentified greens

CHRYSOPHYTA (Yellow-brown Algae)
Stipitococcus spp.

CRYPTOPHYTA (Cryptomonads)
Cryptomonos spp.

CYANOPHYTA (Blue-green Algae)
Anabaena spp.
Anacystis montana (Lightf.) Drouet & Dailey
Calothrix spp.
Chamaesiphon spp.
Hydrocolcum spp.
Lyngbya spp.
L. aerugineo-caerulea (Kuetzing) Gomont
L. diguetti Gomont
L. epiphytica Hieronymus
L. martensiana Meneghini
Microcystis aeruginosa Kuetzing
Oscillatoria spp.
O. agardhii Gomont
O. tenuis C. A. Agardh
Phormidium spp.
P. ambiguum Gomont
P. tenue Meneghini
Rivularia spp.
unidentified blue-greens

EUGLENOPHYTA (Euglenas)
Phacus spp.
Trachelomonas girardiana (Playfair) DePlandre

TABLE 2.2-22

ALGAL TAXA COMPRISING 10 PERCENT OR MORE OF TOTAL PERIPHYTON ABUNDANCE OR BIOVOLUME ON NATURAL SUBSTRATES, 1973-78

Taxa	Neosho River	Wolf Creek
Bacillariophyta (Diatoms)		
Achnanthes lanceolata	–[a]	+
Achnanthes linearis	–	+
Achnanthes sp.	–	+
Amphipleura pellucida	–	+
Amphora veneta	–	+
Caloneis ventricosa	–	+
Caloneis sp.	–	+
Campylodiscus clypeus	–	+
Cocconeis pediculus	+	–
Cocconeis placentula v. euglypta	+	–
Cyclotella sp.	+	–
Cymatopleura elliptica f. spiralis	–	+
Cymbella prostrata	+	–
Cymbella sinuata	+	–
Cymbella triangulum	–	+
Cymbella ventricosa	–	–
Diatoma tenue v. elongatum	–	+
Diploneis puella	–	+
Diploneis sp.	–	+++
Fragilaria vaucheriae	+	–
Fragilaria sp.	–	+
Frustulia vulgaris	–	+
Gomphonema angustatum	–	+
Gomphonema bohemicum	–	+
Gomphonema olivaceum	+	–
Gomphonema parvulum	+	+
Gomphonema parvulum v. micropus	–	+++
Gomphonema sp.	+	+
Gyrosigma scalproides	–	+++
Gyrosigma sp.	+	+
Melosira varians	+	+
Navicula biconica	+	+
Navicula cryptocephala	+	+
Navicula cryptocephala v. veneta	–	+
Navicula heufleri	+	+
Navicula luzonensis	–	+
Navicula menisculus	–	+
Navicula minima	+	–
Navicula pupula	–	+
Navicula radiosa	–	+
Navicula symmetrica	+	+++
Navicula tripunctata v. schizonemoides	+++	+
Navicula sp.	+	+++

TABLE 2.2-22 (Sheet 2)

Taxa	Neosho River	Wolf Creek
Nitzschia acicularis	+	-
Nitzschia amphibia	-	+
Nitzschia dissipata	+	+++
Nitzschia filiformis	-	+
Nitzschia frustulum v. *perpusilla*	-	+
Nitzschia longissima	-	+
Nitzschia lorenziana	+	+
Nitzschia palea	+	-
Nitzschia subhybrida	-	+
Nitzschia sp.	+++	+++
Pleurosigma sp.	+	+
Rhoicosphenia curvata	-	+
Rhopalodia gibba	-	+
Rhopalodia gibberula	-	+
Stephanodiscus sp.	+++	+
Surirella angusta	-	+
Surirella ovata	+	+++
Surirella sp.	-	+
Synedra minuscula	+	+
Synedra ulna	-	+
Chlorophyta (Green Algae)		
Cladophora glamorerata	+	-
Cladophora sp.	+++	+
Oedogonium sp.	+	-
Spirogyra sp.	-	+
Stigeoclonium sp.	+++	-
Ulothrix sp.	+	-
Zygnema sp.	+	-
Cyanophyta (Blue-green Algae)		
Anabaena sp.	-	+
Anacystis montana	+	-
Calothrix sp.	+	+
Hydrocoleum sp.	+	-
Lyngbya epiphytica	-	+
Lyngbya martensiana	+	+
Lyngbya sp.	+	+
Oscillatoria agardhii	+	+
Oscillatoria sp.	+++	+++
Phormidium tenue	+	+
Phormidium sp.	+	+++
Rivularia sp.	+	-

[a] - indicates the taxon was never dominant (<10%) in the stream.
+ indicates the taxon was dominant at least once in the stream.
+++ indicates the taxon was dominant more than five times in the stream.

TABLE [illegible]23

COMPOSITION, MEAN DENSITY (No./m^3) AND GENERAL CHARACTERISTICS OF ZOOPLANKTON, 1973-78

Taxa	John Redmond[a] Reservoir (Location 1)	Neosho River (Locations 10 & 4)	Wolf Creek	Limnetic	Littoral	Parasitic	Occurrence 1973	1974	1975	1976	1977	1978
COPEPODA												
Nauplii[b]	57,294	16,606	66,466	x			R,N,C[c]	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Calanoid copepodites	4,738	524	2,354	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Cyclopoid copepodites	13,514	3,339	12,482	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Cyclops bicuspidatus thomasi S.A. Forbes	619	114	338	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Cyclops varicans rubellus Lilljeborg	5	<1	4		x		R,N,C	N,C	C			
Cyclops vernalis Fischer	928	371	67	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Diaptomus clavipes[d] Schacht	11	3	1	x			R,N,C	N	R,N,C	N	R,N,C	R,N,C
Diaptomus pallidus Herrick	375	105	1,216	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Diaptomus siciloides Lilljeborg	2,735	379	318	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Ergasilus chautauquaensis Fellows	279	14	36	x		x	R,N,C	R,N,C	R,N,C	R,N	R,N	R,N,C
Ergasilus megaceros Wilson	25	3	1	x		x			R,N	R,N	R,N,C	R,N,C
Ergasilus versicolor Wilson	3	<1	<1	x		x			R,N,C	R,N		R
Eucyclops agilis (Koch)	4	8	50		x		R,N,C	R,N,C	R,N,C	R,C	R,N,C	R,N,C
Eucyclops agilis montanus (Brady)	1	1	6		x			R,C	N,C	R,N,C		N
Eucyclops speratus (Lilljeborg)	1	2	83		x		R,N,C	R,N,C	N,C	R,N,C	C	R,N,C
Eucyclops prionophorus Kiefer			2		x		C	C	C			
Macrocyclops albidus (Jurine)		<1	4		x		C		C	C	N,C	N,C
Mesocyclops edax (S.A. Forbes)	38	5	85	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,C
Orthocyclops modestus (Herrick)			1		x				C	C		
Paracyclops fimbriatus poppei (Rehberg)	<1	<1	4		x		C	C	N,C	R,C	C	N,C
Tropocyclops prasinus mexicanus Kiefer	22	9	5,490	x			R,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Harpacticoida	60	94	156		x		R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
TOTAL COPEPODA	80,652	21,578	89,164									
CLADOCERA												
Alona circumfimbriata (Meegard)	11	20	200		x		R,N,C		R,N,C	R,N,C	N,C	R,N,C
Alona costata Sars			1		x		C	C				
Alona guttata Sars	2	<1	1		x		R,C	C	N,C			
Alona pulchella King		<1	18		x				C	R,N,C		N,C
Alona spp.	2	2	129		x		R,C	N,C	N,C	R,N,C	R,N,C	N
Bosmina longirostris (O. F. Muller)	16,901	4,577	5,438	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Camptocercus oklahomensis Mackin			<1		x		C					
Camptocercus rectirostris (Schodler)			<1		x			C	C			
Ceriodaphnia lacustris Birge	351	154	766	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Ceriodaphnia quadrangula (O. F. Muller)	62	4	561	x			R,N,C	N,C	R,N,C	C	C	C
Chydorus sphaericus (O. F. Muller)	35	39	1,677		x		R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Daphnia ambigua Scourfield	155	13	684	x			R,N,C	R,C	N,C	R,N,C	R,N,C	R,N,C
Daphnia parvula Fordyce	2,473	524	370	x			R,N,C	R,N,C	R,N,C	R,A,C	R,N,C	R,N,C
Daphnia pulex Leydig	62	18	424	x			R,N,C	N	C	R,C	R,C	R,C
Daphnia spp. (immature)	1,990	385	31	x			R,N,C	R,N,C	R,N,C	R,C		R,N,C
Diaphonosoma leuchtenbergianum Fischer	3,715	222	701	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C

WCGS-ER(OLS)

TABLE 2.2-23 (Sheet 2)

Taxa	John Redmond[a] Reservoir (Location 1)	Neosho River (Locations 10 & 4)	Wolf Creek	Limnetic	Littoral	Parasitic	Occurrence 1973	1974	1975	1976	1977	1978
CLADOCERA (continued)												
Disparalona rostrata (Koch)	1	10			x					N	N	R,N
Ilyocryptus sordidus (Lieven)		4	16		x		C	C	N,C	N,C	N,C	N,C
Ilyocryptus spinifer Herrick		<1			x							N
Kurzia latissima (Kurz)		<1	71		x		C	N,C	C	C	C	C
Leptodora kindtii (Focke)	24	<1		x							R	R,N
Leydigia acanthocercoides (Fischer)			1		x				C	C		
Leydigia leydigi (Schoedler)	5	1	46		x		R,C	N,C	N,C	R,C	R,C	N,C
Macrothrix laticornis (Jurina)	<1	12	58		x		N,C	R,N,C	N,C	R,N,C	N,C	N,C
Moina micrura Kurz	1,136	8	34	x			R,C	R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Moina minuta	199	<1		x					R	R,N	R	R
Moina wierzejskii Richard	170	2	<1	x					C		R,N	R
Moina spp. (immature)	129	<1	1	x				R	R,N,C	R		R
Pleuroxus denticulatus Birge	<1	2	38		x		C	N,C	R,N,C	N,C	N,C	N,C
Pleuroxus hamulatus Birge	<1	4	14		x		C	N,C	N,C	R,N,C	N,C	N,C
Pseudochydorus globosus (Baird)			3		x			C	C	C		C
Scapholeberis kingi Sars		<1	33		x		C	N,C	C	C	C	
Sida crystallina (O. F. Muller)	1	<1			x					R	R	R,N
Simocephalus expinosus (Koch)			1		x						C	
Simocephalus serrulatus (Koch)	2	2	15		x		C	C	N,C	R,N,C	N,C	R,N
TOTAL CLADOCERA	27,427	6,006	11,333									
ROTIFERA[d]												
Anuraeopsis sp. Lauterborn	54	8	138	x				N	C	C	N,C	R,N,C
Asplanchna sp. Gosse	1,305	153	560	x				R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Bdelloid rotifers	314	342	1,152		x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Brachionus spp. Pallas	54,705	26,161	17,070	x	x			R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Cephalodella sp. Bory St. Vincent	20	144	225		x			N,C	R,N,C	R,N,C	R,N,C	N,C
Collotheca sp. Harring	529	99	33	x				R,N,C	R,N,C	R,N	R,N	R,C
Colurella sp. Bory St. Vincent	<1	4	2		x			C	C	R	N	C
Conochiloides sp. Blava	6,564	871	5,392	x				R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Dicranophorus sp. Nitzsch			13		x				C			
Eosphora sp. Ehrenberg			14		x				C			C
Euchlanis sp. Ehrenberg		4	69		x			N,C	N,C	N,C	N,C	C
Filinia sp. Bory St. Vincent	1,686	1,347	32,561	x				R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Gastropus sp. Imhof			1	x						C		
Hexarthra sp. Schmarda	12,687	2,745	547	x				R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Horaella sp. Donner			50		x				C			C
Itura sp. Harring and Myers			15		x					C		
Kellicottia sp. Ahlstrom	2	5	8	x				R,N,C	N,C		N	R,N,C
Keratella sp. Bory St. Vincent	69,654	26,554	70,656	x				R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Lecane sp. Nitzsch	2	11	313		x			R,N,C	N,C	N,C	N,C	N,C
Lepadella sp. Bory St. Vincent		34	418		x				N,C	N,C	N,C	N,C
Lophocharis sp. Ehrenberg		1	235		x			C	N,C	C	N,C	C

WCGS-ER (OLS)

TABLE 2.2-23 (Sheet 3)

Taxa	John Redmond[a] Reservoir (Location 1)	Neosho River (Locations 10 & 4)	Wolf Creek	Limnetic	Littoral	Parasitic	Occurrence 1973	1974	1975	1976	1977	1978
ROTIFERA[d] (continued)												
Monommata sp. Bartsch	2	1			x							R,N
Monostyla sp. Ehrenberg		10	163		x			N,C	N,C	N,C	N,C	N,C
Mytilina sp. Bory St. Vincent			8		x			C	C	C		
Notholca sp. Gosse	83	106	314	x				R,N,C	R,N,C	R,N,C	R,N	N,C
Notommata sp. Ehrenberg		<1	3		x				N,C	C		
Notommatid rotifers	7	19	64		x			C	C	N	R,N,C	N,C
Platyias sp. Harring	2	7	52		x			N,C	N,C	R,C	R,N,C	C
Pleurotrocha sp. Ehrenberg			16		x				C			
Ploesoma sp. Herrick			2		x			C	C		C	
Polyarthra sp. Ehrenberg	57,169	57,242	17,454	x				R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Pompholyx sp. Gosse	346	202	2,968	x				R,N,C	R,N,C	R,C	R,N,C	R,C
Rotaria sp. Scopoli	14	10	695		x			C	N,C	R,N,C	N,C	R,N,C
Synchaeta sp. Ehrenberg	17,024	10,661	11,619	x				R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Testudinella sp. Bory St. Vincent	8	24	256		x			R,N,C	R,N,C	R,N,C	N,C	N,C
Trichocerca sp. Lamarck	612	74	1,682	x				R,N,C	R,N,C	R,N,C	R,N,C	R,N,C
Trichotria sp. Bory St. Vincent	<1	196	51		x			C	N,C	R,N,C	N,C	N,C
Trochosphaera sp. Semper			23		x							C
Wolga sp. Skorikov	1	29	188		x			N,C	N,C	R,N,C	C	N,C
Unidentified rotifers	98	82	159					R,N,C	R,N,C	R,N,C	R,N,C	R,C
TOTAL ROTIFERA	222,889	127,146	165,173									
TOTAL ZOOPLANKTON	330,968	154,730	265,670									

[a]Location 1 in John Redmond Reservoir tailwaters from 1976 to 1978.
[b]Nauplii averaged from 1974 to 1978.
[c]R = John Redmond Reservoir (Location 1); N - Neosho River (Locations 10 and 4);
C = Wolf Creek (Locations 7, 2, 3, and 5).
[d]*Diaptomus* species averaged from 1974 to 1978.
[e]Rotifer genera averaged from 1974 to 1978.

TABLE 2.2-24

MEAN SEASONAL ABUNDANCE (No./m^3) OF MAJOR ZOOPLANKTON TAXA COLLECTED IN THE NEOSHO RIVER, 1974-78

	Locations							
	February		April		May	June		July
Taxa	1	10 & 4	1	10 & 4	1	1	10 & 4	1
COPEPODA								
Nauplii	65,955	53,838	80,775	8,125	111,006	41,449	20,699	12,541
Calanoid copepodites	249	131	206	42	2,791	3,665	620	2,283
Cyclopoid copepodites	16,361	8,865	21,682	2,306	53,896	9,957	6,434	4,412
Cyclops bicuspidatus thomasi	2,821	661	2,802	54	484	0	0	0
Cyclops vernalis	825	182	584	16	3,131	1,063	1,454	191
Diaptomus pallidus	170	22	61	8	544	315	112	182
Diaptomus siciloides	1,712	304	96	8	1,901	614	334	546
Ergasilus chautauquaensis	0	0	1	0	0	7	7	20
Harpacticoida	43	58	299	442	35	0	Tr[a]	0
Misc. copepoda	20	35	13	41	11	67	61	39
TOTAL COPEPODA	88,156	64,096	106,519	11,042	173,799	57,137	29,721	20,214
CLADOCERA								
Bosmina longirostris	23,688	4,841	27,399	262	82,669	21,083	14,687	851
Ceriodaphnia lacustris	0	0	0	0	48	53	30	22
Daphnia ambigua	0	5	20	Tr	1,760	10	71	0
Daphnia parvula	306	35	1,694	8	5,031	5,448	2,706	575
Daphnia spp. (immature)	0	0	96	23	70	2,495	880	0
Diaphanosoma leuchtenbergianum	0	0	Tr	1	16	2,919	821	7,723
Moina micrura	0	0	0	0	0	169	32	1,404
Moina minuta	0	0	0	0	0	0	0	251
Moina wierzejskii	0	0	0	0	1,898	16	10	36
Misc. cladocerans	16	64	59	315	134	227	52	18
TOTAL CLADOCERA	24,010	4,945	29,268	609	91,626	32,420	19,289	10,880
ROTIFERA								
Asplanchna spp.	1,804	132	791	0	995	1,454	254	348
Brachionus spp.	103,834	36,531	41,373	37,373	6,689	86,016	64,274	70,816
Conochiloides spp.	1,096	831	5,179	642	82	15,808	3,107	11,492
Filinia spp.	4,656	1,183	5,031	2,528	260	1,789	2,361	1,514
Hexarthra spp.	0	0	0	0	10	33,445	13,545	13,517
Keratella spp.	469,791	147,055	28,960	19,928	155,386	8,846	14,811	2,243
Polyarthra spp.	385,244	391,687	21,310	11,713	27,199	52,639	20,940	4,028
Synchaeta spp.	33,723	34,967	13,881	10,046	6,841	17,762	5,779	523
Misc. rotifers	174	1,297	184	1,548	191	1,413	1,605	1,655
TOTAL ROTIFERA	1,000,322	613,683	116,709	83,778	197,653	219,172	126,676	106,136
TOTAL ZOOPLANKTON	1,112,488	682,724	252,496	95,429	463,078	308,729	175,686	137,230

[a]Less than 1/m^3.

TABLE 2.2-24 (Sheet 2)

Taxa	August 1	August 10 & 4	September 1	September 10 & 4	October 1	October 10 & 4	December 1	December 10 & 4
	Locations							
COPEPODA								
Nauplii	89,496	1,209	76,784	10,563	48,814	217	32,168	18,138
Calanoid copepodites	8,172	147	21,916	3,478	12,220	19	3,957	698
Cyclopoid copepodites	10,015	422	10,230	2,636	8,226	83	7,502	3,063
Cyclops bicuspidatus thomasi	0	0	0	0	28	Tr	170	54
Cyclops vernalis	1,341	42	1,037	89	942	11	645	253
Diaptomus pallidus	412	5	1,894	738	407	1	248	119
Diaptomus siciloides	4,597	132	3,638	568	6,630	27	6,127	1,122
Ergasilus chautauquaensis	1,012	47	1,572	74	703	7	1	3
Harpacticoida	0	1	0	2	0	4	0	8
Misc. copepoda	433	27	314	74	297	12	32	19
TOTAL COPEPODA	115,478	2,032	117,385	18,222	78,267	381	50,850	23,477
CLADOCERA								
Bosmina longirostris	622	2	5,810	4,135	1,857	8	6,897	5,823
Ceriodaphnia lacustris	7	9	5,126	1,993	14	1	0	Tr
Daphnia ambigua	0	0	0	0	0	0	0	0
Daphnia parvula	2,229	Tr	5,475	503	2,562	1	1,370	152
Daphnia spp. (Immature)	0	0	1,945	1,072	0	0	32	2
Diaphanosoma leuchtenbergianum	14,199	60	18,148	1,184	1,636	1	0	0
Moina micrura	4,039	6	11,323	34	141	0	0	0
Moina minuta	689	1	2,169	0	0	0	0	0
Moina wierzejskii	0	0	0	0	181	0	0	0
Misc. cladocerans	0	64	2,316	10	34	172	24	49
TOTAL CLADOCERA	21,785	142	52,312	8,931	6,425	183	8,323	6,026
ROTIFERA								
Asplanchna spp.	945	45	8,609	120	226	0	54	32
Brachionus spp.	116,674	7,280	23,085	271	53,537	2,003	5,804	3,094
Conochiloides spp.	1,862	39	30,349	143	557	45	682	286
Filinia spp.	404	31	406	20	209	Tr	8	8
Hexarthra spp.	19,929	235	62,174	1,398	4,684	47	0	0
Keratella spp.	23,641	158	1,076	590	14,149	956	13,625	12,432
Polyarthra spp.	26,977	854	22,199	2,286	4,241	353	18,478	24,989
Synchaeta spp.	2,204	78	13,032	2,201	39,411	2,244	23,432	10,304
Misc. rotifers	3,329	690	6,892	676	4,736	1,264	89	698
TOTAL ROTIFERA	195,966	9,410	167,822	7,705	121,750	6,912	62,172	51,834
TOTAL ZOOPLANKTON	333,229	11,584	337,519	34,858	206,442	7,476	121,345	81,337

[a]Less than 1/m^3.

TABLE 2.2-25

MEAN SEASONAL ABUNDANCE (No./m^3) OF MAJOR ZOOPLANKTON TAXA COLLECTED IN WOLF CREEK, 1974-78

Taxa	Month						
	February	April	June	August	September	October	December
COPEPODA							
Nauplii	17,581	181,226	57,779	90,219	47,778	70,640	4,071
Calanoid copepodites	2	154	1,692	5,581	7,550	6,868	301
Cyclopoid copepodites	3,244	14,390	9,533	44,806	14,905	22,110	621
Cyclops bicuspidatus thomasi	360	1,960	22	0	0	7	195
Diaptomus pallidus	17	16	440	4,541	3,311	2,570	30
Diaptomus siciloides	1	7	351	367	220	467	808
Eucyclops speratus	27	300	70	28	91	66	64
Tropocyclops prasinus mexicanus	30	3	1,436	30,218	8,817	4,551	351
Harpacticoida	418	475	1	0	30	77	247
Misc. limnetic copepods	22	470	250	226	426	63	56
Misc. littoral copepods	22	36	49	14	55	17	44
TOTAL COPEPODA	21,724	199,037	71,623	176,000	83,183	107,436	6,788
CLADOCERA							
Alona circumfimbriata	54	742	62	1	3	87	408
Alona spp.	6	463	21	1	10	639	95
Bosmina longirostris	365	707	18,225	721	889	2,215	1,091
Ceriodaphnia lacustris	0	22	2,261	182	1,716	105	10
Ceriodaphnia quadrangula	0	5	2,320	0	0	1	1
Chydorus sphaericus	588	7,362	374	2	28	198	1,968
Daphnia ambigua	3	240	2,335	32	403	151	1,460
Daphnia parvula	2	36	156	106	3,477	112	10
Daphnia pulex	0	2,299	617	0	0	0	2
Diaphonosoma leuchtenbergianum	0	1	308	2,702	3,928	67	0
Misc. limnetic cladocerans	4	100	83	104	48	0	9
Misc. littoral cladocerans	52	126	311	155	290	515	555
TOTAL CLADOCERA	1,074	12,103	27,073	4,006	10,792	4,090	5,609
ROTIFERA							
Brachionus spp.	8,418	522	12,607	106,300	3,110	1,911	1,372
Conochiloides spp.	0	0	544	6,345	54,886	1,089	0
Filinia spp.	225,396	3,932	1,246	32,126	9,480	106	0
Keratella spp.	443	91,323	38,137	315,507	44,711	57,379	191
Polyarthra spp.	6,368	6,859	23,993	58,577	26,712	13,434	82
Synchaeta spp.	40,411	14,732	4,508	46	1,202	17,859	7,859
Misc. limnetic rotifers	143	2,668	4,458	31,905	2,292	7,300	156
Misc. littoral rotifers	2,870	3,444	3,151	4,978	5,839	9,899	2,518
TOTAL ROTIFERA	284,049	123,480	88,644	555,784	148,232	108,977	12,178
TOTAL ZOOPLANKTON	306,847	334,620	187,340	735,790	242,207	220,503	24,575

TABLE 2.2-26

DRIFT DENSITIES (No. organisms/100m^3) OF SELECTED MACROINVERTEBRATE FAMILES IN THE TAILWATERS OF JOHN REDMOND RESERVOIR ON THE NEOSHO RIVER (LOCATION 1), 1976-78

		Month							
		February		April		May		June	
		Day	Night	Day	Night	Day	Night	Day	Night
Hydridae	1976	-[a]	147	-	110	-	-	19	-
	1977	-	46	4	-	-	-	-	39
	1978	48	37	32	6	8732	1379	6	2
Chironomidae	1976	-	66	-	41	-	-	419	-
	1977	-	184	217	-	-	-	-	108
	1978	5	4	240	173	579	510	263	74
Hydropsychidae	1976	-	139	-	33	-	-	46	-
	1977	-	34	98	-	-	-	-	3
	1978	140	49	26	54	84	201	306	709
Chaoboridae	1976	-	6	-	169	-	-	159	-
	1977	-	18	23	-	-	-	-	247
	1978	-	-	25	105	56	182	32	27
Simuliidae	1976	-	5	-	55	-	-	83	-
	1977	-	224	5	-	-	-	-	-
	1978	1	-	-	11	100	38	15	13
Naididae	1976	-	68	-	5	-	-	4	-
	1977	-	52	1407	-	-	-	-	1
	1978	-	1	27	-	312	19	-	2
Total density	1976	-	495	-	436	-	-	750	-
	1977	-	765	1869	-	-	-	-	404
	1978	204	95	395	372	10041	2370	893	1006
Flow (cfs)	1976	54	-	-	54	-	-	760	-
	1977	35	-	50	-	-	-	-	7345
	1978	976	976	1430	1430	962	962	424	424

TABLE 2.2-26 (Sheet 2)

		Month								
		July		August		October		December		
		Day	Night	Day	Night	Day	Night	Day	Night	Mean
Hydridae	1976	-	-	2	-	-	2118	161	-	426
	1977	-	-	107	-	-	267	-	35	83
	1978	41	41	-	1279	2980	9697	6719	4740	2322
Chironomidae	1976	-	-	108	-	-	242	45	-	153
	1977	-	-	65	-	-	8	-	-	97
	1978	36	136	-	293	111	838	275	222	227
Hydropsychidae	1976	-	-	23	-	-	108	30	-	63
	1977	-	-	28	-	-	56	-	39	43
	1978	50	1708	-	235	21	9	244	115	173
Chaoboridae	1976	-	-	124	-	-	35	6	-	83
	1977	-	-	407	-	-	208	-	-	151
	1978	20	246	-	95	-	51	5	-	31
Simuliidae	1976	-	-	3	-	-	29	58	-	39
	1977	-	-	-	-	-	-	-	-	38
	1978	2	0	-	-	-	3	124	16	17
Naididae	1976	-	-	2	-	-	34	10	-	20
	1977	-	-	-	-	-	-	-	-	243
	1978	10	0	-	37	26	109	681	736	147
Total density	1976	-	-	274	-	-	2702	375	-	839
	1977	-	-	614	-	-	549	-	74	712
	1978	169	1517	-	2087	3174	10815	8479	5879	3036
Flow (cfs)	1976	-	-	50	-	-	50	50	-	
	1977	-	-	500	-	-	250	-	300	
	1978	525	525	51	51	51	51	20	20	

TABLE 2.2-27

MACROINVERTEBRATE DATA FROM THE NEOSHO RIVER (LOCATIONS 10 AND 4), 1973-78

Sampling Date		Discharge Volume cfs	Total Density (no./m²)[a]		Total Taxa		Diversity Index[a]		Mean Density (No./m²)[a] Naididae		Tubificidae		Ephemeroptera		Plecoptera		Trichoptera		Chironomidae	
			4	10	10	4	10	4	10	4	10	4	10	4	10	4	10	4	10	4
25 February	1976	45	4366	3657	46	29	3.78	3.30	378	19	19	198	57	132	38	1172	283	38	3147	1285
22 February	1977	35	35504	8902	48	33	2.27	2.85	66	0	501	94	973	274	0	38	3034	9	29286	8108
21 February	1978	1440	104	718	7	18	1.88	2.39	0	0	28	85	0	19	0	9	38	482	38	104
27 March	1973	6950	-[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26 March	1974	5450	-[c]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17 April	1975	3820	340	388	10	14	1.90	2.23	0	10	218	28	0	19	0	0	0	114	86	104
6 April	1976	57	13098	8496	54	43	4.32	3.76	2873	2618	19	57	142	160	775	671	1105	19	6709	4593
4 April	1977	50	15498	5746	51	37	3.74	3.54	3194	1134	180	208	396	37	9	9	56	0	11000	3884
25 April	1978	1420	1606	1002	20	21	3.43	3.62	9	0	28	19	19	104	57	66	548	208	463	208
11 June	1973	3740	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 June	1974	3260	38	142	4	6	*[d]	*	0	0	9	0	0	38	0	0	0	0	9	38
10 June	1975	1010	2646	2174	29	22	2.05	2.67	28	0	0	10	264	567	19	0	1200	1163	1012	369
15 June	1976	416	350	1890	14	18	2.31	2.10	0	0	28	0	151	1200	0	66	66	321	57	255
8 June	1977	7345	265	605	12	23	1.89	3.33	9	28	104	132	9	95	0	0	9	28	57	113
27 June	1978	424	9894	2022	31	23	2.36	3.09	0	19	94	293	1029	916	19	19	7862	0	803	576
10 September	1973	61	-	1598	-	19	-	*	-	0	-	0	-	906	-	0	-	38	-	416
9 September	1974	4420	265	463	10	7	*	*	0	0	0	350	113	85	0	0	57	0	38	28
9 September	1975	395	974	1257	11	18	1.01	2.41	0	0	19	28	19	76	56	454	832	520	10	57
9 August	1976	48	23795	7560	45	29	3.38	2.92	19	9	28	246	1624	3676	737	85	18919	19	2240	3307
9 August	1977	500	510	1701	17	19	2.49	2.66	0	0	255	47	122	1125	9	47	0	311	104	151
29 August	1978	51	7881	1077	37	17	3.54	3.03	0	0	19	123	1654	19	9	0	793	28	5207	888
5 October	1976	60	16282	4328	42	21	4.05	2.62	85	9	0	397	2930	312	355	38	3496	0	8533	3393
4 October	1977	250	14317	14723	25	26	1.83	2.09	9	9	47	132	302	841	346	208	12786	12748	652	756
10 October	1978	20	4536	3449	29	32	3.18	2.87	123	142	255	387	1143	1143	151	0	28	19	2693	2164
10 December	1973	3920	-	143	-	9	-	*	-	0	-	76	-	20	-	0	-	38	-	19
10 December	1974	1240	189	1370	13	25	*	*	0	9	19	728	19	19	0	0	19	19	94	576
3 December	1975	73	567	2438	19	36	3.36	2.70	19	57	19	180	57	227	10	10	19	57	246	1664
14 December	1976	42	16084	9941	53	42	4.27	3.58	94	104	293	718	3827	672	1011	9	4403	75	4876	7475
13 December	1977	300	2485	1852	19	19	2.69	2.31	19	0	66	38	9	37	9	76	1427	1228	539	217
12 December	1978	20	11179	3081	36	35	3.18	3.71	444	9	47	0	321	132	9	813	28	18	10140	1673

[a]Mean of two replicates.
[b]This location not sampled in 1973.
[c]Not sampled due to rising water conditions.
[d]Insufficient sample size.

TABLE 2.2-28

MACROINVERTEBRATE DENSITIES (No./m^2) OF SELECTED FAMILIES FROM WOLF CREEK (LOCATIONS 7, 2, 3, AND 5), 1973-78

Sampling Date			Naididae				Tubificidae				Chironomidae			
			7	2	3	5	7	2	3	5	7	2	3	5
25	February	1976	0	1191	57	0	1021	614	2854	747	491	737	1077	265
22	February	1977	0	0	0	-[b]	265	0	28	-	274	0	57	-
21	February	1978	76	-[a]	9	0	312	-	19	293	661	-	57	567
27	March	1973	-	9	0	-	-	1531	548	-	-	852	236	-
26	March	1974	-	9	9	0	-	294	370	237	-	161	246	48
17	April	1975	0	9	29	0	95	95	1040	67	322	917	2476	152
6	April	1976	47	7173	501	19	605	832	954	869	94	539	520	217
5	April	1977	19	-	0	-[b]	19	-	444	-	19	-	0	-
25	April	1978	76	-	9	0	416	-	104	444	170	-	1125	113
11	June	1973	-	0	0	-	-	993	284	-	-	738	66	-
11	June	1974	-	9	0	0	-	303	455	76	-	275	341	29
10	June	1975	9	9	0	0	199	520	265	0	1521	2051	72	0
15	June	1976	1644	1729	47	9	28	860	1134	879	4952	378	350	794
8	June	1977	66	-	0	9	142	-	57	255	142	-	85	104
27	June	1978	255	-	0	151	227	-	38	0	1304	-	841	47
10	September	1973	-	0	0	-	-	492	152	-	-	48	57	-
9	September	1974	-	0	0	0	-	57	38	9	-	38	0	0
9	September	1975	19	0	0	0	29	880	691	189	29	105	199	9
10	August	1976	38	57	28	-	57	1162	737	113	66	255	57	57
8-9	August	1977	454	-	0	0	198	-	47	501	66	-	0	85
29	August	1978	-	-	0	0	38	-	76	340	1143	-	227	85
5	October	1976	312	1068	-[b]	-[b]	6095	1786	-	-	5330	2466	-	-
3-4	October	1977	0	-	38	0	180	-	76	47	76	-	463	9
10	October	1978	0	-	9	-[b]	350	-	680	-	624	-	548	-
10	December	1973	-	0	0	-	-	208	38	-	-	898	57	-
10	December	1974	-	9	0	0	-	445	436	38	-	3601	3054	359
3	December	1975	48	76	0	0	161	1247	738	190	95	76	190	9
14	December	1976	38	94	-[b]	-[b]	2788	1380	-	-	1351	973	-	-
12-13	December	1977	2731	-	0	0	652	-	57	539	2088	-	57	425
12	December	1978	0	-	208	0	784	-	350	520	57	-	832	19

TABLE 2.2-28 (Sheet 2)

Sampling Date			Sphaeriidae				Simuliidae				Certapogonidae			
			7	2	3	5	7	2	3	5	7	2	3	5
25	February	1976	19	57	208	19	0	0	0	0	0	19	19	0
22	February	1977	0	0	189	-[b]	0	0	0	-	9	0	0	-
21	February	1978	0	-[a]	0	0	0	-	0	0	9	-	0	0
27	March	1973	-	123	28	-	-	3289	3525	-	-	38	10	-
26	March	1974	-	133	38	0	-	38	444	76	-	19	9	0
17	April	1975	19	9	48	9	0	0	815	1181	9	0	85	0
6	April	1976	0	0	180	85	0	0	0	0	0	0	567	9
5	April	1977	0	-	0	-[b]	0	-	0	-	0	-	0	-
25	April	1978	0	-	0	0	0	-	132	0	9	-	0	0
11	June	1973	-	180	10	-	-	9	0	-	-	19	10	-
11	June	1974	-	19	29	0	-	0	76	0	-	0	0	0
10	June	1975	161	114	0	9	0	0	0	0	19	9	0	0
15	June	1976	0	76	9	47	9	0	0	0	28	38	38	9
8	June	1977	0	-	9	0	0	-	9	0	0	-	0	0
27	June	1978	47	-	66	28	0	-	0	0	0	-	0	0
10	September	1973	-	114	114	-	0	0	0	0	-	0	0	-
9	September	1974	-	9	0	0	-	9	9	0	-	0	0	0
9	September	1975	0	38	85	0	0	0	0	0	0	48	57	0
10	August	1976	19	161	9	94	0	0	0	0	9	9	9	0
8-9	August	1977	0	-	0	0	0	-	0	0	0	-	0	0
29	August	1978	0	-	9	0	0	-	0	0	0	-	0	9
5	October	1976	293	397	-[b]	-[b]	0	0	-	-	964	9	-	-
3-4	October	1977	9	-	0	0	0	-	0	0	9	-	0	9
10	October	1978	0	-	0	-[b]	0	-	0	0	0	-	161	-
10	December	1973	-	198	10	-	-	1494	388	-	-	0	0	-
10	December	1974	-	57	123	19	-	992	803	1266	-	19	19	0
3	December	1975	9	29	274	47	0	0	0	0	0	132	19	0
14	December	1976	0	0	-[b]	-[b]	0	0	-	-	38	0	-	-
12-13	December	1977	0	-	9	0	47	-	397	9	104	-	0	0
12	December	1978	0	-	9	0	0	-	0	0	0	-	217	-

[a] Not sampled.
[b] Location dry.

TABLE 2.2-29

CHECKLIST OF FISH SPECIES COLLECTED BY ALL SAMPLING METHODS, 1973-78[a]

Family and Scientific Name	Common Name	Year Collected 1973	1974	1975	1976	1977	1978
Lepisosteidae (gars)							
Lepisosteus platostomus	Shortnose gar	X		X	X	X	X
Lepisosteus osseus	Longnose gar				X	X	X
Clupeidae (herrings)							
Dorosoma cepedianum	Gizzard shad	X	X	X	X	X	X
Cyprinidae (carps and minnows)							
Campostoma anomalum	Stoneroller	X		X	X	X	
Cyprinus carpio	Carp	X	X	X	X	X	X
Notemigonus crysoleucas	Golden shiner	X	X	X	X	X	X
Notropis buchanani	Ghost shiner	X	X	X	X	X	X
Notropis lutrensis	Red shiner	X	X	X	X	X	X
Notropis rubellus	Rosyface shiner		X	X	X		
Notropis stramineus	Sand shiner		X	X	X	X	X
Notropis umbratilis	Redfin shiner		X	X	X		
Phenacobius mirabilis	Suckermouth minnow	X	X	X	X	X	X
Pimephales notatus	Bluntnose minnow	X	X	X	X	X	X
Pimephales promelas	Fathead minnow	X	X		X	X	X
Pimephales tenellus	Slim minnow		X	X	X	X	X
Pimephales vigilax	Bullhead minnow	X	X	X	X	X	X
Catostomidae (suckers)							
Carpiodes sp.	YOY carpsucker			X			
Carpiodes carpio	River carpsucker	X	X	X	X	X	X
Ictiobus sp.	YOY buffalo			X			
Ictiobus bubalus	Smallmouth buffalo	X	X	X	X	X	X
Ictiobus cyprinellas	Bigmouth buffalo					X	X
Ictiobus niger	Black buffalo					X	X
Moxostoma erythrurum	Golden redhorse	X				X	X
Moxostoma macrolepidotum	Shorthead redhorse	X		X		X	X
Cycleptus elongatus	Blue sucker				X	X	X

TABLE 2.2-29 (Sheet 2)

Family and Scientific Name	Common Name	Year Collected 1973	1974	1975	1976	1977	1978
Ictaluridae (freshwater catfishes)							
Ictalurus melas	Black bullhead	X	X	X	X	X	X
Ictalurus natalis	Yellow bullhead		X	X			
Ictalurus punctatus	Channel catfish	X	X	X	X	X	X
Pylodictis olivaris	Flathead catfish	X				X	X
Noturus flavus	Stonecat				X	X	X
Noturus placidus	Neosho madtom				X	X	
Cyprinodontidae (topminnows)							
Fundulus notatus	Blackstripe topminnow	X	X	X	X		
Poeciliidae (livebearers)							
Gambusia affinis	Mosquitofish		X	X	X	X	X
Atherinidae (silversides)							
Labidesthes sicculus	Brook silversides		X		X	X	
Percichthyidae (temperate basses)							
Morone chrysops	White bass	X	X	X	X	X	X
Centrarchidae (sunfishes)							
Lepomis cyanellus	Green sunfish	X	X	X	X	X	X
Lepomis humilis	Orangespotted sunfish	X	X	X	X	X	X
Lepomis macrochirus	Bluegill	X	X	X	X	X	
Lepomis megalotis	Longear sunfish		X	X	X	X	X
Micropterus punctulatus	Spotted bass	X				X	X
Micropterus salmoides	Largemouth bass	X	X	X	X	X	X
Pomoxis annularis	White crappie	X	X	X	X	X	X
Percidae (perches)							
Etheostoma chlorosomum	Bluntnose darter		X		X		
Etheostoma spectabile	Orangethroat darter	X			X		

TABLE 2.2-29 (Sheet 3)

Family and Scientific Name	Common Name	Year Collected 1973	1974	1975	1976	1977	1978
Percidae (perches) (continued)							
Percina caprodes	Logperch	X	X	X	X	X	X
Percina phoxocephala	Slenderhead darter			X	X	X	X
Stizostedion vitreum	Walleye	X					X
Sciaenidae (drums)							
Aplodinotus grunniens	Freshwater drum	X	X	X	X	X	X
Total no. of species		30	31	31	38	39	37
Accumulated total no. of species		30	39	40	44	46	46

[a]Scientific and common names as listed by Baily (1970).

TABLE 2.2-30

NUMBER AND RELATIVE ABUNDANCE OF FISH COLLECTED ANNUALLY
BY ALL SAMPLING METHODS IN THE NEOSHO RIVER AND WOLF CREEK, 1973-78

Species	Years						Total	Relative Abundance(%)
	1973	1974	1975	1976	1977	1978		
Longnose gar				3	8	7	18	0.1
Shortnose gar	2		1	6	2	2	13	0.1
Gizzard shad	56	520	22	1684	588	1737	4607	19.9
Stoneroller	2		5	23	2		32	0.1
Carp	6	5	4	49	126	135	325	1.4
Golden shiner	52	7	4	23	30	29	145	0.6
Ghost shiner	109	83	135	607	402	274	1610	7.0
Red shiner	445	1113	1888	3053	1391	2660	10550	45.7
Rosyface shiner		2	1	1			4	<0.1
Sand shiner		2	1	10	1	2	16	0.1
Redfin shiner		9	2	12			23	0.1
Suckermouth minnow	7	2	3	16	1	7	36	0.2
Bluntnose minnow	10	11	23	97	31	13	185	0.8
Fathead minnow	20	1		27	40	121	209	0.9
Slim minnow		13	65	47	7	1	133	0.6
Bullhead minnow	106	3	17	242	14	174	556	2.4
River carpsucker	27	6	36	14	211	151	445	1.9
Smallmouth buffalo	5	3	8	10	90	118	234	1.0
Bigmouth buffalo					79	26	105	0.5
Black buffalo					1	6	7	<0.1
Golden redhorse	1				3	1	5	<0.1
Shorthead redhorse	1				2	3	6	<0.1
Blue sucker				18	35	38	91	0.4
Black bullhead	48	6	3	63	27	9	156	0.7
Yellow bullhead		1	2				3	<0.1
Channel catfish	14	7	18	53	110	145	347	1.5
Fathead catfish	1				15	17	33	0.1
Stonecat				8	2	1	11	<0.1

TABLE 2.2-30 (Sheet 2)

Species	Years 1973	1974	1975	1976	1977	1978	Total	Relative Abundance(%)
Neosho madtom				12	19	46	77	0.3
Blackstripe topminnow	28	16	35	63			142	0.6
Mosquitofish		26	110	54	49	72	311	1.3
Brook silversides				36	15		51	0.2
White bass	81	21	23	185	53	65	428	1.9
Green sunfish	33	12	54	22	34	232	387	1.7
Orangespotted sunfish	39	3	32	144	196	211	625	2.7
Bluegill	5	38	6	2	4		55	0.2
Longear sunfish		1	2	8	43	12	66	0.3
Spotted bass	1				11	7	19	0.1
Largemouth bass	2	1	5	16	6	3	33	0.1
White crappie	42	10	19	112	123	98	404	1.7
Bluntnose darter	1			2			3	<0.1
Orangethroat darter		2		8			10	<0.1
Log perch	1	1	3	4	1	1	11	<0.1
Slenderhead darter			3	12	5	3	23	0.1
Walleye	2					5	7	<0.1
Freshwater drum	12	8	62	13	219	223	537	2.3
Total	1159	1933	2592	6759	3996	6655	23094	

TABLE 2.2-31

NUMBER AND RELATIVE ABUNDANCE OF FISH COLLECTED BY SEINING IN WOLF CREEK DURING THE PRECONSTRUCTION AND CONSTRUCTION PHASES, 1973-78

Species	Preconstruction				Construction		Total	Relative Abundance(%)
	1973	1974	1975	1976	1977	1978		
Gizzard shad				4	88		92	2.8
Carp	1			46	8	1	56	1.7
Red shiner	328	176	309	125	221	274	1433	44.1
Ghost shiner				1	13	6	20	0.6
Golden shiner	49	7	4	23	15	20	118	3.6
Rosyface shiner		2	1	1			4	0.1
Redfin shiner		3		12			15	0.5
Sand shiner			2				2	0.1
Suckermouth minnow	7	2	3	9		4	25	0.8
Bluntnose minnow	10	9	20	54	1	2	96	3.0
Slim minnow				15		1	16	0.5
Bullhead minnow	4			4	2		10	0.3
Fathead minnow	19	1		25	34	117	196	6.0
Stoneroller	2		5	16	1		24	0.7
River carpsucker	3		1		5		9	0.3
Smallmouth buffalo	2		1		4	1	8	0.2
Golden redhorse	1						1	<0.1
Shorthead redhorse	1						1	<0.1
Channel catfish	1				1		2	0.1
Black bullhead	48	5	3	62	27	9	154	4.7
Yellow bullhead		1	2				3	0.1
Blackstripe topminnow	28	12	35	59			134	4.1
Mosquitofish		2		1			3	0.1
Largemouth bass	2	1	3	14	1		21	0.6
Bluegill	5	1	5	2			13	0.4
Longear sunfish				6	8	2	16	0.5
Green sunfish	31	9	54	23	6	64	187	5.8
Orangespotted sunfish	28		28	122	186	192	556	17.1
White crappie	4	1	3	2		8	18	0.6

TABLE 2.2-31 (Sheet 2)

Species	Preconstruction 1973	1974	1975	1976	Construction 1977	1978	Total	Relative Abundance (%)
Bluntnose darter	1			2			3	0.1
Orangethroat darter		2		1			3	0.1
Log perch	1	1	3	4	1		10	0.3
Total no. species	22	17	18	25	18	14	32	
Total no. fish	576	235	482	633	622	701	3249	

TABLE 2.2-32

NUMBER AND RELATIVE ABUNDANCE OF FISH COLLECTED BY SEINING IN THE NEOSHO RIVER DURING THE PRECONSTRUCTION AND CONSTRUCTION PHASES, 1973-78

Species	Preconstruction				Construction		Total	Relative Abundance(%)
	1973	1974	1975	1976	1977	1978		
Gizzard shad			3	1669	41	1174	2887	19.1
Carp				2	1	33	36	0.2
Redfin shiner		6					6	<0.1
Red shiner	42	910	1558	2928	981	2381	8800	58.3
Ghost shiner	35	21	100	606	412	270	1444	9.6
Sand shiner		2	1	10		2	15	0.1
Golden shiner	1			3	15	9	28	0.2
Bullhead minnow	92	2	14	238	12	174	532	3.5
Slim minnow		7	64	32	6		109	0.7
Bluntnose minnow		2	3	43	31	11	90	0.6
Fathead minnow				2	6	2	10	0.1
Suckermouth minnow				4	1	3	8	0.1
Stoneroller				8	1		9	0.1
River carpsucker	1			1		12	14	0.1
Smallmouth buffalo						52	52	0.3
Black buffalo						1	1	<0.1
Channel catfish			5	40	13	67	125	0.8
Black bullhead				1			1	<0.1
Stonecat				8	1	1	10	0.1
Neosho madtom				12	19	46	77	0.5
Brook silversides				36			36	0.2
Blackstriped topminnow		1		4			5	<0.1
Mosquitofish		24	108	54	49	69	304	2.0
White bass	5	5	12	185	1	11	219	1.5
Largemouth bass			2	1	4	2	9	0.1
Spotted bass	1				1	1	3	<0.1

TABLE 2.2-32 (Sheet 2)

Species	Preconstruction 1973	1974	1975	1976	Construction 1977	1978	Total	Relative Abundance(%)
Bluegill		2	1		2		5	<0.1
Longear sunfish		1	2		1	1	5	<0.1
Green sunfish	2				2	15	19	0.1
Orangespotted sunfish	10	2	2	22	8	16	60	0.4
White crappie	15	4		13	9	59	100	0.7
Log perch						1	1	<0.1
Orangethroat darter				7			7	<0.1
Slenderhead darter			2	12	6	3	23	0.2
Freshwater drum	3	1	36	3	2	2	47	0.3
Total no. species	11	15	16	27	26	27		
Total no. fish	207	990	1913	5944	1625	4418	15097	

TABLE 2.2-33

FISH COLLECTED BY ELECTROSHOCKING IN THE NEOSHO RIVER, 1977-1978

	Year Collected					
	1977		1978		Total	
Species	No.	%	No.	%	No.	%
Longnose gar	6	0.4	7	0.5	13	0.4
Shortnose gar	2	0.1	3	0.2	5	0.2
Gizzard shad	457	31.1	563	36.7	1020	34.0
Carp	116	7.9	101	6.6	217	7.2
Red shiner	4	0.3	2	0.1	6	0.2
Sand shiner	1	0.1			1	<0.1
Ghost shiner	1	0.1			1	<0.1
Blue sucker	33	2.2	38	2.5	71	2.4
River carpsucker	199	13.5	139	9.1	338	11.3
Bigmouth buffalo	73	5.0	28	1.8	101	3.4
Smallmouth buffalo	79	5.4	63	4.1	142	4.7
Black buffalo	1	0.1	5	0.3	6	0.2
Golden redhorse	3	0.2	1	0.1	4	0.1
Shorthead redhorse	1	0.1	3	0.2	4	0.1
Channel catfish	93	6.3	78	5.1	171	5.7
Flathead catfish	14	1.0	17	1.1	31	1.0
Brook silversides	15	1.0			15	0.5
Mosquitofish			1	0.1	1	<0.1
White bass	48	3.3	54	3.5	102	3.4
Largemouth bass	1	0.1	1	0.1	2	0.1
Spotted bass	8	0.5	6	0.4	14	0.5
Bluegill	2	0.1			2	0.1
Longear sunfish	11	0.7	9	0.6	20	0.7
Green sunfish	26	1.8	153	10.0	179	6.0
Orangespotted sunfish	2	0.1	3	0.2	5	0.2
White crappie	83	5.7	31	2.0	114	3.8
Walleye			5	0.3	5	0.2
Freshwater drum	190	12.9	221	14.4	411	13.7
No. species	26		24		28	
Total no. fish	1469		1532		3001	

TABLE 2.2-34

SPECIES AND NUMBER OF FISH COLLECTED BY ELECTROSHOCKING AT EACH SAMPLING LOCATION IN THE NEOSHO RIVER, 1977-78

Species	Sampling Locations		
	1[a]	10[b]	4[b]
Longnose gar	1	1	11
Shortnose gar	1	1	3
Gizzard shad	901	58	61
Carp	59	118	40
Red shiner	3	1	2
Sand shiner	1		
Ghost shiner	1		
Blue sucker	30	23	18
River carpsucker	236	65	37
Smallmouth buffalo	69	51	22
Bigmouth buffalo	94	6	1
Black buffalo	1	1	4
Golden redhorse	3	1	
Shorthead redhorse	3	1	
Channel catfish	102	55	14
Flathead catfish	23	3	5
Brook silversides	14		1
Mosquitofish	1		
White bass	96	2	4
Largemouth bass	1	1	
Spotted bass	2	5	7
Bluegill	2		
Green sunfish	176	2	
Longear sunfish	16	2	2
Orangespotted sunfish	4		1
White crappie	108	3	3
Walleye	4		1
Freshwater drum	122	171	118
Total no. species	28	21	20

[a] Total of 15 sampling dates.
[b] Total of 11 sampling dates.

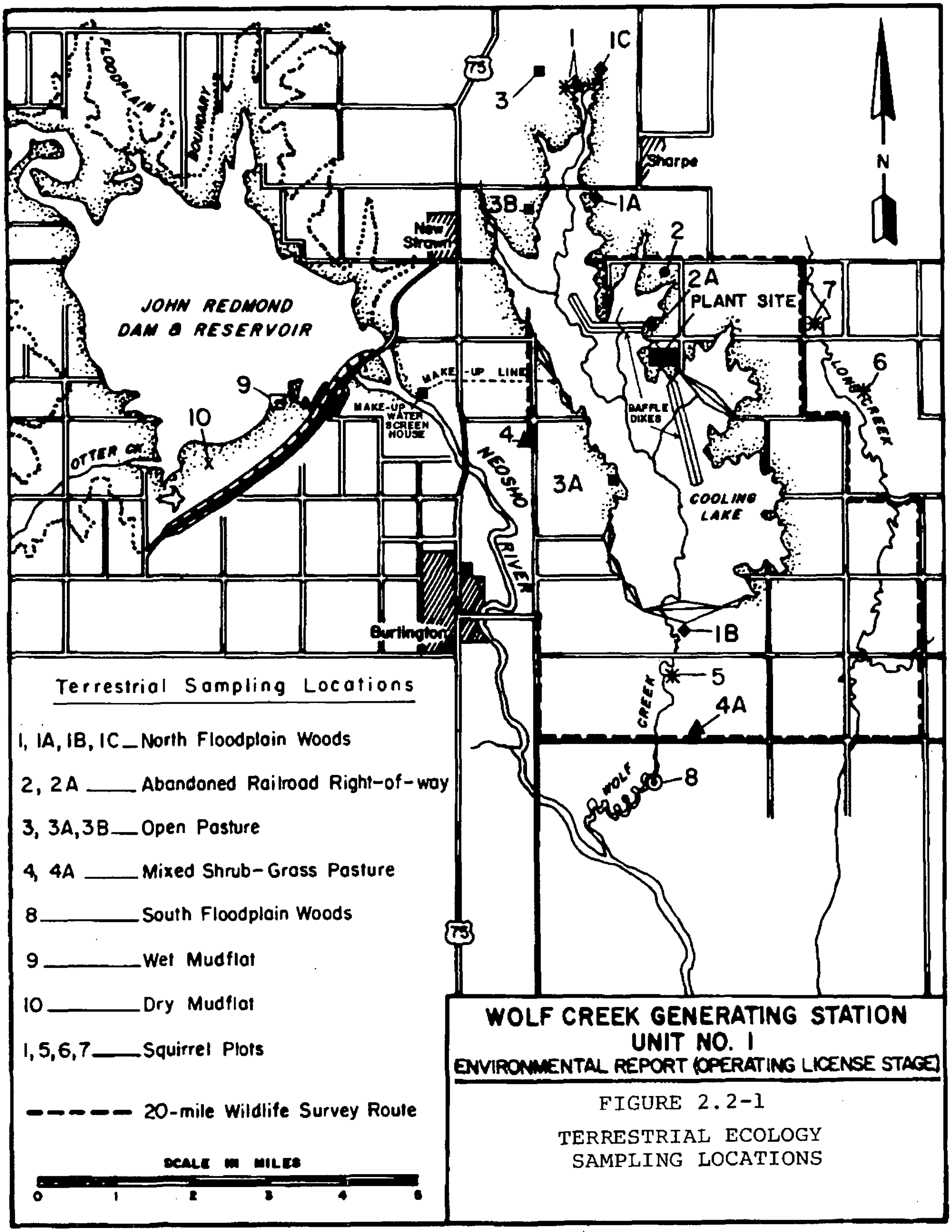
TABLE 2.2-35

ABUNDANCE OF FISH LARVAE COLLECTED FROM THE TAILWATERS OF JOHN REDMOND RESERVOIR, 1976-78

Month	Total Density (No./100 m^3)	Taxa Collected	Relative Abundance(%)
1976			
April	0.0		
May	13.5	Gizzard shad	8.2
		Carp	9.8
		Catostomidae (suckers)	80.3
		White bass	1.6
June	2029.3	Gizzard shad	99.4
		Cyprinidae (minnows)	0.1
		Carp	0.1
		Catostomidae (suckers)	0.2
		White crappie	<0.1
		Freshwater drum	0.2
		Unidentified larvae	<0.1
July	7.9	Gizzard shad	10.0
		Cyprinidae (minnows)	60.0
		Lepomis sp. (sunfish)	10.0
		Freshwater drum	20.0
1977			
April	0.3	Gizzard shad	100.0
May	269.8	Gizzard shad	96.8
		White bass	0.1
		Lepomis sp. (sunfish)	0.1
		Pomoxis sp. (crappie)	0.4
		Freshwater drum	2.6
June	65.7	Gizzard shad	67.4
		Cyprinidae (minnows)	3.2
		Carp	1.0
		Catostomidae (suckers)	16.8
		White bass	0.3
		Freshwater drum	10.0
		Unidentified larvae	1.3
July	6.6	Gizzard shad	11.5
		Cyprinidae	11.5
		Channel catfish	57.7
		Freshwater drum	19.2

TABLE 2.2-35 (Sheet 2)

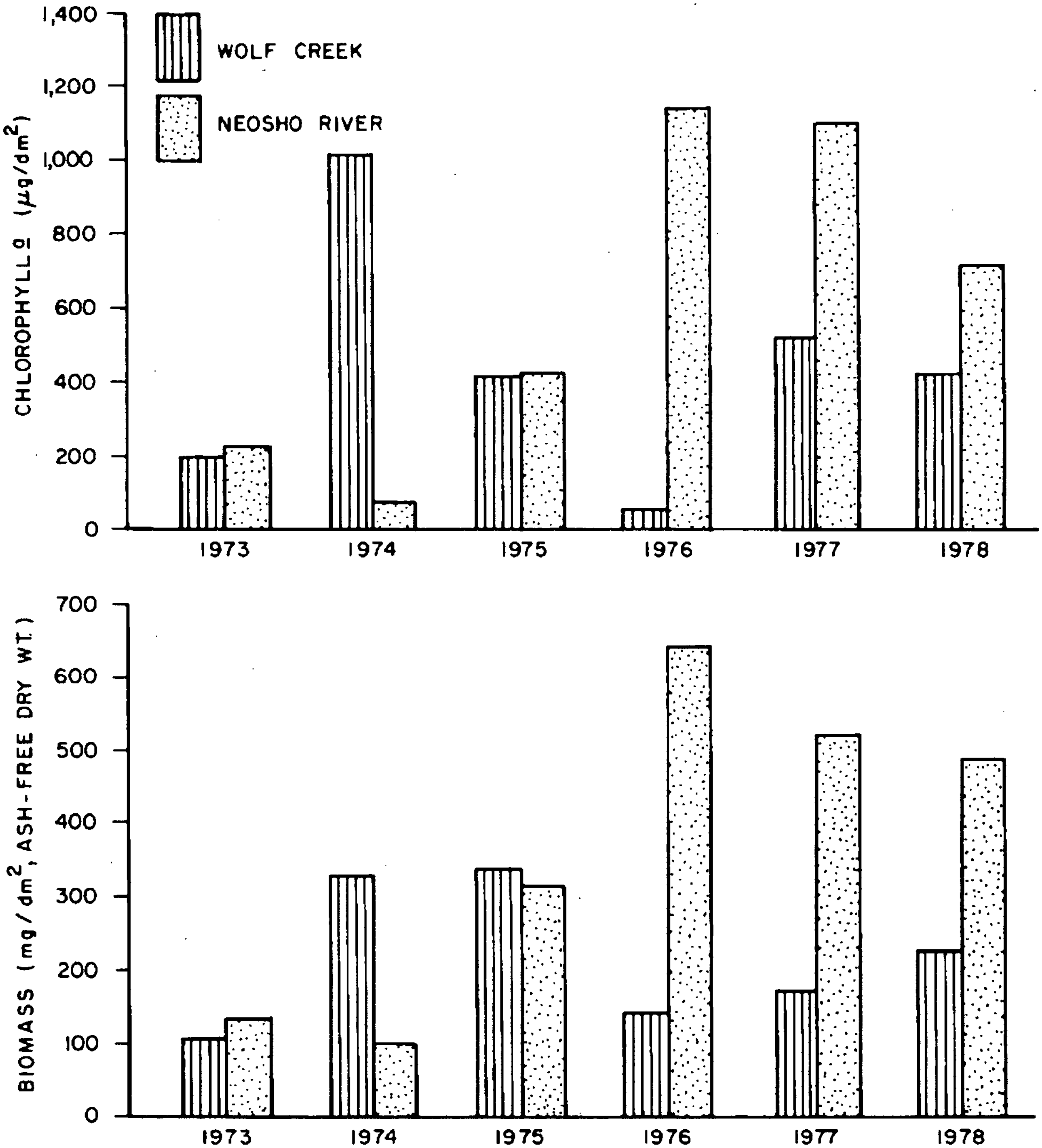
Month	Total Density (No./100 m^3)	Taxa Collected	Relative Abundance(%)
1978			
April	91.6	Carp	65.7
		Catostomidae (suckers)	25.8
		Unidentified larvae	8.5
May	197.1	Gizzard shad	90.8
		Carp	2.9
		Catostomidae (suckers)	4.0
		Percidae (perch and darters)	0.3
		Freshwater drum	1.4
		Unidentified larvae	0.6
June	572.6	Gizzard shad	98.2
		Cyprinidae (minnows)	0.1
		Carp	0.3
		Catostomidae (suckers)	0.2
		White bass	1.0
		Pomoxis sp. (crappie)	0.1
		Freshwater drum	0.1
July	3.4	Cyprinidae (minnows)	84.2
		Freshwater drum	5.3
		Unidentified larvae	10.5



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

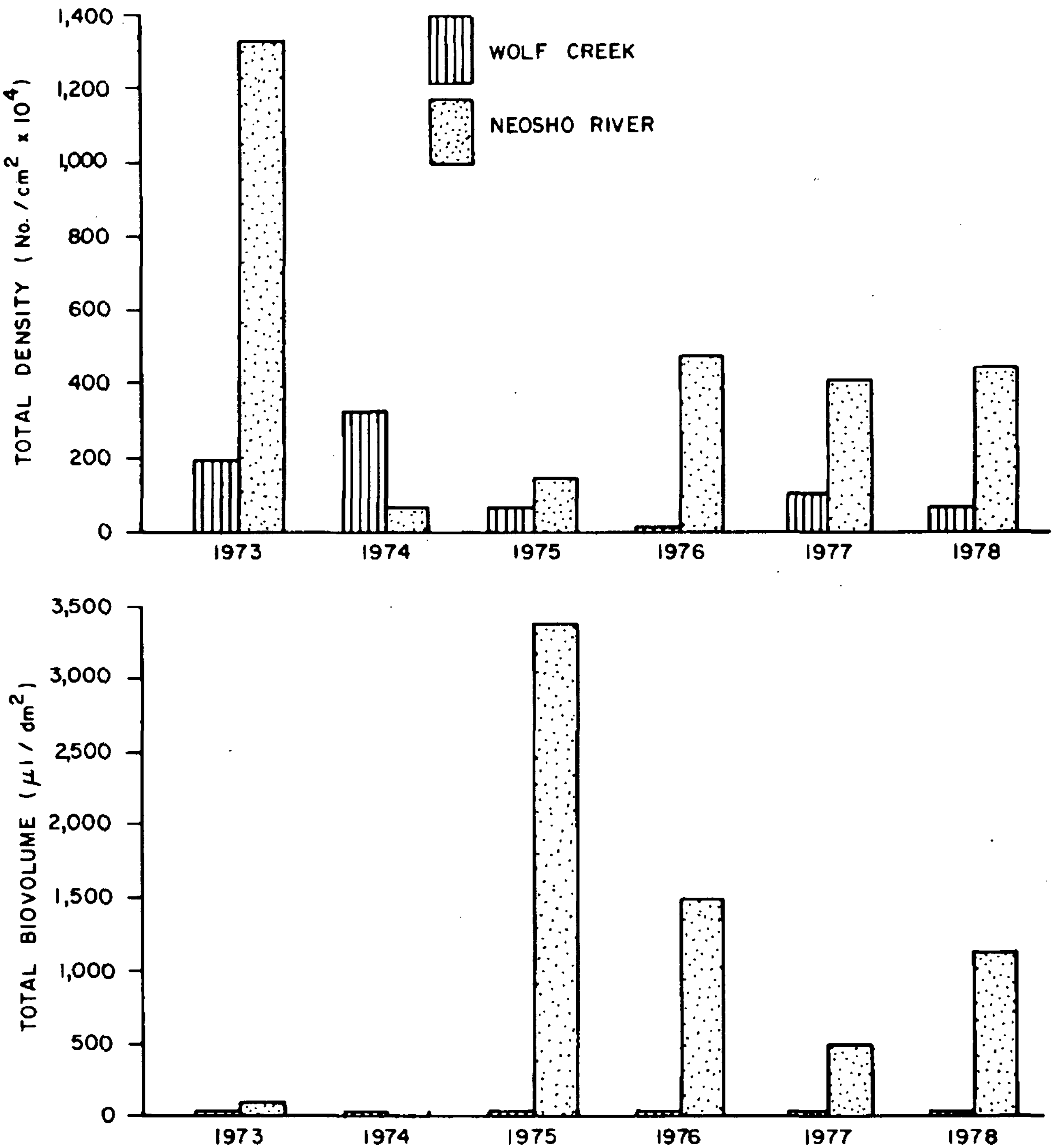
FIGURE 2.2-1

TERRESTRIAL ECOLOGY SAMPLING LOCATIONS



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.2-2
AVERAGE BIMONTHLY CHLOROPHYLL a AND BIOMASS VALUES FOR PERIPHYTON COLLECTED FROM NATURAL SUBSTRATES 1973-78



WOLF CREEK GENERATING STATION
UNIT NO. 1
ENVIRONMENTAL REPORT (OPERATING LICENSE STAGE)

FIGURE 2.2-3
AVERAGE BIMONTHLY DENSITY AND BIOVOLUME VALUES FOR PERIPHYTON COLLECTED FROM NATURAL SUBSTRATES 1973-78

2.3 METEOROLOGY

The meteorology of the Wolf Creek Generating Station site and vicinity have previously been described in Section 2.6 of the Environmental Report - Construction Permit Stage [ER(CPS)]. Section 2.3 of the ER(OLS) updates some of the information previously presented, presents some new information, and also repeats much of the information from the ER(CPS) for continuity.

All onsite meteorological conditions presented in the ER(OLS) are based on the 2-year period from June 1, 1973 to May 31, 1975. The ER(CPS) referenced only the first 12 months of this period. Onsite data for temperature, water vapor, stability, and wind persistence are now included in the ER(OLS), whereas before they were only presented in the Preliminary Safety Analysis Report. Long-term data for cloud cover, sunshine, and the fastest mile winds at Topeka and Wichita are also new.

The long-term data bases for temperature, water vapor, and precipitation in the ER(OLS) have been updated to the following years:

	WICHITA		TOPEKA	
DATA	ER(CPS)	ER(OLS)	ER(CPS)	ER(OLS)
Temperature				
(average)	1931-1960	1941-1970	1931-1960	1941-1970
(extremes)	1965-1972	1953-1978	1966-1972	1947-1978
Water Vapor				
(relative humidity)	1953-1963	1954-1978	1964-1968	1965-1978
(fog)	1953-1963	1954-1978	1964-1968	1947-1978
Precipitation				
(average)	1931-1960	1941-1970	1931-1960	1941-1978
(snowfall)	1954-1972	1954-1978	1947-1972	1947-1978

The indicated revisions to Section 2.3 of the ER(OLS) have been made to incorporate new data and to maintain consistency with the more comprehensive treatment of meteorology presented in Section 2.3 of the Final Safety Analysis Report. Upon the completion of the third full year of onsite monitoring in 1980, this section will be updated.

2.3.1 GENERAL

The climate of east-central Kansas is continental, characterized by rapid changes in temperature, marked extremes, and large daily and annual temperature ranges. Kansas weather is largely affected by two physical features: the Rocky Mountains to the west, and the Gulf of Mexico to the south. The mountains on the west prevent the import of moisture from the Pacific Ocean, while the Gulf is the moisture source for much of the precipitation in Kansas.

The topography of the general site area consists of undulating terrain. The microclimate of the area is largely a result of the synoptic-scale weather phenomena with only a weak influence from the terrain; weather is uniform over the landscape.

In the following sections, weather-station summaries from nearby locations have been used to establish site climatology. These station locations, as well as the site itself, are shown on Figure 2.3-1. Data from onsite measurements and from nearby stations of the National Weather Service are used in preparing this report. The only first order National Weather Service stations in the area are at Topeka and Wichita, both having extensive data. Burlington, 4 miles southwest of the site, has some limited data available that have been used when applicable. Because it has a good length of continuous record, is close to the site, and has approximately the same elevation and exposure, the Chanute, Kansas, Flight Service Station (FSS) (National Climatic Center, 1955-1964) provided data that are used to characterize the wind and atmospheric stability of the site area. In comparison, Topeka is 56 miles north of the site, and its wind data are influenced by its location in the Kansas River Valley, while Wichita has a similar exposure to the site area but is 96 miles southwest of the site (Figure 2.3-1). Although these data are considered to be generally representative of meteorological conditions at the site, local variations, especially in the distribution of wind direction and speed, probably exist. These local variations can only be identified by the onsite meteorological monitoring program.

Data from onsite measurements cover the 24-month period from June 1, 1973 to May 31, 1975. Data from a third year of onsite monitoring will be provided when completed during the second quarter of 1980.

General topographic features to a radius of 5 miles and 50 miles from the site are shown on Figure 2.3-2 and 2.3-3. Topographic cross sections along 5-mile radial and 50-mile radial lines are shown in Figures 2.3-4 and 2.3-5. The detailed plot plan of the meteorological facilities is shown in Figure 2.3-6.

2.3.2 TEMPERATURE

The normal temperatures range from 80 F in July and August to 29 F in January; however, Kansas has occasional severe outbreaks of hot spells in the summer and cold periods in the winter. Burlington has recorded both a high of 117 F and a low of -27 F, Topeka a high of 109 F and a low of -20 F, and Wichita a high of 113 F and a low of -12 F. The annual average number of days with temperatures in excess of 90 F is approximately 60 to 70 for the region, while the average number of freezing days per year is about 120. Table 2.3-1 presents the monthly and annual average and extreme temperatures for Burlington, Wichita, and Topeka. The annual mean temperatures based on these data are 57.0 F for Burlington, 54.3 F for Topeka, and 56.6 F for Wichita.

Table 2.3-2 gives the diurnal variation of temperature for the Wolf Creek Generating Station using the 2-year period of on-site data at the 10-meter level. This table also presents the annual average and extreme temperatures for the site. The annual mean temperature is 55.2 F (12.9 C), which compares favorably to the annual means for Burlington, Topeka, and Wichita. Diurnal variation, average, and extreme temperature data for the site are presented on a monthly basis in Table 2.3-3.

Although Kansas is distant from major bodies of water, significant moist air incursions from the Gulf of Mexico occur during the summer months. This moist air inflow results in marked increases in wet bulb temperatures for the region from June to September. Monthly and annual average dewpoint temperatures for both Topeka and Wichita are presented in Table 2.3-4.

Diurnal variation of dewpoint temperature and annual average and extreme dewpoint temperatures for the 2-year period of on-site data are listed in Table 2.3-2. The mean annual dewpoint temperature is 43.7 F (6.5 C), which compares favorably to the mean annual dewpoint at both Wichita and Topeka. On-site dewpoint statistics on a monthly basis are given in Table 2.3-3.

2.3.3 WATER VAPOR

This portion of Kansas shows a marked diurnal change in relative humidity. As temperatures increase during the day, relative humidities decrease accordingly. Likewise, when temperatures fall during the evening hours, there is an appreciable rise in the relative humidity values. Therefore, the lowest relative humidity values are found during the afternoon hours, while the highest values occur in the early morning just before sunrise. Mean relative humidity values for Topeka and Wichita are shown in Tables 2.3-5 and 2.3-6.

Table 2.3-7 lists the diurnal variation of relative humidity for the 2-year on-site data base period. Annual average and extremes of relative humidity can also be found in this table. Monthly relative humidity statistics are presented in Table 2.3-8 for the 2-year period. The annual averages show that the onsite data period was slightly drier than the long-term period.

2.3.4 FOG

Heavy fog occurs relatively infrequently in the region around the site. Topeka averages about 15 days per year with heavy fog while Wichita has 17 such days. The months of December, January, and February show the greatest incidence of fog, averaging 2 to 3 such days per month (Tables 2.3-5 and 2.3-6). No on-site fog data is available.

2.3.5 PRECIPITATION

Monthly and annual precipitation and snowfall normals and maxima for Burlington, Topeka, and Wichita are presented in Table 2.3-9. This indicates an annual precipitation mean for Burlington of 38.0 inches, with 70 percent occurring from April through September. January is generally the driest month, while May is the wettest. The annual means for Topeka and Wichita are 34.7 and 30.6 inches, respectively. Maximum short-period rainfall during 10 intervals from 5 minutes to 24 hours at Topeka and Wichita appear in Table 2.3-10.

Annual average snowfall in Burlington is 15.2 inches, with the greatest in February (U.S. Weather Bureau, 1965). A monthly total of 17 inches has been recorded at Burlington. The annual means for Topeka and Wichita are 20.9 and 15.4 inches, respectively. Freezing rain can be expected to occur from November through March; Table 2.3-11 shows that during a 10-year period in Wichita, there were 83 such days (Bennett, 1959). Accumulation of ice of 0.25 inches once every year and at least 0.50 inches every 2 years can be expected. The mean duration of glaze ice on utility wires if an ice storm occurs is 53 hours for the State of Kansas as a whole (Bennett, 1959).

The most commonly reported hailstones are less than three-fourths inch in diameter and cause little or no property damage. Hailstones equal to or larger than three-fourths inch in diameter are associated with severe thunderstorms. From 1955-1967, 832 hailstorms having hailstones equal to or larger than three-fourths inch in diameter were reported in 400 days in Kansas (Figure 2.3-7)

2.3.6 WIND CHARACTERISTICS

Joint wind speed and direction frequency distributions for Chanute FSS from 1955 to 1964 are shown on a monthly and annual basis in Table 2.3-12. On the average, the prevailing wind direction at Chanute is southerly from April through December, while north-northwesterly flow prevails during January and February. March has the maximum monthly wind speed, averaging 12.8 knots. July and August have the minimum monthly average wind speed of 9.5 knots.

Calms were present 3.6 percent of the time while strong winds above 20 knots were observed 3.5 percent of the time. Calms occurred primarily during the summer months with a maximum frequency of 5.1 percent in June. Strong winds occurred primarily in the spring, with a maximum frequency of 9.0 in April.

Table 2.3-13 gives the frequency distributions for the persistence of wind direction at Chanute FSS in each season. Southerly and north-northwesterly winds are most persistent, with the former dominating in spring, summer, and fall, and the latter in the winter. In the spring and summer the maximum persistence is 60 hours, while during the fall and winter it is 45 hours and 36 hours, respectively. No calms last longer than 21 hours.

The joint wind-stability characteristics of the site area are defined by Table 2.3-14. The table is based on 10 years of standard National Weather Service (previously the U.S. Weather Bureau) 3-hourly observation at Chanute FSS, covering the period January, 1955 to December, 1964. For each observation the stability existing at that time was calculated by the Turner-Pasquill method in program "STAR", supplied by the National Climatic Center, Ashville, North Carolina. In the version of the program used for this study, Pasquill stability class G is not distinguished from class F; rather, the two are treated as a single class which is designated as F. The mean wind speeds for each stability class are as follows:

Stability Class	Mean Wind Speed (knots)
A	1.7
B	4.7
C	9.2

D	13.1
E	8.2
F	3.9

Tables 2.3-15 and 2.3-16 give the wind roses for the lower level (10-m) and upper level (60-m) winds, respectively, for this 2-year period of onsite data. Wind roses on a monthly basis are provided in Tables 2.3-17 (10-m) and 2.3-18 (60-m). Joint frequencies of wind speed, direction, and stability for the total period are presented in Tables 2.3-19 (10-m) and 2.3-20 (60-m). These joint frequencies are given on a monthly basis in Tables 2.3-21 (10-m) and 2.3-22 (60-m).

Diurnal variation of wind speed and direction, average, and extreme winds for the total period are presented in Tables 2.3-23 (10-m) and 2.3-24 (60-m), and on a monthly basis in Tables 2.3-25 (10-m) and 2.3-26 (60-m). Table 2.3-27 provides the total period lower level wind persistence for each stability class; Tables 2.3-28 and 2.3-29 provide persistence data for all classes combined (Pasquill All) and all stable classes (Pasquill #S#), respectively.

2.3.7 CLOUD COVER AND SUNSHINE

Average monthly and annual daylight cloud cover and sunshine for Topeka and Wichita are given in Table 2.3-30.

2.3.8 STABILITY

The seasonal persistence of stability frequency distribution at Chanute Flight Service Station is depicted in Table 2.3-31. For all seasons, only class D stability conditions have a persistence exceeding 15 hours. In spring, fall, and winter more than 10 percent of class D stability conditions persist for longer than 102 hours, while the upper limit for summer persistence is 96 hours.

Onsite stability statistics can be found for the total period in Tables 2.3-2 and monthly in Table 2.3-3. Table 2.3-32 presents a stability persistence summary for the 2-year onsite data set.

2.3.9 STORMS

2.3.9.1 Thunderstorms

Thunderstorms may occur during every month of the year. The most damaging thunderstorms are those associated with the passage of a cold front or a squall line. The average monthly and annual number of days with thunderstorms for both Topeka and Wichita are presented in Table 2.3-33. The maximum frequency of thunderstorms occurs in late spring and during the summer months, with the wintertime minimum in December and January.

A thunderstorm day is defined as a day on which thunder is heard at least once at that location. Thunder cannot usually be heard if the lightning causing it is more than about 15 miles away. While thunderstorm incidence data are based upon the observation of thunder generated by lightning occurring within a region close to the observation station, these data do not contain a great deal of information which can be used to characterize lightning. For example, these data do not provide information regarding the type (e.g., cloud-to-ground versus cloud-to-cloud lightning) and severity of the disturbance or frequency of lightning occurrences.

Observations indicate that the magnitude and incidence of lightning strikes to ground are substantially greater in frontal storms than experienced in air mass convective storms (Bodle, 1971). Storms of the air mass convection type account for the majority of annual thunderstorm days. Therefore, the mean annual number of days with thunderstorms probably over-estimates the actual number of lightning-producing thunderstorms with strikes to the ground.

Nevertheless, the number of thunderstorm days is used as a measure of lightning occurrences. The mean annual number of such days for Topeka and Wichita is 58 days and 55 days, respectively (Environmental Data Service, 1978). Since the seasonal frequencies of lightning occurrences directly correlate with the seasonal frequencies of thunderstorm days, lightning is least frequent in fall and winter, with 0-4 thunderstorm days per month for Topeka and Wichita, and most prevalent in late spring, with 9-10 thunderstorm days per month in May and June (Environmental Data Service, 1978).

A more pertinent statistic than the number of thunderstorm days per year is the number of lightning strikes per square mile per year (Uman, 1971). The strikes per area have been determined from the combined results of several studies, and they indicate that the number of flashes to ground per square mile per year is between 0.05 and 0.8 times the number of thunderstorm days per year. Therefore, if the largest number of thunderstorm days (Topeka with 58 days) is used, the expected number of strikes per year in a square mile area surrounding the site is betwen 3 and 46.

A 15-year survey of Storm Data (U.S. Department of Commerce, 1959-1973) for the site area showed frequent lightning incidents and associated damage. Qualitatively, lightning frequency directly correlates with that of hail and tornadoes, with a maximum in the spring. No quantitative data on frequency of lightning, however, were listed in those publications.

2.3.9.2 Tornadoes

Tornado activity is significant in the site area. Table 2.3-34 shows that tornadoes have been observed in the area around the site during almost every month, with about 70 percent occurring during April, May, and June. Over 30 percent of the total number were reported during May, the month of greatest frequency. January is the month of least activity with no tornadoes reported during the period (Poultney, 1973). About 90 percent of the Kansas tornadoes occurred between noon and midnight, with the greatest activity between 1600 and 1800 CST. Figure 2.3-6 shows the total number of tornadoes by 1-degree longitude-latitude squares for the 13-year period ending 1967 (Pautz, 1969). It is noted that there are several conflicting published values of tornado occurrences per 1-degree square (Poultney, 1973; Pautz, 1969; Thom, 1963). The differences might be attributed to the years sampled, or to the method of report classifications used by the investigators.

The monthly number of tornadoes per 1-degree longitude-latitude square for the period 1956 to 1971 is summarized in Table 2.3-34. During this period Kansas had a total of 92 tornadoes per 10,000 square miles, the largest in the United States (Poultney, 1973). The most severe storm to occur in the general area, from the standpoint of casualties and damage, was on June 8, 1966, when an early evening tornado passed through Topeka causing 16 fatalities, 406 injuries, and property losses in excess of $100 million. In 1972, there were 45 tornadoes reported in Kansas as a whole, with no deaths reported. Table 2.3-35 summarizes the total amount of damage caused by tornadoes between 1916 and 1950 (U.S. Weather Bureau, 1960).

The probability of tornado occurrence must be examined statistically, since the possibility of a tornado striking a point is so low that it is difficult to predict its occurrence. For this reason, an annual frequency of tornadoes in an area (1-degree longitude-latitude square) is determined from climatological data, after which the point probability and return period are computed. According to Thom (1963), the probability (P) of a tornado hitting a single point within a one-degree longitude-latitude square is:

$$P = \frac{(2.8209 \times \bar{t})}{A} \qquad [2.3\text{-}1]$$

where:

A = the area in square miles of a 1-degree longitude-latitude square centered on the point;

$\bar{t}$ = the mean annual frequency of tornadoes in the area.

For the 1-degree longitude-latitude square enclosing the site, and using Thom's data for the years 1953-1962, t = 3.2. Thus:

$$P = \frac{(2.8209 \times 3.2)}{3788} = 2.38 \times 10^{-3}$$

and the return period (R) for all tornadoes (recurrence interval) is:

$$R = \frac{1}{P} = \frac{1}{2.38 \times 10^{-3}} = 420 \text{ years.}$$

Using more recent data from 1956-1971, the monthly and annual probabilities and recurrence intervals of a tornado occurrence per any 1-degree longitude-latitude square in Kansas are given in Table 2.3-34.

2.3.9.3 Hurricanes

The eastern Kansas location of the site is about 1,400 miles west of the Atlantic Ocean and about 800 miles north of the Gulf of Mexico. Because the strength of a hurricane is dissipated rapidly once the storm commences an overland trajectory, this distance minimizes the influence that a hurricane would have upon the site. For a 93-year period, 1871-1963, the tracks of four dissipating hurricanes have been shown to pass through Kansas (Cry, 1965).

2.3.9.4 Extreme Winds

Strong winds occur in Kansas as a result of extratropical cyclones, thunderstorms, and tornadoes. Tornadoes are discussed in Section 2.3.9.2. Extratropical cyclones usually produce their highest wind speeds in winter or spring because they are energized mainly by temperature contrasts between air masses. Thunderstorms are convectively driven and therefore produce their strongest winds during the spring and summer months.

According to Pautz (1969), there were 877 reports of wind gusts (50 knots and greater) occurring in 453 days in the State of Kansas from 1955 to 1967 (Figure 2.3-8). The diurnal distribution of these wind gusts shows a maximum between 1800 CST and 2400 CST. Pautz also shows these data by 1-degree longitude-latitude squares. About 30 windstorms were reported in the square encompassing the site (Figure 2.3-9). Figure

2.3-10 shows these windstorm reports averaged by 2-degree longitude-latitude squares. About 200 reports occurred in the site vicinity. This is a much higher rate of occurrence than shown in the 1-degree square averages, attributed to the presence of a highly organized severe-storm network and the large number of Severe Local Storm Unit personnel residing in the area (Pautz, 1969).

The fastest-mile wind is defined as the fastest observed 1-minute value when the direction is in tens of degrees (Environmental Data Service, 1978). Thom (1968) chose the annual fastest mile wind speed as the best available measure of wind for design purposes. He calculated fastest mile wind speed values and mean recurrence intervals using Frechet probability distributions. Some typical recurrence intervals and their related wind speeds for eastern Kansas are shown in Table 2.3-36. The 100-year return period fastest-mile wind speed in the site region was calculated at 86 mph. In comparison, the fastest mile wind speed observed is 81 mph from the north in Topeka and 66 mph from the northwest in Wichita (Table 2.3-37). Gusts of lesser speeds are recorded from almost all directions (Environmental Data Service, 1969). In the 2-year period of onsite monitoring, no winds greater than 50 knots were recorded.

2.3.10 AIR POLLUTION

Meteorological conditions which are conducive to high air pollution potential are light winds, surface inversions, and stable layers aloft. The site area is characterized by frequent storm passages, cloudiness, high winds, and thermal instability, all of which favor rapid dispersion of atmospheric pollutants and, therefore, low air pollution potential. The geographical distribution of these periods of relatively good ventilation conditions is indicated by the tracks of the centers of well-defined low pressure systems (Figure 2.3-11). Periods of limited dispersion or stagnation are often associated with slow moving, warm anticyclones with resulting thermal stability and numerous temperature inversions. Hosler (1961) has presented a climatological study on the frequency of temperature inversions in the United States. According to his study, the site is in an area where periods of high air pollution potential may be expected to occur approximately 30-40 percent of the time (Figure 2.3-12).

The mixing height or mixing depth of the atmosphere, defined as that height through which relatively vigorous vertical mixing occurs, plays a significant role in the diffusion potential of a given area. Holzworth (1972) has indicated that maximum mixing heights for eastern Kansas vary from a mean of about 850 meters in the winter to about 1,600 meters in the summer (Figure 2.3-13). Such values indicate that this region has annual mixing heights which are higher than those over about one-half of the United States (Figure 2.3-14).

Periodically, however, a high pressure system in the lower atmosphere will stagnate over a region and result in lower mixing height and limited vertical diffusion. The occurrence of limited dispersion episodes, also called stagnation periods, throughout the contiguous United States has been objectively determined by Holzworth (1972). The critical limiting conditions used are:

(a) All mixing heights 1,500 meters or less;

(b) All mixing layers average wind speeds 6.0 meters per second or less;

(c) Above conditions satisfied continuously for at least two days.

Figure 2.3-15 shows the total number of these episode-days in 5 years to be about 62 in the vicinity of the site. There is a qualitative agreement between the objectively derived patterns and the actual forecast-days of high air pollution potential (Figure 2.3-16) for the region (Holzworth, 1972).

The plant site is in a rural area, and no major pollutant sources are located within 5 miles of the site. The entire site region (within a 50-mile radius of the site) is in attainment with the National Ambient Air Quality Standards for total suspended particulates (TSP), SO_2, CO, and nitrogen oxides. A non-attainment area for ozone exists in Douglas County, which is about 40 miles from the site (Bureau of National Affairs, 1979).

There are no monitoring stations for any pollutants within 50 miles of the site. TSP were measured about 30 miles from the site at Emporia, Kansas (Lyon County), but that monitoring station has been removed. For the period from 1975 through 1977, the TSP annual geometric mean at the Emporia station averaged 62.7 $\mu g/m^3$. This is below the National Ambient Air Quality Standard of 75 $\mu g/m^3$. In view of the air quality of the region, no significant effects of ambient pollution upon the plant, such as acid rain caused by mixing SO_2 plumes with cooling tower effluent plumes, are anticipated. Emissions from the plant are discussed in Section 3.7.

There are no large water bodies or large topographical differences within 50 miles of the site. Therefore, the diffusion characteristics of the area are not expected to exhibit any unusual features.

2.3.11 REFERENCES

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TABLE 2.3-1

MONTHLY AND ANNUAL AVERAGE
AND EXTREME TEMPERATURES FOR BURLINGTON, KANSAS[a]

Month	Average Daily Maximum[b]	Average Daily Minimum[b]	Average[c]	Extreme Maximum	Extreme Minimum
January	42.2	20.5	32.0	75	-22
February	46.8	23.4	36.6	86	-27
March	57.8	32.5	44.6	94	- 6
April	69.1	43.9	56.7	94	13
May	77.3	53.6	65.8	102	24
June	86.4	62.9	75.4	110	40
July	92.2	66.8	80.3	117	47
August	91.9	65.9	79.7	117	43
September	83.9	57.7	71.3	110	30
October	72.6	46.0	60.3	97	15
November	57.5	33.0	45.2	85	0
December	45.1	24.1	35.8	75	- 9
Annual	68.6	44.2	57.0	117	-27

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[a] In degrees Fahrenheit.

[b] Data Period 1897-1960

[c] Data Period 1931-1960

Source:

U.S. Weather Bureau, 1965, Climatic summary of the United States, supplement for 1951 through 1960: U.S. Weather Bureau, Department of Commerce, pp. 86-112.

TABLE 2.3-1 Sheet 2 of 3

MONTHLY AND ANNUAL AVERAGE AND
EXTREME TEMPERATURES FOR TOPEKA, KANSAS[a]

Month	Average Daily Maximum(b)	Average Daily Minimum(b)	Average(b)	Extreme Maximum(c,d)	Extreme Minimum(c,d)
January	38.3	17.7	28.0	73 (1967)	-20 (1974)
February	44.1	22.7	33.4	84 (1972)	-20 (1971)
March	52.6	29.7	41.2	88 (1966)	-7 (1978)
April	66.3	42.6	54.5	94 (1953)	10 (1975)
May	75.8	53.2	64.5	97 (1975)	26 (1963)
June	84.0	63.0	73.5	107 (1953)	44 (1950)
July	89.2	67.2	78.2	109 (1954)	43 (1972)
August	88.5	65.9	77.2	106 (1956)	45 (1956)
September	80.4	56.0	68.2	109 (1947)	30 (1972)
October	70.3	44.8	57.5	96 (1963)	19 (1976)
November	54.3	31.5	42.9	82 (1978)	2 (1976)
December	41.8	21.8	31.8	70 (1963)	-12 (1961)
Annual	65.5	43.0	54.3	109 (1954)	-20 (1974)

a In degrees Fahrenheit.
b Data Period 1941-1970.
c Data Period 1947-1978.
d Most recent in cases of multiple occurrence.

Source:

Environmental Data Service, 1978, Local climatological data, annual summary with comparative data, Topeka, Kansas: Environmental Science Services Administration; U.S. Department of Commerce, Silver Spring, Maryland.

TABLE 2.3-1

MONTHLY AND ANNUAL AVERAGE AND
EXTREME TEMPERATURES FOR WICHITA, KANSAS[a]

Month	Average Daily Maximum(b)	Average Daily Minimum(b)	Average(b)	Extreme Maximum(c,d)	Extreme Minimum(c,d)
January	41.4	21.2	31.3	75 (1967)	-12 (1962)
February	47.1	25.4	36.3	84 (1976)	-6 (1971)
March	55.0	32.1	43.6	89 (1956)	-2 (1960)
April	68.1	45.1	56.6	96 (1972)	15 (1975)
May	77.1	55.0	66.1	100 (1967)	31 (1976)
June	86.5	65.0	75.8	106 (1956)	43 (1969)
July	91.7	69.6	80.7	113 (1954)	51 (1975)
August	91.0	68.3	79.7	110 (1964)	48 (1967)
September	81.9	59.2	70.6	105 (1978)	35 (1967)
October	71.3	47.9	59.6	95 (1954)	21 (1976)
November	55.8	33.8	44.8	81 (1978)	1 (1975)
December	44.3	24.6	34.5	83 (1955)	-5 (1968)
Annual	67.6	45.6	56.6	113 (1954)	-12 (1962)

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a In degrees Fahrenheit.
b Data Period 1941-1970.
c Data Period 1953-1978.
d Most recent in cases of multiple occurrence.

Source:

Environmental Data Service, 1978, Local climatological data, annual summary with comparative data, Wichita, Kansas: Environmental Science Services Administration, U.S. Department of Commerce, Silver Spring, Maryland.