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TUTTLE CREEK HYDROELECTRIC PROJECT

FEASIBILITY ASSESSMENT REPORT

KANSAS ELECTRIC POWER COOPERATIVE, INC.

TOPEKA, KANSAS

R.W. BECK AND ASSOCIATES

ENGINEERS AND CONSULTANTS

PHOENIX, ARIZONA

ORLANDO, FLORIDA

WELLESLEY, MASSACHUSETTS

SACRAMENTO, CALIFORNIA

SEATTLE, WASHINGTON

DENVER, COLORADO

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MARCH 1979

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ENGINEERS AND CONSULTANTS

PLANNING
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TOWER BUILDING
SEATTLE, WASHINGTON 98101
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FILE NO. WW-2141-HG2-QA
3006

March 26, 1979

Mr. Charles Ross
Executive Vice-President
5709 W. 21 St.
Post Office Box 4267
Gage Center Station
Topeka, Kansas 66604

Dear Mr. Mulholland:

Subject: Tuttle Creek Hydroelectric Project
Feasibility Assessment Report

We herewith submit the Feasibility Assessment Report describing our investigations and recommendations for installation of hydroelectric generating facilities at Tuttle Creek Dam.

Our principal findings, conclusions and recommendations are set forth in the Summary of the Report. Details of the investigations, supporting data and conclusions are described in subsequent sections of the Report.

Respectfully submitted,

R. W. BECK AND ASSOCIATES

James V. Williamson
Partner and Assistant Manager
Western Design Office

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SUMMARY

This report summarizes the results of a feasibility assessment study under a DOE grant for the Kansas Electric Power Cooperative, Inc. (KEPCo) to determine if hydroelectric generation could be developed economically at the Corps of Engineers' Tuttle Creek Dam, an existing flood control structure on the Big Blue River near Manhattan, Kansas. The studies and investigations have included site reconnaissance, system load characteristics, site hydrology, conceptual project arrangements and layouts, power studies, estimates of construction costs, development of capital costs, economic feasibility, development of a design and construction schedule and preliminary environmental review of the proposed Project.

The existing Tuttle Creek Project consists of an earthfill embankment, gated spillway in the left abutment, twin-barrel concrete conduit outlet works with intake tower and stilling basin near the right abutment, and a 2,346,000 ac.-ft. reservoir, of which about 1,900,000 ac.-ft. is reserved for flood control storage. The average annual discharge at the site is 2,120 cfs.

Two alternative Project layouts were compared. One alternative is to construct a tunnel through the left (east) abutment with a powerhouse discharging through a long concrete outlet channel into the pond below the dam. The second alternative is to place a steel liner in one of the existing flood control outlet works conduits with a powerhouse discharging into the stilling basin. The tunnel alternative proved to be very costly because of the long waterway required and is not economically feasible. Hence the outlet works alternative was selected as the Project concept for economic analysis.

The selected Project arrangement will consist of a steel liner placed inside the existing right outlet works conduit from the service gates to the outlet portal, a wye at the portal with

one branch leading to the powerhouse and one fitted with a butterfly valve to allow flood releases, and a powerhouse at the stilling basin. The powerhouse will contain three Allis-Chalmers standardized 4,750 kW TUBE units and one Allis-Chalmers 500 kW TUBE unit for a total installed plant capacity of 14,750 kW. The small unit will be included to allow generation with minimum flow releases. The generating units will operate under a rated net head of 60 feet.

The dependable capacity of the Project as delivered into the existing transmission and distribution network is 12,290 kW and the average annual energy is 56,690 MWh. For the scheduled on-line date of July 1984, the Project is estimated to have a Total Investment Cost of \$19,662,000 (equal to \$1,333/kW installed at that time frame) with an estimated annual cost for the first year of operation of \$2,696,000, assuming REA financing at 9.5% interest rate. With REA financing at 7%, which is not currently available, the Total Investment Cost is estimated to be \$19,192,000 (equal to \$1,301/kW). With a loan under the new National Energy Act administered by DOE, at 7-1/8% interest on 75% of the Project cost and additional financing at 9.5% on the balance, the estimated Total Investment Cost is \$19,327,000 (equal to \$1,310/kW).

Economic feasibility was studied by comparison of the Project estimated cost with the projected cost of continued power purchases equal to the power output of the Project, with financing from loans from three alternative sources. These alternatives are 9.5% and 7% interest rate REA loans, and financing under the National Energy Act, referred to as 7-1/8% DOE financing. The 7% financing is not currently available from REA, but is considered a possibility in the future. With the 9.5% REA financing alternative the Project benefit-cost ratio is 0.68 during the first year. With costs based on REA financing at 9.5% and benefits based on the projected power rates of Kansas Power and Light Company, benefits begin to exceed the costs during the eighth year of operation. However, on a present worth basis, the costs exceed the benefits for the first ten years

of Project operation, which indicates lack of viability with 9.5% REA financing. With 7% REA financing, the benefit-cost ratio during the first year of operation is 0.84 and over the first 10 years, the Project shows a surplus of \$1,166,000 on a present worth basis, which indicates feasibility. With 7-1/8% DOE financing, the accumulated present worth values show that the Project benefits are less than the costs which indicates lack of viability with that type of financing.

The Project is considered technically feasible and without any major environmental issues. It shows economic feasibility providing satisfactory financing terms are available. Such satisfactory financing alternatives include a 7% REA loan or DOE financing under the new National Energy Act with the 25% portion for construction not covered being financed with 7% or lower interest loans (possibly through REA). In addition, application should be made to DOE for demonstration grant funds.

It should be noted that the feasibility of the Project will be totally negative if Federal dam-user fees are imposed. A policy decision must be made at a Federal level to eliminate the imposition of dam-use charges on small scale hydroelectric projects or the overall program of small hydro development at existing Federal dams will prove futile.

If satisfactory construction financing arrangements and agreements with the Corps can be arrived at, it is considered that an application should be made to DOE under the new Energy Act for a 90% loan for the cost of feasibility studies and preparing a License Application. A Preliminary Permit Application to FERC should be made to establish priority on the site.

SECTION I

INTRODUCTION

1. DEPARTMENT OF ENERGY PROPOSAL AND GRANT

In response to a Program and Research Development Announcement by the Department of Energy (DOE), the Kansas Electric Power Cooperative, Inc. (KEPCo) submitted a proposal dated February 18, 1978 to study the feasibility of installing hydroelectric generating facilities at the Army Corps of Engineers' (Corps) existing Tuttle Creek Dam, with financial assistance from the DOE.

KEPCo's proposal was approved by the DOE and the grant was awarded to KEPCo with the feasibility study work to be performed pursuant to Cooperative Agreement No. EW-78-F-07-1798 between KEPCo and the DOE. The proposal was prepared for KEPCo by R. W. Beck and Associates (Beck).

2. AUTHORIZATION

Beck was authorized to proceed with the Feasibility Assessment of developing hydroelectric generating facilities at Tuttle Creek Dam, by an Agreement for Engineering Services authorized on September 27, 1978.

3. SCOPE OF SERVICES

The scope of work was planned to provide engineering services to determine the preliminary feasibility of developing hydro power at Tuttle Creek Dam. The proposed development is referred to as the Tuttle Creek Hydroelectric Project. The scope includes the following services:

a. Expected configuration and capacity of the hydropower facility.

b. Estimated performance characteristics of the hydroelectric power facility including the potential for peak power production and an estimate of average annual energy production.

c. Expected impact of the hydropower installation on other known water resource needs of the area and the current use of the reservoir.

d. Marketing potential of the power produced.

e. Information made available to the Consulting Engineer relating to necessary requirements of the Federal Energy Regulatory Commission (FERC), the U.S. Army Corps of Engineers (Corps), and other appropriate Federal, State, regional and local agencies.

f. Estimated capital investment per installed kilowatt and total estimated cost per kWh.

g. Anticipated annual operation and maintenance costs.

h. Anticipated project life.

i. An initial assessment of the environmental impact and socio-economic and institutional factors.

j. An initial assessment of the safety hazard, if any, introduced by the addition or rehabilitation of a power plant and other hydropower appurtenances.

k. Appropriate analyses and recommendations as to the engineering acceptability of the proposed site for hydroelectric power development.

1. Investigation of the availability of a suitable turbine(s), generator(s), and accessories required for the proposed hydroelectric power development.

m. Development plan (schedule) for putting power on-line.

n. Furnishing technical data to the Client to support reports required by the Cooperative Agreement to be submitted to DOE by the Client.

4. BACKGROUND TO PRESENT STUDY

Within the last few years a national shortage of natural gas, fuel oil and the better grades of coal has occurred and is expected to continue. The decreased supply of fuel for thermal generation was accompanied by significant increases in the costs of this fuel, and hence of power generated by facilities which use these depletable resources.

The current Federal support for the development of low-head hydroelectric power recognizes this as a clean, safe and renewable resource. Hydroelectric power is not subject to substantial inflation of costs, since the major portion of the annual operating cost is debt service which is a sunk cost and will not change during the project life.

Preliminary studies of hydrology and power output were made for the DOE proposal and the results are considered to be order-of-magnitude only.

SECTION II

SITE CONDITIONS

1. GENERAL

Tuttle Creek Dam is a Corps existing flood control structure located on the Big Blue River about 126 miles west of Kansas City and about 6 miles north of Manhattan in northeastern Kansas. Tuttle Creek Dam and the reservoir behind the dam, known as Tuttle Creek Lake, occupy portions of Riley, Pottawatomie and Marshall Counties. The location of the Tuttle Creek Dam and Lake is shown in Fig. 1.

2. TOPOGRAPHY

The Big Blue River basin drains a total area of 9,681 square miles above its mouth at the Kansas River. The topography of the basin is comprised of well defined stream channels with roughly half of the basin being generally flat land, roughly one-third of the basin being rolling land and the remaining 18% of the basin being hilly to rough escarpment areas. Relief between the stream floodplains and the tops of the ridges is usually about 150 feet. Land elevations in the basin range from a maximum of about El 2230 (msl) at Axtell, Nebraska to El 1000 at the mouth of the river.

The valley widths of the Big Blue River above Tuttle Creek Lake vary from slightly over one-quarter mile to nearly a mile, averaging approximately three-quarters of a mile from the upper end of Tuttle Creek Lake to the vicinity of Seward, Nebraska which is near the upper end of the drainage basin. From the upper end of Tuttle Creek Lake to Beatrice, Nebraska the river channel varies in width from 150 to 200 feet, with a slope of 1.6 feet per mile. Upstream from Beatrice to Seward, the slope is about 2.7 feet per mile

with the channel becoming smaller. In the reaches above Seward, the channel has a width of 150 to 200 feet and is crooked and easily obstructed by debris.

3. CLIMATE

The climate of the Big Blue River Basin varies from a moist, subhumid climate in the southeastern portion of the basin to a dry, subhumid climate in the western portion. Erratic patterns of behavior are typical of the basin's climatic history, including intense and prolonged rainfall in some years and severe drought in others. The basin experienced the severe plains area drought of the 1930's when the below average precipitation and excessive summer temperatures were the extremes for any decade of record. In the decade from 1950 to 1960, the maximum flood of Record occurred in the Big Blue River as well as a severe 5-year drought period.

The average annual rainfall for the basin above Tuttle Creek Dam is 27.4 inches with the average annual rainfall varying from 22 to 30 inches from the west side of the basin to the east side. The average annual snowfall for the basin is 22 inches. The average annual temperature varies from approximately 55°F in the southeast portion of the basin to about 50°F in the western portion. Temperatures of over 100°F have been recorded in each month from April through October and temperatures of -10°F to -25°F have been recorded in November through April.

4. GEOLOGY

The Big Blue River drainage basin is situated within the Interior Plains region and is divided in a generally north-south direction with the Great Plains Province on the west and the Central Lowlands Province on the east. Tuttle Creek Dam is located within the Osage Plains sub-province of the Central Lowlands Province.

The site occupies the Erving Syncline, with limestone and shale beds dipping a gentle 5 degrees to the west. The jointing is generally tight with joint spacing at one to three feet. One high angle fault passes through the left bank of the spillway approach channel.

A reconnaissance was made of the site on November 30 and December 1, 1978 in company with Consulting Engineering Geologist, Kim de Rubertis. The purpose of the inspection was to note conditions which could affect feasibility of the proposed Project features and to provide data for preliminary cost estimates. The Consultant's report on the regional and site geology is included in Appendix A. That report relates to the "proposed project" which is the tunnel alternative for the project. However, the consultant's remarks have general application to the outlet works alternative (which shows more favorable economics).

SECTION III

EXISTING PROJECT

1. GENERAL

The existing Tuttle Creek Dam is owned and operated by the Army Corps of Engineers for purposes of flood control, recreation, enhancement of fish and wildlife habitat and downstream water quality. The dam is located on the Big Blue River 10 miles upstream from the mouth at the Kansas River. The reservoir behind the dam is known as Tuttle Creek Lake. The location of Tuttle Creek Dam and Lake is shown in Fig. 1. Construction of the Tuttle Creek Dam began in October 1952. The dam was closed in 1959 and construction was completed in July 1962. Hydroelectric generating facilities have never existed at the site. Details of the Tuttle Creek Dam features are shown in Fig. 2.

2. DAM AND SPILLWAY

Tuttle Creek Dam is a zoned earthfill embankment with a maximum height above the streambed of 134 feet and maximum structural height of 157 feet. The crest of the dam is at El 1159.0 and the width of the crest is 50 feet. The maximum base width is 1,640 feet and the length along the crest is 7,487 feet. The volume of dam embankment is about 21,000,000 cubic yards. The upstream face has slopes of 2 horizontal to 1 vertical (2:1), 4:1, 13:1 and 4:1. The downstream face has slopes of 2.5:1, 3:1, 13:1 and 4:1.

The spillway is located in the left abutment and consists of a gated concrete weir structure with 18 40-foot by 20-foot tainter gates. The crest of the spillway weir is at El 1116.0. The top of the tainter gates in the closed position is El 1136.0. The approach channel is approximately 800 feet wide and 1,500 feet

long, and the downstream chute is 600 feet long and 839 feet wide. The chute terminates in a flip bucket which discharges flows into an outlet channel that returns the water to the natural channel of the Big Blue River. The discharge capacity of the spillway is 579,000 cfs (design flood peak discharge) with the reservoir at El 1151.4, which is the top of the flood surcharge pool. With the reservoir at the top of the flood control pool at El 1136.0, it will discharge 233,500 cfs with gates wide open.

3. OUTLET WORKS

The outlet works of Tuttle Creek Dam are located near the right abutment and pass through the dam in the floor of the river valley. It consists of an approach channel, an intake structure, a twin-barrel concrete conduit, a stilling basin and an outlet channel.

The intake structure contains 4 - 10-foot by 20-foot hydraulically operated service gates. The outlet works consist of twin 20 foot diameter horseshoe conduits, each 860 feet in length. The two conduits are constructed as a single unit with a common center wall. The conduits terminate at a stilling basin which is 290 feet in length and 160 feet in width at the widest points. A center division wall divides the stilling basin into two symmetrical parts. The discharge capacity of the outlet works is 45,900 cfs with the reservoir at the top of the tainter gates, El 1136.0.

Two hand-operated gated 24-inch pipes bypass the service gates to provide for low-flow releases. Each pipe will pass about 100 cfs at a reservoir elevation of 1061.0, which is the bottom of the conservation pool.

4. RESERVOIR

The total storage in Tuttle Creek Lake below the top of the flood control pool at El 1136.0, is the sum of the storage in the flood control pool, the multipurpose pool and the sedimentation reserve pool and is 2,346,000 acre-feet. Area-capacity curves for the reservoir are shown in Fig. 3.

The normal flood control pool in Tuttle Creek Lake extends from El 1075.0 to El 1136.0 and contains 1,933,000 acre-feet of storage between those limits. At the top of the normal flood control pool at El 1136.0, the reservoir extends approximately 50 miles upstream from Tuttle Creek Dam and covers an area of 54,050 acres.

The multipurpose pool extends from El 1061.0 to El 1075.0 and contains 185,000 acre-feet of storage between those limits. At the top of the multipurpose pool at El 1075.0, the reservoir surface area is 15,830 acres and extends upstream from the dam for a distance of about 30 miles. A sedimentation reserve pool extends from El 1000.0 to El 1061.0 and contained 228,000 acre-feet of storage at the time of allocation of this storage.

The flood surcharge pool in Tuttle Creek Lake extends from the top of the normal flood control pool at El 1136.0 to El 1151.4 and contains 957,200 acre-feet of storage. The area of the lake at El 1151.4 is 70,060 acre-feet.

SECTION IV

SYSTEM LOADS AND RESOURCES

1. GENERAL

Kansas Electric Power Cooperative, Inc. (KEPCo) is a Rural Electric Cooperative organized in 1965 to provide generation and power wholesaling benefits to member consumer cooperatives. KEPCo currently provides services to 26 member cooperatives located throughout Kansas with over 100,000 customers. The power distributed by KEPCo is purchased from local utilities, including Kansas Power and Light (KPL), Kansas City Power and Light (KCPL), Kansas Gas and Electric (KGE), Empire District Electric (EDE) and Central Telephone and Utilities (CTU). KEPCo currently does not presently own any generating facilities, but is negotiating for purchase of a 195 MW portion of the Wolf Creek Nuclear Power Plant under construction near Burlington, Kansas. In 1980, KEPCo will also receive 90 MW of hydroelectric power from the Southeastern Power Administration.

The KEPCo load is primarily rural and agricultural in nature, with some municipal and industrial elements. The system as a whole experiences a summer peak, although a few of the member cooperatives have winter peaks. The summer peaks are caused primarily by irrigation and air conditioning loads, while the winter peaks are caused primarily by heating demands. The net result is a minimum monthly peak which is about 70% of the annual peak.

The Tuttle Creek Project is located between two of the KEPCo member cooperatives, PR&W Electric Cooperative Association, Inc., and C&W Rural Electric Cooperative Association, Inc. The nearest tie-in to the existing grid is located about 5 miles to the south near Manhattan near the service area of PR&W Electric

Cooperative Association. KPL currently supplies all the power requirements for this area, and owns the major transmission lines and substations which will be used to wheel and distribute Project power. For the purposes of this study, it has been assumed that power from the Project will be delivered to the nearest substation (Manhattan) and distributed into the KPL system as desired by KPL. KEPCo will then receive a credit for the Project generation against the cost of its total KPL purchases. The value of the power generated by the Project will then be the amount of credit received for the generation, based on estimated wholesale power costs from KPL in the future as discussed in Section IX.

2. KEPCO HISTORICAL LOAD GROWTH

Table IV-1 shows KEPCo's historical monthly peak demand for the period of 1965 to 1977. Table IV-2 presents the historic non-coincidental annual peak and energy requirements for KEPCo for the same period. The number of member cooperatives increased in 1967 and 1973, which is reflected in the sharp increases in load in these years. The current membership of 26 cooperatives has existed since 1973, and for the period 1973 to 1977, KEPCo experienced growth rates of 6.2% for energy and 9.1% for peak demand.

The consumption of power by KEPCo has consistently increased, although the rates of increase have varied considerably. The system annual load factor averaged about 51% for the period of 1965 to 1977 but has shown an overall decrease from 55.6% in 1965 to 45.9% in 1977. For this period of time KPL has supplied about 40% of the system load requirements, CTU has supplied about 35%, KGE about 22%, and 3% came from other utilities.

3. KEPCO FUTURE LOAD GROWTH

A 1977 KEPCo power requirements study contains estimated load requirements until 1990. The projection include a

substantial increase in both energy and peak demand requirements during the period 1976-1980 from expected industrial expansion. The average energy and peak demand growth for this period were estimated as 9.4% and 10.1% respectively. For the period 1981-1990, the estimated 6.1% energy and 6.4% peak demand growth rates correspond more closely to the historic rates. The predicted industrial expansion has not occurred and thus these load forecasts proved optimistic. As a more conservative estimate, for this study the 1975 KEPCo historic loads have been projected at the previously estimated growth rates of 6.1% for energy and 6.4% for peak demand. These projected loads are presented in Table IV-3.

4. KPL SYSTEM CHARACTERISTICS

The Project generation will be distributed in the KPL system, as discussed earlier. KPL has a summer peak and for the year ending October 31, 1978 experienced a peak load of 1,630 MW with an annual energy requirement of 7,073 GWh. The utility also has 115-kV and 230-kV transmission lines near the Project, which will allow efficient transmission of the Project generation to surrounding load centers.

5. UTILIZATION OF PROJECT OUTPUT

As discussed in Section VII, the Tuttle Creek Hydroelectric Project will generate at a maximum output of 15,000 kW with an average annual generation of 57,000 MWh. These values represent 2.5% of the estimated peak demand and 2.4% of the energy requirements for KEPCo in 1985, the first full year of operation. The Project generation also represents less than 1% of the current KPL requirements. KEPCo obviously then can utilize or receive credit for all of the Project power and the marketing potential of the power from the Project is therefore not a critical issue with regard to the economic feasibility of the Project. Hence, a study of the availability of an outside market for the power from the

Project was not performed. It is considered reasonable to assess the viability of the Project on the basis that the value of the power from the Project will be equal to the cost of the continued purchase of power under estimated future wholesale costs from KPL.

TUTTLE CREEK HYDROELECTRIC PROJECT
KANSAS ELECTRIC POWER COOPERATIVE, INC.
HISTORICAL MONTHLY NON-COINCIDENT
PEAK DEMANDS

<u>Year</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Annual</u>
1965	76,610	74,992	68,079	67,849	59,587	59,926	71,299	74,299	70,597	63,859	68,577	72,343	76,610
1966	77,511	86,682	76,983	69,155	67,745	67,281	88,423	88,388	75,831	69,722	76,117	81,400	88,423
1967	119,512	115,268	110,980	105,167	98,213	103,472	118,166	126,080	110,825	98,543	111,208	120,941	126,080
1968	137,360	125,056	122,618	113,310	106,735	113,081	132,450	143,728	132,642	110,731	123,210	132,351	143,728
1969	147,597	141,518	132,180	123,155	113,354	120,132	154,098	158,557	143,774	119,689	130,668	138,201	158,557
1970	155,803	155,566	137,323	133,615	122,618	131,406	166,801	180,468	172,457	131,609	140,258	152,451	180,468
1971	164,758	161,499	154,637	150,798	128,266	135,194	180,487	170,398	180,323	146,064	144,847	157,136	180,487
1972	175,524	182,299	159,300	145,707	140,072	165,550	186,164	196,897	198,232	170,946	164,015	190,005	198,232
1973	222,616	208,974	193,579	183,896	168,963	199,410	259,306	250,333	256,283	181,464	195,104	205,834	259,306
1974	237,878	210,360	203,954	198,151	187,229	210,944	292,650	293,400	235,219	191,428	207,866	229,552	293,400
1975	242,769	247,189	232,240	224,061	196,046	210,800	285,020	318,486	301,141	212,477	218,074	252,181	318,486
1976	266,970	252,109	236,438	221,373	210,446	229,015	291,125	338,487	333,679	238,555	237,576	267,966	338,487
1977	296,381	292,179	250,741	240,047	213,005	263,516	329,507	367,146	299,610	236,849	239,629	275,877	367,146
AVERAGE % OF ANNUAL	87.7	92.5	79.2	77.7	69.1	75.1	94.4	99.0	85.9	74.6	78.7	86.2	100.0

TABLE IV-1

TABLE IV-2

TUTTLE CREEK HYDROELECTRIC PROJECT
KANSAS ELECTRIC POWER COOPERATIVE, INC.
HISTORICAL LOAD REQUIREMENTS

<u>Year</u>	<u>Energy, MWh</u>	<u>Non-Coincident Peak, MW</u>	<u>Load Factor, %</u>
1965	372,900	76.6	55.6
1966	405,700	88.4	52.4
1967	590,000	126.1	53.4
1968	632,100	143.7	50.2
1969	689,100	158.6	49.6
1970	797,700	180.5	50.5
1971(1)	833,200	180.5	52.7
1972(1)	906,300	198.2	52.2
1973	1,160,100	259.3	51.1
1974	1,239,600	293.4	48.2
1975	1,325,400	318.5	47.5
1976	1,434,600	338.5	48.4
1977	1,475,200	367.1	45.9

(1) Based on estimated loads for one member cooperative.

TABLE IV-3

TUTTLE CREEK HYDROELECTRIC PROJECT
KANSAS ELECTRIC POWER COOPERATIVE, INC.
FORECAST OF FUTURE LOADS

<u>Year</u>	<u>Energy, MWh</u>	<u>Peak Demand, MW</u>
1980	1,782,100	434
1981	1,890,800	462
1982	2,006,100	492
1983	2,128,500	523
1984	2,258,300	557
1985	2,396,100	592
1986	2,542,200	630
1987	2,697,300	671
1988	2,861,900	713
1989	3,036,400	759
1990	3,221,600	808
1991	3,418,200	859
1992	3,626,700	914
1993	3,847,900	973
1994	4,082,600	1,035
1995	4,331,700	1,101

SECTION V

HYDROLOGY

1. GENERAL

The Big Blue River basin drains a total area of 9,681 square miles above its mouth at the Kansas River, with 9,628 square miles of drainage area being located above Tuttle Creek Dam. The major tributary in the basin is the Little Blue River which drains a total of 3,538 square miles. Approximately three-fourths of the basin lies within Nebraska with the remainder being in Kansas. The runoff characteristics in the Big Blue River vary with the climatic variations in the basin and the natural streamflows throughout the year are therefore relatively erratic.

2. HISTORICAL STREAMFLOWS

Historical streamflows in the Big Blue River basin have been well documented as evidenced by the numerous United States Geological Survey (USGS) gaging stations with more than 70 years of record. The Corps Engineers provided a record of monthly inflows into Tuttle Creek Lake which have been used in the preparation of this report for purposes of power output analyses. This period of record of monthly inflows extends from January 1935 to December 1974 and is shown in Table V-1. A flow duration curve for this period of record is shown in Fig. 4. Prior to 1950, the inflows were transposed from the USGS gage on the Big Blue River near Randolph on a drainage area ratio basis ($1.05 \times$ flows at Randolph). Records from the USGS gage at the Manhattan gage were used from 1951 through 1959 when closure of Tuttle Creek Dam was made. The inflow values from 1960 to 1974 have been calculated using records of reservoir contents, as recorded at the USGS gage at Tuttle Creek Lake near Manhattan, Kansas and streamflow stations upstream from the reservoir.

The average annual discharge for the period of record is 2,120 cfs which corresponds to an average run-off in the basin of about 3 inches per year. The streamflows between October and April usually are the lowest of the year with peak flows generally occurring in June during the spring runoff.

3. EVAPORATION

The loss of water from Tuttle Creek Lake due to evaporation is significant, due to the large surface area and a relatively high evaporation rate. The average evaporation rate has been estimated by the Corps as 51 inches annually, with 38 inches occurring from April to October and a peak of 9.9 inches in July. Based on these statistics, an annual distribution of evaporation has been developed for use in the power output studies. The evaporation represents an average annual loss of about 100 cfs.

4. MINIMUM DOWNSTREAM RELEASES

The minimum daily flow below Tuttle Creek Dam for the period of record from October 1954 to 1974 is 11 cfs, occurring on August 4, 1966. This flow was recorded at the USGS gage on the Big Blue River near Manhattan, which is 2.5 miles downstream from Tuttle Creek Dam. The Corps has stated in the Lower Kansas River Basin Lake Regulation Manual for Tuttle Creek Lake that under current operating objectives and procedures, the normal minimum release below the dam is 100 cfs. This minimum release has been used in the power study analyses in the preparation of this Report.

5. FLOOD MAGNITUDES AND FREQUENCIES

a. Flood History

The Big Blue River basin experiences flooding mostly in the spring and early summer months, although floods have occurred

during almost every month of the year. The maximum flood of record occurred on July 12, 1951 and had a peak inflow into Tuttle Creek Lake of 93,400 cfs. A flood occurred in 1903 which had an estimated peak discharge of 98,000 cfs at the mouth of the Big Blue River. Other floods of considerable magnitude occurred in 1908, 1935, 1943, 1947, 1960, 1967 and 1969.

b. Spillway Design

In the design of the Tuttle Creek Dam, the Corps developed a spillway design flood inflow hydrograph. This design flood was developed by transposition of the storm of May 6 to May 12, 1943 from the southwest Missouri-northeast Oklahoma area to the Big Blue River basin. That storm had a maximum rainfall of 25 inches and this amount of precipitation was increased by 25% for the Big Blue River Basin, with an average of 14.51 inches over the entire basin. Using an initial loss rate of 0.5 inches per hour and infiltration rates varying from 0.08 to 0.18 inches per hour, an average of 8.05 inches of rainfall excess for the duration of the storm was determined. Using the unit hydrographs for the basin, a peak inflow into Tuttle Creek Lake of 800,000 cfs was determined. A Standard Project Flood (SPF) was also developed by the Corps which has a computed peak inflow to Tuttle Creek Lake of 405,000 cfs.

6. SPILLWAY CAPACITY

The Corps routed the spillway design flood through Tuttle Creek Lake with the reservoir at the top of the flood control pool, El 1136.0, at the beginning of the storm. The maximum spillway discharge during the storm with the gates fully open is 579,000 cfs which occurs when the reservoir is at El 1151.4, the top of the flood surcharge pool. This provides a freeboard of 7.6 feet between the top of the dam and the maximum reservoir elevation during the spillway design flood which satisfies the Corps' design freeboard requirements for Tuttle Creek Lake.

The discharge capacity of the spillway at the top of the flood control pool at El 1136 is 233,500 cfs. The maximum computed spillway discharge during the SPF is 322,000 cfs, corresponding to a maximum reservoir level of El 1142.0.

A detailed review of the adequacy of the stability of the dam and appurtenant structures, and the ability of the spillway to pass the Probable Maximum Flood was not given major attention during this study, since the safety of the existing flood control structure is the responsibility of the Corps.

The presence of the proposed hydroelectric generating facilities will not impair the ability of the spillway to function as designed and to release flood flows from the reservoir.

TUTTLE CREEK HYDROELECTRIC PROJECT
TUTTLE CREEK LAKE MEAN MONTHLY INFLOWS (CFS)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AVERAGE
1935-36	545.	649.	433.	280.	2,091.	2,217.	641.	1,715.	483.	164.	104.	289.	797.
1936-37	317.	221.	279.	211.	1,885.	1,396.	374.	428.	850.	798.	683.	279.	636.
1937-38	239.	225.	236.	281.	305.	453.	427.	4,064.	3,712.	2,604.	1,250.	1,007.	1,240.
1938-39	261.	372.	296.	320.	287.	1,388.	1,985.	420.	3,764.	1,416.	960.	152.	967.
1939-40	200.	210.	233.	191.	345.	547.	360.	374.	451.	144.	1,288.	339.	391.
1940-41	151.	269.	275.	336.	896.	1,250.	841.	702.	10,171.	604.	852.	3,780.	1,661.
1941-42	6,485.	1,800.	1,679.	2,509.	1,042.	2,404.	979.	3,630.	4,982.	1,156.	1,687.	2,869.	2,614.
1942-43	784.	535.	584.	559.	2,633.	619.	695.	1,494.	14,829.	2,045.	613.	288.	2,114.
1943-44	283.	320.	274.	331.	344.	599.	3,733.	5,015.	7,359.	2,695.	6,781.	3,621.	2,613.
1944-45	1,078.	884.	958.	867.	1,000.	2,987.	6,307.	17,243.	8,040.	5,937.	1,345.	591.	3,960.
1945-46	723.	533.	339.	674.	897.	962.	619.	561.	1,560.	3,587.	599.	1,865.	1,077.
1946-47	1,612.	2,264.	648.	478.	674.	1,045.	5,705.	1,659.	17,649.	2,016.	594.	443.	2,878.
1947-48	314.	348.	382.	491.	3,224.	10,411.	1,273.	869.	1,426.	2,732.	3,376.	1,076.	2,167.
1948-49	497.	599.	513.	3,427.	7,239.	9,357.	2,037.	5,702.	13,615.	3,607.	1,818.	5,729.	4,478.
1949-50	1,403.	662.	516.	475.	615.	1,180.	625.	5,855.	2,464.	10,268.	3,910.	4,162.	2,703.
1950-51	7,321.	973.	748.	624.	862.	2,169.	2,904.	5,638.	28,597.	17,413.	5,356.	8,205.	6,745.
1951-52	1,681.	1,282.	923.	1,044.	949.	4,945.	7,141.	2,916.	2,656.	4,883.	1,973.	775.	2,602.
1952-53	491.	652.	785.	785.	948.	997.	843.	1,172.	1,499.	734.	481.	256.	802.
1953-54	304.	520.	696.	417.	616.	468.	558.	2,178.	4,927.	317.	6,562.	700.	1,528.
1954-55	626.	432.	409.	408.	1,774.	890.	589.	408.	1,665.	1,005.	157.	177.	703.
1955-56	288.	238.	274.	314.	370.	417.	345.	414.	1,728.	1,944.	373.	223.	578.
1956-57	181.	194.	235.	214.	305.	414.	954.	1,598.	6,926.	1,629.	1,662.	1,539.	1,317.
1957-58	660.	422.	347.	362.	832.	3,016.	1,651.	1,568.	1,177.	10,143.	2,587.	6,057.	2,416.
1958-59	729.	543.	472.	479.	1,516.	1,569.	1,309.	9,239.	2,222.	5,187.	824.	2,096.	2,195.
1959-60	3,831.	856.	704.	1,704.	2,145.	9,365.	8,223.	4,438.	6,304.	2,888.	1,632.	1,029.	3,596.
1960-61	708.	516.	535.	510.	602.	1,260.	1,652.	6,277.	3,472.	1,080.	752.	3,960.	1,780.
1961-62	4,218.	2,675.	1,120.	2,073.	4,726.	5,936.	1,851.	4,070.	4,245.	2,299.	1,221.	1,286.	2,967.
1962-63	1,775.	691.	571.	492.	1,274.	1,829.	1,001.	2,010.	2,937.	1,412.	1,245.	2,024.	1,437.
1963-64	886.	503.	327.	413.	426.	573.	1,175.	1,038.	5,183.	760.	953.	1,328.	1,124.
1964-65	354.	516.	350.	430.	1,640.	5,533.	1,581.	3,120.	6,661.	6,548.	805.	4,115.	2,640.
1965-66	2,690.	650.	708.	538.	1,602.	696.	585.	498.	796.	500.	896.	669.	899.
1966-67	250.	283.	216.	285.	362.	524.	593.	427.	14,082.	2,021.	906.	1,377.	1,764.
1967-68	1,329.	516.	552.	528.	487.	464.	693.	671.	1,535.	1,803.	4,973.	1,621.	1,270.
1968-69	2,958.	971.	941.	1,460.	4,600.	9,780.	6,346.	5,821.	2,284.	3,784.	1,383.	1,816.	3,510.
1969-70	666.	589.	561.	476.	601.	526.	816.	2,874.	5,686.	535.	710.	927.	1,244.
1970-71	1,366.	756.	451.	375.	2,781.	4,546.	1,105.	6,906.	2,934.	1,304.	484.	239.	1,938.
1971-72	405.	937.	504.	383.	456.	498.	531.	2,765.	879.	1,187.	3,180.	2,038.	1,151.
1972-73	441.	2,806.	1,634.	4,150.	4,147.	9,079.	7,864.	4,770.	2,387.	4,724.	1,564.	8,987.	4,369.
1973-74	21,561.	4,497.	2,930.	3,584.	3,264.	1,910.	1,890.	2,638.	1,750.	550.	676.	356.	3,823.
AVERAGE	1,811.	844.	632.	858.	1,558.	2,672.	2,021.	3,159.	5,228.	2,934.	1,723.	2,007.	2,120.

SECTION VI

PROPOSED PROJECT MODIFICATIONS

1. GENERAL

Two alternative arrangements of the Project have been compared for the installation of hydroelectric generation facilities at Tuttle Creek Dam. One arrangement, termed the tunnel alternative, involves a power tunnel through the left abutment and was developed to avoid any interference with the existing flood control function of the dam as well as to avoid the use of, and modification to, the existing features of Tuttle Creek Dam. The other arrangement, termed the outlet works alternative, utilizes one of the existing outlet conduits near the right abutment for conveyance of water to the powerhouse. The outlet works alternative has significant environmental and economic benefits compared to the tunnel alternative, but it will affect the flood control capability. Therefore both arrangements have been analyzed in these studies. Both alternatives have been discussed with the Corps and related correspondence is included in Appendix C.

Subsequent studies may determine the desirability of a slightly different size, arrangement, installed capacity or method of operation than those of the alternative arrangements. However, variations of a magnitude sufficient to affect decisions based on the outcome of this study are not anticipated.

Both alternatives have long power conduits in comparison to the head and thus may be subject to waterhammer and surge problems. This is particularly true for the tunnel alternative which has a hydraulic length almost twice the outlet works alternative. However, the Project will be a relatively small component of the

total regional power supply system, and it will therefore be possible to slow down the governor on the Project generating units and thus limit hydraulic transients without causing system frequency regulation problems. Further the maximum velocities in the waterways have been limited to lower values to reduce the hydraulic transient problems.

2. TUNNEL ALTERNATIVE

a. General

The major features of the tunnel alternative are a power intake, power tunnel, gate shaft, powerhouse, tailrace channel and switchyard, all located in or near the left abutment of the dam. Also included in the arrangement are transmission facilities to carry the project power to the distribution system. No measures would need to be taken to adapt the proposed features to the existing structures, and the proposed facilities would not affect the flood release ability. Figure 5 shows plan and profile views of the project arrangement.

b. Power Intake

The power intake would be a submerged concrete structure founded on limestone with a square bellmouth opening transitioning to a 19-foot diameter tunnel. A trashrack and concrete apron would be located upstream of the bellmouth section. The intake, including trashrack and transition, would be about 65 feet long and 33 feet wide. The invert of the approach channel would be approximately at El 1038 and the top of the trashrack at El 1065. Normal tunnel closure would be accomplished at the gate shaft. Stoplog slots would be provided for closure of the intake, and stoplog would be inserted from a barge.

A 340-foot long excavated entrance channel would allow water from the reservoir to flow into the intake. The channel would be unlined and have a base width of 40 feet.

The intake excavation would be undertaken in two phases. The first will involve excavating a pit and access road to the intake area, leaving a ridge of rock to act as a natural cofferdam. This natural cofferdam would have a crest elevation of 1095 and would limit the probability of flooding the intake area to roughly a 1 in 5 year occurrence. The second phase of intake excavation would involve the removal of the ridge once the intake, gate shaft and tunnel were completed.

c. Gate Shaft

The emergency gate shaft would be located about 200 feet downstream of the intake, and would include a 115-foot high, 20-foot diameter shaft and a 75 foot section of the power conduit where the section changes from circular to rectangular to circular. The emergency gate would be 14 feet wide by 21 feet high, fixed-wheel type, operated by a hoist at the top of the shaft.

The transition section of the conduit would be steel lined and the shaft would be concrete lined.

d. Power Tunnel

The power tunnel would be 19-foot diameter, steel and concrete lined. The total length of the circular power tunnel would be about 1,600 feet and would include a 55 degree, 190-foot radius bend. The steel liner would provide an impervious membrane and thus no provision would be required for drainage behind the tunnel or grouting of the portal rock.

At the maximum plant discharge, the velocity in the tunnel would be about 12 feet per second. A review of existing geological exploration data indicates that due to the erodible nature of the rock which would be encountered in the tunnel alignment, tunneling condition would be poor and extensive support measures would therefore be required, including rock bolts, shotcrete, steel sets and timber lagging.

e. Powerhouse

The powerhouse would be located in a ravine in the left abutment adjacent to the toe of the dam and would be founded on limestone bedrock. This location is proposed to minimize the length of the costly power conduit. The powerhouse would be an indoor type and contain three Allis-Chalmers standard adjustable blade turbine/generator units rated at 4,750 kW each at 60 feet of net head, and one unit rated at 500 kW at 60 feet of net head, providing a total installed capacity at the powerhouse of 14,750 kW. The smaller unit would be included to allow generation with the minimum reservoir release of 100 cfs. The standardized TUBE units have been proposed because of their low cost, comparatively small dimensions and quick delivery.

A profile of the powerhouse along one of the larger units is shown in Fig. 6. A steel trifurcation would connect the 19-foot diameter power tunnel and the 9-1/2 foot diameter inlet tubes. A 3-1/2 foot diameter feed pipe for the small unit would branch from the adjacent arm of the trifurcation. The small unit would not operate concurrently with the large units to prevent disturbance of the flow to the adjacent large unit. Draft tube closure for dewatering would be accomplished by stoplogs inserted into piers constructed for that purpose.

The powerhouse would be about 62 feet long and 75 feet wide, and includes space for routine maintenance and support facilities. The top of the powerhouse would be at El 1030, and would be made watertight. For project outflows greater than 95,000 cfs the powerhouse would be submerged; however, this would be a very rare occurrence as the Corps of Engineers wishes to limit the outflow from the reservoir to less than 30,000 cfs whenever possible to avoid downstream damage. Hatches would be installed in the powerhouse roof for removal of the machinery, which could be accomplished by a truck-mounted crane. The deepest excavation would be to El 982 and backfill would be placed at El 1030, with a black-top cover. A drainage system would be provided to handle the runoff occurring in the ravine in which the powerhouse is located. The powerhouse excavation will generally be downstream of the main north abutment of the dam and would not affect the dam's stability. Excavation slopes would be 0.5:1 for the temporarily exposed slopes and 1:1 for the permanently exposed slopes.

f. Outlet Channel

A concrete-lined tailrace and outlet channel would connect the powerhouse with the dredged pond downstream of the dam. The outlet channel would have a 12-foot base width with the invert at El 1000 and side slopes of 1-1/2:1, with concrete lining extending to El 1016 and riprap to El 1030. A 50-foot concrete-lined transition would connect the powerhouse and the outlet channel. The outlet channel would be about 2,100 feet long and generally follows the intersection of the valley floor and side, discharging into the pond at the spillway channel.

g. Transmission and Switchyard

The main transformers would be located behind the powerhouse on the backfill, and would step up the generator voltage to

34.5 kV. A switchyard would be located on top of the knoll between the powerhouse and spillway. From the switchyard, a single circuit 4/0 ACSR, 34.5-kV transmission line would run to the existing KPL-owned substation near Rocky Ford Dam, a distance of about 2.5 miles. The existing 1/0 34.5-kV line to this substation will be restrung with 4/0 conductors for a distance of about 2.5 miles to an existing KPL substation near Manhattan. The exact alignment of the transmission line has not been determined at this time.

h. Access Roads

Access to the project features for construction and maintenance would require only short lengths of new road, since all features are near existing service roads. Approximately 500 feet of permanent, surfaced road would be required for the powerhouse, 500 feet of branch service road for the switchyard and gate shaft and 500 feet of temporary construction road for the intake. A bridge would need to be constructed over the outlet channel.

3. OUTLET WORKS ALTERNATIVE

a. General

The primary features of the outlet works alternative are a waterway formed by a steel liner through one (westside) of the two existing outlet conduits, a wye from the existing conduit at the entrance to the stilling basin where a shutoff gate (valve) would be installed to permit flood control discharges when necessary, a short penstock from the wye to a manifold, and a powerhouse discharging into the stilling basin. Figure 7 shows general plan and profile views of the arrangement and Fig. 8 shows plan and profile views of the powerhouse. No new roads would need to be built for access to the project features.

b. Power Conduit

The existing outlet conduits are not designed for pressure flows, and thus a primary emphasis of the design of the power conduit must be the prevention of pressurizing and cracking the existing conduit. This design requirement is emphasized in correspondence received from the Corps of Engineers, dated December 20, 1978, which is included in Appendix C. This can best be accomplished by installing a steel liner from the existing service gates in the intake tower all the way through the conduit.

The existing intake tower contains two 10-foot by 20-foot emergency gates and two 10-foot by 20-foot service gates for each conduit (8 gates total). Each pair of gates (emergency and service) control a 10-foot by 20-foot rectangular channel. Approximately 40 feet downstream of service gates, the 4 rectangular channels enter a 60-foot long transition to the twin 20-foot horseshoe conduits.

The proposed power facilities would use the right (west-erly) conduit. The required tower modifications would begin with a 40 foot by 90 foot trashrack fastened to the front of the existing piers. This trashrack would require underwater construction. All other conduit work could be accomplished in the dry by closure of the emergency and/or service gates, and construction of a cofferdam to close off the right stilling basin. Required releases could be discharged through the other conduit.

The steel liner would begin immediately downstream of the service gates with a transition to two 9 foot by 18 foot fabricated steel sections. The central pier in the 60-foot long transition section would be removed and the two steel box sections would transition to a single 18-foot diameter steel penstock. The penstock

section would be 800-feet long and would extend to the conduit portal at the drop to the stilling basin. The space between the steel liner and the existing concrete would be grouted and a layer of compressible material would be placed between the steel and grout to prevent transfer of stress to the existing concrete structures.

At the entrance to the stilling basin, the power conduit would branch through a wye section. A shutoff gate (18'Ø butterfly valve) would be located just downstream, which would be closed during power operation and fully opened during flood discharges through the conduit. The flood control capability of this system is discussed later in this section. The other arm of the wye would connect to the powerhouse by a 90-foot long 18-foot diameter concrete saddle supported penstock and a 50-foot long manifold.

c. Powerhouse

The powerhouse would contain the same equipment as the powerhouse for the tunnel alternative and would be similar in design except the 500 kW unit and service area would be on the opposite side of the 4,750 kW units and the roof deck would be at El 1027 to match the existing parking surface, as shown in Fig. 8. Much of the excavation for the powerhouse will be in the existing backfill for the stilling basin, although the foundation would be on bedrock or the existing stilling basin wall footings.

About 90 feet of the gravity-type stilling basin walls would be removed to provide an outlet channel for the powerhouse, and 65 feet of new wall would be built. The discharge velocity into the stilling basin would be about 6 feet per second and would enter above the tops of the chute blocks. The actual orientation of the powerhouse would be determined as a result of hydraulic model studies to produce maximum dissipation of power flows in the

basin, and minimize erosion of the outlet channel downstream. It should be noted that the maximum discharge through the generating units is 3,300 cfs which can be compared with the maximum capacity of one outlet work conduit is about 15,000 to 20,000 cfs.

d. Transmission and Switchyard

The main transformers and switching equipment would be located on the backfill behind the powerhouse. Required transmission line facilities would include 0.5 miles of new 4/0 ASCR, 34.5-kV single circuit line and new 4/0 ASCR conductor on 2.5 miles of existing 1/0 ASCR, 34.5-kV line.

e. Flood Release Capability

During major floods, when the desired release is greater than the capacity of the single conduit, the butterfly valve on the stilling basin branch of the wye would be opened to allow flood releases through the power conduit. Regulation of the discharge would be provided by the gates in the intake tower and the butterfly valve would be fully open. The powerhouse would probably not be able to operate during these times of flood release as the existing outlet works system would not be able to supply water under pressure to the powerhouse. The amount of time this would occur would need more detailed study.

The decrease in conduit size would cause some decrease in the discharge capacity of the outlet works. Figure 9 shows the discharge capacities of the modified conduit, existing conduit and combined system. As can be seen from the curves, the modified conduit would be able to discharge about 78% of the existing capacity and the combined outlet works system would be able to pass about 89% of its current capacity. The Corps of Engineers wishes to limit the downstream release to 30,000 cfs to avoid major damage downstream,

and this release capacity can be met by the modified outlet works when the reservoir is above El 1088, approximately. Further studies are needed to determine the impact of this system on the flood control operation if this arrangement is pursued further.

4. COMPARISON OF PROJECT ALTERNATIVES

Construction cost estimates have been prepared for both project alternatives. The detailed Direct Construction Cost estimate for the tunnel alternative is contained in Appendix D, and Section VIII contains the detailed estimate for the outlet works alternative. A comparative summary of the direct construction costs of the alternative (January 1979 bid level) is shown in Table VI-1. This shows that the comparative direct construction of the outlet works alternative is \$4,830,000 less than the tunnel alternative. This savings in cost with the outlet works alternative would be about \$9 million when translated to Total Capital Investment at the on-line date (July 1984). The estimated capital investment of the tunnel alternative amounts to about \$1,500/kW installed which is very high. Feasibility analyses show that this alternative is not economically feasible even with the most favorable financing conditions. In addition there are significant environmental advantages to the outlet works alternative, including aesthetics and less disruption of the river pond recreation area. Therefore, the outlet works alternative was chosen as the selected alternative for assessment and the economic analyses were based only on this alternative.

TABLE VI-1

TUTTLE CREEK HYDROELECTRIC PROJECT
SUMMARY OF COMPARATIVE DIRECT CONSTRUCTION COSTS (1)

<u>Project Feature</u>	<u>Tunnel Alternative</u>	<u>Outlet Works Alternative</u>
1. Preparatory Work	\$ 526,000	\$ 250,000
2. Power Waterway	8,818,000	4,019,000
3. Powerhouse Civil	1,121,000	1,446,000
4. Powerhouse Mechanical and Electrical	4,416,000	4,416,000
5. Switchyard and Transmission	<u>325,000</u>	<u>245,000</u>
DIRECT CONSTRUCTION COST	\$15,206,000	\$10,376,000

- (1) These costs are estimated at a January 1979 price level and do not include contingencies, engineering costs, owner administration, or interest during construction.

SECTION VII

RESERVOIR OPERATION AND POWER OUTPUT

1. STUDY CRITERIA AND METHODS

a. General

Power studies have been performed for the Tuttle Creek Hydroelectric Project using a mathematical model of project operation over the 39-year historical record of streamflows from October 1935 to September 1974 (see Section V). The power studies model accounts for evaporation losses from the reservoir, based on the reservoir surface area and monthly evaporation rates, as discussed in Section V. The Project has the ability to provide a dependable source of peaking capacity and this type of operation has been assumed in the power studies. The energy output will be largely dependent on the method of reservoir operation, which will be influenced by recreation interests and the Corps of Engineers as well as KEPCo. Two methods of reservoir operation (rule curves) have been considered and are described later in this section.

b. Definitions

Firm (prime) energy is that generated and delivered to the load centers on an annual basis during severe low flow conditions. For the Tuttle Creek Project, it is considered reasonable to establish the firm energy by the second worst year of generation, which would have a probability of occurrence of about once in 20 years. The estimate is made on a water year basis to bracket a complete load cycle of the KEPCo system, which experiences high loads in both winter and summer.

Average annual energy is that generated and delivered to the load centers on a long-term average annual basis. The difference between the average and firm energy is termed secondary.

Dependable capacity is defined herein as the peak capability of the plant with the turbines operating at full gate at the second lowest reservoir elevation during the peak load season. Under these conditions, the dependable capacity will be available with daily peaking operation for short periods, utilizing the reservoir as peaking pondage.

c. Generation Capability

The generating units for the Project will be Allis-Chalmers standard TUBE units which will provide the most economical installation. The power plant will contain 3 units rated at 60 feet of net head with 4,750 kW generator output, and one unit rated at 60 feet of net head with 500 kW generator output for a total plant installed capacity of 14,750 kW.

The small unit is included to allow generation with the minimum flow of 100 cfs. The minimum flows will be required only during times when the reservoir is at normal levels, and thus the head on the unit will not vary greatly. Accordingly, the small turbine will be fixed propeller type, and thus avoid the additional cost of adjustable blades.

The three large units will have adjustable blades to allow operation over the wide range of heads resulting from the flood control operation. However, at the high heads, the turbine capacity will exceed the generator capacity, which, at an assumed 5% overload capability, will be 5,000 kW each. Therefore, at pool elevations greater than about El 1077 the turbine blades will be adjusted to maintain the 5,000 kW generator output. It is

estimated that this adjustment can be accomplished for heads up to about 80 feet, corresponding to a pool of about El 1100 and frequency of about once in 7 years.

d. Assumptions

In the power output studies, it is assumed that the conservation storage in Tuttle Creek Lake above El 1070 will be used to support power production during low inflow periods. It was assumed the plant would be operated strictly for peaking during low flow periods, and the reservoir could be drafted to the minimum pool level (El 1070) twice during the historical period of record.

The turbines installed in the powerhouse will have adjustable blade runners which have the characteristics of relatively constant efficiency and maximum discharge over a wide range of head. Average efficiencies of 89% for the turbine, 99% for the speed increaser, 98% for the generator and 99% for the transformer have been assumed, for a combined efficiency of 85% at the high voltage side of the transformer. Hydraulic losses of about 4 feet at the maximum conduit discharge have been determined for the power waterway and are considered applicable to both alternative arrangements.

e. Transmission Losses

The Project generation will be transmitted about 3 miles to the KPL Manhattan Substation and from there into the KPL distribution system. The expected transmission losses in the line from the powerhouse to the substation have been determined to be 2.0% for energy and 2.5% for peaking.

2. RESERVOIR OPERATION

a. Flood Control Operation

It is expected that Tuttle Creek Lake will continue to be operated primarily for flood control purposes and hydroelectric generation will not be allowed to interfere with the flood control function. Consequently, the generating facilities will be designed to operate within the framework of the flood control operation.

Normal flood control operation is typified by a relatively steady-state reservoir during non-flood periods and temporary storage of excess flood waters during flood periods. At Tuttle Creek Lake, the flood waters are currently released by the twin horseshoe conduits near the right abutment. With the hydro plant in operation, some of this flood water could be released through the generating units; however, the hydraulic capacity of the hydro plant is not great enough to regulate the floods as desired and some release through the outlet works would continue to be necessary. In the power studies, the maximum allowable release from the reservoir is varied as a function of the reservoir elevation so that the resultant elevations correspond to the Corps' desired mode of reservoir operation during flood conditions.

b. Conservation Operation

Tuttle Creek Lake is currently being operated to support some recreational and fish and wildlife functions in addition to flood control. This operation involves fluctuation of the pool several feet during non-flood periods, as described later in this section. The availability of the reservoir for use in a similar manner, particularly to support peaking capability of the Project and the generation of firm energy during low flow periods, will be

of great importance to the Project's feasibility. Two alternative methods of conservation regulation have been studied for power production and are described below.

(1) State Rule Curve

The conservation regulation procedure currently being followed is a reservoir rule curve recommended by the Kansas Water Resources Board and is herein referred to as the state rule curve. The purposes and functions of this regulation plan are explained in correspondence with the Kansas Water Resources Board contained in Appendix C. The plan of operation involves a reservoir elevation of 1073 during the winter, rising to a spring peak elevation of 1078, followed by a summer elevation of 1075 and a late autumn elevation of 1079. A graphical representation of this regulation plan is shown in Fig. 10. Attempts to follow this rule curve in 1978 were severely disrupted by the need for flood control operation, but it will be tried again in 1979.

For the power studies it was assumed that during low flow periods the reservoir could be drafted to El 1070 to support minimum flow releases and the generation of dependable capacity and firm energy.

(2) Power Rule Curve

As an alternative to the State rule curve, a plan of operation was developed which would benefit primarily the production of power. This plan, referred to herein as the power rule curve, envisions a pool level near 1075 during the winter and spring followed by spring runoff storage to El 1084 during late spring and early summer, with a gradual release back to El 1075 the remainder of the year. A graphical representation of this plan of

regulation is shown in Fig. 10. The power benefits to this plan are an increased average head, more average energy and a higher dependable capacity.

3. OPERATION STUDY RESULTS

a. Power Output with State Rule Curve

Table VII-1 presents a summary for the power output for both the state rule curve and the power rule curve. The average annual generation is 57,844 MWh. Table VII-2 is a month-by-month summary of the estimated energy production for the historical period of record, based on a frequency of drawdown to minimum pool of twice in the period. Table VII-3 is a summary of the end of month of record reservoir elevations for the period of record. The worst reservoir draft occurs in July 1940 and the pool is low for a period of 18 months. The second occurrence of minimum pool is in the spring of 1957, and the reservoir is at reduced levels for 21 months during this cycle.

The dependable peaking capability from the state rule curve operation is 12,610 kW based on a reservoir elevation of 1072.6 feet which occurred in September 1955, as shown in Fig. 10. The firm energy is 16,265 MWh, based on water year 1956. These values are at the high voltage side of the transformer. As delivered to the Manhattan Substation with allowances for transmission losses, the dependable capacity is 12,290 kW, the firm energy is 15,940 MWh, and the average annual energy is 56,690 MWh.

b. Power Output with the Power Rule Curve

The power output for the Project generation using the alternative power rule curve is summarized also in Table VII-1.

The average annual energy is 58,698 MWh. The month-by-month summary of energy generation is presented in Table VII-4, and a summary of the end-of-month reservoir elevation is presented in Table VII-5. For this mode of operation, during the historical period the worst drawdown occurs late in 1940 and the minimum pool lasts for 3 months with low reservoir levels occurring for a period of 18 months. The second occurrence of drawdown is in April 1938, with low reservoir levels for 12 months. The dependable peaking capability from the power rule curve operation is 13,180 kW at a reservoir elevation of 1074.7 feet which occurs at the end of September 1936, as shown in Fig. 10. The firm energy is 16,143 MWh, based on water year 1956. As delivered to the load center, the dependable capacity is 12,850 kW, the firm energy is 15,820 MWh and the average annual generation is 57,520 MWh.

c. Comparison of Rule Curves

As shown in Table VII-1, the power rule curve does provide greater dependable capacity and average annual energy. However, the differences are relatively small and therefore the economic analysis has been based on the generation from the accepted state rule curve.

5. WATER LEVEL FLUCTUATIONS

a. Tuttle Creek Lake

The proposed peaking operation of the Project will cause some fluctuation of Tuttle Creek Lake. However, the surface area of the reservoir is relatively large and the fluctuations will be small. The maximum daily fluctuation will be about 1 inch at normal reservoir levels. The maximum draft of the reservoir during low flow periods will also amount to about 1 inch per day.

b. Dredged Pond

The power plant, when operated on a peaking basis, will also cause fluctuation of the dredged pond at the toe of the dam, a major recreation resource for the area. The outflow from the pond is controlled by the discharge capacity of the weir at the downstream Rocky Ford Power Plant. The maximum daily fluctuation will be about 1.5 feet. The corresponding maximum daily fluctuation in the river downstream of Rocky Ford Dam will be about 4.4 feet.

TUTTLE CREEK HYDROELECTRIC PROJECT
ALTERNATIVE RESERVOIR OPERATION CASES
SUMMARY OF POWER STUDIES RESULTS

ITEM	Alternative Reservoir Operation Case	
	<u>State Rule Curve</u>	<u>Power Rule Curve</u>
<u>Rule Curve Parameter Summary (see Fig. 10):</u>		
Normal Maximum Reservoir Elevation, Feet	1079	1084
Normal Minimum Reservoir Elevation, Feet	1073	1075
Normal Reservoir Storage Use, Acre-Feet	75,250	75,250
Minimum Reservoir Elevation, Feet	1070	1070
<u>Generation at Site (1):</u>		
Installed Capacity, kW	14,750	14,750
Second Lowest Peak Load Period - Reservoir Elevation, Feet (see Fig. 10)	1,072.6	1,074.7
Dependable Capacity, kW (2)	12,610	13,180
Firm Energy, MWh (3)	16,265	16,143
Year of Firm Energy Generation, MWh	1956	1956
Average Annual Energy, MWh	57,844	58,698
<u>Generation at Delivery Point (4)</u>		
Dependable Capacity, kW	12,290	12,850
Firm Energy, MWh	15,940	15,820
Average Annual Energy, MWh	56,690	57,520
(1) Generation at the high voltage side of the transformer.		
(2) Capacity available at the second lowest peak period reservoir water surface elevation with turbine blades in the full open position.		
(3) Second lowest annual energy generation, on a water year basis.		
(4) Generation considering peak losses of 2.5% and energy losses of 2.0%.		

TUTTLE CREEK HYDROELECTRIC PROJECT
TOTAL ENERGY PRODUCTION (MWh)
STATE RULE CURVE

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1935-36	1,046.	994.	5,523.	1,013.	4,575.	4,631.	1,724.	3,856.	1,135.	2,292.	1,013.	980.	28,782.
1936-37	1,014.	981.	1,013.	1,013.	2,248.	2,132.	1,018.	1,015.	994.	4,219.	1,612.	991.	18,250.
1937-38	1,013.	980.	1,013.	1,014.	916.	1,013.	984.	7,214.	10,120.	9,837.	3,334.	1,034.	38,472.
1938-39	1,028.	977.	3,366.	1,013.	916.	1,046.	5,558.	1,038.	9,817.	6,180.	2,454.	988.	34,381.
1939-40	1,013.	980.	1,013.	1,013.	916.	1,016.	984.	1,010.	978.	237.	1,013.	1,006.	11,179.
1940-41	1,013.	980.	1,013.	1,014.	930.	1,063.	1,547.	1,049.	11,026.	11,145.	3,128.	9,258.	43,166.
1941-42	10,889.	10,599.	9,831.	7,206.	1,899.	5,198.	2,745.	9,844.	10,312.	7,832.	4,656.	6,569.	87,580.
1942-43	1,067.	998.	6,388.	1,521.	6,126.	1,054.	999.	2,714.	11,132.	11,283.	10,971.	978.	55,231.
1943-44	1,014.	981.	1,084.	1,010.	914.	1,019.	8,383.	10,433.	10,926.	11,187.	11,149.	10,829.	68,929.
1944-45	4,679.	2,550.	7,635.	2,425.	1,786.	6,961.	10,409.	11,546.	11,017.	11,355.	11,201.	3,741.	85,305.
1945-46	1,022.	995.	5,480.	1,859.	1,511.	1,060.	1,412.	1,036.	3,607.	10,163.	1,834.	3,585.	33,564.
1946-47	3,147.	6,872.	6,687.	1,291.	933.	1,068.	10,284.	8,809.	11,189.	11,300.	11,132.	978.	73,690.
1947-48	1,011.	976.	2,048.	1,327.	7,989.	11,312.	10,808.	3,204.	4,039.	10,189.	9,728.	1,235.	63,866.
1948-49	1,043.	991.	5,459.	9,489.	9,412.	11,395.	10,846.	11,229.	11,103.	11,311.	11,175.	10,446.	103,899.
1949-50	7,597.	1,851.	6,283.	1,282.	931.	1,310.	1,676.	10,670.	10,564.	11,425.	11,278.	10,842.	75,709.
1950-51	11,285.	10,773.	6,993.	1,712.	1,417.	4,485.	8,508.	10,623.	11,401.	11,588.	11,376.	11,026.	101,187.
1951-52	11,199.	8,420.	7,528.	2,943.	1,741.	9,946.	10,707.	11,143.	8,712.	10,611.	10,191.	981.	94,122.
1952-53	1,027.	992.	5,757.	2,184.	1,647.	1,061.	2,194.	2,143.	4,264.	4,066.	1,013.	981.	27,329.
1953-54	1,014.	981.	2,873.	1,117.	926.	1,024.	989.	3,791.	10,301.	5,070.	10,618.	7,828.	46,532.
1954-55	1,013.	989.	5,076.	1,092.	3,850.	1,060.	1,103.	1,023.	3,441.	4,907.	1,013.	980.	25,547.
1955-56	1,013.	980.	1,013.	1,014.	913.	1,012.	979.	1,010.	1,026.	5,293.	1,031.	981.	16,265.
1956-57	1,013.	980.	1,013.	1,013.	915.	1,010.	1,001.	1,078.	10,575.	10,780.	4,581.	2,612.	36,571.
1957-58	1,058.	991.	4,918.	1,013.	1,282.	7,048.	4,765.	3,393.	3,271.	11,426.	11,227.	10,899.	61,291.
1958-59	7,748.	1,480.	6,148.	1,294.	3,163.	2,660.	3,738.	11,353.	10,799.	10,921.	7,952.	4,274.	71,530.
1959-60	10,180.	2,462.	6,858.	4,869.	5,039.	11,112.	11,009.	11,263.	10,932.	11,194.	8,347.	1,098.	94,363.
1960-61	1,045.	995.	5,954.	1,381.	934.	1,506.	4,768.	10,767.	10,714.	6,327.	1,822.	9,764.	55,977.
1961-62	10,458.	8,151.	8,129.	5,942.	8,710.	10,542.	10,409.	10,310.	10,109.	9,293.	3,246.	1,855.	97,154.
1962-63	3,667.	1,943.	6,451.	1,330.	2,518.	3,452.	2,811.	4,783.	8,675.	6,168.	3,319.	4,059.	49,176.
1963-64	1,067.	1,129.	5,703.	1,106.	921.	1,021.	1,228.	1,719.	10,357.	7,036.	2,433.	1,981.	35,701.
1964-65	1,047.	984.	4,242.	1,154.	3,493.	10,151.	7,303.	8,257.	10,681.	11,327.	11,009.	9,754.	79,402.
1965-66	6,577.	1,814.	6,871.	1,459.	3,392.	1,053.	998.	1,023.	995.	2,897.	2,259.	1,005.	30,343.
1966-67	1,016.	981.	1,815.	1,011.	912.	1,018.	992.	1,021.	11,121.	11,262.	10,621.	2,127.	43,897.
1967-68	2,242.	1,398.	6,393.	1,431.	934.	1,019.	993.	1,033.	2,427.	7,375.	10,107.	5,493.	40,845.
1968-69	7,426.	2,824.	7,583.	4,158.	8,672.	11,315.	10,967.	11,294.	10,777.	10,379.	5,466.	3,439.	94,300.
1969-70	1,059.	996.	6,108.	1,285.	931.	1,026.	999.	6,903.	10,471.	7,512.	1,694.	1,012.	39,996.
1970-71	2,129.	2,148.	6,084.	1,013.	6,498.	9,876.	3,124.	10,911.	10,784.	6,482.	1,022.	981.	61,052.
1971-72	1,014.	998.	3,809.	1,020.	920.	1,019.	989.	5,193.	2,349.	5,471.	9,142.	4,101.	36,025.
1972-73	1,053.	6,799.	9,694.	9,452.	8,635.	11,050.	11,003.	11,274.	10,779.	10,625.	8,668.	10,759.	109,791.
1973-74	11,609.	10,971.	11,313.	11,262.	9,707.	7,308.	5,482.	6,752.	5,037.	3,494.	1,590.	994.	85,519.
AVERAGE	3,476.	2,664.	5,184.	2,429.	3,079.	4,181.	4,524.	5,967.	7,896.	8,243.	6,037.	4,165.	57,844.

**TUTTLE CREEK HYDROELECTRIC PROJECT
END-OF-MONTH RESERVOIR ELEVATION (FEET)
STATE RULE CURVE**

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AVERAGE
1935-36	1,077.5	1,078.4	1,073.0	1,072.6	1,074.0	1,076.5	1,076.5	1,078.0	1,078.0	1,075.0	1,073.5	1,072.8	1,075.5
1936-37	1,072.4	1,071.7	1,071.2	1,070.4	1,074.0	1,076.5	1,076.4	1,076.5	1,077.9	1,075.0	1,075.0	1,074.3	1,074.3
1937-38	1,073.6	1,072.9	1,072.3	1,071.9	1,071.5	1,071.7	1,071.8	1,078.0	1,078.0	1,075.0	1,075.0	1,077.0	1,074.1
1938-39	1,076.5	1,076.4	1,073.0	1,072.7	1,072.3	1,076.2	1,076.5	1,076.5	1,078.0	1,075.0	1,075.0	1,073.8	1,075.2
1939-40	1,073.0	1,072.2	1,071.5	1,070.7	1,070.5	1,071.1	1,070.8	1,070.6	1,070.6	1,070.0	1,073.3	1,072.8	1,071.4
1940-41	1,071.7	1,071.1	1,070.6	1,070.3	1,072.2	1,073.5	1,076.5	1,077.6	1,091.7	1,076.2	1,075.0	1,077.0	1,075.4
1941-42	1,084.0	1,079.0	1,073.0	1,073.0	1,074.0	1,076.5	1,076.5	1,078.0	1,080.5	1,075.0	1,075.0	1,077.0	1,076.8
1942-43	1,078.4	1,078.9	1,073.0	1,073.0	1,074.0	1,074.9	1,076.0	1,078.0	1,100.6	1,085.7	1,075.0	1,074.4	1,078.5
1943-44	1,073.9	1,073.6	1,073.0	1,072.8	1,072.6	1,073.5	1,076.5	1,079.8	1,086.8	1,078.7	1,085.1	1,080.5	1,077.2
1944-45	1,079.0	1,079.0	1,073.0	1,073.0	1,074.0	1,076.5	1,083.3	1,106.6	1,100.3	1,093.6	1,079.6	1,077.0	1,083.0
1945-46	1,078.2	1,078.7	1,073.0	1,073.0	1,074.0	1,076.2	1,076.5	1,077.0	1,078.0	1,075.6	1,075.0	1,077.0	1,076.0
1946-47	1,079.0	1,079.0	1,073.0	1,073.0	1,074.0	1,076.5	1,081.9	1,078.0	1,105.1	1,089.2	1,075.0	1,075.0	1,079.9
1947-48	1,074.6	1,074.4	1,073.0	1,073.0	1,074.0	1,091.7	1,078.8	1,078.0	1,078.0	1,075.0	1,075.0	1,077.0	1,076.9
1948-49	1,077.3	1,078.1	1,073.0	1,073.0	1,083.4	1,092.5	1,081.2	1,083.8	1,100.3	1,088.9	1,077.8	1,082.3	1,082.6
1949-50	1,079.0	1,079.0	1,073.0	1,073.0	1,073.8	1,076.5	1,076.5	1,082.3	1,078.0	1,092.1	1,084.8	1,081.6	1,079.2
1950-51	1,087.6	1,079.0	1,073.0	1,073.0	1,074.0	1,076.5	1,076.5	1,081.8	1,120.5	1,116.1	1,103.3	1,099.5	1,088.5
1951-52	1,084.6	1,079.0	1,073.0	1,073.0	1,074.0	1,077.4	1,085.5	1,079.0	1,078.0	1,080.2	1,075.0	1,076.2	1,077.9
1952-53	1,076.5	1,077.5	1,073.0	1,073.0	1,074.0	1,076.3	1,076.5	1,078.0	1,078.0	1,075.0	1,075.0	1,074.2	1,075.6
1953-54	1,073.8	1,074.3	1,073.0	1,073.0	1,073.8	1,074.1	1,074.7	1,078.0	1,080.5	1,075.0	1,083.4	1,077.0	1,075.9
1954-55	1,077.9	1,078.0	1,073.0	1,073.0	1,074.0	1,075.9	1,076.5	1,076.5	1,078.0	1,075.0	1,073.7	1,072.6	1,075.3
1955-56	1,072.1	1,071.4	1,070.8	1,070.5	1,070.4	1,070.4	1,070.1	1,070.0	1,075.0	1,075.0	1,074.5	1,073.7	1,072.0
1956-57	1,072.7	1,071.9	1,071.2	1,070.4	1,070.0	1,070.0	1,072.2	1,076.8	1,084.7	1,075.0	1,075.0	1,077.0	1,073.9
1957-58	1,077.9	1,078.1	1,073.0	1,072.9	1,074.0	1,076.5	1,076.5	1,078.0	1,078.0	1,091.9	1,081.5	1,084.6	1,078.6
1958-59	1,079.0	1,079.0	1,073.0	1,073.0	1,074.0	1,076.5	1,076.5	1,090.0	1,079.8	1,081.6	1,075.0	1,077.0	1,077.9
1959-60	1,079.0	1,079.0	1,073.0	1,073.0	1,074.0	1,089.6	1,092.7	1,086.5	1,087.3	1,079.4	1,075.0	1,077.0	1,080.5
1960-61	1,078.1	1,078.6	1,073.0	1,073.0	1,073.7	1,076.5	1,076.5	1,083.3	1,079.3	1,075.0	1,075.0	1,077.0	1,076.6
1961-62	1,079.0	1,079.0	1,073.0	1,073.0	1,075.4	1,082.1	1,076.5	1,078.0	1,078.4	1,075.0	1,075.0	1,077.0	1,076.8
1962-63	1,079.0	1,079.0	1,073.0	1,073.0	1,074.0	1,076.5	1,076.5	1,078.0	1,078.0	1,075.0	1,075.0	1,077.0	1,076.2
1963-64	1,078.7	1,079.0	1,073.0	1,073.0	1,073.2	1,073.9	1,076.5	1,078.0	1,081.1	1,075.0	1,075.0	1,077.0	1,076.1
1964-65	1,076.8	1,077.3	1,073.0	1,073.0	1,074.0	1,079.5	1,076.5	1,078.0	1,084.6	1,086.7	1,075.0	1,077.0	1,077.6
1965-66	1,079.0	1,079.0	1,073.0	1,073.0	1,074.0	1,075.2	1,075.9	1,076.2	1,077.5	1,075.0	1,075.0	1,075.8	1,075.7
1966-67	1,075.2	1,074.8	1,073.0	1,072.6	1,072.5	1,073.0	1,073.7	1,073.8	1,098.1	1,083.9	1,075.0	1,077.0	1,076.9
1967-68	1,079.0	1,079.0	1,073.0	1,073.0	1,073.4	1,073.7	1,074.8	1,075.7	1,078.0	1,075.0	1,078.1	1,077.0	1,075.8
1968-69	1,079.0	1,079.0	1,073.0	1,073.0	1,074.9	1,090.7	1,089.6	1,087.8	1,078.7	1,077.1	1,075.0	1,077.0	1,079.6
1969-70	1,077.9	1,078.7	1,073.0	1,073.0	1,073.7	1,074.3	1,075.8	1,078.0	1,082.3	1,075.0	1,075.0	1,076.7	1,076.1
1970-71	1,079.0	1,079.0	1,073.0	1,073.0	1,074.0	1,076.5	1,076.5	1,084.8	1,078.7	1,075.0	1,075.0	1,074.2	1,076.6
1971-72	1,074.2	1,076.2	1,073.0	1,073.0	1,073.3	1,073.7	1,074.2	1,078.0	1,078.0	1,075.0	1,075.0	1,077.0	1,075.0
1972-73	1,077.1	1,079.0	1,073.0	1,073.4	1,074.0	1,088.9	1,091.7	1,086.7	1,078.4	1,080.0	1,075.0	1,088.6	1,080.5
1973-74	1,114.1	1,098.5	1,086.9	1,081.4	1,078.3	1,076.5	1,076.5	1,078.0	1,078.0	1,075.0	1,075.0	1,074.6	1,082.8
AVERAGE	1,078.3	1,077.6	1,073.1	1,072.8	1,073.8	1,077.3	1,077.6	1,079.7	1,083.4	1,079.5	1,076.8	1,077.5	1,077.3

TUTTLE CREEK HYDROELECTRIC PROJECT
TOTAL ENERGY PRODUCTION (MWh)
POWER RULE CURVE

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1935-36	2,799.	2,183.	1,797.	1,336.	5,974.	6,194.	2,087.	1,384.	1,336.	1,329.	1,328.	1,286.	29,033.
1936-37	1,329.	1,287.	1,328.	1,328.	1,643.	3,705.	1,305.	1,329.	1,296.	1,350.	1,342.	1,288.	18,530.
1937-38	1,329.	1,287.	1,328.	1,328.	1,201.	1,329.	1,286.	4,259.	7,760.	9,949.	5,586.	4,153.	40,795.
1938-39	1,891.	1,346.	1,377.	1,454.	1,201.	3,293.	6,038.	1,335.	2,884.	5,864.	4,613.	1,447.	32,743.
1939-40	1,695.	1,287.	1,329.	1,329.	1,201.	1,324.	1,283.	1,329.	1,287.	1,293.	1,337.	1,311.	16,005.
1940-41	1,328.	731.	647.	843.	1,202.	1,385.	1,784.	1,353.	10,917.	11,132.	4,250.	10,359.	45,931.
1941-42	11,122.	10,618.	5,662.	8,136.	2,901.	6,759.	3,084.	6,908.	10,773.	4,966.	7,049.	10,001.	87,979.
1942-43	3,562.	1,836.	2,267.	2,186.	7,243.	1,351.	2,237.	1,376.	11,061.	11,188.	7,343.	1,874.	53,524.
1943-44	1,961.	1,287.	1,329.	1,372.	1,202.	1,328.	9,546.	10,359.	10,818.	11,132.	11,237.	10,813.	72,384.
1944-45	6,864.	2,898.	3,429.	3,132.	2,786.	8,516.	10,284.	11,525.	10,960.	11,284.	11,132.	2,836.	85,646.
1945-46	3,368.	1,829.	1,505.	2,539.	2,503.	2,382.	2,022.	1,335.	1,331.	7,828.	3,399.	6,857.	36,898.
1946-47	6,197.	7,072.	2,466.	1,337.	1,890.	2,636.	10,121.	6,372.	11,127.	11,230.	11,132.	2,366.	74,546.
1947-48	2,060.	1,287.	1,625.	1,977.	9,157.	11,425.	10,830.	1,572.	1,338.	9,224.	11,128.	4,371.	65,994.
1948-49	2,646.	2,031.	2,046.	9,986.	9,708.	11,399.	10,872.	11,200.	11,034.	11,235.	11,132.	10,783.	104,072.
1949-50	10,076.	2,222.	2,055.	1,928.	1,728.	3,047.	2,040.	10,439.	5,097.	11,348.	11,219.	10,825.	72,024.
1950-51	11,309.	10,773.	2,777.	2,386.	2,407.	6,049.	8,718.	10,367.	11,357.	11,531.	11,333.	11,010.	100,017.
1951-52	11,225.	10,285.	3,321.	3,674.	2,740.	10,133.	10,824.	11,132.	4,297.	11,135.	8,437.	3,419.	90,622.
1952-53	2,627.	2,192.	2,892.	2,880.	2,643.	2,489.	2,683.	1,363.	1,352.	1,371.	1,794.	1,773.	26,059.
1953-54	2,028.	1,790.	2,615.	1,750.	1,731.	1,335.	1,380.	2,325.	10,773.	2,057.	11,230.	9,235.	48,249.
1954-55	3,058.	1,522.	1,722.	1,722.	4,905.	2,163.	1,933.	1,328.	1,329.	1,391.	1,330.	1,286.	23,689.
1955-56	1,329.	1,287.	1,329.	1,329.	1,201.	1,329.	1,287.	1,329.	1,335.	1,439.	1,377.	1,572.	16,143.
1956-57	1,634.	1,287.	1,329.	1,329.	1,201.	1,329.	1,304.	1,398.	10,795.	8,238.	6,965.	5,831.	42,640.
1957-58	3,167.	1,492.	1,529.	1,581.	2,325.	8,603.	5,060.	1,383.	1,355.	11,333.	11,159.	10,869.	59,856.
1958-59	9,505.	1,860.	1,918.	1,940.	4,200.	4,230.	4,056.	11,222.	10,773.	11,149.	5,345.	7,582.	73,780.
1959-60	10,461.	3,326.	2,640.	5,690.	6,127.	11,239.	11,027.	11,241.	10,829.	11,132.	6,865.	4,222.	94,799.
1960-61	3,320.	1,778.	2,114.	2,036.	1,692.	3,291.	5,063.	10,578.	9,969.	4,703.	3,914.	10,390.	58,848.
1961-62	10,640.	10,157.	3,932.	6,813.	9,102.	10,826.	10,279.	8,468.	9,499.	8,903.	5,489.	5,034.	99,142.
1962-63	6,714.	2,311.	2,226.	1,980.	3,538.	5,019.	3,149.	1,792.	5,221.	5,850.	5,569.	7,356.	50,725.
1963-64	3,888.	1,738.	1,470.	1,737.	1,256.	1,332.	3,526.	1,360.	9,504.	3,595.	4,590.	5,166.	39,162.
1964-65	2,188.	1,778.	1,538.	1,790.	4,539.	10,333.	9,289.	5,303.	10,789.	11,209.	9,430.	10,424.	78,610.
1965-66	10,300.	2,186.	2,653.	2,122.	4,435.	1,570.	1,922.	1,332.	1,297.	1,334.	1,337.	1,306.	31,794.
1966-67	1,325.	1,287.	1,329.	1,329.	1,201.	1,325.	1,292.	1,328.	11,053.	11,155.	6,055.	5,321.	44,000.
1967-68	5,298.	1,778.	2,167.	2,091.	1,423.	1,334.	1,762.	1,346.	1,334.	2,190.	11,167.	8,160.	40,050.
1968-69	10,447.	3,162.	3,377.	4,946.	9,064.	11,415.	10,991.	11,264.	10,773.	11,132.	6,032.	6,703.	99,306.
1969-70	3,186.	2,000.	2,195.	1,931.	1,689.	1,337.	2,315.	4,527.	10,773.	2,814.	3,773.	3,900.	40,440.
1970-71	5,416.	2,508.	1,853.	1,621.	7,644.	9,990.	4,606.	10,718.	9,869.	5,477.	3,012.	1,719.	64,433.
1971-72	2,352.	3,059.	2,018.	1,645.	1,338.	1,332.	1,397.	4,183.	1,367.	2,069.	11,132.	7,400.	39,292.
1972-73	2,467.	8,700.	5,523.	10,041.	9,130.	11,386.	11,017.	11,247.	10,773.	11,131.	6,679.	10,979.	109,073.
1973-74	11,622.	10,996.	11,290.	11,231.	9,716.	8,086.	5,760.	3,782.	1,397.	2,784.	3,658.	2,090.	82,412.
AVERAGE	4,968.	3,294.	2,460.	2,985.	3,764.	4,963.	5,012.	5,190.	6,842.	7,063.	6,433.	5,726.	58,699.

TUTTLE CREEK HYDROELECTRIC PROJECT
END-OF-MONTH RESERVOIR ELEVATION (FEET)
POWER RULE CURVE

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AVERAGE
1935-36	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,079.4	1,079.2	1,077.5	1,075.7	1,074.7	1,076.4
1936-37	1,073.9	1,072.7	1,071.8	1,070.6	1,075.0	1,075.5	1,075.0	1,074.6	1,075.8	1,076.3	1,076.7	1,075.7	1,074.5
1937-38	1,074.6	1,073.5	1,072.5	1,071.6	1,070.7	1,070.5	1,070.0	1,080.0	1,084.0	1,082.2	1,080.2	1,078.7	1,075.7
1938-39	1,077.2	1,076.7	1,076.0	1,075.2	1,074.5	1,075.5	1,075.0	1,074.6	1,084.0	1,082.2	1,080.2	1,078.7	1,077.5
1939-40	1,077.2	1,076.2	1,075.3	1,074.1	1,073.6	1,073.8	1,073.2	1,072.6	1,072.1	1,070.0	1,072.8	1,071.9	1,073.6
1940-41	1,070.2	1,070.0	1,070.0	1,070.0	1,071.4	1,074.4	1,075.0	1,075.7	1,091.2	1,082.2	1,080.2	1,078.7	1,075.8
1941-42	1,084.7	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,080.0	1,084.0	1,082.2	1,080.2	1,078.7	1,078.6
1942-43	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,078.6	1,100.8	1,085.8	1,080.2	1,078.7	1,079.6
1943-44	1,077.2	1,076.6	1,075.8	1,075.2	1,074.8	1,075.2	1,075.0	1,080.0	1,086.8	1,082.2	1,086.4	1,081.2	1,078.9
1944-45	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,083.0	1,106.5	1,100.3	1,093.5	1,080.2	1,078.7	1,083.2
1945-46	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,075.1	1,078.8	1,082.2	1,080.2	1,078.7	1,077.1
1946-47	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,081.2	1,080.0	1,105.7	1,089.6	1,080.2	1,078.7	1,080.9
1947-48	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,091.9	1,079.0	1,080.0	1,082.9	1,082.2	1,080.2	1,078.7	1,079.6
1948-49	1,077.2	1,076.7	1,076.0	1,075.2	1,084.6	1,092.9	1,081.5	1,083.9	1,100.3	1,088.9	1,080.2	1,083.3	1,083.4
1949-50	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,081.4	1,084.0	1,094.1	1,086.0	1,082.2	1,079.9
1950-51	1,087.8	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,080.6	1,120.9	1,116.1	1,103.3	1,099.5	1,088.5
1951-52	1,084.6	1,076.7	1,076.0	1,075.2	1,075.0	1,078.3	1,085.8	1,080.0	1,084.0	1,082.6	1,080.2	1,078.7	1,079.8
1952-53	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,077.5	1,080.7	1,081.0	1,080.2	1,078.7	1,077.4
1953-54	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,074.9	1,075.0	1,080.0	1,084.0	1,082.2	1,086.0	1,078.7	1,078.4
1954-55	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,074.6	1,078.6	1,079.8	1,078.4	1,077.1	1,076.6
1955-56	1,076.2	1,075.3	1,074.5	1,073.8	1,073.4	1,073.0	1,072.3	1,071.8	1,076.3	1,080.9	1,080.1	1,078.7	1,075.5
1956-57	1,077.2	1,076.2	1,075.2	1,074.2	1,073.5	1,073.1	1,074.8	1,078.8	1,085.4	1,082.2	1,080.2	1,078.7	1,077.5
1957-58	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,078.9	1,081.0	1,092.9	1,082.2	1,084.8	1,079.2
1958-59	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,089.5	1,084.0	1,083.4	1,080.2	1,078.7	1,078.9
1959-60	1,077.8	1,076.7	1,076.0	1,075.2	1,075.0	1,089.9	1,092.8	1,086.6	1,087.3	1,082.2	1,080.2	1,078.7	1,081.5
1960-61	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,082.8	1,084.0	1,082.2	1,080.2	1,079.1	1,078.3
1961-62	1,079.4	1,076.7	1,076.0	1,075.2	1,077.5	1,083.0	1,075.2	1,080.0	1,084.0	1,082.2	1,080.2	1,078.7	1,079.0
1962-63	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,080.0	1,084.0	1,082.2	1,080.2	1,078.7	1,078.0
1963-64	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.3	1,075.0	1,077.0	1,084.0	1,082.2	1,080.2	1,078.7	1,077.7
1964-65	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,080.4	1,075.0	1,080.0	1,085.3	1,087.0	1,080.2	1,079.5	1,079.0
1965-66	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.5	1,075.0	1,074.9	1,075.8	1,075.3	1,076.4	1,076.9	1,075.8
1966-67	1,075.9	1,075.1	1,074.0	1,073.2	1,072.7	1,072.8	1,073.1	1,072.6	1,097.8	1,083.8	1,080.2	1,078.7	1,077.5
1967-68	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,074.9	1,075.0	1,075.6	1,079.1	1,082.2	1,082.3	1,078.7	1,077.3
1968-69	1,077.2	1,076.7	1,076.0	1,075.2	1,077.1	1,091.3	1,090.0	1,088.0	1,084.0	1,082.2	1,080.2	1,078.7	1,081.4
1969-70	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.1	1,075.0	1,080.0	1,084.0	1,082.2	1,080.2	1,078.7	1,078.0
1970-71	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,076.9	1,075.0	1,084.3	1,084.0	1,082.2	1,080.2	1,078.7	1,078.5
1971-72	1,077.2	1,076.7	1,076.0	1,075.2	1,075.0	1,075.0	1,075.0	1,080.0	1,081.1	1,082.2	1,080.2	1,078.7	1,077.7
1972-73	1,077.2	1,076.7	1,076.0	1,076.4	1,076.7	1,089.8	1,092.1	1,086.9	1,084.0	1,082.3	1,080.2	1,090.3	1,082.4
1973-74	1,114.2	1,099.4	1,087.4	1,081.7	1,078.4	1,075.5	1,075.0	1,080.0	1,083.9	1,082.2	1,080.2	1,078.7	1,084.8
AVERAGE	1,078.5	1,076.8	1,075.8	1,074.9	1,075.1	1,077.5	1,076.9	1,080.1	1,085.8	1,083.7	1,080.8	1,079.5	1,078.8

TABLE VII-5

SECTION VIII

ESTIMATED CONSTRUCTION COST AND SCHEDULE

1. GENERAL

Detailed cost estimates have been prepared for both the tunnel alternative and the outlet works alternative. As discussed in Section VI, the tunnel alternative is relatively expensive and is considered economically infeasible; therefore, the economic analysis will be based only on the outlet works alternative. The detailed estimate of direct construction cost items for the selected outlet works alternative is shown in Table VIII-2. For comparative purposes the detailed estimate for the tunnel alternative is included in Appendix D.

Quantities were established for major civil features to which unit costs were applied. The cost of the generation equipment was estimated on the basis of a preliminary cost estimate obtained from Allis-Chalmers. The correspondence containing this information is included in Appendix B. Additional amounts were added to these costs to include installation costs. For other items of equipment and other features, costs were developed from experience with similar installations, and in part from preliminary pricing information from equipment suppliers.

The civil works costs are based on contractor bid prices adjusted to a January 1979 level. These contractor bid prices have a built-in escalation which is assumed to apply to a 21 month construction period. Assuming completion of the work in this period, this corresponds to the Project being on-line October 1980. As discussed later in this section, additional escalation was applied to these costs to arrive at the estimated cost for the Project to actually enter service by July 1984, considered to be the earliest practical on-line date for either arrangement and corresponding to a bid price level of October 1982.

2. BASIS OF COSTS

a. Direct Construction Cost

The Direct Construction Cost consists of the total of all costs directly chargeable to the construction of the Project and, in essence, represents a contractor's bid.

Indirect costs are defined as those costs which are added to the Direct Construction Cost to result in the Total Construction Cost. Indirect costs include an allowance for contingencies, engineering and owner administration.

b. Contingencies

To allow for unforeseen difficulties during construction and to reflect omissions of the smaller cost items in the estimate, an allowance of 15% was applied to the Direct Construction Cost estimates.

c. Engineering and Owner Administration

Engineering costs for the Project were based on a comparison with actual costs for similar work. The item includes all preliminary engineering work, field investigations, feasibility and design engineering, field inspection of construction, and owner administration. An allowance of 15% of Direct Construction Cost plus Contingency was applied for the Tuttle Creek Project. An additional \$150,000 was also included for a model study of the effect of powerhouse discharges on the existing stilling basin and outlet channel.

d. Total Construction Cost

Total Construction Cost consists of the sum of the Direct Construction Cost, Contingencies, Engineering and Client Administration and Escalation.

e. Interest During Construction

Interest During Construction was determined based upon an assumed cash flow developed from the construction schedule modeled after similar projects. The interest rate during the construction period is based on a 9.5% and 7% interest rate for REA financing and a weighted average of 7-1/8% and 9-1/2% interest rates for DOE financing, as described in Section IX.

f. Escalation

The preliminary cost estimate for this Project has been considered as a January 1979 bid level which is assumed to include escalation for the 21-month construction period. Bid prices for the anticipated actual project schedule have been escalated from the January 1979 bid level to an October 1982 bid date (corresponding to a project in-service date of July 1984) at an average annual rate of 7% for the 3.75-year period.

g. Total Investment Cost

Total Investment Cost for the conventional economic analysis consists of the Total Construction Cost plus Interest During Construction and represents the total investment in the Project.

h. Total Capital Requirements

The Total Capital Requirements are based on both REA and DOE financing as described in Section IX and is the Total Investment Cost plus a Working Capital fund.

3. CONSTRUCTION COST ESTIMATE

A cost estimate summary for the outlet works alternative is shown in Table VIII-1, and detailed direct construction costs are shown in Table VIII-2. The estimated Total Investment Cost is \$19,662,000 for 9.5% REA financing, \$19,192,000 for 7% REA financing and \$19,327,000 for 7-1/8% DOE financing.

4. DESIGN AND CONSTRUCTION SCHEDULE

A design and construction schedule is shown in Fig. 12. This schedule contemplates operation of the plant by July 1984, which is considered to be the earliest possible date for completion considering the time requirements for further investigations, Federal Energy Regulatory Commission (FERC) License processing, design and construction. The schedule provides 18 months for the processing of the FERC License Application, which is considered to be a reasonable period assuming no or limited hearing procedures. The schedule further contemplates the initiation of the design and contract documents phase work about halfway through the estimated licensing period. At that time, an indication of the approval of the License should be possible as input from Federal, State and local agencies and other interest groups becomes available.

The schedule shows the application being sent to the FERC by KEPCo and the initiation of the final investigations for design by January 1981. The major effort of the feasibility evaluation investigations will be to support the FERC License Application,

firm up the technical, economic and financial feasibility of the Project, and to collect and develop data necessary for final design. Final design and preparation of contract bid documents would proceed in about mid-1981 with bidding and award of the major civil contract and major equipment contracts by the fall of 1982.

The conduit and powerhouse phases of construction are for the most part independent. However, the conduit construction will involve fabrication and erection of steel liner transitions and is expected to be time consuming. Therefore the total construction period is estimated at 21 months. Startup and testing of the units is expected to require about 6 months.

TUTTLE CREEK DAM PROJECT
CONSTRUCTION COST ESTIMATE SUMMARY (1)

ITEM	Financing Method		
	<u>9.5% REA</u>	<u>7% REA</u>	<u>7-1/8% DOE</u>
1. Preparatory Work		\$ 250,000	
2. Power Waterway		4,019,000	
3. Powerhouse		5,862,000	
4. Transmission and Switchyard		<u>245,000</u>	
DIRECT CONSTRUCTION COST		\$10,376,000	
Contingencies		<u>1,556,000</u>	
Subtotal		\$11,932,000	
Engineering and Owner Administration		<u>1,940,000</u>	
TOTAL CONSTRUCTION COST	\$13,872,000	\$13,872,000	\$13,872,000
Interest During Construction	<u>1,384,000</u>	<u>1,020,000</u>	<u>1,124,000</u>
TOTAL INVESTMENT COST (Bid 1/79, On-line 10/80)	\$15,256,000	\$14,892,000	\$14,996,000
Escalation	<u>4,406,000</u>	<u>4,300,000</u>	<u>4,331,000</u>
TOTAL INVESTMENT COST (Bid 10/82, On-line 7/84)	\$19,662,000	\$19,192,000	\$19,327,000

(1) For outlet works alternative.

CONSTRUCTION COST ESTIMATE

January 1979 Bid Level

PROJECT Tuttle Creek

FEATURE Outlet Works Alt

LOCATION Kansas

WW-2141-HG2-QA

TYPE EST: PLANNING ~~INFORMATION~~ ~~XXXX~~ TAKE-OFF

LDC

PRICED

LDC

__CALC CHKO.

AWP

APPROVED

JVW

 DAY

March 1979

[illegible]

CONSTRUCTION COST ESTIMATE

January 1979 Bid Level

PROJECT Tuttle Creek

FEATURE Outlet Works Alt

LOCATION Kansas

u.o. WW-2141-HG2-OA

TYPE EST. PLANNING-PRODUCTION-TESTING-XXX TAKE-OFF LDC

PRICED LDC

 CALC. CHKD. AWP

APPROVED JVW

DATE March 1979

[illegible]

TABLE VIII-2

CONSTRUCTION COST ESTIMATE

January 1979 Bid Level

PROJECT: Tuttle Creek

FEATURE Outlet Works Alt

LOCATION Kansas

WFO. WW-2141-HG2-OA

TYPE EST: PLANNING ~~PRODUCTION~~ ~~TAKE-OFF~~ LDC

PRICED LDC

CALC CNKD. AWP

APPROVED JVW

DATE **March 1979**

[illegible]

TABLE VIII-2

CONSTRUCTION COST ESTIMATE

January 1979 Bid Level

PROJECT Tuttle Creek

FEATURE Outlet Works Alt.

LOCATION Kansas

WW-2141-HG2-QA

TYPE EST: PLANNING ~~DESIGN~~ XXXX TAKE-OFF

LDC

PRICED.

LDC

__CALC CHỜD..

AWP

APPROVED JVW

DATE

March 1979

[illegible]

SECTION IX

ECONOMIC ANALYSIS

1. GENERAL

In a typical economic analysis for a hydroelectric project, the annual cost of a proposed project is compared with the annual value of the project power output, allowing comparisons to be made between the benefits and costs of the Project which will show the viability of developing it. The value of the power generated by the Project is considered to be the cost of an equivalent amount of power from the most economical alternative source. The annual cost of the Project includes all costs for the debt service, operation, maintenance, interim replacements, insurance and taxes. In this analysis for the Tuttle Creek Hydroelectric Project, the most economical alternative source of power is considered to be the continued purchase of power under wholesale rates from Kansas Power and Light (KPL). The basic assumptions for the economic analysis are listed in Table IX-1. As discussed in Section VI, this economic analysis will be performed only on the outlet works alternative which was selected for economic analysis.

The economic analyses presented herein consist of the following comparisons: (1) the estimated costs of power from the Project during its first year of operation versus the cost of an equivalent amount of power from the alternative considered, and (2) the estimated total cost of power from the Project in the first 10 years of operation versus the estimated cost of an equivalent amount of power from the purchase alternative for the same 10-year period, on a present-worth basis. The analyses will be performed for 3 financing alternatives. Two of these will be with Rural Electrification Administration (REA) financing with different interest rates, and

a third assumes financing under the terms of Title IV, Small Hydroelectric Power Projects of the recently passed Public Utilities Regulatory Policies Act, being administered by DOE. It is assumed for all these analyses that the Project would be completed and on-line by July 1984 as shown in Fig. 12.

For economic evaluation purposes the useful life of a hydroelectric project can be considered to be 50 years, although such projects can have a longer useful life. FERC has used periods up to 100 years to evaluate hydroelectric projects and the procedure for filing License Applications identifies the basis for financial feasibility should be for a period of 50 years, and that for economic feasibility is 100 years. However, the economic analysis herein has been based on the period of financing imposed by either the REA or DOE loans, which of course results in a conservative view of the economic viability of the Project.

2. BASIS FOR COSTS OF ALTERNATIVE

The Tuttle Creek Hydroelectric Project would serve to displace power purchases by KEPCo in the amount of 56,690,000 kWh of energy on an average annual basis, and 12,290 kW of dependable capacity (allowing for transmission losses), delivered at the load centers.

The cost of purchased power, both capacity and energy, used in this analysis is based on a 1979 KEPCo study of the estimated cost of future power generation from the KPL system for wholesale purchases by KEPCo and other cooperatives and municipalities. The costs for the years 1984-1994 are shown in Table IX-2.

For this study it is anticipated that KEPCo would, in the years discussed herein, be faced with purchasing power at the rates appropriate to those years. The savings in the costs of purchased power due to the operation of the Project represents potential benefits to KEPCo. The potential Project benefits discussed herein do

not represent a cash inflow but are a measure of potential savings based on the alternative of continued purchase power. The power costs include the effects of transmission wheeling and losses as well as forced outage reserves for the purchased power alternative.

3. HYDROELECTRIC PROJECT COSTS

a. Capital Costs

The Total Investment Cost for the Project on an on-line date of July 1984 was developed in Section VIII and is \$19,662,000 with 9.5% REA financing, \$19,192,000 with 7% REA financing, and \$19,327,000 with 7-1/8% - 9-1/2% DOE financing, as shown in Table IX-3. The economic feasibility was based on these total investments and the corresponding loan terms for the different methods of financing.

b. Annual Costs

(1) Amortization Cost

The debt service on the loans for the various methods of financing were determined on the following bases:

(a) 9-1/2% interest, 35 year term loan for REA. For the first 7 years principal payments are deferred and only the interest is paid. In the following 28 years both interest and principal are paid.

(b) 7% interest, 35 year term loan from REA, with repayment conditions similar to those for the 9.5% REA loan discussed above. This 7% financing is not currently available from the REA. However, an economic analysis using 7% REA financing has been included to display the advantage of lower interest financing

and reflects the possibility that REA could obtain this lower interest financing under the current Federal policy of accelerated small hydro development. This possibility has been generally discussed in the past and was addressed in Resolution D-17 of the 1978 NRECA annual meeting.

(c) 7-1/8% interest, 30 year term loan from the Department of Energy (DOE) under Title IV, Small Hydroelectric Power Project section of the Public Utilities Regulatory Policies Act (part of the National Energy Act). Under the terms of this Act 75% of the construction loan would be furnished by DOE but the remaining 25% would have to be obtained from other sources. It is assumed that this additional 25% would be financed with a 9-1/2%, 30 year term loan. The 7-1/8% interest rate is determined under Section 80 of the Water Resources Development Act of 1974, and has been increased by 1/4% from the 1978 value. For convenience this combined loan is referred to herein simply as the 7-1/8% DOE loan without explicit mention of the 9-1/2% fraction.

(2) Operating Costs

Annual costs consist of amortization costs and operating costs, including wheeling, for the various methods of financing. The general bases for the operation and maintenance cost of the Project are stated in Table IX-1. Annual costs of operation and maintenance of the Project were developed for a remote operated plant based on experience with comparable plants and were compared with numbers developed by the FERC. Other costs are based on historic cost data published by the FERC and include administration and general, insurance and interim replacements. The resultant annual costs for the first year of operation are shown in Table IX-3.

(3) Charge for Use of Federal Project

During the course of these investigations, inquiry was made of the Kansas City District, Corps of Engineers as to possible charges to the Project for use of storage in the reservoir. In response, the Corps presented charges of \$150 per acre-foot capital cost and \$0.36 per acre-foot operation and maintenance (assumed to be 1979 costs), subject to change in subsequent studies. The correspondence from the Corps which delineates these charges is contained in Appendix C. To illustrate the impact of such a user fee on the economic feasibility of this Project, the annual benefits from the Project resulting from the most attractive method of financing (which is 7% REA financing, as discussed below) were computed both with and without the use charge being included in the annual cost of the Project.

(4) Transmission Wheeling

Cost of transmission wheeling will depend upon negotiations between KEPCo and KPL for delivery of power from this small project. Although information is available in the region for long distance high voltage transmission wheeling rates, there is no corresponding data for lower voltage and smaller deliveries as are required for the Project. It is possible that the cost of wheeling could be reduced, or even eliminated on a displacement basis. For the purpose of the economic feasibility it is assumed that the cost of wheeling of power from the Project is \$75,000 during the first year of operation (7/84 - 6/85).

(5) Total Annual Cost

The total annual costs for the first year of operation, including debt service and operation and maintenance are \$2,696,000 for the 9.5% REA financing, \$2,158,000 for the 7% REA financing and \$2,490,000 for the 7-1/8% DOE financing as shown in Table IX-3.

c. Reserve Requirements

The power pooling agreement by which KEPCo and KPL operate requires members to provide a 15% capacity reserve requirement. For economic analysis then, the dependable capacity of the Tuttle Creek Project must be reduced from the 12,290 kW developed in Section VII to 10,450 kW.

4. ANNUAL BENEFITS

Benefits for the first year of Project operation from the alternative of continuing with power purchases are shown in Table IX-4 based on the rates shown in Table IX-2. This is based on the alternative delivering the same amount of energy and capacity to the load center as the Project, including forced outage reserves. Table IX-3 shows that this results in total annual benefits from the Project during the first year of operation of \$1,837,000. When compared with the estimated annual costs for each of the three methods of financing, it can be seen that the Project benefits in the first year are less than the project cost. Hence the first year benefit-cost ratio is less than one for all methods of financing, the largest B-C ratio being 0.84 for 7% REA financing. It should be noted that it is now generally accepted by FERC and others that a hydroelectric project can show a B-C ratio in the first year of operation of possibly only 0.80 to 0.90 and yet still be considered feasible because its costs are essentially fixed with time as compared to alternatives. The following 10-year present-worth analyses demonstrate this concept.

5. ECONOMIC ANALYSIS OVER TEN-YEAR PERIOD

It is common current practice to perform economic analyses for hydroelectric projects over about the first 10 years of project operation to reflect the future escalation of costs of the alternative. If a longer period is used the results are not considered

meaningful since the value of the dollar continues to decrease. Annual costs have been developed for the Project and compared with estimated purchased power costs over the first 10 years of operation. As discussed previously, for DOE financing, the debt service portion of the annual costs would remain fixed, and for REA financing the debt service would increase when the 7 year deferral of payment on the principal ends. However, other costs are considered to escalate at an annual rate of 7%.

The annual surplus or deficit amounts of the Project annual costs as compared to the purchased power costs, were developed on a present-worth basis during the first ten years of operation and are summarized in Tables IX-5 through IX-7 for the three financing methods.

With the 7-1/8% DOE and 9.5% REA financing, the Project will result in a deficit, or loss, over the continued purchase alternative in the first 10 years of operation on a present worth basis. Although the Project costs are less than the purchase power cost in the later years of the 10 year period, the losses in the early years are not offset by the latter year gains. As indicated in Tables IX-5 and IX-7 the losses amount to \$2,592,000 for the 9.5% REA financing and \$699,000 for the 7-1/8% DOE financing for the 10-year period on a July 1984 present-worth basis. Thus the Project is infeasible with the 7-1/8% DOE and 9.5% REA financing.

With the 7% REA financing, the early year losses are offset by the later year gains, and the Project exhibits feasibility over the 10-year period. As indicated in Table IX-6, on a July 1984 present-worth basis, the Project will result in a savings for the 10 years of \$1,166,000 over the alternative of wholesale power purchases.

The REA criterion for feasibility is that a project show a savings over the first 10 years of operation, without present

worth. Using this criterion, the Project still shows a deficit with the 9.5% REA financing (\$2,679,000), but a very small surplus with the 7-1/8% DOE financing (\$56,000). With the 7% REA financing, of course, the Project still shows a surplus (\$2,438,000).

The comparison of the 10-year cost and benefits is shown graphically in Fig. 11. With 7% REA financing a breakeven point of cost of the Project and the cost of power purchases, occurs within 4 years after the Project enters into service. For 7-1/8% DOE financing a breakeven point occurs at about the sixth year. For 9.5% REA financing a breakeven point occurs within the seventh year.

6. EFFECT OF RESERVOIR STORAGE CHARGE

As discussed above, during the course of these investigations, inquiry was made of the Kansas City District, Corps of Engineers as to possible charges to the Project for use of storage in the reservoir. In response, the Corps tentatively proposed charges of \$150 per acre-foot capital cost and \$0.36 per acre-foot operation and maintenance (assumed to be 1979 costs), subject to change in subsequent studies. These costs would amount to \$11,250,000 in capital costs and \$27,000 in operation costs (1979) for the 75,000 acre-feet of storage between El 1075 and El 1070 considered herein for use. The charges would increase the annual cost in the first year of operation by about \$1,182,000. Table IX-8 presents a 10-year analysis of the Project with 7% REA financing including the reservoir charges. As can be seen, the addition of the charges changes the \$1,166,000 benefit to a \$7,988,000 deficit for the 10-year period on a present worth basis (July 1984 dollars). Obviously, such charges would render hydro generation at Tuttle Creek Dam totally infeasible.

It is recognized that such dam use fees have sometimes been assessed on the licenses of hydroelectric developments at some other

Federal dams. However, for low head projects the concept of Federal dam-user fees flies in the face of the current concentrated Federal program for development of small hydro, and here, as in most cases, imposition of such fees would inevitably preclude development.

7. RESULTS OF ECONOMIC ANALYSIS

The economic analysis shows that if only 9.5% REA financing is available, the Project does not show economic feasibility over the initial 10 years of Project operation. If KEPCo can obtain financing at a lower interest rate (7% or less) than is currently available from REA, the Tuttle Creek Hydroelectric Project shows economic feasibility when compared with the cost of purchasing the same amount of power over the initial ten years of Project operation. This is so even though the first year benefit-cost ratio of the Project is less than one (0.84). Further, the Project does not show economic feasibility on a present worth basis with DOE financing (under the National Energy Act) if the 25% component is at a 9.5% interest rate. It is probable, however, that if the 25% component could be obtained at a 7% or less interest rate that this would also indicate economic feasibility for the Project on a present worth basis. If the reservoir use charge is included in the Project cost in the amount that the Corps has tentatively indicated, the Project is clearly unfeasible, even if KEPCo can obtain 7% financing from the REA.

TUTTLE CREEK HYDROELECTRIC PROJECT
BASIC ASSUMPTIONS FOR ECONOMIC ANALYSIS
(July 1984 Level)

PROJECT:

On-Line Date	July, 1984
Economic Life	50 Years
Loan Alternatives:	
a. 7% REA	35 Years at 7% with 7 years of deferral on principal.
b. 9.5% REA	35 Years at 9.5% with 7 years of deferral on principal.
c. 7-1/8% DOE	30 Years with 75% at 7.125% and 25% at 9.5% interest
Working Capital	45 Days of O&M
Operation and Maintenance	\$180,000
Administrative and General	39% of O&M
Insurance	0.1% of Total Investment Cost
Interim Replacements	0.2% of Total Investment Cost
Property Taxes	2.2% of Total Investment Cost
Transmission Wheeling(1)	\$75,000
Escalation Rate for Operating Costs	7%
Discount Rate for Present Worth Analysis	7%
Forced Outage Reserves	15%

CONTINUED POWER PURCHASE ALTERNATIVE:

Demand and Energy Charges See Table IX-2

(1) - For first year of operation (7/84 - 6/85)

TABLE IX-2

TUTTLE CREEK HYDROELECTRIC PROJECT
COST OF PURCHASED POWER(1)

<u>Year</u>	<u>Demand, \$/kW-Year</u>	<u>Energy, Mills/kWh</u>
1984	68.63	18.78
1985	76.68	19.24
1986	77.58	21.04
1987	87.57	22.95
1988	101.06	25.02
1989	104.77	27.46
1990	115.41	29.70
1991	116.34	34.02
1992	118.98	43.55
1993	130.05	46.74
1994	146.04	50.32

(1) Cost of power based on 1977 KEPCo study.

TUTTLE CREEK HYDROELECTRIC PROJECT
PROJECT ESTIMATED COSTS

	Financing Method		
	<u>9.5% REA (2)</u>	<u>7% REA (1)</u>	<u>7-1/8% DOE (3)</u>
CAPITAL COSTS (4)			
TOTAL INVESTMENT COST	\$19,662,000	\$19,192,000	\$19,327,000
WORKING CAPITAL	<u>22,000</u>	<u>22,000</u>	<u>22,000</u>
TOTAL CAPITAL COSTS	\$19,684,000	\$19,214,000	\$19,349,000
ANNUAL COSTS (5)			
<u>Amortization Costs</u>	\$ 1,870,000	\$ 1,345,000	\$ 1,673,000
<u>Operating Costs (6)</u>			
Operation and Maintenance	\$ 186,000	\$ 186,000	\$ 186,000
Administrative and General	73,000	73,000	73,000
Insurance	20,000	19,000	19,000
Interim Replacements	39,000	38,000	39,000
Property Taxes	433,000	422,000	425,000
Transmission Wheeling	<u>75,000</u>	<u>75,000</u>	<u>75,000</u>
TOTAL OPERATING COSTS	\$ 826,000	\$ 813,000	\$ 817,000
TOTAL ANNUAL COSTS	\$ 2,696,000	\$ 2,158,000	\$ 2,490,000

- (1) Financing at 7% interest rate, 35-year term, with principal payments deferred for 7 years after completion.
- (2) Financing at 9.5% interest rate, 35-year term with principal payments deferred for 7 years after completion.
- (3) Financing at 7.125% interest rate, 30-year term for 75% of Project cost and 9.5%, 30-year term for the remaining 25%.
- (4) Based on Project coming on-line in July 1984.
- (5) Values shown are for the first year of operation, July 1984 through June 1985.
- (6) Operating costs escalated at 7% annually.

TUTTLE CREEK HYDROELECTRIC PROJECT
ANNUAL PROJECT BENEFITS AND COSTS(1)

	Financing Method		
	<u>9.5% REA (3)</u>	<u>7% REA (2)</u>	<u>7-1/8% DOE (4)</u>
<u>PROJECT ANNUAL COSTS:</u>			
Amortization Costs	\$1,870,000	\$1,345,000	\$1,673,000
Operating Costs	<u>826,000</u>	<u>813,000</u>	<u>817,000</u>
Total Project Costs	\$2,696,000	\$2,158,000	\$2,490,000
<u>CONTINUED POWER PURCHASE COSTS:</u>			
Capacity Value (5)	\$ 759,000	\$ 759,000	\$ 759,000
Energy Value (6)	<u>1,078,000</u>	<u>1,078,000</u>	<u>1,078,000</u>
Total Project Benefits	\$1,837,000	\$1,837,000	\$1,837,000

- (1) Values shown are for first year of operation, July 1984 through June 1985.
- (2) Financing at 7% interest rate, 35-year term, with principal payments deferred for 7 years after completion.
- (3) Financing at 9.5% interest rate, 35-year term, with principal payments deferred for 7 years after completion.
- (4) Financing at 7.125% interest rate, 30-year term for 75% of Project cost and 9.5% interest rate, 30-year term for the remaining 25%.
- (5) Dependable capacity is 10,450 kW after 15% allowance for reserves. Capacity valued at \$68.13/kW for the first half of the year and \$76.13/kW for the second half of the year.
- (6) Average annual energy is 56,690 MWh, valued at 18.79 mills/kWh for the first half of the year and 19.25 mills/kWh for the second half of the year.

**TUTTLE CREEK HYDROELECTRIC PROJECT
10-YEAR PRESENT WORTH ANALYSIS(1)
9.5% REA FINANCING**

<u>Period</u>	<u>Project Cost</u>	<u>Project Benefits (2)</u>	<u>Surplus or (Deficit) Amount</u>	<u>Present Worth(3) of Surplus or Deficit</u>	<u>Cumulative Present Worth</u>
7/84 - 6/85	\$2,696,000	\$1,837,000	\$ (859,000)	\$ (830,000)	\$ (830,000)
7/85 - 6/86	2,754,000	1,948,000	(806,000)	(728,000)	(1,558,000)
7/86 - 6/87	2,816,000	2,110,000	(706,000)	(596,000)	(2,154,000)
7/87 - 6/88	2,882,000	2,346,000	(536,000)	(423,000)	(2,577,000)
7/88 - 6/89	2,953,000	2,563,000	(390,000)	(288,000)	(2,865,000)
7/89 - 6/90	3,029,000	2,770,000	(259,000)	(179,000)	(3,044,000)
7/90 - 6/91	3,270,000	3,017,000	(253,000)	(163,000)	(3,207,000)
7/91 - 6/92	3,356,000	3,429,000	73,000	44,000	(3,163,000)
7/92 - 6/93	3,449,000	3,860,000	411,000	231,000	(2,932,000)
7/93 - 6/94	3,548,000	4,194,000	646,000	340,000	(2,592,000)

- (1) Initial 10 years of Project operation.
(2) Power purchase costs based on values shown in Table IX-2.
(3) Discount rage of 7%, July 1984 level.

TUTTLE CREEK HYDROELECTRIC PROJECT
10-YEAR PRESENT WORTH ANALYSIS(1)
7% REA FINANCING

<u>Period</u>	<u>Project Cost</u>	<u>Project Benefits (2)</u>	<u>Surplus or (Deficit) Amount</u>	<u>Present Worth(3) of Surplus or Deficit</u>	<u>Cumulative Present Worth</u>
7/84 - 6/85	\$2,158,000	\$1,837,000	\$ (321,000)	\$ (310,000)	\$ (310,000)
7/85 - 6/86	2,215,000	1,948,000	(267,00)	(241,000)	(551,000)
7/86 - 6/87	2,276,000	2,110,000	(166,000)	(140,000)	(691,000)
7/87 - 6/88	2,341,000	2,346,000	(5,000)	(4,000)	(687,000)
7/88 - 6/89	2,411,000	2,563,000	152,000	112,000	(575,000)
7/89 - 6/90	2,485,000	2,770,000	285,000	196,000	(379,000)
7/90 - 6/91	2,803,000	3,017,000	214,000	138,000	(241,000)
7/91 - 6/92	2,889,000	3,429,000	540,000	325,000	84,000
7/92 - 6/93	2,980,000	3,860,000	880,000	495,000	571,000
7/93 - 6/94	3,078,000	4,194,000	1,116,000	587,000	1,166,000

- (1) Initial 10 years of Project operation.
(2) Power purchase costs based on values shown in Table IX-2.
(3) Discount rate of 7%, July 1984 level.

TUTTLE CREEK HYDROELECTRIC PROJECT
10-YEAR PRESENT WORTH ANALYSIS(1)
7-1/8% DOE FINANCING

<u>Period</u>	<u>Project Cost</u>	<u>Project Benefits (2)</u>	<u>Surplus or (Deficit) Amount</u>	<u>Present Worth(3) of Surplus or Deficit</u>	<u>Cumulative Present Worth</u>
7/84 - 6/85	\$2,490,000	\$1,837,000	\$ (653,000)	\$ (631,000)	\$ (631,000)
7/86 - 6/87	2,547,000	1,948,000	(599,000)	(541,000)	(1,172,000)
7/86 - 6/87	2,608,000	2,110,000	(498,000)	(421,000)	(1,593,000)
7/87 - 6/88	2,674,000	2,346,000	(328,000)	(259,000)	(1,852,000)
7/88 - 6/89	2,744,000	2,563,000	(181,000)	(133,000)	(1,985,000)
7/89 - 6/90	2,819,000	2,770,000	(49,000)	(34,000)	(2,019,000)
7/90 - 6/91	2,899,000	3,017,000	118,000	76,000	(1,943,000)
7/91 - 6/92	2,985,000	3,429,000	444,000	267,000	(1,676,000)
7/92 - 6/93	3,077,000	3,860,000	783,000	441,000	(1,235,000)
7/93 - 6/94	3,175,000	4,194,000	1,019,000	535,000	(699,000)

(1) Initial 10 years of Project operation.

(2) Power purchase costs based on values shown in Table IX-2.

(3) Discount rate of 7%, July 1984 level.

TUTTLE CREEK HYDROELECTRIC PROJECT
10-YEAR PRESENT WORTH ANALYSIS(1)
7% REA FINANCING WITH RESERVOIR USE CHARGES(2)

<u>Period</u>	<u>Project Cost</u>	<u>Project Benefits (2)</u>	<u>Surplus or (Deficit) Amount</u>	<u>Present Worth(3) of Surplus or Deficit</u>	<u>Cumulative Present Worth</u>
7/84 - 6/85	\$3,340,000	\$1,837,000	\$(1,503,000)	\$(1,453,000)	\$(1,453,000)
7/85 - 6/86	3,400,000	1,948,000	(1,452,000)	(1,312,000)	(2,765,000)
7/86 - 6/87	3,464,000	2,110,000	(1,354,000)	(1,143,000)	(3,908,000)
7/87 - 6/88	3,532,000	2,346,000	(1,186,000)	(936,000)	(4,844,000)
7/88 - 6/89	3,605,000	2,563,000	(1,042,000)	(768,000)	(5,612,000)
7/89 - 6/90	3,683,000	2,770,000	(913,000)	(629,000)	(6,241,000)
7/90 - 6/91	4,207,000	3,017,000	(1,190,000)	(767,000)	(7,008,000)
7/91 - 6/92	4,297,000	3,429,000	(868,000)	(523,000)	(7,531,000)
7/92 - 6/93	4,392,000	3,860,000	(532,000)	(299,000)	(7,830,000)
7/93 - 6/94	4,495,000	4,194,000	(301,000)	(158,000)	(7,988,000)

(1) Initial 10 years of Project operation.

(2) Reservoir use charges of \$150.00/ac.-ft. capital cost and \$0.36/ac.-ft. annual operation and maintenance cost for 75,000 ac.-ft. of storage from El 1075 to El 1070.

(3) Power purchase costs based on values shown in Table IX-2.

(4) Discount rage of 7%, July 1984 level.

SECTION X

ENVIRONMENTAL CONSIDERATIONS

1. GENERAL

This section evaluates the potential for significant adverse environmental impacts created by proposed energy generation modifications to the Tuttle Creek Dam. The primary purpose is to identify any significant adverse impacts that could be caused by the Project.

From on-site observations and discussions with relevant agencies, a basic outline of issues and sources was constructed. Follow-up telephone conversations and data acquisition were made on those issues believed to be significant.

2. STREAM FLOWS

Current downstream use of Tuttle Creek Lake multipurpose storage includes the following: (1) augmentation of flows and improvement of water quality in the Big Blue and Kansas Rivers; and (2) supplementation of Missouri River flows for navigation, within certain limits.⁽¹⁾

The normal minimum release from the existing project is 100 cfs for recreation and fish and wildlife purposes in the Big Blue River below the dam. This minimum low flow also helps meet low flow objectives for the lower Kansas River and the Missouri River at Kansas City.⁽¹⁾

(1) Department of the Army, Kansas City District Corps of Engineers, Final Environmental Impact Statement, Tuttle Creek Lake, Kansas, February 1976.

Under average conditions, the proposed mode of daily operation for the hydroelectric project is a 4-hour peaking generation cycle with peaking releases of about 3,300 cfs and 20-hour base releases of at least 100 cfs. Ordinarily there will be no peaking generation on Saturdays or Sundays. The corresponding water level fluctuations downstream at River Pond State Park (directly below the dam) and in the Big Blue River 2.5 miles downstream from the dam are shown below.

<u>Powerhouse Discharge (cfs)</u>	<u>River Pond State Park W.S. El</u>	<u>Big Blue River 2.5 Miles Downstream from dam W.S. El</u>
Base discharge 100	1011.3	992.7
Peak discharge 3300	1012.8	997.1
Maximum fluctuation	1.5 ft.	4.4 ft.

The impacts of the water level fluctuations in the pond at River Pond State Park are not expected to be significant. The impact of the volume of flow from the powerhouse during peaking should also be insignificant since the peaking releases of 3,300 cfs are less than 4,000 cfs maximum release recommended by the Water Resources Board of the State of Kansas for the proposed 1979 Water Level Management Plan of Tuttle Creek Reservoir. Daily flow fluctuations are expected to impact downstream water use, especially fishing and boating. Impacts upon fish and other aquatic life may also occur if abrupt water level fluctuations occur. Controlled changes of flow during the transition from base to peak discharge is expected to minimize adverse downstream effects.

3. RESERVOIR LEVELS

The Corps of Engineers is responsible for all water control regulation of Tuttle Creek Lake. Other agencies associated with the regulation of Tuttle Creek Lake include the Environmental

Protection Agency, U.S. Public Health Service, U.S. Fish and Wildlife Service, and several Kansas State agencies, including the Kansas Water Resources Board, Kansas State Park and Resources Authority, and the Kansas Forestry, Fish and Game Commission. Coordination among these agencies, which function in a consulting and advisory capacity, is the responsibility of the Corps of Engineers.⁽¹⁾

Historically water level fluctuations in Tuttle Creek Reservoir, as a result of flood control and other multipurpose water uses, have had a major impact upon the environment of the reservoir and project lands. Shoreline erosion is a problem at the reservoir, particularly when water levels rise into the flood control storage zone.⁽¹⁾ Riprap is used in some areas to protect important recreation or operations facilities, but the practice is expensive, so its use has been limited to protection of small areas.

Water level fluctuations and associated sedimentation problems have also adversely affected the establishment and survival of shoreline vegetation, recreation use and facilities, fish and wildlife resources and the activities of those people leasing project lands for interim agricultural use. These fluctuations are unavoidable because of the physical design of the existing project, the hydrologic characteristics of the Blue River Basin, and the necessary adherence to lake flood control operation regulations.⁽¹⁾

To minimize these impacts and increase the usefulness of Tuttle Creek Reservoir, consideration has been given to the use of a narrow band of storage (1 to 4 feet) in the flood control pool above El 1075.0 for seasonal multipurpose uses. The Kansas Water Resources Board (KWRB) and the Kansas Forestry, Fish and Game Commission in Fall 1974 submitted a proposed regulation plan for Corps

lakes in Kansas. This plan was implemented for operation of Tuttle Creek Reservoir on an experimental basis in 1976. Objectives of the proposed plan included controlled reservoir levels in the spring at elevations varying from El 1075 to El 1078 to enhance fish spawning conditions, and a summer drawdown to El 1075 and subsequent fall rise in lake levels to benefit waterfowl to El 1079.⁽¹⁾ The maximum drawdown associated with this plant of operation is El 1073, during the winter. A graphical representation of this plan of operation is shown in Fig. 10.

Operation of the proposed hydroelectric project is planned to comply with the KWRB rule curve. Because deviations from the curve are expected only during extreme low flow years no significant environmental impacts are expected associated with reservoir levels.

4. RECREATION

The River Pond State Park is located immediately downstream of the Tuttle Creek Dam. It is a heavily used recreation area consisting of a broad grassy field with picnic facilities and a slackwater pond for fishing, swimming, boating, kayaking and related water sports. During weekday peaking operations the recreational use is expected to be impacted during the transition between peak flow and base flow. These impacts are not expected to be noticeable since the water level change will be approximately 1.5 feet over a 2 hour period. Thus, the fluctuations will affect the recreation area for a total of approximately 4 daytime hours on weekdays. Since peaking operations will not occur on weekends during periods of maximum use there will not be any impacts during these time periods.

Rocky Ford fishing area is located about 1.4 miles downstream from the dam on the Big Blue River. This recreational facility would experience some minor fluctuations in river flows and elevations during operation of the plant, as discussed above. Minor impacts upon fishing and boating activities would therefore be expected to occur.

5. FISH AND WILDLIFE

All fish and wildlife activities in the project area are coordinated through the Kansas Forestry, Fish and Game Commission.

The production of game and forage fish in the Big Blue River may be affected by water level fluctuations. Varying depths of water covering spawning areas may decrease spawning for some species of fish and inhibit egg incubation. However, since the proposed mode of reservoir operation will comply with the KWRB rule curve, no increased adverse impacts on fish and wildlife resulting from the operation are expected to occur.

6. FLOOD LEVEL REDUCTIONS

The operation of Tuttle Creek Reservoir for purposes of hydroelectric power generation is not expected to significantly affect existing flood control operations.

7. STRATEGIC NATIONAL RESOURCES

Within the last few years, a national shortage of natural gas, fuel oil and the better grades of coal has occurred and this condition is expected to continue. The decreased supply of fuel for thermal generation has been accompanied by significant increases in the cost of fuel, and of the power generated by facili-

ties dependent upon these depletable resources. It is estimated that on an average annual basis, the Tuttle Creek Hydroelectric Project would generate 56,690,000 kWh per year. This amount of energy would save about 95,000 barrels of fuel oil per year. Over the 50 year life of the Project, this would amount to approximately 4,750,000 barrels of oil.

8. SOCIO-ECONOMIC

a. Employment

The mean family income for the three County area of the Project in 1969 was \$8,671 with about 12% of all families having an income below the national poverty level. This can be compared to a Statewide 1970 average of 9.9% of all families with an income below poverty level.⁽¹⁾ Thus, beneficial impacts associated with new jobs may be significant.

The Project will beneficially impact the socio-economic character of the Tuttle Creek area. Construction of the Project will create temporary benefits by providing new jobs.

b. Historical/Archaeological

Since the lake levels and the proposed power generation fluctuations are planned to fall within the existing range of fluctuations, no inundation of historical/archaeological sites is expected. A clearance from the State Historical/Archaeological office would be required prior to licensing of the Project.

c. Aesthetic

Construction of the powerhouse will have a minimal effect on the aesthetics of the area since it will be backfilled with earth

along three sides and will not cause a major change in the overall appearance of the general area downstream of the dam. The transmission lines will be restrung along existing power poles except for a small portion of about 0.5 miles from the powerhouse to the existing line. This new power line will be visible from the River Pond State Park and the top of the dam.

SECTION XI

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

From the Feasibility Assessment Study of the Tuttle Creek Hydroelectric Project it is concluded that:

a. The Tuttle Creek Hydroelectric Project is technically feasible for either the tunnel through the left abutment alternative or the alternative of utilizing one of the flood control outlet works conduits.

b. The tunnel alternative would be significantly more costly than the outlet works alternative because of the long waterway. The use of one of the conduits for power development as well as flood control will require acceptance by the Corps of Engineers of the concept, but it is the only economical scheme and results in minimal adverse environmental impacts.

c. The Tuttle Creek Hydroelectric Project (Outlet Works Alternative) will consist of a steel liner placed inside the right outlet conduit, a powerhouse discharging into the right side of the stilling basin and a shutoff valve to allow flood releases through the modified conduit.

d. The Project will have an installed capacity of 14,750 kW provided by three 4,750 kW Allis-Chalmers standardized TUBE units and one 500 kW TUBE unit. It will have a dependable capacity of 12,290 kW and will generate on an average annual basis 56,690 kWh, all as delivered into the existing transmission and distribution network.

e. For the scheduled on-line date of July 1984, considered to be the earliest practical date, the estimated Total Investment Cost with 9.5% interest rate REA financing is \$19,662,000. With 35 year REA financing at 7%, which is not currently available, the Total Investment Cost is estimated to be \$19,192,000. With a 30 year loan under the new National Energy Act administered by DOE, at 7-1/8% interest on 75% of the Project cost and additional financing at 9.5% on the balance, the estimated Total Investment Cost is \$19,327,000.

f. Comparison of the cost of the Project with the most economical alternative of continued power purchases, based on 9.5% REA financing, shows a deficit on a July 1984 present-worth basis even after 10 years, and therefore is unfeasible with this higher interest method of financing. With 7% REA financing which is not currently available, the Project shows a savings over the first 10 years of operation of \$1,166,000 on a July 1984 present-worth basis. The Project thus shows feasibility with this type of financing, even though the first year benefit-cost ratio is only 0.84. With 7-1/8% DOE financing the Project shows a deficit on a 10-year present worth basis and thus is unfeasible. However, it is probable that economic feasibility would result with 7-1/8% DOE financing, if the 25% portion could be financed at a 7% or less interest rate.

g. The reservoir use charges tentatively suggested by the Corps of Engineers on the use of reservoir storage for power production will render the Project economically infeasible. Before proceeding with detailed Project studies it is essential that a decision be obtained from the Corps on the application of such a charge to this small scale hydroelectric generation.

h. No major environmental changes are anticipated. Additional investigations are required to provide detailed information on the environmental effects of the development.

1. The Tuttle Creek Hydroelectric Project shows sufficient promise of feasibility to justify proceeding with the recommended investigations. This effort should proceed as soon as possible so that if the Project continues to show feasibility it can be completed to meet the proposed July 1984 on-line date.

2. RECOMMENDATIONS

It is recommended that:

a. KEPCo respond to the second PON (DOE Program Opportunity Notice) whereby a grant may be obtained to defray up to 25% of the cost of installing generating facilities. This is expected to be announced in April 1979 with proposals submitted by about June 1979.

b. In-depth discussions should be held with the Corps of Engineers to resolve the issues of utilizing the existing outlet works for power development and the imposition of dam and reservoir-user fees.

c. An application be made to obtain a low interest loan under Title IV, Small Hydroelectric Power Projects of the Public Utilities Regulatory Policies Act (part of the new National Energy Act), to defray up to 90% of the costs of feasibility studies and preparation of a License Application. *what is this study?*

d. Discussions be held with REA regarding obtaining low interest (7%) financing for development of the Project.

e. If the REA discussions on financing and those with the Corps are positive, application be made to the FERC for a Preliminary Permit to establish priority on the site and to undertake the next stage of the investigations.

f. Detailed evaluation studies be initiated leading to preparation of a FERC License Application, assuming that suitable financing can be obtained and a satisfactory agreement concerning use of the outlet works and reservoir use-fees is reached.

PLAN
SCALE IN FEET
0 1000 2000

NOTE

This figure is a reproduction of Plate 16,
Tuttle Creek Lake Regulation Manual,
August 1973

SPILLWAY SECTION

SECTION OF DAM

OUTLET WORKS SECTION

R. W. BECK and ASSOCIATES

ENGINEERS AND CONSULTANTS

Seattle, Washington

Denver, Colorado

General offices: Tower Building, Seattle, Washington 98101

KANSAS ELECTRIC POWER COOPERATIVE, INC.

TOPEKA, KANSAS

TUTTLE CREEK HYDROELECTRIC PROJECT

EXISTING PROJECT -
GENERAL PLAN AND SECTIONS

DATE:
MARCH 1979

DRAWN:
E. R. JAM

APPROVED:

FIG:
2

R. W. BECK and ASSOCIATES

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Denver, Colorado

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KANSAS ELECTRIC POWER COOPERATIVE, INC.

TOPEKA, KANSAS

TUTTLE CREEK HYDROELECTRIC PROJECT

TUTTLE CREEK LAKE
AREA-CAPACITY CURVES

DATE:
MARCH 1979

DRAWN:
T.R.

APPROVED:
JAM

FIG:
3

NOTE

Based on inflows developed by the Corps of Engineers for the period 10/35 to 9/74.

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KANSAS ELECTRIC POWER COOPERATIVE, INC.
TOPEKA, KANSAS

TUTTLE CREEK HYDROELECTRIC PROJECT

FLOW DURATION CURVE
TUTTLE CREEK LAKE INFLOWS

DATE:
MARCH 1979

DRAWN:
F.A.

APPROVED:
JAH

FIG:
4

PLAN

TYPICAL TUNNEL SECTION

PROFILE ALONG $\varnothing$ WATERWAY

R. W. BECK and ASSOCIATES

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KANSAS ELECTRIC POWER COOPERATIVE, INC.
TOPEKA, KANSAS

TUTTLE CREEK HYDROELECTRIC PROJECT

TUNNEL ALTERNATIVE
PROJECT ARRANGEMENT
PLAN AND PROFILE

DATE:
MARCH 1979

DRAWN:
S.R.

APPROVED:
JAM

FIG:
5

NOTE

Powerhouse contains three Allis Chalmers 4750 kW tube units and one 500 kW tube units, providing a total installed capacity of 14750 kW.

R. W. BECK and ASSOCIATES ENGINEERS AND CONSULTANTS Seattle, Washington Denver, Colorado General offices: Tower Building, Seattle, Washington 98101			
KANSAS ELECTRIC POWER COOPERATIVE, INC. TOPEKA, KANSAS TUTTLE CREEK HYDROELECTRIC PROJECT TUNNEL ALTERNATIVE POWERHOUSE PROFILE 4750 kW UNIT			
DATE: MARCH 1979	DRAWN: S.A.	APPROVED: JAM	FIG: 6

NOTE
Proposed Project features shown with bold lines.

R. W. BECK and ASSOCIATES ENGINEERS AND CONSULTANTS Seattle, Washington Denver, Colorado General offices: Tower Building, Seattle, Washington 98101			
KANSAS ELECTRIC POWER COOPERATIVE, INC. TOPEKA, KANSAS TUTTLE CREEK HYDROELECTRIC PROJECT OUTLET WORKS ALTERNATIVE PROJECT ARRANGEMENT PLAN AND SECTIONS			
DATE: MARCH 1979	DRAWN: S.A.	APPROVED: J.A.M.	FIG: 7

R. W. BECK and ASSOCIATES

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Denver, Colorado

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KANSAS ELECTRIC POWER COOPERATIVE, INC.

TOPEKA, KANSAS

TUTTLE CREEK HYDROELECTRIC PROJECT

OUTLET WORKS ALTERNATIVE

POWERHOUSE PLAN AND SECTION

DATE:
MARCH 1979

DRAWN:
T.R.

APPROVED:
J.M.

FIG:
8

R. W. BECK and ASSOCIATES

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KANSAS ELECTRIC POWER COOPERATIVE, INC.

TOPEKA, KANSAS

TUTTLE CREEK HYDROELECTRIC PROJECT

**MODIFIED OUTLET WORKS
RATING CURVE**

DATE:

MARCH 1979

DRAWN:

T.G.

APPROVED:

JAM

FIG:

9

- Power Rule Curve
- State Rule Curve
- - - Operation with Power Rule Curve During Second Worst Historical Period (Water Years 1936 and 1937)
- - - Operation with State Rule Curve During Second Worst Historical Period (Water Years 1955 and 1956)
- Point at which dependable capacity is determined.

R. W. BECK and ASSOCIATES ENGINEERS AND CONSULTANTS Seattle, Washington Denver, Colorado General offices: Tower Building, Seattle, Washington 98101			
KANSAS ELECTRIC POWER COOPERATIVE, INC. TOPEKA, KANSAS TUTTLE CREEK HYDROELECTRIC PROJECT ALTERNATIVE RESERVOIR OPERATION RULE CURVES			
DATE: MARCH 1979	DRAWN: T.A.	APPROVED: JAM	FIG: 10

NOTES

1. Project annual cost with a 35 year REA loan at 7% interest rate.
2. Project annual cost with a 35 year REA loan at 9.5% interest rate.
3. Project annual cost with a 30 year DOE loan at 7 - $\frac{1}{8}$ % for 75% of total loan and the balance at 9.5 % with a 30 year conventional loan.
4. Project benefits based on Kansas Power and Light wholesale power costs as projected by KEPCo.

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KANSAS ELECTRIC POWER COOPERATIVE, INC.

TOPEKA, KANSAS

TUTTLE CREEK HYDROELECTRIC PROJECT

COST OF PROJECT VERSUS
CONTINUED POWER PURCHASES

DATE:
MARCH 1979

DRAWN:
S.A.

APPROVED:
JAM

FIG.:
11

LEGEND

———— Major effort
..... Continuing effort

R. W. BECK and ASSOCIATES

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Denver, Colorado

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KANSAS ELECTRIC POWER COOPERATIVE, INC.

TOPEKA, KANSAS

TUTTLE CREEK HYDROELECTRIC PROJEC

DESIGN AND CONSTRUCTION SCHEDULE

DATE: MAR. 1979

DRAWN: S.A.

APPROVED: VAM

FIG: 12

APPENDIX A

GEOLOGICAL RECONNAISSANCE REPORT

RIM DE RUBERTIS
CONSULTING ENGINEER

February 15, 1979

Mr. Val Maxim
R. W. Beck and Associates
200 Tower Building
Seattle, Washington 98101

Dear Mr. Maxim:

The purposes of this letter report are to describe the results of a geologic reconnaissance of the site of the existing Tuttle Creek Dam and to describe the site geology and how it relates to the design for the proposed project features.

1. GENERAL

Tuttle Creek Dam is located on the Big Blue River about six miles north of Manhattan, Kansas. A reconnaissance was made of the site on 30 November and 1 December 1978 in the company of Messrs. Maxim and McLemore and Ms. Maykut of R. W. Beck and Associates and Mr. Hamman of KEPCO.

The existing project consists of dam, spillway, and outlet works. The dam is of earthfill construction about 7,490 feet long and with a maximum height of about 134 feet. The spillway is constructed of concrete and is located in the left abutment. Eighteen 20x40-foot gates control spillway discharge. An outlet works is located near the right abutment with two, 20-foot horse-shoe conduits through the dam conveying water from the intake tower to the outlet channel.

The proposed project would be concentrated in the low hill between the left abutment of the dam and the right abutment of the spillway. It would consist of an intake, a pressure tunnel, a powerhouse, and a tailrace channel.

Reviewed in the preparation of this letter were several drawings prepared by the Corps of Engineers which appear as part of the Operations and Maintenance Manual for Tuttle Creek Dam.

2. REGIONAL GEOLOGY

Tuttle Creek Dam is located within the Flint Hills east of the Central Kansas Uplift.

a. Geologic History

The geologic history of the region is complex. Pre-Mississippian sedimentation resulted in spotty deposition atop an

irregular Precambrian basement surface. Erosion ensued. Late Mississippian and early Pennsylvanian rocks were deposited unconformably on the pre-Mississippian surface. Regional deformation followed, and deposition resumed with post-early Pennsylvanian to Quaternary sediments being laid down upon the deformed surface. The northeastern region of Kansas was subjected to glaciation during Pleistocene time.

b. Stratigraphy

Rocks ranging in age from Mississippian to Permian crop out in the eastern part of the region. They consist mainly of limestone and shale. Successively younger rocks occur to the west. A number of kimberlite plugs of igneous origin and of basaltic composition occur near the Big Blue River. Overburden ranges from alluvium in the valleys to remnants of glacial drift in the higher areas to the north and east. Accumulations of loess are common.

c. Geologic Structure

The dominant geologic structures of the region are the Salina Basin, Abilene Anticline, Irving Syncline, Nemaha Anticline, and Forest City Basin. These features, believed to be early Mississippian in age, trend northeast-southwest. A well-defined regional joint pattern consisting of two sets striking roughly east-west and north-south controls much of the topography including the angular shape of the Tuttle Creek Reservoir. Numerous faults of various origin, but generally with limited displacement, cut through to the surface. Some appear to follow the regional joint pattern, but others apparently are reactivations of older buried faults.

d. Earthquake Hazard

As shown on Fig. 1, the site is located within Seismic Hazard Zone 2, as designated by the Corps of Engineers. Some recent minor earthquakes have been associated with the Nemaha Anticline. Earthquake hazard is considered moderate and is not believed to have an influence upon the future stability of existing structures or upon the design for the proposed project features.

3. SITE GEOLOGY

The site occupies the Big Blue River Valley with the reservoir extending about 40 miles upstream.

a. Geologic History

The site geologic history conforms to the history of the region with post-early Pennsylvanian deposition and deformation dominating the geology of the site.

b. Stratigraphy

Permian rocks composed of interbedded limestones and shales comprise the geologic section at the site. From oldest to youngest, all of the Council Grove Group and the lower portion of the Chase Group are represented. The limestones are generally argillaceous, occasionally flinty or cherty, and are thin bedded (Glenrock) to massive (Neva). The shales range in color from chocolate to red, are commonly fossiliferous and calcareous, and range in thickness from thin bedded (Bennett) to massive (Eskridge).

c. Geologic Structure

The site occupies the Irving Syncline, a structural trough formed between the Nemaha and Abilene Anticlines. The beds at the site dip gently, less than 5°, to the west. Well developed joints paralleling the regional trends are apparent in the cuts for the existing project. Jointing, in general, appears tight and ranges in spacing from less than one foot to about three feet. Minor folds and kimberlite plugs dot the right bank of the reservoir area, closer to the axis of the Abilene Anticline. A few minor thrust faults with limited displacement (10 feet) occur to the west of the reservoir. One high angle normal fault passes through the left bank of the spillway approach channel. This fault strikes roughly east-west, shows displacement of about 20 feet, and has cut through to the ground surface.

4. ORIGINAL DESIGN AND CONSTRUCTION

A number of as-built drawings prepared by the Corps of Engineers as part of the Operations and Maintenance Manual were reviewed. The drawings revealed that a prudent job of exploration was accomplished prior to design and that the major project features were well conceived and constructed relative to the geology of the site.

5. CURRENT CONDITION

The dam and appurtenant structures appear to be in good to excellent condition. It was noted that seepage through the right abutment of the dam above the outlet channel is heavy, but not alarming, compared to seepage through the dam, itself. No substantial seepage was noted in the left abutment of the dam. The open rock cuts (1:1) in the spillway approach and outlet channels have survived with nothing more than minor ravelling over the 15-year period since construction. However, it is noted that the spillway has operated once and then only for a test, during its history. The excavated outlet channel exhibits bank stability problems with numerous small slides having developed.

6. PROPOSED PROJECT

The proposal to construct an intake, pressure tunnel, powerhouse, and tailrace channel involves a number of geologic considerations.

The intake is proposed to be located in the hill between the spillway and the left abutment of the dam. Assuming minimal intake submergence, it is believed that the intake could be founded between El 1010 and El 1030. A foundation in limestone, rather than in shale, would be desirable. From the drawings (5A and 106A), it appears that the Long Creek limestone would crop out at the intake site somewhere between El 1005 and El 1035. The actual elevation requires confirmation. The low level outlet works utilize this formation for a foundation throughout. It appears to have performed well and is anticipated to provide an adequate power intake foundation. Temporary construction slopes against which concrete is to be placed could be made vertical or nearly so, depending upon slope height, the location of shale interbeds, and the time/length of exposure. If required, permanently exposed rock slopes subject to alternate wetting and drying or to high velocity flow should be flattened to at least 2:1. Additional protection may be required. If required, permanently exposed rock slopes subject only to the elements may be excavated at 1:1 with some consideration given to benching at the limestones similar to the detail shown on Drawing 113-A.

Cofferdam and dewatering requirements would be, to a large extent, the function of how the reservoir will be operated during the construction period. If minimum conservation levels were maintained throughout, requirements might be minimal. Some consideration should be given to arrangements in this regard prior to proceeding with design.

The pressure tunnel connecting the intake to the powerhouse is planned to be a 22-foot outside diameter tunnel about 1,700 feet long. Care will have to be exercised in aligning the tunnel to avoid the left abutment cutoff trench and to maximize the amount of cover over the tunnel. Judging from the drawings and from the probable intake location, it appears that the tunnel would penetrate the Hughes Creek shale and Americus limestone from upstream to downstream. The exact vertical alignment of both beds and tunnel should be confirmed; however, there may be advantages, ease of tunneling in the Hughes Creek and overbreak control, to retaining the Long Creek limestone in the back of the tunnel to the extent possible with transitions at both ends. Machine tunneling is not believed to be attractive because of the relatively short length and the wide variation in hardness of the beds. Conventional tunneling, with care exercised to immediately reinforce the rock after pulling each round, should prove adequate. A horseshoe-shaped tunnel would be most practical. The erodable nature of the rock and the need to defend the dam abutment and

spillway slopes from seepage pressures not considered in the original design dictate that the tunnel should be fully lined. It appears that steel lining will be required near the powerhouse where the cover is light. The remainder of the tunnel either could be fully steel lined or could be concrete lined. If concrete lined, it should be assumed that the liner will crack and introduce full headwater pressure at any point in its length thereby requiring provisions both for grouting and drainage. If fully steel lined, it is felt that the provisions for grouting and drainage would be minimal. A vertical gate shaft, if required, could be constructed without difficulty but should be concrete lined to prevent raveling of material into the shaft.

The powerhouse is planned to be constructed in the prominent ravine just downstream from the toe of the dam at the left abutment. The ravine aligns with the north-south joint set. Exposed beds appear continuous across the ravine and along the projection of the ravine in the spillway outlet channel. The powerhouse would be founded at about El 980 which may correspond to the elevation of the Americus limestone. In any event, the Americus and immediately underlying formations should be anticipated to present relatively weak foundations. Confirmation of the actual conditions will be required. The excavation slope constraints noted in the above discussion of the intake would apply to the powerhouse as well.

The plan to connect the powerhouse to the river by excavating a tailrace channel either to the spillway outlet channel or to the existing pond will require substantial excavation in alluvium. Borings D-52 and D-523 at the mouth of the ravine show rock overlain by from 35 to 45 feet of alluvium varying in composition from clay to gravel. The condition of the slopes in the low level outlet channel argue for modest excavation slopes, say 2.5:1 or 2:1, with riprap and possibly slush grout protection. An alignment to the existing pond may raise two other questions: does the continuation of the dam slope intersect the wall of the proposed channel; and what seepage forces will act on the walls of the channel? More information will need to be developed to address these questions.

Other concerns relate to all of the proposed features. Blasting control for excavation will be required to insure the continued integrity of the adjacent structures. Some assessment should be made of the relative density of the granular fill materials in the embankment to determine the liquefaction potential of those materials during ground shaking induced by blasting. It is believed that adequate blasting techniques exist to reduce the risk of damage to an acceptable level.

A substantial volume of spoil will be generated from the required excavation, and a suitable disposal area should be located.

Mr. Val Maxim

-6-

February 15, 1979

It is felt that the proposed project is technically feasible from the geological point of view; however, prior to design, it is recommended that a thorough exploration program be carried to determine a number of critical design parameters. It is suggested to explore and test for (1) the nature and quality of the rock mass at the intake, along the tunnel alignment and gate shaft sites, and at the powerhouse; (2) the quality and nature of the overburden materials in the tailrace channel; (3) the requirements for cofferdams and dewatering at the intake and powerhouse; (4) the energy transmitting capabilities of the rock mass and the energy absorbing capabilities of the existing structures; and (5) the site for disposal of spoil material.

If you have any questions concerning this letter, please let me know.

Yours very truly,

Kim de Rubertis

Figure 1

APPENDIX B

CORRESPONDENCE WITH EQUIPMENT MANUFACTURERS

RECEIVED
DEC 14 1978

Project WW-2141-HG2-MA
File 5123

BOX 712 • YORK, PENNSYLVANIA 17405 / 717 792-3511

YORK PLANT
HYDRO-TURBINE DIVISION

December 8, 1978

R. W. Beck & Associates
Tower Building
Seattle, Washington 98701

ATTENTION: Mr. Don K. Smith
Executive Engineer

SUBJECT: Tuttle Creek Dam
Your File No. WW-2141-HG2-MA
A-C Reference 6-33302

Gentlemen:

Reference is made to your letter of November 6, 1978 sent to the attention of Mr. Wiley B. Ford concerning Montgomery Dam and on Pages 2 and 3 of that letter you list seven other low head studies and preliminary designs presently being investigated by your firm.

Inasmuch as the Tuttle Creek Dam falls within the realm of the application of the Allis-Chalmers standardized TUBE turbine, we shall base our studies on this type of equipment.

Our calculations indicate that a horizontal, 2,250 mm, standardized TUBE generating unit will develop 5 MW when subjected to a head of 19.2 m requiring a discharge of approximately 1,050 cfs of water.

For the supply of two (2) horizontal TUBE turbines having the basic dimensions as indicated on Page 5 of the enclosed Bulletin 54B10241-02 comprising an intake valve, an adjustable blade runner, connected to a speed increaser, which in turn is connected to a 5,000 KW horizontal, 3 phase, 60 Hertz, 4,160 volt synchronous generator, complete with the adjustable blade control, pumping unit, control and excitation cubicles including the indoor synchronous generator protection and panel, the outdoor high voltage module including the utility metering section and the high voltage switch and fuse including the power transformer. The two units can be supplied for the present day estimating sum of -

TWO MILLION DOLLARS.....\$2,000,000.00

Total for two (2), F.O.B. cars York, Pennsylvania.

Mr. Smith

-2-

December 8, 1978

If any additional information is required, please advise.

Very truly yours,

R. E. Coates, P.E.
Senior Sales Engineer

REC/db
Enclosure

cc: Mr. R. Gore, Buckley-Gore Electric, Inc., Redmond
Mr. W. B. Ford, A-C York
Mr. H. H. Wirschal/Mr. D. L. Brandl, A-C York

APPENDIX C

CORRESPONDENCE WITH FEDERAL AND STATE AGENCIES

DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
700 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106

REPLY TO
ATTENTION OF

MRKED-BA

20 December 1978

Mr. Dave Larson
Technical Specialist
Kansas Electric Power Cooperative, Inc.
P.O. Box 4267, Gage Center Station
Topeka, KS 66604

Dear Mr. Larson:

This is in response to your letter of 6 December 1978 in which you requested information about Tuttle Creek Lake. I understand the requested information is needed for your feasibility study of low head hydroelectric power development at Tuttle Creek Lake.

Your first request concerned the design of the outlet tubes. Except for the central wall which is designed for a minimal differential head of 1,800 pounds per square foot, the twin barrel concrete conduit is not designed for internal pressure. To withstand the pressure caused by penstocks a properly designed steel pipe would have to be grouted inside the twin conduits. Also, provisions would be necessary to insure that the area between the steel pipe and the concrete conduit would not become pressurized due to leakage or other factors.

A tabulation of the elevations of Tuttle Creek Lake at the end of each month is inclosed as inclosure 1.

Your third request concerns soil boring logs. The Operation and Maintenance Manual which was provided earlier contains logs of explorations. Refer to plates 18-A, 26-A, 36-A, 105-A, and 221-A in Book 1 of Appendix II. Detailed field logs and test data are not stored in this office but can be obtained if needed. In order to avoid unnecessary effort and expense we would ask that only those logs that are essential for your study be requested. The locations and numbers of the logs are shown in the Operation and Maintenance Manual.

Four topographical maps showing contour lines at two foot intervals are inclosed. There is a charge of \$1.50 per map. You will be billed for these maps by separate correspondence.

MRKED-BA
Mr. Dave Larson

20 December 1978

In response to your requests numbered 5, 6, 9, and 10 inclosed is the Lake Regulation Manual for Tuttle Creek Lake. This manual also contains hydrographs which you requested verbally.

Water and air quality data are contained in the Final Environmental Statement for operation and maintenance of Tuttle Creek Lake. A copy of this document is inclosed for your reference.

Regarding your request numbered 8, published geologic mapping and reports can be obtained from the Kansas Geological Survey, 1930 Ave. A, Campus West, Lawrence, Kansas 66044. Pertinent publications might include: The Geology of Riley and Geary Counties, Bulletin 39 and Structural Geology of the Manhattan, Kansas Area, Bulletin 204.

In response to your verbal request, inclosed as inclosure 5 is a pool frequency curve of Tuttle Creek Lake.

I trust the information provided herein will be adequate for your feasibility study.

Sincerely yours,

PAUL D. BARBER

Chief, Engineering Division

5 Incl

1. As stated
2. Map file no. A-9-7-2885
Map file no. A-9-7-2886
Map file no. A-9-7-2887
Map file no. A-9-7-2888
- 3-5. As stated

RECEIVED

FEB 20 1979

DEPARTMENT OF THE ARMY

KANSAS CITY DISTRICT, CORPS OF ENGINEERS

700 FEDERAL BUILDING

KANSAS CITY, MISSOURI 64106

REPLY TO
ATTENTION OFProject WV-2141-AE 94
File 3104.2
JFW

15 FEB 1979

MRKED-BA

Mr. Richard H. McLemore
Executive Engineer
R. W. Beck and Associates
200 Tower Building
Seattle, Washington 98101

Dear Mr. McLemore:

This is in regard to your study of hydropower development at Tuttle Creek Lake and the meeting in our office on 3 January 1979. In response to your request at that meeting comments and information are provided below. Because the data furnished at the meeting was very preliminary in nature these comments are also preliminary and may be modified as more detail becomes available.

Alternative 1 - Left Abutment. It appears the tunnel crown would be in the Roca shale and the geologic units from the Roca down through the Oaks shale would be encountered. The powerhouse would probably be founded on the Oaks. It should be noted that the bedrock is moderately jointed and the shales tend to slake on exposure to air. At this stage of the study considerable temporary tunnel support should be anticipated. In addition, slight to moderate groundwater inflow can be expected. The spillway fault would pass fairly close to the intake structure and its location and effect on the structure would have to be carefully evaluated. The outlet would discharge into the downstream State Park area. The effects of discharges in this area and downstream would have to be evaluated.

Alternative 2 - Right Abutment. The tunnel crown would probably be in the Neva limestone and the powerhouse founded on the Hughes Creek shale. All bedrock members between these units would be encountered. No unusually severe geologic conditions are known to exist in this area. This alternative would extend beneath a portion of the dam and would be close to the outlet works structure. Any blasting near this structure would have to be very carefully controlled and monitored to prevent damage. Comments on Alternative 1 regarding effects of discharges, exposure of bedrock, tunnel support, and infiltration also apply to this alternative.

15 FEB 1979

MRKED-BA

Mr. Richard H. McLemore

Alternative 3 - Conduit. This scheme would consist of a connection from the downstream portion of the conduit to a powerhouse downstream of the stilling basin by means of a short tunnel or more probably a cut and cover section. Any blasting near the existing conduit would have to be very carefully controlled and monitored to prevent damage to the structure. Backfill around the power conduit and any of the present structure that was exposed during the excavation would have to be carefully controlled. It also appears that the powerplant would discharge at right angles to outlet channel which would cause severe erosion of the outlet channel unless it is modified. As indicated in previous correspondence with Kansas Electric Power Cooperative, the existing conduit is not designed for internal pressure. Alteration of the existing intake and stilling basin structures would likely be required.

The capital cost of using Tuttle Creek Lake for hydropower has been estimated at \$150 per acre-foot of storage utilized. Based on the storage space between elevation 1070 feet mean sea level (m.s.l.) and elevation 1075 feet m.s.l. (75,000 acre-feet), this would amount to \$11,250,000. This value may be used for your study. In the event your study leads to more detailed implementation studies and an application for a license, we would undertake more extensive studies to equitably allocate a share of the Tuttle Creek Lake costs to hydropower. Such studies could result in a value significantly different than the value shown above.

In addition to the capital cost, it likely would be necessary to repay a portion of the annual operation, maintenance, and replacement costs of Tuttle Creek Lake. This would amount to an estimated average of \$0.36 per acre-foot per year. As with the capital cost, this is subject to revision based on subsequent studies.

I trust these comments and information are useful for your study. If I may be of further assistance to you on this or any other matter, please do not hesitate to contact me.

Sincerely yours,

PAUL D. BARBER

Chief, Engineering Division

JAN 2 1978
R. W. BECK and ASSOC
SEATTLE, WASH.

THE STATE

OF KANSAS

WATER RESOURCES BOARD

Suite 303
503 Kansas Avenue
Telephone (913) 296-3185
TOPEKA, KANSAS 66603

December 26, 1978

Mrs. Nadine Maykut
R. W. Beck and Associates
200 Tower Building
Seattle, Washington 98101

Dear Mrs. Maykut:

In reply to your telephone request for information which would assist you in evaluating the hydroelectric potential at Tuttle Creek Dam and specifically concerning the pool level management plan, I am sending you a copy of the Kansas Fish and Game Commission's proposal. The proposals are examined annually with an objective of managing the lake to benefit the greatest number of interests. The Kansas Water Resources Board coordinates the proposals with various state agencies and recommends the plan acceptable to all.

The other studies on feasibility of hydropower in eastern Kansas which I mentioned were in-house reviews with no formal report written.

Sincerely,

A handwritten signature in cursive script that reads "Larry M. Sheets".

Larry M. Sheets
Associate Hydrologist

LMS:mf

Enclosure

Water Level Management Plan 1979
and 1978 Summary for Tuttle Creek Reservoir

TUTTLE CREEK RESERVOIR - Proposed Water Level Management Plan for 1979

1979 Recommendations - The proposed 1979 management plan is nearly identical to the 1978 plan except for the requested date to initiate holding water in September was changed from the 1st to the 15th of the month. This request is based on giving more time for natural revegetation of exposed shoreline, in areas not seeded with millet.

The 1979 proposed plan is listed below:

<u>DATES</u>	<u>WATER LEVEL (msl)</u>	<u>ACTIONS</u>
Jan 1 - Feb 15, 79	1073	(2) Hold steady
Feb 15 - Apr 1, 79	1073 - 1076.5	(3) Raise as inflow occurs
Apr 1 - May 1, 79	1076.5	(4) Hold steady
May 1 - May 15, 79	1076.5 - 1078	(3) Raise as inflow occurs
May 15 - July 1, 79	1078	(2) Hold steady-drawdown
July 1 - July 15, 79	1078 - 1075	maximum 4000 c.f.s.
July 15 - Sept 15, 79	1075	(2) Hold steady, raise
Sept 15 - Nov 1, 79	1075 - 1079	as inflow occurs
Nov 1 - Dec 10, 79	1079	(2) Hold steady drawdown
Dec 10 - Jan 1, 80	1079 - 1073	maximum 4000 c.f.s.

- (1) February 15 or at ice breakup, whichever is earliest.
- (2) Match outflows with inflows.
- (3) Zone of close coordination:
Area 1. Minimize drawdowns and releases.
- (4) Reservoir elevation should be allowed to rise to 1078 m.s.l. if release rates above 4000 c.f.s are necessary to maintain pool.

Tuttle Creek Water Level Management Proposals - 1979

1. Jan 1 - Feb 15 maintain water at 1073. All inflow water to be released as soon as possible with release rates not to exceed 4000 c.f.s.

2. Beginning Feb. 15 a gradual rise in water level to be initiated to provide inundation of terrestrial vegetation, and improve early walleye spawning conditions.
3. Stable water conditions to be attained by April 1 and be extended through May 1. This time period is needed to insure suitable spawning conditions and early survival of desirable game and panfishes. During this period native terrestrial vegetation will grow to the extent to provide fish nursery habitat and bank stabilization, and assure navigation in tributary streams, with release rates not to exceed 4000 c.f.s.
4. May 1 - May 15 an additional rise in water level of 18 inches to be attained to inundate terrestrial vegetation.
5. May 15 - July 1 water level to be maintained to insure good fish nursery conditions and survival.
6. July 1 - July 15 evacuation of water to 1075 m.s.l. to prepare mud flats for seeding and natural revegetation.
7. July 15 - Sept 15 a holding action is requested for the revegetation of the mud flats.
8. Initiating Sept. 15 through Nov 1 a rise in water level is requested for the purpose of flooding of vegetation for attraction of waterfowl.
9. A holding action is requested through Dec. 10 to attract and hold migrating waterfowl.
10. Evacuation of water to a level of 1073 to provide buffer for spring runoff and minimize ice damage.

Summary of 1978 Water Level Management Program

The water level program for Tuttle Creek Reservoir had many problems during the 1978 year. Untimely flooding and high release rates, due to excessive runoff, caused the abandonment of the water level management plan.

The pool level was drawn down to approximately 2 feet below conservation pool during winter months as proposed. However, during mid March, Tuttle Creek rose 20 feet into flood pool as winter snows and ice quickly melted in its drainage. High release rates during water evacuation caused high turbidity. Water clarity of 4 inches and less were common during the spring months. Release rates ranging from 5,000 - 15,000 c.f.s. occurred for a total of over 60 days through the season. To combat turbidity, water release should not exceed 4,000 c.f.s. when possible.

Unfortunate runoff problems persisited in mid April and May, which coincided with optimum walleye and panfish spawning periods. Sportfishing harvest also declined, due to turbidity and frequent water level fluctuations in prime fishable habitat along the shoreline, however, this lead to increased angler harvest at the outlet structure.

A positive benefit of water level fluctuations was multiple shad spawns, which was documented by seine hauls in the months of July and August. However, appreciably lower numbers of young-of-the-year predaceous and panfish fingerlings were sampled in 1978, in comparison to 1977, when more stable conditions existed.

Abnormal heavy rainfall during the month of July eliminated the effects of the summer drawdown. Millet was seeded on the exposed flats, but was inundated within one week. The reservoir level rose to 1,080 by August 1, causing loss of all vegetation below 1,080 m.s.l. into mid August.

Though the 1978 results are disappointing, I recommend that we attempt to follow the 1979 proposed plan. In past years water level management has resulted in benefits to fish and waterfowl, through better wildlife habitat.

APPENDIX D

TUNNEL ALTERNATIVE COST ESTIMATE

CONSTRUCTION COST ESTIMATE

PROJECT Tuttle Creek

FEATURE Tunnel Alternative

LOCATION Kansas

w.o. WW-2141-HG2-QA

TYPE EST: PLANNING - ~~RECONSTRUCTION~~ TAKE-OFF

LDC

PRICED LDC

...CALC. CHKD. AWP

APPROVED JVW

DATE March 1979

APPENDIX D

CONSTRUCTION COST ESTIMATE

January 1979 Bid Level

PROJECT Tuttle Creek

FEATURE Tunnel Alternative

LOCATION Kansas

W.O. WW-2141-HG2-QA

TYPE EST: ~~PLANNING-DESIGN-CONSTRUCTION~~ TAKE-OFF LDC

PRICED LDC

CALC. CHKD. AWP

APPROVED JVW

DATE March 1979

ITEM AND DESCRIPTION		QUANTITY	UNIT	MAT'L	LABOR	UNIT COST	TOTAL	
2.	POWER WATERWAY							\$8,818,000
2.1	Power Intake							
	2.1.1 Excavation							
	a. Common	8,000	CY			2.00		16,000
	b. Rock	191,000	CY			7.00		1,337,000
	c. Channel Plug	9,000	CY			15.00		135,000
	2.1.3 Concrete	840	CY			175.00		147,000
	2.1.4 Cement	4,200	CF			3.00		13,000
	2.1.5 Reinforcing Steel	84,000	LBS			0.40		34,000
	2.1.6 Rock Bolts	1,940	LF			8.00		16,000
	2.1.7 Trashrack	40,000	LBS			2.20		88,000
	2.1.8 Dewatering		LS					50,000
2.2	Gate Shaft							
	2.2.1 Excavation	1,800	CY			90.00		162,000
	2.2.2 Rock Bolts	3,400	LF			8.00		27,000
	2.2.3 Concrete	550	CY			140.00		77,000
	2.2.4 Cement	2,800	CF			3.00		8,000
	2.2.5 Reinforcing Steel	55,000	LBS			0.40		22,000
	2.2.6 Gate & Operator		LS					267,000
2.3	Tunnel							
	2.3.1 Excavation	27,200	CY			60.00		1,632,000
	2.3.2 Tunnel Supports							
	a. Rock Bolts	23,400	CY			8.00		187,000
	b. Shotcrete	26,400	CF			6.00		158,000
	c. Steel Sets	186,000	LBS			1.25		232,000
	d. Timber Lagging	55	MBM			500.00		28,000
	2.3.3 Concrete	8,360	CY			85.00		711,000
	2.3.4 Steel Liner							
	a. Circular Tunnel	1,520,000	LBS			0.80		1,216,000
	b. Transitions	115,000	LBS			1.00		115,000

CONSTRUCTION COST ESTIMATE

January 1979 Bid Level
WW-2141-HG2-QA

PROJECT: Tuttle Creek

FEATURE Tunnel Alternative

LOCATION Kansas

W.O. WW-2141-HG2-QA

TYPE EST: PLANNING - PRELIMINARY DESIGN TAKE-OFF LDC PRICED LDC CALC CHKD. AWP APPROVED JVW DATE March 1979

[illegible]

CONSTRUCTION COST ESTIMATE

January 1979 Bid Level

PROJECT: Tuttle Creek

FEATURE Tunnel Alternative

LOCATION Kansas

WW-2141-HG2-QA

TYPE EST: PLANNING-FUELED KN-HOLD KN XXXX TAKE-OFF

LDC

PRICED.

LDC

CALC CHKD.

AWP

APPROVED

JVW

DATE: March 1979

ITEM AND DESCRIPTION		QUANTITY	UNIT	MAT'L	LABOR	UNIT COST	TOTAL	
3.	PCWERHOUSE							\$5,537,000
3.1	Civil							
	3.1.1 Excavation							
	a. Overburden	1,000	CY			2.00		2,000
	b. Rock	50,000	CY			10.00		500,000
	3.1.2 Concrete							
	a. Powerhouse Substructure	1,560	CY			125.00		195,000
	b. Powerhouse Superstructure	710	CY			175.00		124,000
	c. Tailrace Transition Lining	220	CY			175.00		38,000
	3.1.3 Cement	12,600	CF			3.00		38,000
	3.1.4 Reinforcing Steel	290,000	LBS			0.40		116,000
	3.1.5 Structural Steel	34,000	LBS			1.25		42,000
	3.1.6 Backfill	6,200	CY			4.00		25,000
	3.1.7 Riprap	100	CY			12.00		1,000
	3.1.8 Architectural		LS					
	3.1.9 Miscellaneous		LS					
3.2	Mechanical & Electrical							
	3.2.1 Package Generating Sets							
	a. 2250mm tubular units	3	EA			1,035,000		3,105,000
	b. 750mm tubular units	1	EA			171,000		171,000
	c. Shipping & Installation		LS					1,040,000
	3.2.2 Miscellaneous Powerhouse Mechanical	1	LS					50,000
	3.2.3 Miscellaneous Powerhouse Electrical		LS					50,000

R W Beck and Associates
CONSTRUCTION COST ESTIMATE

January 1979 Bid Level

PROJECT	<u>Tuttle Creek</u>	FEATURE	<u>Tunnel Alternative</u>	LOCATION	<u>Kansas</u>	W.O.	<u>WW-2141-HG2-0A</u>
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TYPE EST: PLANNING-~~PROPOSED~~~~DESIGN~~~~CONSTRUCTION~~ TAKE-OFF LDC PRICED LDC CALC CHKD. AWP APPROVED JWV DATE: March 1979

[illegible]