MASTER

Gilmore

FEASIBILITY STUDY OF
LOW HEAD HYDROELECTRIC POWER
ON CARLYLE RESERVOIR
FOR THE CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC UTILITY

City of Carlyle, Illinois

March, 1979

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BARNES, HENRY, MEISENHEIMER AND GENDE
CONSULTING ENGINEERS
ST. LOUIS, MO.

U.S. DEPARTMENT OF ENERGY
IDAHO FALLS, IDAHO

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CAROL BUDDE

City of
CARLYLE *Illinois*

850 FRANKLIN STREET • CARLYLE, ILLINOIS 62231 • TELEPHONE 618 594-2611

March 9, 1979

Mr. Charles E. Gilmore, Chief
Advanced Technology Branch
Energy and Technology Division
U.S. Department of Energy
550 Second Street
Idaho Falls, Idaho 83401

Re: Contract No. EW-78-F-07-1769

Dear Mr. Gilmore:

The City of Carlyle, Illinois respectfully submits the attached "Feasibility Study of Low-Head Hydroelectric Power on Carlyle Reservoir" to fulfill our obligations under the above referenced contract.

At this time, I would like to express my appreciation on behalf of the City of Carlyle for the assistance and co-operation which your agency provided for the completion of this study.

We are forwarding to you nine (9) copies for your use, all of which are considered to be "camera ready" as specified in contract documents. The final cost report for this project will be submitted upon receipt of final invoices from the members of the assessment team.

If you should have any questions on the enclosed, please advise.

Again, we have enjoyed our association with your agency during preparation of this study, and hope that we will be given opportunity to work together in the future.

Respectfully yours,

CITY OF CARLYLE, ILLINOIS

J. Leo Davis, Mayor

SC

Enclosures

DOE/ID/01769--1

A80012360

FEASIBILITY STUDY OF
LOW-HEAD HYDROELECTRIC POWER ON CARLYLE RESERVOIR
FOR THE CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC UTILITY ✓

MARCH, 1979

CITY OF CARLYLE, ILLINOIS

CONTRACT NO. EW-78-F-07-1769

U.S. DEPARTMENT OF ENERGY
Advanced Technology Branch
Energy and Technology Division
550 Second Street
Idaho Falls, Idaho 83401

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951 0022

Prepared by:

BARNES, HENRY, MEISENHEIMER AND GENDE, INC.
Consulting Engineers
4658 Gravois Avenue
St. Louis, Missouri 63116

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CITY OF CARLYLE, ILLINOIS

FEASIBILITY STUDY OF
LOW-HEAD HYDROELECTRIC POWER ON CARLYLE RESERVOIR
FOR THE CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC UTILITY

CITY OFFICIALS

J. Leo Davis, Mayor

Don Koch, Alderman
Dean Newkirk, Alderman
Gearold Pierce, Alderman
Al Schmitz, Alderman
Charles Schuchman, Alderman
Michael Stanfa, Alderman
Don Taylor, Alderman

Ed Kleber, Superintendent of Utilities
Van Johnson, City Clerk
Bernard Heiligenstein, Attorney
Carol Budde, Treasurer

AND GENDE, INCORPORATED

March 8, 1979

Honorable Mayor and City Council
City of Carlyle
Carlyle, Illinois 62231

Re: Feasibility Study of
Low Head Hydroelectric
Power for Carlyle Reservoir

Gentlemen:

We have attached our study and report concerning the feasibility of developing Low Head Hydroelectric Power on Carlyle Reservoir to be operated by the Carlyle Municipal Electric Utility.

Our conclusions and recommendations are included in this report. At this time, we would merely like to state that it does appear that it would be feasible for the City of Carlyle to give serious consideration to developing hydroelectric power on Carlyle Reservoir.

The conceptual plant design which resulted from our study of the project, is to utilize two (2) horizontal shaft, adjustable blade, fixed vane hydraulic turbines with each being connected through a speed increaser to a 4,375 KW generator. The site selected is west of and immediately adjacent to the spillway stilling basin with two 13.5 foot diameter penstocks bored through the non-overflow monolith at that location. This proposed project as conceptually developed could average approximately 21,500,000 kilowatt hours a year for a project cost of \$7,550,000 or an average installed cost of \$863 per installed kilowatt.

The proposed project is expected to require approximately 45 months to develop from the initial authorization for the project to the eventual production of electricity by the project.

Hon. Mayor and City Council
City of Carlyle

Page 2
Hydroelectric
Feasibility Study

We have enjoyed working with the City of Carlyle in the development of this study, and appreciate the opportunity to be of service. If you should have any questions or comments regarding the attached study please do not hesitate to contact us.

Respectfully yours,
Barnes, Henry, Meisenheimer
and Gende, Inc.

Bruce F. Barnes, P.E.
President

Copies submitted (25)

CITY OF CARLYLE, ILLINOIS

FEASIBILITY STUDY OF
LOW-HEAD HYDROELECTRIC POWER
ON CARLYLE RESERVOIR
FOR THE CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC UTILITY

ABSTRACT

The attached study determines the feasibility of the City of Carlyle, Illinois developing hydroelectric power on Carlyle Reservoir.

The hydrologic conditions under which the proposed project would operate were investigated herein along with the marketability of production from the facility and the facility's compatability with present reservoir functions as well as with the environment. A conceptual plant design has been developed in detail for a power plant consisting of two (2) horizontal shaft, adjustable blade, fixed vane hydroelectric turbines each connected through speed increasing gear boxes to 4,375 KW generators. The site selected is west of and immediately adjacent to the stilling basin of the spillway for Carlyle Reservoir. Two (2) 13.5 foot penstocks would be bored through the existing concrete non-overflow dam adjacent to the present gated spillway structure.

The total estimated project cost is \$7,550,000 or an average of \$863.00 per installed kilowatt. The development of the proposed project is believed to require forty-five (45) months and will produce an estimated average annual output of approximately 21,500,000 kilowatt hours.

The conceptual design herein developed is believed to have the capability of an eventual detailed engineering design which will be acceptable to all approving authorities, and particularly the U.S. Corps of Engineers. It is felt that design and construction of the proposed facility can be accomplished to a degree of structural integrity at least as great as that for existing structures.

Several assumptions have been made and are pointed out in the study which will require more detailed development and analysis before this proposed project can be developed. Solutions to these problems do appear to be available.

FEASIBILITY STUDY OF
LOW-HEAD HYDROELECTRIC POWER
ON CARLYLE RESERVOIR
FOR THE CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC UTILITY

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FOR THE CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC UTILITY.

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FEASIBILITY STUDY OF
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ON CARLYLE RESERVOIR
FOR THE CARLYLE, ILLINOIS
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FEASIBILITY STUDY OF
LOW-HEAD HYDROELECTRIC POWER
ON CARLYLE RESERVOIR
FOR THE CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC UTILITY

SECTION I - INTRODUCTION

A. AUTHORITY

This report was prepared under the authority and direction of the Mayor and City Council of the City of Carlyle, Illinois by a motion adopted at a regular meeting of the City Council on February 13, 1978. By contract dated October 4, 1978, the City of Carlyle, Illinois authorized the firm of Barnes, Henry, Meisenheimer and Gende, Inc. to proceed with engineering services as proposed, to prepare this report for presentation to the U.S. Department of Energy.

B. SCOPE

The scope of this study is to determine the technical, environmental and economic feasibility for constructing and operating a low-head hydroelectric power plant on the Carlyle Reservoir and to be operated in conjunction with the Carlyle, Municipal Electric Utility. This feasibility determination will be based upon extensive engineering and economic analyses with appropriate consideration given to the environmental and institutional aspects of this type of project.

C. PURPOSE FOR STUDY

This study will seek to determine the net benefit to electricity consumers in the area which would result from the construction and operation of such a proposed power plant. Such analytical services would then serve to assist utility management decisions to assure reliable and

adequate electric power to the customers of the Carlyle Electric System, while at the same time maintaining adequate income to the City of Carlyle, Illinois and competitive charges to consumers.

A further purpose for this feasibility assessment is to assist in achieving the national goal of the United States of America of energy independence by adequate consideration and development of alternative energy sources and particularly renewable energy sources.

D. DESCRIPTION OF PROPOSED PROJECT

The project being studied herein is for the construction of a hydroelectric power plant on the existing dam of Carlyle Reservoir. This project would fall under the category of a low-head plant, in that the maximum head available at the reservoir is approximately 35 feet. Section II of this report will seek to review the operating conditions for the reservoir and select a range of operating conditions for this proposed plant based on existing reservoir characteristics. This project is proposed to serve the Municipal Electric Utility of Carlyle, Illinois, whose power plant and control center are located within approximately 3,000 feet of the spillway for the reservoir. Any hydroelectric plant located on the reservoir would likewise have the advantage of close proximity to the Carlyle Municipal Power Plant. For this reason, it is proposed that the City of Carlyle will construct and manage the proposed project, and therefore will be responsible for the plant's operation, maintenance and ownership. Although this report is prepared on the basis of plant ownership by the City of Carlyle, Illinois, it is readily acknowledged that the dam and reservoir are the property of U.S. Corps

of Engineers, and that final approval and authorization for construction of this proposed plant will rest with that agency. It is believed that based on the co-ordination and co-operation extended by the U.S. Corps of Engineers during the preparation of this feasibility study, a similar level of co-ordination can be achieved to accomplish the necessary design reviews and approvals required prior to construction of this project. The proposed power plant will be operated on a "run-of-the-river" basis or in other words the present water releases called for in the Master Reservoir Regulation Plan VII, adopted by the St. Louis District Office, U.S. Corps of Engineers for Carlyle Reservoir will be maintained. This feasibility study has been prepared on the basis that no additional water will be stored for the purposes of producing electrical energy.

It is believed that this project can serve two purposes. First, this project will develop a renewable natural resource into a source for electrical energy and thus offset a certain amount of fossil-fueled energy generation. Second, this project is expected to offset escalating fuel costs by fixing future electrical energy costs from this proposed facility at the approximate level of initial construction costs for the project.

The proposed project will be located approximately 50 miles due east of the metropolitan area of St. Louis, Missouri, as indicated on Figure No. 1 in this report. The dam of Carlyle Reservoir is located at Mile 107 of the Kaskaskia River very near to the City of Carlyle, Illinois, as shown on the aerial photograph of Figure No. 2. This photograph shows the relationship of the City of Carlyle, the dam itself and the

Scale: 1" = 1,000'

Carlyle
Power Plant

City of Carlyle, Illinois and Carlyle Reservoir Dam

Carlyle Municipal Power Plant which is specifically identified with respect to both the dam and the City of Carlyle.

The reservoir was constructed for the purposes of providing flood protection, creating recreational opportunities, to augment water supplies, to enhance water quality, to augment flows for navigation on the Kaskaskia River, and to provide fish and wildlife conservation. The spillway structure is of the ogee type and is equipped with four (4) 38 ft. wide by 39 ft. high tainter gates. The crest for the spillway is at elevation 425.0 ft. M.S.L. Figure No. 3 of this report is a photograph of this structure. The dam proper consists of an earthen, non-overflow section across the main valley floor with a crest of 472 ft. M.S.L. or approximately 67 ft. above the stream bed. The total length of the earthen dam, including the spillway section, is 6,610 ft. Appendix A entitled "Pertinent Data Summary, Carlyle Lake" is reproduced from the U.S. Corps of Engineers Reservoir Regulation Manual for Carlyle Lake. The reservoir regulation plan will be discussed in more detail in Section II of this report, but it can generally be summarized that from December 1 through April 30, the desired pool elevation is 443 ft. M.S.L. and the desired pool level from May 1 through November 30 is 445 ft. M.S.L. Describing the lake further, construction began in late 1958 with the diversion of water from the natural river channel on August 16, 1965 and first closure of the tainter gates on April 1, 1967. The U.S. Corps of Engineers anticipates a one hundred (100) year service life from the dam and spillway structure, and thus would exceed any probable service life to be expected from any hydroelectric power plant which would be constructed in the near future.

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The existing facilities for the Carlyle Municipal Electric System include two (2) 69,000 volt transmission lines, a distribution system serving approximately 1,500 customers, and a municipal power plant with 6 generating units. A summary of the plant's facilities is as follows:

Engine No. 1 - Manufactured by Worthington Corp., Model SWBG0-12, dual fuel internal combustion engine, 3937.5 KVA, 3150 KW, 2400/4160 volt, 514 RPM, 3 phase, 60 Hz., installed new in 1969 for approximately \$600,000.

Turbine No. 2 - Manufactured by Westinghouse Electric Co., Steam Turbine, 3750 KVA, 3000 KW, 2400/4160 volt, 3 phase, 60 Hz., 3600 RPM. Installed new in 1950 for approximately \$320,000. This unit is not presently being used because its coal fired steam boiler does not meet air pollution regulations.

Engine No. 3 - Manufactured by Caterpillar Engine Co., Internal Combustion Diesel Engine, 437.5 KVA, 350 KW, 2400/4160 volt, 3 phase, 60 Hz., installed new in 1959 for approximately \$100,000.

Engine No. 4 - Identical to Engine No. 3.

Engine No. 5 - Identical to Engine No. 3.

Engine No. 6 - Manufactured by Fairbanks-Morse Co., dual-fuel internal combustion engine, 2560 KVA, 2050 KW, 2400/4160 volt, 720 RPM, 3 phase, 60 Hz., installed new in 1963 for approximately \$480,000.

Electrical Interconnections - High voltage transmission line to the Breese, Illinois Municipal Power Plant and the Illinois Power Company Grid System, a private investor-owned electric utility, 69,000 volt delta, 9.6 miles long and served through a 7 MVA transformer at the Carlyle Power Plant.

Section III of this report will discuss the loading characteristics for the Carlyle Municipal Electric System, however, at this time, these electrical energy requirements are summarized as being 100% fueled by non-renewable sources of energy, such as fuel oil, natural gas and bituminous coal. Because the Carlyle Power Plant is not presently able to burn coal itself without violating Illinois air pollution regulations, the plant depends totally on fuel oil and natural gas for its own

generation. Fortunately, Carlyle is able to purchase approximately 75 to 85% of its requirements from the coal-burning sources of Illinois Power Company.

The present status of this proposed project is preliminary and in the study phase. The City of Carlyle, however, has applied and received a preliminary permit from the Federal Energy Regulatory Commission for the purpose of studying this proposed project and protecting its commitment of resources during that study phase. A copy of that preliminary permit has been attached as Appendix B. The term for that permit is for eighteen (18) months from November 1, 1978.

More detailed descriptions of the project will be developed in the following analysis and report.

E. INVESTIGATIONS

In order to obtain the data which was required to prepare this report, we conferred with Carlyle's Mayor J. Leo Davis and Mr. Ed Kleber, Superintendent of Utilities. Valuable background data was also obtained from the Carlyle City Hall with the assistance of Mr. Van Johnson, City Clerk, and Mrs. Jean Parson, Office Manager. The St. Louis District Office of the U.S. Corps of Engineers was also solicited for a great deal of background information on Carlyle Reservoir and for informal comments on preliminary conceptual designs of alternative hydroelectric power plants. The Geotechnical Consulting firm, Shannon and Wilson, Inc., St. Louis, Missouri was used extensively for comparing geotechnical aspects of plant alternatives and development of the selected conceptual design. The U.S. Department of Energy also played a major role in the

development of this study. In all cases, these investigations were met with co-operation and understanding. In general, these investigations included the following:

1. A review of the characteristics of Carlyle Reservoir, including existing structures of the spillway and embankment and historic records of hydrologic data for the area.
2. A determination of the potential energy available from the Carlyle Reservoir.
3. A determination of the peak power capacity of the reservoir.
4. Evaluation of operating conditions for proposed hydroelectric equipment and tentative selection of conditions upon which to base designs for proposed hydroelectric equipment.
5. A survey of the available loads to be served by the proposed hydroelectric power plant.
6. Confirmation of the worth of electric energy in the load centers to be served by this proposed facility.
7. Investigation of the compatibility of this proposed project with the present purposes for the reservoir's operation.
8. Performance of an initial assessment of the impact of this proposed project upon the the environment.
9. Comparison of alternative conceptual designs.
10. Selection of a primary alternate design concept and further development of that concept.
11. Estimates of construction cost, project development costs, and project development schedules.
12. Estimates of capital costs, operating costs and maintenance costs over project service life.
13. Projections of savings in energy costs in non-renewable fuels.
14. Preparation of conclusions and making recommendations based upon those conclusions.

Generally speaking, for the purpose of brevity throughout this report, the City of Carlyle will be referred to as the "City", and the Carlyle Municipal Electric Utility will be referred to as the "Utility".

SECTION II - HYDROLOGIC CONDITIONS

A. SUMMARY OF SITE HYDROLOGY

The Carlyle Reservoir is in the Kaskaskia River Basin and has a drainage area of 2,680 square miles. Also on the Kaskaskia and upstream from the Carlyle Reservoir is Lake Shelbyville which is located at Mile 221.8 and has a drainage area of 1,030 square miles. Both Carlyle Reservoir and Lake Shelbyville are operated by the U.S. Corps of Engineers.

The precipitation in this area averages 40.23 inches per year, and can be experienced as either rain, snow, sleet or hail. Of the annual precipitation, snowfall averages 17 inches a year, and on approximately six days, a year, snowfall is experienced in excess of 1 inch.

The Kaskaskia River itself flows from its source in Champaign County, Illinois, southwesterly through Illinois to the Mississippi River above Chester, Illinois, for an approximate distance of 310 miles. The mouth of the Kaskaskia empties into the Mississippi approximately 118 miles above the junction of the Mississippi and the Ohio Rivers. The channel slope averages approximately 0.1 ft. per mile, between River Miles 0 and 23; 0.7 ft. per mile between Mile 23 and the Carlyle Dam. The channel capacity below Carlyle Dam to River Mile 51.0 has been determined to be 4,000 c.f.s. and below River Mile 51.0, the improved channel has a capacity of 25,000 c.f.s. Table No. 1 of this report shows the recorded stream flows for the Kaskaskia River near Carlyle, Illinois. These flows have been modified to reflect the program of water releases outlined in the Regulation Plan VII, which has been adopted by the St. Louis District Office of the U.S. Corps of Engineers specifying the regulation procedures for both Carlyle Reservoir and Lake Shelbyville.

CARLYLE DAM - CORP OF ENGINEERS
TABLE NO. 1 RECORDED STREAM FLOWS FOR THE KASKASKIA RIVER

YEAR	JAN. FLOW CFS	FEB. FLOW CFS	MAR. FLOW CFS	APR. FLOW CFS	MAY FLOW CFS	JUNE FLOW CFS	JULY FLOW CFS	AUG. FLOW CFS	SEPT. FLOW CFS	OCT. FLOW CFS	NOV. FLOW CFS	DEC. FLOW CFS
1935	3900	1800	2300	2000	4100	4200	3800	300	400	300	400	1900
1936	400	1900	3900	200	900	300	400	500	400	300	1000	1800
1937	4100	5000	4000	3500	4000	1800	600	200	300	700	400	3000
1938	1000	1800	4000	7000	4100	3800	1800	800	200	300	300	2000
1939	500	4000	5000	5000	4000	1400	600	1800	200	400	500	1000
1940	200	300	1000	500	2100	1000	300	200	300	400	400	400
1941	600	400	400	800	600	1000	400	500	300	1000	500	4000
1942	500	3800	4000	4000	2000	3500	4000	3800	100	200	1900	4000
1943	4000	3000	2600	1800	6200	6500	5000	4000	200	400	400	1000
1944	400	300	1000	1200	4500	4200	2200	300	400	500	500	800
1945	300	600	3900	7000	4200	5200	5200	2800	600	1800	1200	2400
1946	3900	3500	3700	200	4000	4200	2100	2200	200	300	4000	3800
1947	2100	2200	1000	3400	3900	3900	3900	1800	300	300	300	1700
1948	1800	1900	3000	4800	4000	3000	1800	500	200	300	2100	1900
1949	5000	7600	6000	4000	2200	800	900	600	700	2600	500	3300
1950	6500	9000	8500	7500	4000	2800	2500	300	900	500	1500	2200
1951	3000	3500	4000	4000	4000	2000	4000	3500	600	500	2000	2800
1952	3500	4000	3500	4000	3300	1800	1800	400	400	400	500	700
1953	300	300	2000	1000	1000	700	800	300	400	400	500	600
1954	400	500	500	400	400	400	400	400	400	300	300	300
1955	200	200	300	300	400	800	1600	400	500	400	1800	2000
1956	500	1900	3300	300	600	1200	1000	1000	500	500	600	1100
1957	600	1800	2000	4200	5000	6100	8100	7000	4200	900	1200	3300
1958	4000	1600	2100	500	1800	2100	3000	4000	3000	600	1200	2800
1959	1200	2800	3800	3300	1000	600	200	900	600	400	800	2000
1960	1700	2600	800	3200	2000	2700	4000	2100	200	200	300	900
1961	300	600	2300	1300	3800	4800	2200	1800	400	400	1200	3300
1962	3600	4200	5000	4600	3800	2600	900	600	300	500	700	1000
1963	300	300	3700	400	1900	700	800	700	300	300	300	1100
1964	400	400	1900	1800	3000	1000	400	400	400	400	400	700
1965	400	900	1000	700	800	1800	900	400	900	900	400	1900
1966	1400	2200	2100	800	4000	2600	400	500	500	400	700	4000
MAX WATER FLOW:	6500	9000	8500	7500	6200	6500	8100	7000	4200	2600	4000	4000
AVG. WATER FLOW:	1781.25	2340.63	2893.75	2615.63	2862.50	2484.38	2062.50	1406.25	603.13	556.25	900.00	1990.63

The Carlyle Reservoir was designed for a joint-use pool elevation of 445.0 ft. M.S.L. At this level, the storage is 233,000 acre ft. For the purposes of flood control, the reservoir was designed for an additional storage of 699,900 acre ft. between elevations 445.0 and 462.5 ft. M.S.L. The following section of this report will discuss in more detail the plan for water releases from Carlyle Reservoir in respect to power generation.

B. POTENTIAL ENERGY OF CARLYLE RESERVOIR

This proposed project is being studied based on present procedures for operating Carlyle Reservoir as stated in the earlier project description. This plan has been reproduced and included in this report as Appendix C. At this time, we will summarize this water control plan by saying that the normal winter pool will be 443 ft. M.S.L. with a minimum flow release of 50 c.f.s. and a maximum flow release of 10,000 c.f.s. during the period December 1 through April 30. This 10,000 c.f.s. may be exceeded if the pool should exceed 462.5 ft. M.S.L. During the remainder of the year from May 1 through November 30, the normal pool level will be 445.0 ft. M.S.L. and the flows will range from a minimum of 50 c.f.s. to a maximum of 4,000 c.f.s. unless the pool should exceed elevation 450.0 ft. M.S.L., at which time the releases will be increased gradually such that the release rate will reach a maximum rate of 10,000 c.f.s. at pool elevation 462.5 ft. M.S.L. Appendix D to this report is a Tailwater Rating Curve for the Carlyle Reservoir. This graph shows the actual operating experiences for the tailwater elevations below the spillway of the reservoir when certain water volumes are being released.

Knowing the pool elevations, the water volumes being released and the tailwater elevations, it is now possible to determine the potential energy of Carlyle Reservoir. This determination will be made for a basis of comparing various alternate hydroelectric plants to determine their relative efficiencies in utilizing reservoir energy. Thus, at this time, plant dependent efficiencies and losses will be disregarded. The period to be studied utilizes pre-reservoir hypothetical Plan VII releases for the period 1935 to 1966 and also utilizes actual reservoir operating graphs from 1967 through 1978. These records are maintained on a daily basis. However, for simplification this information has been compiled on an average monthly basis for a more convenient analysis. Appendix E in the back of this report summarizes the 44 year history of pool and tailwater elevations and flow releases for Carlyle Reservoir. This information has been converted into the potential energy available as a result of the difference in elevation of the water from pool level to tailwater level on Appendix F. This calculation was done by taking the product of the average monthly flow, times the difference in elevation, times the number of hours per month, times a factor 8.46×10^{-5} to convert into megawatt hours. Appendix F utilizes all heads available although in actuality this may not be the case on the belief that this gives a target operating range for any hydroelectric equipment for the reservoir. This will more definitely be determined later in this report. The full range of flows was used in determining the potential energy of the reservoir on Appendix F. These flows are often outside of the operating range of a single turbine design. Appendix F does show that the theoretical annual potential energy for

the reservoir ranges from a low of 8627 megawatt hours to a high of 83,262 megawatt hours for an average theoretical annual potential energy of 32,704 megawatt hours. This table must be correlated to the operating range of prospective equipment. While it is possible at times to generate electricity year-round, this appendix also shows that generally September, October and November are probably only available for marginal generation. The month of highest energy production occurs in May, with a theoretical average production of 3,981 megawatt hours during that month. Again, it must be emphasized that Appendix F is a theoretical determination and depending on the characteristics of the proposed power plant and the equipment used, the probable energy produced will be reduced.

C. ESTIMATED PEAK OUTPUT OF RESERVOIR

This proposed project is being studied on the basis that there will be no additional water stored in Carlyle Reservoir for the purpose of generating power. As a result, there will be a wide range of operating conditions experienced by the reservoir. Specifically during minimum flow and minimum head conditions, an output of 120 HP is all that may be expected. Minimum conditions do occur periodically, generally in the fall as previously explained. On the other hand, during periods of high flow and high head conditions, it is conceivable that the reservoir could produce approximately 28,000 HP. This, obviously, is a condition that occurs very infrequently. It follows, therefore, that some optimum range of operation will need to be selected. Figure Nos. 4, 5 and 6 of this report have been prepared to demonstrate the duration of output from this reservoir under the present Reservoir Regulation Plan (Plan VII)

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FIGURE 5

adopted by the Corps. Although the reservoir began operating prior to 1968, the early months were concentrated on filling the reservoir and thus characteristic flows from actual operation were not experienced until 1968. The flow duration curve of Figure No. 4 is the summary of 10 years of information. This particular graph may also be viewed as an Annual Expected Flow Duration Curve simply by viewing the X-Axis as 1/10 of the value indicated. Since the usual practice for reviewing flow duration is on an average annual basis, this 1/10 scale may be a more convenient reference. The ten years summary has been used on Figure No. 4 because of the fact that there is not power storage for this project. In other words, while several years did not experience peak flows of 10,000 cfs, the probability of that flow occurring in any one year is the same.

The difference in Figure No. 4 and Figure No. 5 is the former has a Y-Axis representing flow while the Y-Axis represents horsepower on Figure No. 5. This confirmation of horsepower output duration was believed appropriate in this case because the same power production can be achieved under varying conditions of head and flow. Here again, this is an additional determination felt necessary because of this project's varying conditions of operation resulting from the lack of storage for power generation. These varying conditions are further emphasized on Figure No. 6, 44 Year Flow and Head Duration Curves, and Table No. 2, entitled 44 Year Seasonal Variation in Reservoir Power Output. The period of flow records for the Kaskaskia River near Carlyle, Illinois begins in 1935. Figure No. 6 reflects the duration of hypothetical heads and flows determined by the Corps of Engineers which would have

KW	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Accum. Total	KW
19770		1	1										2	2	19770
19400															19400
19025															19025
18650															18650
18275															18275
17900															17900
17525															17525
17150															17150
16775		1											1	3	16775
16400															16400
16025					1								1	4	16025
15650															15650
15300			1										1	5	15300
14925							1						1	6	14925
14550		1											1	7	14550
14175	1			1									2	9	14175
13800															13800
13425															13425
13050		1											1	10	13050
12675															12675
12300					1			1					2	12	12300
11925		1		1									2	14	11925
11550						1							1	15	11550
11200	2												2	17	11200
10800				2									2	19	10800
10450				1		1	2					1	5	24	10450
10075			1		1								2	26	10075
9700	1												1	27	9700
9325		1				1							2	29	9325
8950								1					1	30	8950
8575			1				1					1	3	33	8575
8200				1		1	2						4	37	8200
7825			1		1	1			1				4	41	7825
7450	1			2		3	1	1	1			1	10	51	7430
7075	1	3	3	1	5	1						1	15	66	7075
6700			2	1	5	1	3					2	14	80	6700
6350	1	1	2	1	5	2	1	3			1	1	18	98	6350
5975	2		2	2	4	2	1	1	1		1		16	114	5975
5600	3	3	3	3	2	2	2	1				3	22	136	5600
5222	3	3	4	3		2	1			1		3	20	156	5222
4850	2	1	1		1	1	2	2				5	15	171	4850
4476		2	3	1	2	1	3		1	2	2	1	18	189	4476
4100	1	2	4	2	4	4	2	3		1	4	6	33	222	4100
3775	2	6	2	1		1	1				1	3	17	239	3775
3350		3	1	1							1		7	246	3350
2975	2					1	1	2		1	4		11	257	2975
2600	1		1	1	3	3	2		1	1	2	4	19	276	2600
2225	1	1	4	3	1	4	4	2	2	3		2	27	303	2225
1850			3	3	1	3	3	3	2	1	4	4	27	330	1850
1500	2	2			2	1	2	3	5	2	2	2	23	353	1500
1100	4	1	1	3	1		4	11	9	17	9		60	413	1100
750	10	6	1	6	2	2	3	6	8	8	8	2	62	475	750
375	2	2	1	2		2	1	2	10	3			25	500	375
0	1	1		1	2	2	1	1	2	3	4	1	19	519	0
	43	43	43	43	44	44	44	43	43	43	43	43	519		

TABLE NO. 2. 44 YEAR SEASONAL VARIATION IN RESERVOIR POWER OUTPUT

been experienced under those historic flow conditions if Carlyle Reservoir had been in operation under Plan VII during that time. Based on the hypothetical application of Plan VII over the past 44 years, Table No. 2 shows very clearly the range of theoretical output available at any time of the year from one month to the next. This range of wide variations in output again indicates the need to select an optimum point for this project's operation rather than to attempt to install equipment to utilize the reservoir's full range of conditions. It should be mentioned that the vertical axis of Figure No. 5 is in theoretical horsepower while Table No. 2 represents theoretical power in kilowatts assuming certain equipment losses under gross reservoir head.

Because of the fact that several conditions can occur which will produce the same reservoir output, this selection of a plant design point could be based on weighting each operating point experienced during the 44 year history with its theoretical power output. Figure No. 7; entitled 44 Year Frequency Distribution of Carlyle Reservoir Monthly Conditions, gives a dramatic representation of the pattern of operating conditions created by the present reservoir regulation procedure known as Plan VII. Superimposed on Figure No. 7 is a calculated Weighted Average Operating Condition of 23.9 ft. gross head and 3,492 cfs. This point specifically has been calculated to determine that point at which the reservoir would produce an equal amount of energy at flows either greater than or less than, and heads greater than or less than that given operating condition. While this may not be the ultimate design point for equipment for this proposed project, it does give a point from which to make an approximate determination. Another advantage

to be observed from Figure No. 7 is that it makes it obvious that the best use of Carlyle Reservoir would be made by equipment which would best utilize that range of operating conditions which would follow a line through the area of greatest concentration in operating conditions. That line would approximately go through two points, the first of which being 26 ft. of gross head and 2,000 cfs flow and the second point being approximately 20 ft. of gross head and 3,500 cfs of flow. This is a situation where the Regulation Plan VII causes the heads to reduce as flows are increased primarily because the Kaskaskia River below Carlyle Reservoir is not capable of handling higher flows and that causes the tailwater to rise resulting in lower heads available to hydroelectric equipment. While it is not possible for one hydroelectric unit to fully take advantage of this diagonal trend in operating conditions, a properly selected combination of units could conceivably take full advantage of this condition of higher flows under reduced heads.

SECTION III - MARKETABILITY FOR POWER DEVELOPED BY THIS PROJECT

A. PROPOSED ELECTRIC LOADS

This proposed project is intended to serve the following loads in the following order of priority.

1. City of Carlyle, Illinois Municipal Electric System.
2. City of Breese, Illinois Municipal Electric System.
3. The Illinois Power Company.

Appendix G in the back of this report is a strip chart showing the hourly loads experienced by the Carlyle Municipal Electric System for the entire year of 1978. This information has been summarized on Figure No. 8 entitled Annual Load Duration Curve - 1978. Of interest in this figure is the fact that the minimum load experienced by Carlyle was 1,050 kilowatts and the peak load experienced for that year was 6,950 kilowatts. Using the peak loads and annual system requirements for the past five years, Figure No. 9 develops the electric load projection for the Carlyle Municipal Electric Utility. This projection, based on the utility's historic development, indicates that a 4.1% per year rate of annual growth is reasonable to expect in the near term future for this utility.

In order to determine the ability of the local electric loads to utilize hydroelectric power, it is necessary to know some of the characteristics of that load as it changes from one month to the next. Table No. 3 entitled Carlyle, Illinois Monthly Electric Load Characteristics, attempts to describe these fluctuations from month to month in terms of percent of annual peak load, percent of annual system requirements, monthly diversity factor and monthly load factor. These first two

Spillway Structure of Carlyle Reservoir
Downstream View (Photographer facing north)

descriptors are rather self-explanatory in that they represent an approximate percentage which that month's peak load or energy requirement may be of the annual peak load or annual energy requirement, respectively. The monthly diversity factor merely establishes the ratio between the minimum load in KW for a month to the maximum load in KW for that month, while the final descriptor of monthly load factor indicates the system's ability to fully utilize that month's peak load requirement by calculating the ratio of that month's kilowatt hours to those kilowatt hours which would have been utilized had the month's peak KW been experienced for the entire month.

TABLE NO. 3
CARLYLE, ILLINOIS MONTHLY ELECTRIC LOAD CHARACTERISTICS

<u>Month</u>	<u>% of Annual Peak KW</u>	<u>% of Annual Systems Requirements KWH</u>	<u>Monthly Diversity Factor</u>	<u>Monthly Load Factor</u>
May	73.4	7.1	.216	.43
June	100.0	9.1	.158	.416
July	97.8	11.5	.162	.526
Aug.	95.7	10.2	.195	.472
Sept.	81.3	8.5	.186	.477
Oct.	41.7	6.2	.379	.655
Nov.	47.5	6.8	.333	.659
Dec.	57.6	8.2	.350	.633
Jan.	63.3	9.7	.386	.682
Feb.	59.7	8.6	.470	.708
Mar.	54.0	8.2	.360	.672
Apr.	43.2	5.9	.367	.627

While these descriptors in Table No. 3 were actually determined for the Carlyle Utility, it is believed that the load characteristics for the Breese, Illinois Municipal Electric Utility are enough similar to that for Carlyle, that these same descriptors are reasonably appropriate for use in reviewing that load with a slight correction in magnitude. Specifically, the peak load for Carlyle averages approxi-

mately 22% greater than the peak load for Breese, and the system kilowatt hour requirements for Carlyle average approximately 17% greater for Carlyle than for Breese.

A third load to be served with power from this proposed facility is the private utility of Illinois Power Company. This is a very large investor owned utility, in comparison to the size of Breese and Carlyle electric utilities, located in southern Illinois. Appendix V in the back of this report is a general arrangement of the power transmission facilities which interconnect the Carlyle Power Plant, the Breese Power Plant and the Illinois Power Company. The relative size of these utilities to one another is seen by the installed nameplate capacity of 3,383,500 kilowatts for Illinois Power Company as compared to 6,000 kilowatts for Breese and 6,250 kilowatts for Carlyle.

B. WORTH OF LOCAL ELECTRIC POWER

Both the Illinois Power Company and the City of Breese, Illinois were contacted as part of this feasibility study to determine their interest in receiving power from this proposed hydroelectric power plant. Enclosed as Appendixes H and I are the responses received from those utilities indicating interest provided the economics and the system loadings permit the use of such hydroelectric power. It is conceivable, for example, that during the spring when the hydroelectric power would be greatest, the load for Illinois Power Company could be at a minimum creating a loss in efficiency in their generating equipment, such that they would rather be selling more power than purchasing hydroelectric power. Although this is an obvious marketability problem with respect to the large generating facilities for the Illinois Power Company,

the minimum loading problem appears to be solvable by the fact that they are a member of a power transmission grid which would allow that excess hydroelectric power to be transmitted to other utilities in southern Illinois or even the midwest United States. Specifically, Illinois Power Company is a member of the ILL-MO Pool which includes the companies of Union Electric in Missouri, Central Illinois Public Service Company in Illinois and the Illinois Power Company. This pool is also a member of the Mid America Interpool Network (MAIN), Regional Reliability Council monitored by the Federal Energy Regulatory Commission. A copy of the latest Power Purchase Agreement (Partial Requirements Contract) between the Illinois Power Company and the Cities of Breese and Carlyle has been included in this report as Appendix J. From 1975 to 1979, the two Cities purchased power from IP under an interconnection agreement, which did not allow the Cities to reserve capacity to meet future load planning. The attached contract (Appendix J) corrects this deficiency. Appendix K has been included in this report to summarize the variations in recent power prices quoted to these Cities by the Company. From Appendix K it is seen that those hourly prices vary from a high of \$60.75 per megawatt hour to a low of \$9.25 per megawatt hour. Generally speaking, the higher prices are the combined result of maintenance requirements on their equipment and loading characteristics which would require IP to use less efficient equipment to serve the Cities. Appendix K is included to dramatize the range of fluctuations in hourly prices experienced by the Illinois Power Company and does not fully represent the cost of power to the Cities. By peaking, the Cities can avoid having to purchase power on the occasions when the costs for Illinois Power Company become

extreme. It should also be pointed out on Appendix K that November, 1977 through approximately March, 1978, the Illinois Power Company was experiencing extreme costs because of a nation-wide coal miners strike at that time. Following March of 1978, there was a period of approximately 3 or 4 months, in which the company recovered from that strike. The last 3 months, specifically October, November and December, 1978, represent a more stable operation of the Company and coal prices. Those three months then can be viewed as a more normal price range and frequency experienced by the Cities. To the energy charges reflected on Appendix K, the capacity charges must be added in order to determine the total purchased power cost experienced by the Cities. Table No. 4, entitled Projected Fuel and Energy Costs Based on Present Operating Conditions, attempts to summarize those purchase power costs as well as additional costs of generation to supplement that purchased power. Specifically, referring to the columns entitled Generation Unit Fuel Cost and Unit Cost of Purchased Power, it is difficult to determine a trend of increases in generation and purchased power expense due to the escalation in fossil fuel costs and reductions in natural gas and fuel oil availability. Over the historic period shown on Table No. 4, Carlyle's fuel and purchased power costs have escalated 15 - 20% and 10 - 13%, respectively. For purposes of projection on that same table, these trends were not believed to continue and Carlyle's fuel costs and purchased power costs were projected at the rate of 8% per year and 6% per year, respectively.

Similar information summarizing power costs for Breese, Illinois has not been prepared on the understanding that that utility is

CITY OF CARLYLE, ILLINOIS - MUNICIPAL ELECTRIC UTILITY

TABLE NO. 4. PROJECTED FUEL AND ENERGY COSTS BASED ON PRESENT OPERATING CONDITIONS

Fiscal Year Ending April 30	Carlyle's Peak Load KW (1)	System Energy Requirement KWH (1)	System Load Factor	Coal Fired Generation KWH (1)	Engine Generation KWH (1)	Total Fuel Cost (2)	Gen. Unit Fuel Cost \$/KWH	Purchased Power KWH (1,5)	Purchased Power Cost (2)	Unit Cost of Purch. Power	Total Fuel & Purchased Power Cost (2)	Avg. Fuel Purch. Power Cost
1974	5,900	21,331,400	0.413	--	--	\$142,551	--	--	\$ 7,987	--	\$ 150,538	\$.0071
1975	5,800	19,943,580	0.393	2,000,000	15,356,800	235,265	\$.0136	2,586,780	43,843	\$.0169	279,108	.0140
1976	6,245	21,107,800	0.386	78,000	2,731,800	66,775	.0238	18,298,000	237,440	.0130	304,215	.0144
1977	6,750	21,586,000	0.365	169,000	2,520,000	56,246	.0209	18,897,000	350,059	.0185	406,305	.0188
1978	7,150	23,242,000	0.371	--	5,803,000	138,386	.0238	17,439,000	442,862	.0254	581,248	.0250
1979 (3)	6,950	23,250,000	0.382	--	3,250,000	81,523	.0251	20,000,000	482,600	.0241	564,123	.0243
PROJECTED: (4)												
1980	7,387	24,589,074	0.38	--	3,983,430	103,569	.0260	20,605,644	525,444	.0255	629,013	.0256
1981	7,691	25,600,508	0.38	--	4,147,282	116,539	.0281	21,453,226	579,237	.0270	695,776	.0272
1982	8,007	26,653,546	0.38	--	4,317,874	130,832	.0303	22,335,672	641,034	.0287	771,866	.0290
1983	8,336	27,749,899	0.38	--	4,495,484	147,452	.0328	23,254,415	706,934	.0304	854,386	.0308
1984	8,679	28,891,349	0.38	--	4,680,399	165,686	.0354	24,210,950	779,593	.0322	945,279	.0327
1985	9,036	30,079,750	0.38	--	4,872,917	186,145	.0382	25,206,831	859,553	.0341	1,045,698	.0348
1986	9,408	31,317,035	0.38	--	5,073,360	209,530	.0413	26,243,675	950,021	.0362	1,159,551	.0370
1987	9,795	32,605,214	0.38	--	5,282,045	235,579	.0446	27,323,169	1,046,477	.0383	1,282,056	.0393
1988	10,198	33,946,379	0.38	--	5,499,313	264,517	.0481	28,447,066	1,154,951	.0406	1,419,468	.0418
1989	10,617	35,342,712	0.38	--	5,725,519	297,727	.0520	29,617,193	1,276,501	.0431	1,574,228	.0445
1990	11,054	36,796,481	0.38	--	5,961,030	334,414	.0561	30,835,451	1,409,180	.0457	1,743,594	.0474

NOTES:

- (1) Information is from Monthly Power Plant Reports.
- (2) Information is from Annual Certified Audits.
- (3) May-Jan. information is from Monthly Power Plant Reports. Feb.-April are estimated.
- (4) Projections of KWH are based on historic trends.
- (5) Projections of Generating costs are based on historic trends to obtain estimates for 1980 and the engine generation costs are projected at 8% per year for 16.2% of system requiremts, compared to 6% per year for purchased power cost projections for 83.8% of the system's requirements. Maximum capacity for Carlyle's interconnect is 6250 KW at unity pf. (transformer capacity). In order to optimize the average annual fuel and purchased power costs, this projection is based on maximum power purchases which requires increased interconnection capacity sometime during the period of projection.

experiencing identical purchased power costs and also by the fact that similar internal combustion generating equipment should be experiencing similar fuel costs. The similarity of loading characteristics for the two utilities has already been pointed out.

C. SUMMARY OF MARKETABILITY

In summary, it is believed that the municipal utilities of Carlyle, Illinois and Breese, Illinois will be experiencing over-all fuel and purchase power costs of approximately \$.025, \$.035, and \$.047 by the years 1980, 1985 and 1990, respectively, assuming no change in the present method of operating those utilities.

Depending on the ultimate economics of this proposed project, all three electric utilities of Carlyle, Breese, and Illinois Power Company are interested in receiving power from this project.

SECTION IV - COMPATIBILITY OF PROJECT WITH RESERVOIR

A. CURRENT RESERVOIR PURPOSES

Carlyle Reservoir presently has six (6) functions to perform in the Kaskaskia River Basin. These general purposes are flood control, recreation, water supply, improved water quality, navigation and enhancement of fish and wildlife: The U.S. Corps of Engineers has developed their plan for Carlyle Reservoir to achieve all of these purposes simultaneously. This report is based upon the premise that hydroelectric power generation can be added to these previous six goals for Carlyle Reservoir without modification to the present Regulation Plan VII. As indicated previously, Appendix C in the back of this report is a copy of that regulation plan.

The requirement that this proposed project not interfere with or modify the present reservoir purposes is critical to this project's development, because it apparently requires Congressional approval to perform any activity which would affect the present authorized functions of the reservoir. This requirement is specifically mentioned in Appendix L which is a copy of correspondence from General Drake Wilson, Deputy Director of Civil Works dated February 7, 1978 to the Honorable Charles B. Curtis, Chairman, Federal Energy Regulatory Commission in reference to the City of Carlyle's application for a preliminary permit. As presented earlier in Figure No. 7 in this report, the weighted average operating condition for the reservoir under the present method of regulation occurs at a gross head of 23.9 ft. and a water flow of approximately 3,500 cfs. This operating condition was determined from information compiled by the U.S. Corps of Engineers which took the recorded flow data for the Kaskaskia River going back to 1935 and, based on a hypothetical

beginning pool level of 445 ft. MSL, developed what the pool level fluctuations and required releases would have been had Carlyle Reservoir been in operation under present procedures defined in Plan VII. By selecting an approximate design point for hydroelectric equipment on this basis, this project is assured of maintaining the present purposes for the reservoir.

The development of this feasibility study considered several different alternates for proposed plant sites and methods of installation. The site which was finally selected as the optimum, and the plan that was developed for further conceptual plant design was chosen for several reasons which included the fact that it did not appear to affect the present design capacity of the gated spillway, while at the same time it appeared to have the most straight-forward method of construction in order to assure the integrity of the existing dam structure. As a further assurance that this proposed hydroelectric power plant as conceptually developed in Section V of this report will remain compatible with the reservoir's purposes, during the preliminary engineering, it is assumed that a considerable degree of design data will be compiled in order that the U.S. Corps of Engineers will have full details of design from which to review the project so that compliance with established design criteria is maintained. At this time this design review by the Corps is believed to require preparation of what will be called a Feature Design Memorandum. This term is specifically used at this point to indicate to the Corps of Engineers the detail to which this proposed project will be developed for review by that agency for final approval prior to beginning any construction.

It is also contemplated that a hydraulic model test could very likely be required by the Corps. As various alternates were discussed unofficially with members with the St. Louis District Office of the U.S. Corps of Engineers, it was obvious that certain alternates would require hydraulic model tests. However, as the conceptual design was finally selected, this model test may not be required. Specifically, the St. Louis District was concerned that certain alternates located in existing tainter gates may restrict the spillway's capacity. The conceptual design selected for full development does not involve an existing tainter gate, and thus, it is believed the requirement for a hydraulic model test may not be an ultimate requirement of the Corps of Engineers.

In summary, by selection of a plant design point which is within the criteria of present reservoir regulation, the purposes for operating the reservoir will be maintained. Similarly, by development of detailed engineering design for review by the Corps of Engineers prior to construction, the proposed project will be assured of a structural integrity at least as good as that of the structure already in existence. This desire will become apparent in Section V of this report where development of the conceptual plant design is discussed. This project's compatibility with proposed highway FAP 409 in the area has been discussed in Section VI concerning possible socio-economic impacts of constructing a hydro-electric power plant on Carlyle Reservoir.

SECTION V - DEVELOPMENT OF A CONCEPTUAL PLANT DESIGN

A. ALTERNATE SITES CONSIDERED

In the development of a conceptual design for this proposed project, seven (7) alternates were considered. Briefly, these can be described as involving three different sites and two types of hydraulic generating equipment. The sites considered were in the embankment, in the spillway and beside the spillway. The types of hydraulic equipment considered were of the horizontal shaft or vertical shaft arrangements with both utilizing propeller-type runners. The following section of this report will be devoted to fully describing the selected conceptual design. For further discussion of the other alternates considered, please refer to the Appendix M in the back of this report. Summary descriptions and sketches are provided for each of the other six (6) alternates. The alternate which was selected for conceptual development is described as a plant utilizing two horizontal "TUBE" units of approximately 4,000 kilowatts each located west of and immediately adjacent to the spillway structure, and behind what is identified as monolith 2D of the spillway structure. This design requires boring two circular holes through monolith 2D to facilitate penstocks and installing a basin type of inlet on the upstream side of monolith 2D. In the development of this feasibility study, two (2) informal conferences were held at the St. Louis District Office of the U.S. Corps of Engineers. Based on comments received at those conferences, it is believed that the following conceptual design will have the greatest opportunity for final approval by that agency. Since the Corps will be ultimately responsible for the review of this project, this appeared to be the most practical conceptual

design to be developed. While the District Office agreed to discuss the project in the early phases of development, no approvals were given or implied nor were they even requested on behalf of the City. The advantage however, in that communication was to have access to those individuals with the greatest degree of experience in operation and construction of dams and reservoirs.

B. TURBINE SELECTION

During the development of this feasibility study, four separate hydraulic equipment suppliers were contacted. In alphabetical order, these suppliers were A. B. Bofors Nohab, Allis-Chalmers, The James Leffel and Company, and the Tampella Engineering Division of Tampere, Finland. The equipment selected for the conceptual plant is similar to the program of Allis-Chalmers for Standardized Hydroelectric Generating Units. Specifically, two units of 3,000 mm for operating conditions as outlined in Section II of this report were considered. Each unit would be sized to produce up to 4,375 KW under a net head of up to 34 feet and a maximum flow of 1,850 cfs. The maximum net head to be experienced by this equipment is 35 feet. A centerline elevation selected for preliminary design is 418.5 ft. MSL. This is believed to be an elevation capable of cavitation-free operation over the entire range of operating conditions to be experienced by this equipment. This, however, will be confirmed in final design. Although the feasibility study is based on selecting the Allis-Chalmers equipment, it is realized that each of the suppliers previously contacted and any number of additional suppliers could eventually provide the type of equipment utilized in the conceptual design.

The Allis-Chalmers Standardized Hydroelectric Unit utilizes an adjustable blade, fixed inlet vane arrangement with an On/Off inlet butterfly valve and elbow draft tube. By selecting a turbine with a 6 m rating, the range of operating heads available are from approximately 14.5 ft. to 36 ft. of net head. Under the lower head condition of 14.5 ft., the turbine's range of operation can utilize from between 500 cfs to approximately 1,300 cfs of water. At the upper end of the range of operating heads, say approximately 32 ft. net head, the turbine is able to utilize between 750 and 1,900 cfs of water.

C. STRUCTURAL DEVELOPMENT OF CONCEPTUAL DESIGN

1. DESCRIPTION OF STRUCTURAL ASPECTS

The conclusive features of the hydroelectric plant conceptual design as set forth in this study requires that structures be constructed in the area of the West abutment of the gated spillway of the reservoir. The structures included in the proposed project must be designed for a maximum flow of about 4,000 cfs and a maximum reservoir headwater elevation of 467.0 ft. (MSL) and an average reservoir level of about 445.0 ft. The structures also must be designed to provide for a submerged outlet from the plant, with a bottom elevation of 394.92 ft., which is approximately 5.0 ft. below the top of the stilling basin floor of the reservoir. The transfer of the water from the intake works to the hydroelectric equipment requires a pair of intake conduits each with an inside diameter of 12 ft. and 6 inches. The proximity of the proposed structures in relation to the gated spillway structures also requires that the intake conduits penetrate the massive non-overflow dam designated as monolith 2D. This monolith is adjacent to the West end of the gated

spillway structure. The physical dimensions of the generating equipment require a plant structure with an operating floor at elevation 415.0 ft. and a finished roof elevation of 440.0 ft. The plant structure will be 48.0 ft. wide and 75.0 ft. long measured to the inside face of the below-grade structural walls. The established elevation of the runner shaft and the size of the outlet tube for each unit requires an open cut for the plant structure that will be 40 to 50 ft. deep. This excavation will be located partially within the downstream embankment at the west abutment and adjacent to the west training wall.

The elevation of the water discharged from the outlet works of the plant will be determined by the elevation of the water in the downstream channel below the gated spillway. The elevation of the tailwater thus will fluctuate under variable release conditions both through the proposed plant and the spillway. For design purposes, the tailwater is assumed to range between a maximum elevation of 427.0 ft. to about 411.0 ft.

2. EXISTING STRUCTURAL COMPONENTS AFFECTED BY THE PROPOSED FACILITY

Starting with the proposed inlet structure and proceeding in the downstream direction, the existing structures will be affected by the proposed structures as described in the following discussions. The inlet structures will require excavation of the upstream embankment at the west abutment to an elevation of 412.0 ft. at the lowest point at the upstream face of monolith 2D, the bottom elevation of which is approximately 400.0 ft. The inlet structure will be tied in to the approach wall and to the monolith 2D. These ties will be accomplished by placing dowels anchored into the approach wall and cast into the

north wall of the intake structure. The west wall of the inlet structure will be tied to monolith 2D using post tensioned anchors. The base slab of the inlet structure will be seated and doweled to the approach wall and to monolith 2D and 3D.

The two intake conduits will require boring through monolith 2D. the centerline elevation of each hole on the upstream face will be T29.30 ft. and the boring will slope downward to an elevation on the downstream face of approximately 423.97 ft. The inside diameter of the finished conduit will be 12 ft. 6 inches constant diameter from the upstream face to the downstream face. The two holes through the monolith at the upstream face will have a centerline separation of 18 ft. This separation will increase to a downstream face separation of 20.24 ft. The length of the two holes will be 33 ft. 6 inches.

The section of inlet conduit that will connect the bored conduit to the inlet at the plant will be approximately 27.0 ft. long and will require an excavation of the downstream embankment to an elevation of approximately 410.0 ft. or about 10 ft. above the bottom of monolith 2D. At this point, the bottom of the excavation will be about 50 ft. from the highest point on the sloped embankment.

The centerline axis of the plant facility is located at a distance of 39.0 ft. west of the channel face of the west training wall. This location appears to best fit all of the existing conditions. That is, the two holes in monolith 2D are situated to protect the structural integrity of the structure; the excavation in the upstream and downstream embankments around monolith 2D, although extensive, is not insurmountable; and the plant structure will be slightly separated from

the training wall, which is an advantage for construction and will allow for maintaining the existing drainage system to a discharge point into the outlet channel. Although the deep excavation along the training wall will require a full excavation to the dry face of the training wall, the plant structure itself will be independent of the training wall and the manholes for the drainage system that was constructed behind it. The plant structure, however, will be attached to the training wall with short tie walls of the same thickness as the outside vertical walls of the plant structure. This will be accomplished by either using drilled dowels or post tensioned anchors. The dimensions of the existing training wall will allow either method. The space between the training wall and the plant structure will be backfilled.

The outlet works will require a continuation of the deep excavation for the plant structure for the entire length of the training wall. In addition to this, the outlet works will require the removal of the radius portion of the training wall and the removal of the last manhole. These structures will be removed completely to the top of the footings.

3. DESCRIPTION OF STRUCTURAL COMPONENTS OF THE PROPOSED PLANT FACILITY

The structural components of the proposed facility were developed on a preliminary plan basis, and include the following generally described structures. Design concepts are based on anticipated soil, hydrostatic and dynamic forces and live loads.

Inlet Structure

The inlet structure (Sketch A and Appendixes N, O and P) was designed as an open top box structure and will consist of a main west wall and north wall that form one-half of the box. The proposed walls

PROPOSED INLET STRUCTURE

will tie in to the approach wall and the monolith together which form the other two sides of the box. The proposed walls will be cantilevered from the proposed concrete basin floor of the inlet structure, which slopes from an elevation of 420.0 ft. at the face of the monolith to an elevation of 430.0 ft. at the proposed north wall. The west wall will retain the existing upstream embankment to an elevation of 458.5 ft. The north wall will retain the sloping embankment from an elevation from 458.5 ft. to the intersection of the approach wall which has a top elevation of 435.0 ft.

Intake Conduit

The intake conduit will consist of a steel-lined monolith tunnel section and a section of concrete encased steel tube connecting the monolith tunnel to the plant structure. It is proposed to hold the tolerance of the two holes through the monolith 2D to a diameter of 13 ft. 4 inches plus or minus 2 inches. The annular space between the monolith steel tunnel liners and the monolith holes will be filled with a pumped in grout mixture. This detail and a detail of the intake entrance is shown on a drawing included in this study. (Sketch B).

Plant Structure

The plant structure (Sketch C and Appendixes N, O and P), will consist of a series of monolithic pours starting with the bottom lift at elevation 394.92 ft. and proceeding with four additional lifts to an elevation of 415.0 ft. which is the level of the operating floor of the structure. The walls of the plant structure will begin at the floor elevation of 415.0 ft. The roof structure will consist of 32 inch deep post-tensioned beams spaced 15.0 ft. on centers and spanning wall to

ELASTOMERIC SEAL

3/4" PLATE ASTM A514

GROUT (PUMPED)

1/2" PLATE ASTM A514

3/8" PLATE ASTM A514

STIFFNER ANGLE

NORTH FACE OF
MONOLITH

VERTICAL FACE
OF MONOLITH

OF EACH
INTAKE CONDUIT

INTAKE CONDUIT-BELL MOUTH DETAIL

PROPOSED PLANT STRUCTURE

wall a distance of 48.0 ft. The structural slabs spanning between the beams will be 8 inches thick, will be post-tensioned, and will have a finished elevation of 440.0 ft. The roof structure will include equipment removal openings at locations convenient with the installed equipment. The openings will be framed with edge beams. The exterior walls of the plant structure will be 30 inches thick and will be either reinforced with mild steel or post-tensioned.

The first five monolithic lifts of the plant structure will encase the prefabricated steel draft tube sections up to the elevation of 415.0 ft. The plant structure will include two box culverts which will transfer the flow of water from the prefabricated draft tube to the outlet works. The bottom and sides of the box culverts will extend 3 ft. 0 inches beyond the outlet works face of the plant structure. This extension will provide for channel supports for the tailwater stop logs.

The outlet works of the plant will provide for an open channel discharge and will consist of a continuous straight and curved retaining wall on the west side to retain the existing earth from the discharge face of the plant structure to the existing berm in the downstream channel. The open discharge channel will then be confined by the proposed retaining wall and the existing training wall on the east side, which will be exposed. The bottom elevation of the discharge channel will require an excavation below the top of the footing for the existing training wall. This area will be protected by a retaining wall and riprap to an elevation of 405.0 ft. The entire channel floor will consist of both finished concrete and riprap protection. Velocities through the discharge channel will be a maximum of slightly more than

6.0 ft. per second and will occur at the exit from the plant structure. The design of the proposed discharge channel includes a concrete basin floor that will extend 51 ft. 6 inches downstream from the outlet face of the plant structure. The floor will be sloped up from point of plant discharge with an elevation of 394.92 ft. to an elevation of 403.0 ft. at the downstream end.

The proposed plant facility will also include flow control apparatus, which will be a significant part of the final design. Included will be two steel fabricated headwater stop gates and one fixed fabricated steel trash rack covering both of the intake openings. The headwater stop gates will be fabricated from heavy structural wide flange shapes and heavy steel plate. Each gate will weigh approximately 7.1 tons. Steel wide flange beams will be attached to the face of monolith 2D to provide guides for the headwater stop gates when placed in service. The stop gates will seal against the flanges of the intake conduits. The fixed trash rack will consist of racks with one-half inch steel plates placed at 3 inches on centers and fabricated in sections that will be supported by a steel framework which in turn is supported off the inlet basin floor and the guide beams mounted on the face of monolith 2D.

Also included in the design will be a system of tailwater stop log sections that will consist of structural steel shapes and plates. The sections will be supported by channel frames embedded in the box culvert draft tube extensions. The top of the channel supports will be placed at elevation 430.0 ft. The tailwater stop log sections will extend to an elevation of approximately 411.0 ft.

The development of the plant facility also includes an overhead crane mounted inside the plant structure. The overhead crane system will span approximately 46.0 ft. from the end rails. The capacity of the overhead crane will be 15.0 tons.

The access to the operating floor of the plant structure will be provided by an enclosed stairwell located outside of the plant thus providing for an operating floor area free of any access stairs.

4. DESIGN PARAMETERS

The development of the plant facility structures was based on the following assumed loads and forces.

Equipment Weights

<u>Item</u>	<u>Weight (Kips)</u>
Inlet Butterfly Valve	61.5
Generator	65.6
Speed Increaser	48.4
Turbine Runner and Shaft	30.0
Intake and Diffusure Including Draft w/o Cover	22.0
Removable Cover Portion of Draft Tube	18.0

Vertical Loads

Soil Not Submerged	0.120 kcf
Soil Submerged	0.058 kcf
Concrete Not Submerged	0.150 kcf
Concrete Submerged	0.088 kcf
Water	0.062 kcf
Roof Live Load	0.200 ksf

Lateral Forces

The lateral forces used for the development of the structures consisted of a soil pressure resulting from non-submerged backfill and from submerged backfill in combination with hydrostatic pressure. Lateral forces were developed from the Coulomb trial wedge theory and assumed weights of backfill listed above. At-rest pressures were

increased by a factor of 1.33 over the forces resulting from soil pressure acting against yielding supports.

Dynamic Load

The only critical dynamic loading condition considered in the development was at the location of the inlet valve at the front of the inlet tube in the plant structure. A massive concrete thrust block is included in the design to support this dynamic load resulting from the moving water which will have a velocity at that point of approximately 15 to 16 ft. per second maximum. It was assumed that when the stop gates and stop logs are installed, the butterfly valve in the inlet tube will be closed and that only hydrostatic pressure and not dynamic loads be considered. Dynamic loads will also be considered in final design in other areas such as at the head of intake conduits, for example.

Assumed Stresses

The following ultimate strengths and working stresses were used in the development:

Concrete - $f'_c = 3,750$ psi for cast in place concrete
 $f'_c = 4,000$ psi for cast in place concrete to be post-tensioned

$$f_c = 0.45 f'_c$$

Reinforcing Steel - $f_y = 40,000$ psi
 $f_s = 20,000$ psi

Structural Steel - $f_y = 36,000$ psi
 $f_s = 0.66 f_y$ for Flexural design

The assumed modulus of elasticity for concrete was developed from the formula given in the ACI Code 318-71. The assumed modulus of elasticity for structural steel used was 30,000,000 psi.

For development of the post-tensioning requirements for selected applications, high strength alloy steel bars and strands were used. Generally, a 160 ksi post-tensioning bar and 270 ksi post-tensioning strands were used.

5. DESIGN DETAILS

Design of the Inlet Structure

The inlet structure was developed as a three member unit. The primary unit is the west wall that retains the upstream embankment. The average depth is 33.5 ft. above the inlet basin floor and the length from the face of the monolith 2D to the face of the north retaining wall is approximately 58.0 ft. This member of the unit was assumed to be a plate fixed to the concrete base and pinned on each end. A thickness of 7.0 ft. was selected. This will allow for a post-tensioned system to resist bending moments and to also tie the member to the monolith 2D. Main vertical reinforcement will be made continuous with the base.

The second member of the inlet structure that was developed is the north wall that retains the upstream embankment which slopes from an elevation of 458.5 ft. to an elevation of 435.0 ft. The average depth of this member is 20.75 ft. above the inlet basin floor. A thickness of 4 ft. 6 inches was selected. The length is 56.5 ft. measured from the embankment side of the approach wall to the inside of the west retaining wall. The wall will also be designed as a plate similar to the west wall.

The third member of the inlet structure is the basin floor. The basin floor was developed in two parts. A thickness of 8.0 ft. for the west one-half of the basin floor and 5.0 ft. for the east one-half of

the basin floor was selected. The thicker west half of the slab will resist the bending moment transferred from the west retaining wall. The thicker slab will also resist the bending moment transferred to the base from the north retaining wall where it will be a maximum. The thinner section of the basin floor will be adequate to resist the bending moment transferred from the north retaining wall to the base where the bending moment will be a minimum. The basin floor will not be extended substantially from the outside face of the inlet structure walls in order to reduce the sheet piling and bracing requirements of the excavation.

The inlet structure as developed can resist uplift forces and buoyancy forces for a de-watered condition with lake reservoir elevation at 450.0 ft. For precautionary reasons, a relief valve system with relief valves placed at an elevation of about 443.0 ft. is proposed. Also, it should be noted that an inlet structure larger than that developed might improve the flow characteristics of the inlet works. This will be determined by hydraulic studies as part of the final design.

Intake Conduits

The intake conduits including the steel liner within the monolith tunnels and the sections that connect the tunnel liner to the inlet tube at the plant were developed on the design basis of a hydrostatic pressure resulting from a reservoir level of 467.0 ft. As a result of these conditions, a wall thickness of 1/4 inch of A36 structural steel would suffice. However, the tunnel liner will probably be a minimum of 3/8 inch thick to provide for corrosion and erosion under operating conditions. In addition to this, steel angles will be welded to the outside of the

intake conduit to provide stiffness for handling and other conditions. The development of the intake tubes also included provision for a bell mouth and flange type opening fabricated from ASTM A-514 steel plates. The steel plate flanges will be mounted flush with the face of the monolith and will provide for a surface to which the stop gate can engage. Connecting sections of the intake conduits will be encased in reinforced concrete. These sections of the intake conduit were investigated for uplift forces as well as backfill loads.

Plant Structure

Preliminary design development determined that the approximate wall thickness of 30 inches will be adequate to resist all of the at-rest soil pressures and also the anticipated hydrostatic ground water pressures. Either reinforcing steel or post tensioning tendons can be used to resist the bending moments induced in the wall sections. The plant structure was investigated for uplift and buoyant forces and it was determined that rock anchors will be required to resist these buoyant forces. Rock anchors similar to those used in construction of the stilling basin floor of the reservoir will be used. A drainage system around the plant structure itself was included in the design concept. To prevent hydrostatic pressures being transferred to the training wall, it was determined that a drain system connected in with the one that exists in back of the training wall would be required. A sophisticated waterproofing system was included also. The water tightness of the inlet structure could be greatly improved if a post-tensioning system is selected for the final design.

The depth of the beams and the slabs forming the roof system are adequate to provide for the post-tensioning system. Again, the post-tensioning system used in the roof slab will help maintain the concrete roof in a watertight condition.

Discharge Channel

The design of the basin floor slab must account for the fact that a significant heel section outside of the discharge channel retaining wall cannot be used primarily for the same reasons as mentioned for the inlet structure basin floor. In the case of the discharge channel basin floor slab however, rock anchors can be utilized to resist the overturning moments transferred to the base from the cantilevered retaining wall above. In addition to this, rock anchors will be required to resist uplift forces that will occur in the same fashion for which the reservoir stilling basin floor was designed. The main section of the cantilevered retaining wall that is supported from the west side of discharge channel floor will have an average height of 36.0 ft. and will retain the existing grade of approximately elevation 435.0 ft. A thickness of 24 inches at the top of the wall was selected with a uniform slope one to ten. For development of this particular member, it was assumed that lateral loads acting inward toward the discharge channel would result only from the backfill soil pressure. A drain system similar to that behind the training wall was included and for that reason a zero differential hydrostatic pressure was assumed.

The base for the downstream section of retaining wall will be subject to the same restrictions in the area of the heel of the base as was the case with the discharge basin floor. The elevation of the top

of the retaining wall base will be 403.0 ft. Riprap protection will be placed over the toe section of the base inside the discharge channel to an elevation of 405.0 ft. The average height of the sloping retaining wall will be 22.0 ft. with a toe of 8 ft. and a heel of 4 ft. 6 inches, the resulting uplift pressure at the toe under the specified conditions, will be less than 3.0 kips per sq. ft.

Head Water Stop Gates

The head water stop gates will be fabricated from structural steel shapes and plates as previously mentioned. They will be fabricated in two pieces and field assembled into one piece. Each gate will be approximately 18 ft. wide and 16 ft. high. The stop gates will be designed to support a hydrostatic pressure resulting from a reservoir level elevation of 467.0 ft. The guide rails for the head stop gates will extend to at least elevation 467.0 ft. so that the stop gates can be lowered into place during flood conditions when the reservoir is at its maximum level. The guide rails for the stop gates will be fabricated with the outside flanges removed to an elevation sufficient to allow for the entry of the stop gates. This is necessary due to the slope of the face of the monolith.

Trash Racks

The trash racks were developed on a concept of providing a fixed single unit that will enclose the intake area of the intake conduits. Consideration in development of the concept for the trash rack was given to reduce interference with flow of the water entering the intake conduits. The trash rack will have one-half inch by 4 inch bars spaced three inches apart and supported with intermediate structural steel

shapes as required to resist the dynamic forces induced by the flow of the water which will approach a velocity of 15 ft. per second near the inlet. The trash racks will be bolted or welded in place and the framework will be attached to the intake basin floor and to the guide rails and the monolith. The top of the trash rack will have a removable section located next to the face of the monolith whereby the small section may be removed whenever the stop gate is required to be placed in operation.

Tailwater Stop Logs

The tailwater stop logs were developed on the concept that the stop logs be fabricated in several sections to lower into the channels provided in the draft tube extensions. The size of the openings to be closed is 19 ft. 8 inches long and 14 ft. 11 inches high. The sections will necessarily extend from elevation 394.92 ft. to elevation 411.0 ft. and will be required to seal off the tailwater up to a maximum elevation of 427.0 ft. This will require a perimeter seal along the edges, the bottom and the top as well as intermediate seals between the sections of stop logs themselves. The seals will be made up of elastomeric material placed between two steel angles and will be designed to compress under the weight of the stop log section and the seating pressure of the tailwater. The seal must be placed on the top of each section in order to store the sections with the seals on top and to prevent the necessity of turning the stop log sections over when placed in operation. The final design of the stop logs will require providing for six sections, three for each opening. Each section will be designed as a simple beam loaded with the maximum head of water. Tailwater head is the only design head to consider, which will create a seating pressure.

6. CONSTRUCTION DETAILS

The construction of the proposed plant facility will be more difficult than for a structure built under conventional conditions. Most of the structure will necessarily have to be constructed around sheet piling bracing systems and similar obstructions. The depth of the structures and the proximity of the reservoir will make it difficult to keep the excavations dry during construction. Delivery of materials will be somewhat congested due to the fact that the only access to the site is the road that approaches the gated spillway reservoir and the public park area on the downstream side of the spillway.

Construction schedules must be carefully planned and executed to prevent delays in installing the equipment. A large section of the wall of the plant structure may have to be omitted to allow for completion of the roof structure and the subsequent installation of the equipment that will be located above the operating floor. All of the materials for the construction of the plant will be handled with cranes located either on the roadway or on the embankment area.

A method of removing the concrete for the bored section through the monolith was not fully developed. However, large power equipment and rock drills could probably be used to accomplish this phase of the project. Other methods could be used, but any method, of course, would have to be approved by the Corps of Engineers. The construction area will necessarily be limited to the minimum possible due to the length of cross-bracing required to retain the water levels and the embankments. This factor will affect the final design and construction of the various retaining walls as were previously discussed.

The sheet piling and cofferdams that will be used for construction will be designed to withstand the soil and hydrostatic pressures to a reasonably safe elevation. During construction periods, overtopping of construction area is a possibility. Construction procedures must be carried out accordingly.

7. SPECIAL CONSIDERATION OF FINAL DESIGN

Of primary importance to the project, is the verification of the structural integrity of monolith 2D after the tunnel removal is completed. A special analysis will be required to verify that the structural integrity of the monolith will not be affected by the penetration of the holes through it. Also, in relation to monolith 2D, overturning forces resulting from floodwater conditions must be investigated. The affects of the attachments of proposed structures will be considered in the analysis.

The use of post-tensioning methods for resisting the forces on the structures will be thoroughly investigated in the final design. Utilization of this type of construction would be very advantageous for this particular facility. Considerable effort was spent during the development of this study to investigate the advantages, the methods and the potential for post-tensioning concrete structures. Favorable response was the result of this investigation.

Particular attention for the final design of the headwater stop gates and the tailwater stop logs will be necessary. The final details of these items shall provide for a reasonably watertight installation, as well as ease in handling the units.

Special consideration must be given for the final design of the waterproofing system around the plant structure to insure that the plant interior be kept as dry as possible to prevent deterioration and maintenance problems on the equipment.

Special design consideration must be given also to the configuration of and the type of alloy steel specified for the bell mouth shaped intake conduit. Hydraulic and metallurgical studies should determine the final optimum design to meet the severe conditions encountered.

D. GEOTECHNICAL ASPECTS OF PROJECT

1. GEOLOGY

As discussed in the U. S. Army Corps of Engineers Design Memoranda Nos. 2 and 7, the area containing the Carlyle Reservoir lies in the Springfield Plains Portion of the Till Plains Section of the Central Lowlands Physiographic Province. The reservoir area is one of moderately low relief. The uplands are generally flat except where interrupted by occasional drift hills. These uplands range between elevations 450 to 550 with the drift hills standing 30 to 50 feet higher. Most of the surface features are a result of glaciation and subsequent stream erosion. A thin veneer of glacial drift blankets the upland, which, in turn, is overlain by 5 to 30 feet of loess (except where removed by erosion).

The Glacial Drift of Illinoian Age, which blankets most of the uplands and forms the drift hills, consists of an intimate mixture of clay with pebbles and a few cobbles. Most of the pebbles are less than one inch in diameter and there are few boulders larger than one-half cubic foot. Occasional sand and gravel lenses are encountered, particularly in the drift hills. The pebble lithology is predominantly silicate, with some carbonate rocks and a varied suite of igneous types.

The bedrock strata underlying the region belong to the McLeansboro Group of Pennsylvania Age and crop out very sparingly. The McLeansboro Group consists of some ten recognizable cyclothems, but members of only four have been encountered in the course of the investigations for

the original dam and reservoir project. The limestone of the Shoal Creek Cyclothem is the only stratum that can be actually observed at the surface.

The abutments on both sides of the valley at the damsite are glacial-drift hills which rise above the general elevation of the uplands and which consist of till with sand and gravel lenses. The right abutment reaches an elevation near 500 while the left abutment rises to a little over elevation 540. Beneath both abutments, a considerable amount of bedrock has been removed by pre-glacial erosion and the amount of drift overlying the present bedrock surface is comparatively large.

A bedrock terrace, thought to be due to pre-glacial channel erosion, exists on both sides of the valley. The bench on the left side of the valley is somewhat lower than the right because of the dip of the rocks. Apparently the softer rocks overlying the limestone surface rock of this left terrace were also removed prior to glaciation. No evidence of faulting within the immediate damsite area has been disclosed by the borings.

The dam crosses three significantly different areas. The major portion of the dam overlies a valley area. This area encompasses approximately the eastern two-thirds of the embankment. Progressing westwardly, a terrace area and a small draw area are encountered in order. The ground surface in the valley area is at approximately elevation 423. Immediately below the surface are cohesive soils varying in thickness from approximately 5 to 18 feet. These soils are underlain by silty sands and fine-to-medium, poorly graded sands. The silty sands and poorly graded sands vary in thickness from approximately

7 to 20 feet. Cohesive soils are composed of lean clays, fat clays, and clayey sands that are generally brown in color. The silty sands and poorly graded sands are brown to gray in color. The upper portion of the sand zone is generally of fine-to-medium gradation with traces of small gravel. The lower portion of the sand zone is, as a rule, medium to coarse with traces of gravel. Silt and sandy-silt soils are found in the cohesive soils, and shaly clay is usually present immediately on top of the sandstone in the valley area. The water table in the valley area prior to reservoir filling was approximately at elevation 406.

The terrace area in which the spillway is located has an average surface elevation of about 438 resulting in an embankment height of 34 feet. The foundation consists of lean clays, silts, sands, and silt-sand mixtures. Stratigraphically, 10 to 15 feet of lean clay overlies a transition zone of silt and silty sand 3 to 6 feet thick. A sand zone, 0 to 8 feet thick, tops a thin (3 to 10 feet thick) limestone bedrock cap. The water table in the terrace area from Station 43+00 to Station 49+00 prior to reservoir filling was approximately at elevation 422. Present water levels are expected to vary with levels of the reservoir and downstream channels.

The foundation soils in the draw area are lean clays interspersed with fat clays which rest on a limestone bedrock cap as in the terrace area.

The rock strata penetrated for the foundation investigations show considerable variation in their lithology, but exhibit much uniformity in occurrence throughout the area. On the basis of physical characteristics, the rocks at the site have been classified in some

sixteen readily recognizable categories, six of which are intimately associated with the spillway. The strata occurring in the spillway area are described below beginning with the stratigraphically-highest member.

The Shoal Creek Limestone forms the uppermost rock at the damsite and appears to be a continuous, hard, compact, and predominantly-sound limestone that averages almost ten feet in thickness. No structures of the spillway were founded on this material as immediately subjacent are black shale and indurated clay that are unsatisfactory foundation materials for the dam.

The black shale below the limestone generally is a hard, sheety, black, carbonaceous material and contains some light grey siltstone lentils. However, in some borings, cores were almost plastic. The shale varies from two to three and one-half feet thick.

Below the black shale is an indurated clay or clay shale. The clay shale as recovered in the core borings consists of light gray, indurated clay with limey nodules occurring in the lower portion. Atterberg limit test results indicate that the clay is of the non-swelling type. Most of the clay as recovered is soft to plastic. The indurated clay averages almost five feet in thickness.

Below the clay shale is a moderately-hard, highly-variable, green argillaceous sandstone. Generally, the top one foot is high in clay and locally somewhat soft. Locally there are some clay or sand filled fractures associated with limestone nodules that range up to two inches in diameter. Some shale or siltstone zones with clay or sand laminations are also found within this strata that averages about six feet in thickness.

The shale underlying the sandstone is moderately-hard, greenish-gray, only-slightly-sandy shale with an occasional soft clay seam.

The lowermost foundation rock is an alternating siltstone and sandstone. This strata consists of alternating layers of gray, very fine-grained, shaly sandstone with undulating, closely-spaced shale partings and slightly-micaceous siltstone containing occasional thin stringers of clean whitish-gray sandstone. This formation is about 60 feet thick.

The results of the unconfined-compression tests on 4-inch core samples from the sandstone and below indicate an average compressive strength of these rocks in excess of 1,400 p.s.i. or 100 tons per square foot.

2. INTAKE STRUCTURE

The intake structure of the proposed hydro-electric power plant will be located upstream of the existing dam and spillway adjacent to non-overflow monolith 2D as shown on Plate N. Physical characteristics of the plant have been described previously. Briefly, however, the intake structure consists of a floor slab, the base of which, varies in elevation from El 412 to 422 and is five (5) to eight (8) feet thick. The soil of the existing embankment located north and west of the structure, will be retained by walls 4.5 to 7 feet thick which will extend from the base of the structure to about one foot above the adjacent embankment. The maximum height of the wall will be about 39 feet above the floor slab. It will be necessary to construct a cofferdam for construction of the intake structure to retain the embankment and water. In addition, some special features may be required

for construction of the intake structure. Subsurface conditions at the structure, a preliminary cofferdam design, and special construction features related to geotechnical aspects are discussed in the following paragraph.

3. SUBSURFACE CONDITIONS. The subsurface conditions at the intake structure are about the same as those discussed in the geology section of this report. Basically, the soil above El 436 consists of the compacted impervious embankment and is thought to be clay and silty clay. Natural in-situ soil is encountered below El 436 and for a depth of 16 feet consists of a lean clay stratum. The clay is underlain by a five (5) foot thick clayey sand stratum which in turn is underlain by a one (1) foot thick seam of highly plastic clay. Immediately below the clay at about El 414 is limestone bedrock. The rock stratigraphy below El 414 is the same as previously noted. In addition to the dam embankment and natural soils, at the structure, there is a zone of pervious backfill adjacent to the existing approach wall as shown on Section 5 (Plate T). Adjacent to non-overflow monolith 2D, the natural soils were removed during core trench construction to the top of rock and the soil replaced with compacted impervious soil.

4. STRUCTURE REQUIREMENTS. The new intake structure will be essentially mat supported and will have a bearing pressure of less than one ton per square foot, which the soils at the site should be capable of supporting. The embankment and soil presently impose a pressure of 1.0 to 2.0 tons per square foot on the soil at the proposed footing levels.

The effect of any construction should result in a negligible net pressure below the foundation and it is our opinion that settlements of the new structure will probably be minor.

To minimize differential hydrostatic water head behind the structure which could be caused by a sudden drawdown of the reservoir, we recommend that a pervious zone and relief drains be constructed. The pervious zone should extend from the structure wall to the cofferdam wall and also for one (1) foot below the base of the structure. The pervious soil should be brought to within four (4) feet of the finished grade and then covered with impervious soil. The hydrostatic pressure can be released into the intake structure basin through the wall by use of one-way flap relief valves.

5. COFFERDAM.

Reservoir levels of Carlyle Lake may vary from about El 440 upward to about El 467. The embankment near the proposed intake structure varies from about El 435 to about 462. Since excavation for construction will vary from El 412 to 422, a cofferdam will be necessary to construct the intake structure. The cofferdam will have a height as necessary to protect the existing dam embankment, and to protect against overtopping at a reasonably high lake level. A preliminary cofferdam system has been designed for cost estimating purposes and is presented in the following paragraphs. Additional investigation, analyses, and detailing would be required for use in construction.

The cofferdam will protect against a lake level of El 455 or less, and since the lake may go above El 455, the possibility of the lake

overtopping the cofferdam does exist. Construction sequences should be such that there is not a possibility of downstream flooding because of construction through the non-overflow monoliths, i.e., the stop log gates of the intake structure should be available prior to excavating through the monolith so the stop logs can be placed if required.

The cofferdam walls will consist of PZ 27 steel sheet piling (ASTM-A-328 steel) located as shown on Plates N and Q. The non-overflow monolith will act as the south wall of the cofferdam. The sheet piling should be provided with protective shoes and driven to rock except on the east where sheet piling will be mounted on top of the existing approach wall. Since the approach wall is usually submerged, underwater construction with divers will probably be required. A special seal and connection to the existing wall will be required at the top of the wall. A detailed design of the seal and connection has not been made as a part of this study.

The bracing of the system will consist of a combination of tiebacks and structural steel cross-bracing. Since lateral forces imposed on the cofferdam by the earthen embankment cannot be resisted by the east wall of the sheet piling, the earth above the level of the approach wall will be retained by a tieback retention system. Water forces above the approach wall will be resisted by cross-bracing and below the approach wall, cross-bracing will be utilized to retain both earth and water. All steel unless noted is ASTM-A-36 steel with a yield strength of 36,000 p.s.i. An elevation and plan view of the cofferdam and bracing is shown on Plate Q and a section of the wall is shown in Section 5, (Plate T).

Bracing levels 1 and 2 may be installed with the water level at the top of the sheeting, however, subsequent installations will require the water level to be at about El 442 or less for installation. Once the bracing level at El 432 is in place, the excavation can be made to grade irrespective of the position of the water table.

Tiebacks should be one and three-eighths diameter steel rods (ASTM-A-322 steel) spaced at six (6) foot centers at the elevations shown on Plate Q. The rods should be anchored to a common wale. The tieback should be installed in a drilled hole having a minimum diameter of eight (8) inches and embedment into the underlying limestone of at least 12 feet. Tiebacks should be drilled at a 45 degree angle and grouted into the rock. Above the rock, the tiebacks should be provided with a protective cover so the tieback is free to move and the annular area filled with a lean cement grout. The load per tieback will be about 100 kips. Wales for the tiebacks will be two-MC 8 X 21.4 channels placed back-to-back. During placement, the tiebacks should be test loaded to 120 percent of their design capacity and should be locked off at 80 percent of the design capacity.

The bracing members at El 446 will be W 14 X 111 struts and W 33 X 200 wales. The bracing at El 432 will be W 14 X 237 struts and two-W 36 x 245 sections welded together for the wale. Rakers will be necessary as part of the retention system at El 420 to provide adequate resistance for the toe of the sheeting in an area which will penetrate to the top of rock as shown on Plate Q. The rakers will be HP 14 x 73 sections and are connected to a W 14 X 111 wale section. HP 12 X 53 soldier piles should be driven at the strut intersections to provide support for the bracing. Secondary features such as support

brackets and stiffener plates will be required at numerous locations on the struts and wales.

Excavation of the material from within the cofferdam will probably require a clam shell operating from the top of the monoliths. Some assistance may be required in the hole from a light, track-type vehicle. Special excavation techniques will be required at the junction of the sheet piling with the existing concrete monolith and approach wall. Excavation at these corners should proceed very carefully so that the sheet piling is stiffened as the excavation proceeds to prevent a "blow-in" of the sheeting. Some grouting behind the sheeting may be required in order to seal the sheeting at the contacts with the existing structures. It is probable that one or two sump locations will be required within the excavation to drain water coming into the excavation through seams in the limestone rock and interlocks of the sheeting.

The intake structure should be constructed around the bracing and the backfill in place to the level of the bracing before a bracing member of removed. Upon completion of the intake structure, the sheet piling can be removed.

6. POWER PLANT AND OUTLET WORKS

The power plant and outlet works for the proposed hydro-electric power plant will be located downstream from the existing dam and spillway monoliths adjacent to the spillway as shown on Plate N. Physical characteristics of the plant have been described previously. Briefly, the plant consists of penstocks or draft tubes, power plant, and outlet works. The penstocks have a diameter of about 12.5 feet and will vary in invert elevations from about El 417.72 at non-overflow monolith

2D to about El 412 at the power plant, 25 feet downstream. The power plant structure begins from this point and is about 80 feet long.

Dowstream of the power plant to the existing river channel, the out-fall basin and channel will be constructed. The plant structure from the face of the existing training walls will be about 65 feet wide.

The dam embankment will be replaced over the penstocks after construction. A retaining wall will be constructed as part of the power plant to retain the embankment on the north and west sides of the plant. The outlet will consist of an open channel flow with the earth retained by a training wall. A portion of the existing training wall will be removed as shown on Plate N. Excavation for the plant will be as deep as El 392.

It will be necessary to construct a cofferdam for construction of the penstocks, power plant and outlet works to retain the embankment and adjacent water. In addition, some special features may be required for construction of the downstream structures. Subsurface conditions at the structure, a preliminary cofferdam design, and special construction features related to geotechnical aspects are discussed in the following paragraphs.

7. SUBSURFACE CONDITIONS. The subsurface conditions in the vicinity of construction downstream are about the same as those discussed in the geology section of the report. Basically, the soil stratigraphy consists of compacted impervious embankment above El 435 (in the vicinity of the penstocks and the power plant) which is thought to be clay and silty clay. Below the compacted embankment and in areas where natural ground conditions exist, the soils consist of a lean

clay to about El 420. A four (4) feet thick stratum of clayey sand is encountered below the clay. Immediately above limestone bedrock and below the clayey sand is a one (1) foot stratum of highly plastic clay. The bedrock is encountered at about El 416 and the stratigraphy is about the same as previously noted. An 8.5 foot thick layer of very hard sound limestone is underlain by three (3) feet of shale which in turn is underlain by a 5.5 foot thick stratum of indurated clay. The indurated clay is underlain by sandstone, shale, and alternating strata of sandstone and siltstone.

In addition to the dam embankment, natural soils, and rock at the site, there are zones of pervious backfill which are drained by a drain system adjacent to existing training walls. The extent of pervious backfill is shown on sections 2 and 6 on Plate T.

8. STRUCTURE REQUIREMENTS. The penstocks will be tube type structures and the soil above the penstocks will be replaced after construction. Therefore, the penstocks will not impose additional load on the foundation and bearing capacity and settlement should not be a problem. Uplift may be a problem should the penstocks be drained.

The plant will be founded on the rock at the site at various elevations at a bearing pressure of about one (1) ton per square foot. It is our opinion that this bearing pressure is nominal compared to the soundness of the rock at the site. It is our opinion that bearing capacity at this pressure should not be a problem and settlements due to plant construction should be minor. The retaining walls of the outfall channel will be founded on sandstone at about El 395 to 398. It is our opinion that the sandstone is probably capable of supporting a high bearing pressure with negligible settlement. U. S. Army Corps

of Engineers Design Memorandum No. 7 indicates that this rock can safely withstand as much as 25 tons per square foot.

To minimize differential hydrostatic pressure behind the structures which could be created by sudden fluctuations of the water level in the downstream channel, we recommend installation of a pervious fill and drain behind the new wall and plant structure. The design should be similar to that adjacent to the existing training walls. The drain adjacent to the plant may discharge to the downstream outlet works and the wall adjacent to the outfall channel through a series of one-way flap type relief valves. The pervious soil at the site should be placed to about El 432, but should have a minimum of four (4) feet of impervious cover.

The penstocks, plant structure, and possibly the outfall discharge basin will be subject to uplift. Rock anchors may be used to resist the uplift and may be designed assuming wall friction in the rock of 50 pounds per square inch. No capacity should be allowed for anchor penetration into the indurated clay. The anchors should have a minimum length and spacing of ten (10) feet and a maximum load of about 100 kips per anchor. The rock anchor should be load tested to 120 percent of the design capacity.

The velocities in the outfall channel will be about six (6) feet per second or less and to protect the outfall channel, we recommend that a minimum of six (6) inches of riprap filter and 18 inches of riprap be placed. It is probable that a properly sized riprap having a maximum size of about 120 pounds should be sufficient.

9. COFFERDAM. Water levels in the discharge channel below the spillway at the Carlyle Dam generally vary between El 411 and 427, however, the training walls are constructed to about El 437. The ground surface adjacent to the construction varies from about El 415 to about El 462 on the west and, on the east, the structure will be adjacent to the existing training wall or open to the existing river channel. Since excavations will go as deep as El 392, a cofferdam will be necessary to construct the penstocks, power plant, and outfall works. A preliminary cofferdam has been designed for cost estimating purposes and is presented in the following paragraphs. Additional investigation, analyses, and detailing would be required for use in construction.

The cofferdam will have a height as necessary to protect the existing embankment and will have a minimum elevation of El 435. It is highly probable that the downstream water levels would not go above El 435, however, during the maximum design spillway release of 160,000 cfs, the cofferdam would be overtopped.

The cofferdam walls will consist of PZ 27 steel sheet piling (ASTM-A-328 steel) located as shown on Plates N and R. Sheet piling should be provided with protective shoes and driven to rock. On the east where the sheet piling will be in the existing channel and bear on rock, it may be necessary to construct a small berm for temporary toe support during construction.

The bracing of the system will consist of a combination of tie-backs and structural steel cross-bracing. Loads on the sheeting imposed by the embankment and natural soils will be resisted by tie-back anchors. The cross-bracing will be designed to resist loads imposed by water in areas where sheet piling is exposed to water,

and in the area of the existing training wall, earth and water pressure. The existing training wall will be braced at several locations and elevations to prevent sliding and possible overturning of the training wall during high water levels. It is probable the training wall was not designed to withstand water forces without support on the landward side. All steel used in the bracing system will be ASTM-A-36 steel with a yield strength of 36,000 p.s.i. unless noted. A plan view of the downstream cofferdam is shown on Plate R and in elevation on Plate S. Selected sections are shown on Plate T.

Bracing levels above El 425 can be installed as the excavation proceeds irrespective of the position of the water table. However, below El 425, special precautions should be implemented. The lower level of tiebacks at about El 425 to 420 will require dewatering of the clayey sand stratum to about El 420 during installation. Based on reports given by the Corps of Engineers from their observations of dewatering during construction of the core trench in this area, as noted in Design Memorandum No. 7, it is probable that the quantity of water to be pumped during dewatering will be minor. Several small capacity dewatering wells will be temporarily required. The cross-bracing below El 425 should not be accomplished with the water level in the discharge channel above about El 425.

The tieback system should consist of one and three-eighths diameter steel rods (ASTM-A-322 steel) spaced at 5.5 to ten (10) foot intervals at the locations and elevations shown on Plates R and S. The tiebacks should be anchored to a common wale. Tiebacks should be installed in an eight (8) inch diameter hole drilled at a 45 degree angle and should be embedded into the underlying limestone at least

12 feet. The tieback should be grouted into the rock and the annular area about the rock backfilled with a lean cement grout. Above the rock zone, the tieback should be isolated by a protective sleeve so that it is free to move. The load per tieback will be about 100 kips. Wales for tiebacks consist of double channels of various sizes placed back-to-back as noted in elevation on Plate S. The channel sizes vary between MC 8 X 21.4 and 10 X 28.5. During placement, the tiebacks should be load tested to 120 percent of the design capacity and should be locked off at 80 percent of the design capacity.

Cross-bracing will occur at three levels, an upper level at about El 420, an intermediate level at El 420, and a lower level that will be at either El 410 or 408. The cross-bracing members will generally be 20-inch O.D. steel pipe with a wall thickness of 1.031 inches. However, some of the cross-braces which will have less lateral load (south of existing training wall) may be 18 - inch O.D. pipe with a wall thickness of 0.375 inch. The pipe should be ASTM-A-53 Class B pipe. The wales for the cross-bracing members at El 430 and 420 will be W 14 X 84, W 14 X 119, W 24 X 145, or W 27 X 177 members as shown on Plate S. Since the excavation will penetrate into rock, the east face of the lower bracing level may be braced against a bearing frame rather than a wale. Details of the bearing frame have not been accomplished. The wale at the lower level adjacent to the training wall will be a W 30 X 172 member. Secondary features such as support brackets and stiffener plates will be required at numerous locations on the struts and wales.

Excavation of the soil materials from the cofferdam may probably be accomplished using track equipment above El 425 and a clam shell

operating from the top of the monolith and at the toe of the dam below El 425. Some assistance will be required in the clam shell excavation from a light, track-type vehicle. To facilitate crane mobility and protect against inundation, we recommend that about five (5) feet of fill be placed adjacent to the southwest wall of the cofferdam. The excavation penetrates into the limestone which the Corps of Engineers has noted to be hard and requires blasting to assist in removal. A combination of line drilling, closely spaced holes, multiple delays, and small blast areas will probably be required during blasting. Vibrations will need to be kept to a minimum.

It is probable that the excavation will require several sumps to remove water infiltrating through sheeting interlocks and through openings in the limestone and sandstone.

The plant and outlet structures should be constructed around the bracing and the backfill in place to a level of bracing before the bracing member is removed. Upon completion of the downstream construction, the sheet piling can be removed.

10. INSTRUMENTATION. Instrumentation of retention structures during construction and permanent monitoring of the structures should be accomplished. We recommend installation of several slope inclinometers behind the retention systems, both upstream and downstream. In addition, we recommend placing mechanical strain gauges on some of the cross-bracing members and tiebacks. Vertical and horizontal movements of the sheet piling should be monitored during construction as conditions warrant. It is our opinion that the rock below the power plant structure be permanently instrumented with several uplift pressure cells and pneumatic piezometers. Additional instrumentation may be accomplished as required.

E. GENERATION AND CONTROL

1. MODE OF OPERATION

The station is to be designed for manual start-up and shut-down, but is to be remotely controlled while in operation from the City of Carlyle Municipal Power Plant. The City plant has and will maintain full time operating personnel.

When a turbine unit is to be started and put on the line, an operator will proceed to the hydro plant, and manually start a unit, put it on the line, and adjust the loading on the unit, to the flow release that has been authorized by the Corps of Engineers.

With one or both of the turbine units on the line, the operation of the unit will be supervised from the City power plant, with occasional visits to the hydro plant. These visits are contemplated to be at least once each eight hour shift.

The operator from the power plant will have instrumentation to show the flow of water through each turbine, the electric power being produced by each unit, the power factor of each unit, as well as pool elevations. The operator from the City power plant will be able to change blade angle and raise and lower the power output of the units. The operator can also adjust the power factor, through voltage control, on each unit, from the City power plant.

An alarm system will be incorporated to alert the operator to any impending abnormal condition. The alarm will also sound, should a unit have been shut-down, due to an automatic shut-down, because of the occurrence of some dangerous condition.

The operator can take a unit off the line, should this action be required.

The turbine units will be equipped for a black start, should some emergency condition arise, that the hydroelectric plant be put in service to provide electric power and no other source is available.

The following listing gives the contemplated instrumentation and control of the units as designed on Appendix W.

Each Generator Control Panel (Two required)

Instrumentation

- Indicating wattmeter - suitable scale
- A.C. Ammeter
- D.C. Ammeter with shunt
- D.C. Voltmeter
- P.F. Meter
- Elapsed Time Meter
- 2½ Element Watt-Hour Meter, Draw-Out Type
- Water Flow - C.F.S.
- Valve Position Indicator

Switches

- A.C. Ammeter Switch
- Breaker Control Switch with lights
- Voltmeter Switch - removable handle
- Exciter Field Disconnect Switch
- Voltage - Raise-Lower Switch
- Governor Control Switch
- Valve Position Switch

Relays

- 3-D.C. Relays with volt restraint (50/51)
- 3-Differential Relays (87)
- 1-Veri-sync. Relay (25)
- 1-D.C. Relay - Ground (50N/51N)
- Field Relay (40)
- Over Voltage Relay (59)
- 1-Reverse Power Relay (32)

Controls

- Voltage Regulator with series boost
- 3-P.Ts - 20/1, with primary metering
- 9-Cts. - 800/5
- 1-Motor Oper. Pot. - Volt Control
- 1-D.P. Transmitter (Flow)
- 1-Watt Transducer
- 1-Power Factor Transducer
- 1-Surge Protection
- 1-1200 Ampere A.C. Breaker, 500 MVA interrupting
- 1-Neutral Ground Reactor

Synchronizing Panel (One required)

Instrumentation

- 2-Voltmeters
- 1-Hertz Meter
- 1-Synchroscope with lights

T.I.E. Panel(One required)

Instrumentation

- 1-Upper Pool Elev. Instr.
- 1-Tail Water Elev. Instr.

Switches

- 1-Breaker Control Switch with lights

Controls

- 1-Veri-Sync Relay
- 1-Set-Lightning Arresters (Station Type)
- 1-2000 ampere, A.C. Breaker, 500 MVA
- 3-PT.S - 20/1 with primary fusing

Remote Control Panel - Power Plant

- 2-Ind. Wattmeters
- 2-Water Flow Instruments
- 2-P.F. Meters
- 2-Gov. Control Switches
- 2-Volt Control Switches
- 2-Breaker Trip Switches with lights
- 1-Pool Elev. Meter
- 1-Tail Water Elev. Meter
- 2-Valve Control Switches
- 2-Valve Position Indicators

Alarm System Annunciation

- Each Protective Relay
- Low Oil Pressure

In order to maintain firm capacity for the Carlyle Municipal Electric Utility, a 10 MVA, 69,000/4,160 Volt transformer and associated substation equipment and structure has been included in this proposed project. This assurance of capacity is warranted for system reliability even though Carlyle would apparently have engine and transformer capacity for the proposed project through approximately 1990. That capacity, in other words, could not be considered firm.

F. PLANT ACCESSORY EQUIPMENT

The following discussion of equipment to be included in the hydro-electric power plant is not intended to be conclusive, but does attempt to enumerate the major items. On the conceptual design drawings in the appendix of this report, such items as trash racks, headwater stop logs, tailwater stop logs, plant hoists, draft tubes and speed increasers are specifically identified. These items are primarily steel fabrications and felt to be generally available, although they are customized designed. The conceptual design was developed with the intent to limit penstock length such that pressure surge projection would not be required. This would have to be confirmed in final design, but for the conceptual development, penstock surge protection is not believed to be required. The turbine and generator bearings will need a lubricating oil circulating system and hydraulic control operators for the inlet butterfly valve and blade positioners will require a hydraulic pressure system all of which has been incorporated into the Standardized Hydroelectric Generating Units developed by Allis-Chalmers. This package unit is promoted as being available within nine (9) months of receipt of an order.

G. APPROVALS

The approval which is first and foremost as the project is herein conceptually developed, is the approval of the City Council of the City of Carlyle, Illinois. This approval will precede any further development of the project as well as any future funding which would be required. This project's development will require review from numerous individuals and agencies prior to beginning any construction. Probably of foremost

concern, is the ultimate approval of design, plans and construction which will rest with the U.S. Corps of Engineers. It is envisioned that in order to accomplish this ultimate Corps approval, a complete design will have to be developed for their review. This design will be comparable to the design which was required under the development of the spillway for Carlyle Reservoir. Specifically, the term which is generally used by the Corps is that the project will require a Feature Design Memorandum. This detailed document covering the design of the proposed facility would then be circulated for review at three levels of authority in the U.S. Corps of Engineers. Those levels include first the St. Louis District Office, next, the Division Office of the Corps of Engineers in Vicksburg, Mississippi, and a final review will probably be required at the office of the Chief of Engineers located in Washington, D.C. It is very probable that each of these three levels of review will require modifications to the design memorandum such that revisions will have to be made and the design memorandum returned for review again through the three levels. Although this is a lengthy process, the nature of the Corps' responsibility for the project is understood and will be cooperated with. After a feature design memorandum is approved, it will then be possible to prepare plans and specifications for construction of the facility. This, too, will require the multiple level review of the U.S. Corps of Engineers. It is believed, however, that this review will not take as long as the review of the design memorandum since the particulars were covered in that first review. It is felt at this point, that it is very likely that the final plans and specifications will incorporate to a high degree the standard specifications in effect at the time for the U.S. Corps of Engineers. Once this point is reached,

proposals can be received from contractors for building the structure itself.

Another approving authority over this project is the Federal Energy Regulatory Commission. While this agency has the responsibility of issuing licenses to hydroelectric projects such as proposed here, their responsibility can be summarized as supervisory to assure that all agencies at the federal, state and local level are given the opportunity for review and approval of the project. The Federal Energy Regulatory Commission licensing procedure is a two step process. The first of which the City of Carlyle has already accomplished. Specifically, they have received their preliminary permit to study this project, effective November 1, 1978, for an 18 month duration. The next step in order to apply for a license on the project, is to begin the various agency reviews required for an ultimate license. Such agencies to be contacted for interrum approvals, include the Illinois Dept. of Conversation, the Illinois Historic Preservation office and the Illinois Department of Transportation. This list is not conclusive but those agencies are at least immediately affected by the project. The requirement in the licensing procedure for an environmental impact statement is in the planning at this time but could conceivably be ommited because of the fact that this proposed project is to follow reservoir operation procedures already in effect, and is to be constructed on a site which has already been disturbed. This discussion will be persued in more detailed in Section VI of this report.

An over-simplification of the approval process would be for the City of Carlyle municipal officials first to decide to implement the

project by applying for license through the Federal Energy Regulatory Commission who oversee the subsequent approvals from other agencies. Since the lead time required to get design approval from the Corps of Engineers is so extensive, it is believed that a tentative approval based on the conceptual design presented herein can be received from the Corps of Engineers, subject to final development of an acceptable engineering design. This approval of the concept is believed to be satisfactory in meeting the requirements for Corps review prior to receiving a license from the Federal Energy Regulatory Commission, in conjunction with subsequent approvals from the Illinois Department of Conservation, the Illinois Department of Transportation and other agencies. This approval of the design concept by the Corps of Engineers in the early stages is believed necessary to facilitate the City of Carlyle's authorization for the project and subsequent funding in order to expedite the detailed engineering required for ultimate project approval by the Corps.

H. PROJECT DEVELOPMENT AND COST

This feasibility study has attempted to determine the major items of planning involved during the development phases of this proposed project. Figure No. 10 of this study presents the major items in the project's development, while graphically representing their time magnitude and relationship to other phases of the project which may be accomplished either simultaneously or sequentially. Based on equipment deliveries, estimated review periods for project approvals, and estimates of engineering development time, the proposed hydroelectric power plant for Carlyle Reservoir could conceivably be accomplished within a period

PROPOSED HYDROELECTRIC POWER PLANT CARLYLE RESERVOIR

of forty-five (45) months. If the project receives authorization to proceed by approximately May 1, 1979, it is reasonable to expect that by December 1, 1982, the proposed facility will be able to produce electricity. The completion date of December, 1982 is important to mention at this time because it is the beginning of the season in which the project will experience its greatest production. This is an advantage, in that the project will be able to have five months of production to assist in meeting debt service requirements for fiscal year 1983.

The first and foremost step for project development is for the City of Carlyle, Illinois to review the project as described in this study along with their financial and legal consultants, in order to assure complete and accurate information is available upon which to base a decision of whether to proceed or not. In this first phase, it will be necessary for the City of Carlyle to have an official meeting with the St. Louis District Office of the U.S. Corps of Engineers to obtain that agency's interim approval of the conceptual design as herein presented, subject to ultimate approval by that agency of a final engineering design. It is believed that this interim approval can be used in the application for FERC license and whatever arrangements become necessary for funding the project.

After interim approval is received from the Corps, it is believed that several subsequent phases can begin simultaneously. These include development of the engineering design memorandum for detail review by the Corps, preparation and application for a license for the project, contractual arrangements between the utilities involved, as well as between the City of Carlyle and the Corps, and financial arrangements can be developed in detail.

The financial arrangements should be completed as early as possible in the project in order to allow for taking contractor's proposals for equipment to be utilized in the proposed hydroelectric power plant. This is necessary because the details of the ultimately selected hydraulic equipment will have a major affect on the details of the plant design and thus must be incorporated into the detailed design to be reviewed by the U.S. Corps of Engineers.

At this time, it should also be emphasized that the preliminary permit which the City of Carlyle has received from the Federal Energy Regulatory Commission for this proposed project will expire May 1, 1980. Due to the lengthy process for reviewing and receiving such a license, this application should be prepared and filed as soon as possible. Various determinations resulting from this feasibility study can eventually be used in the license application, however, several federal, state and local agencies will need to comment on this proposed project as part of the application procedure and that is a particularly time-consuming process. The requirements that the project receive its license prior to expiration of its preliminary permit is not critical to the ultimate development of the project, but is believed to be to the project's advantage.

The conceptual design presented in this Section V can now be analyzed with respect to estimated project costs and the affect on those costs which would result from the four year development period for the project. The following project cost estimate itemizes the major components of the project with respect to quantities, unit prices and total price.

PROJECT COST ESTIMATE
CARLYLE HYDROELECTRIC PLANT

<u>DESCRIPTION</u>	<u>QUANTITY</u>	<u>UNIT</u>	<u>UNIT PRICE</u>	<u>PRICE</u>
<u>Equipment:</u>				
Hydro Tube Units (turbine, inlet valve, draft tube, blade positioner, gov., 4375 KW, 250% O.S., speed incr. oil pressure system)	2	EA	\$1,275,000.00	\$2,550,000
Shipment & Plant Equipment Installation	LS	LS	---	620,000
Intake Conduit to Building and Installation	68,500	LB.	\$.80	54,800
Overhead Crane 15T	1	LS	---	18,000
Trash Racks including Installation of Guides	2	EA	19,325.00	38,650
Headgates - 7.1 Tons Each	2	EA	20,000.00	40,000
<u>Construction:</u>				
Earth Excavation (Hauled)	4600 + 9300	CY	7.61	105,800
(Non Hauled)	9300	CY	4.20	39,100
Rock Excavation	2,500	CY	100.00	250,000
Backfill & Compaction	2,000	CY	4.00	8,000
Rip-Rap (Max. Size 2'x2'x2')	1,000	T	8.00	8,000
Rock Anchors (10" Long)	42	EA	100.00	4,200
(20" Long)	50	EA	200.00	10,000
Sheet Pile w/Tie Back Anchors (no ramp) 450' HW, 435 TW	20,000	SF	15.00	300,000
De-Watering & Connection into Existing Drainage System	LS	LS	---	50,000
<u>Concrete Placement & Removal:</u>				
Concrete (reinforcing & forms)	5,404	CY	153.77	831,000
Concrete Removal for Tunnel Installation	366	CY	400.00	146,400
Grouting Conduit	56	CY	250.00	14,000
Concrete Removal of Training Wall	321	CY	75.00	24,100
Post-Tension of Structures	LS	LS	---	50,000
Waterproofing	9,000	SF	1.25	11,250
Instrumentation for Embankment	LS	LS	---	20,000
SUB-TOTAL CONSTRUCTION COST				<u>\$5,207,300</u>

PROJECT COST ESTIMATE - CARLYLE HYDROELECTRIC PLANT (Cont'd)

Subtotal Construction Cost	\$5,207,300
Contingency 6%	<u>312,400</u>
	\$5,519,700
Performance Bond 1%	<u>55,200</u>
Estimated Plant Cost	\$5,574,900
Engineering:	\$532,000
Incl.- Corps of Engineer's Project Review (\$100,000)	
FERC License	
C of E Design Memorandum Approvals (\$20,000)	
Hydraulic Model (\$50,000)	
Computer Optimization of Turb. Select. (\$5,000)	
Structural Investigation of 2D	
Environmental Impact Statement (\$10,000)	
Resident Engineering (\$30,000)	
Legal: FERC License, FERC Annual Charge Exemption, Contracts, etc.	<u>\$50,000</u>
Subtotal for Project	<u>\$6,156,900</u>
Escalation (Project Duration - 45 Months)	\$1,288,100
Total Estimated Construction Cost	\$7,445,000
Financing Costs	<u>\$105,000</u>
TOTAL PROJECT COST	<u>\$7,550,000</u>
Cost Per Installed KW	\$863
Cost per Peak Anticipated Output	\$1,018

The Total Project Cost has been estimated to be \$7,550,000, and would result in an average cost per installed kilowatt of \$863, with power to be available on December 1, 1982.

I. HYRDAULIC PLANT PERFORMANCE

This subsection of the feasibility study attempts to take the features of the conceptual plant design and the equipment capabilities to determine the probable energy production from the proposed project. The operating conditions used for this determination will be from information which was used in Section II of this report and which was prepared by the U.S. Corps of Engineers taking the period of recorded flow information for the Kaskaskia River going back to the year 1935 and developing the resulting pool levels and flow releases which would have occurred had Carlyle Reservoir been in existence during that period. Table No. 5, entitled Pro Forma Frequency Distribution of Hydroelectric Output of Selected Conceptual Design, consists of twelve pages (one for each month of the year) and takes the available flow and gross head for that month during the period of record, to determine the net head, flow available for generation, net KW output, number of units operating, and month's generation which would have probably been experienced had the proposed project been in operation at the time of those conditions of available flow and gross head.

At the bottom of each page of Table No. 12, an average monthly KW output and KWH generation is presented. For direct comparison between months, Table No. 6, entitled 44 Year Summary of Pro Forma Hydroelectric Output of Conceptual Design, has been prepared to show the monthly

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TABLE NO. 5
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Jan.	Available Flow CFS	Gross Head Ft.	Net Head Ft.	Flow For Generation CFS	Net Output One Unit KW	Number Units Operating	Month's Generation KWH
1935	3,900	21.0	20.1	1,509	2,067	2	3,075,304
1936	400	31.0	-	-	-	-	-
1937	4,100	24.5	23.4	1,630	2,604	2	3,875,324
1938	1,000	30.0	29.6	1,832	2,018	1	1,501,444
1939	500	31.0	-	-	-	-	-
1940	200	31.5	-	-	-	-	-
1941	600	30.5	-	-	-	-	-
1942	500	31.0	-	-	-	-	-
1943	4,000	24.0	22.9	1,613	2,526	2	3,759,400
1944	400	31.0	-	-	-	-	-
1945	300	31.0	-	-	-	-	-
1946	3,900	22.0	21.0	1,544	2,216	2	3,298,230
1947	2,100	26.0	25.5	1,703	1,850	2	2,753,838
1948	1,800	27.0	26.6	1,739	1,620	2	2,411,105
1949	5,000	22.0	21.0	1,544	2,216	2	3,298,230
1950	6,500	29.0	27.7	1,773	3,354	2	4,991,398
1951	3,000	19.0	18.1	1,435	1,779	2	2,647,537
1952	3,500	18.0	17.2	1,396	1,638	2	2,438,614
1953	300	31.0	-	-	-	-	-
1954	400	31.0	-	-	-	-	-
1955	500	30.0	-	-	-	-	-
1956	200	25.5	-	-	-	-	-
1957	600	29.5	-	-	-	-	-
1958	4,000	23.0	21.9	1,579	2,368	2	3,523,899
1959	1,200	29.0	28.4	1,796	2,376	1	1,768,473
1960	1,700	27.5	26.4	1,713	3,125	1	2,325,157
1961	300	31.0	-	-	-	-	-
1962	3,600	22.5	21.5	1,561	2,291	2	3,409,252
1963	300	31.0	-	-	-	-	-
1964	400	31.0	-	-	-	-	-
1965	400	31.0	-	-	-	-	-
1966	1,400	28.5	27.7	1,773	2,788	1	2,074,431
1967							
1968	7,000	19.0	18.1	1,435	1,779	2	1,647,537
1969	900	23.0	22.6	1,604	1,392	1	1,035,942
1970	430	31.0	-	-	-	-	-
1971	1,400	26.5	25.7	1,708	2,587	1	1,924,876
1972	3,500	24.5	23.4	1,630	2,604	2	2,875,324
1973	6,200	27.5	26.3	1,727	3,096	2	4,608,103
1974	4,100	28.0	26.7	1,742	3,181	2	4,734,733
1975	5,700	15.5	14.8	1,296	1,309	2	1,948,969
1976	2,700	21.5	20.8	1,535	2,036	2	3,030,238
1977	50	29.0	-	-	-	-	-
1978	2,900	24.5	23.7	1,639	2,492	2	3,708,245
TOTAL					97,242		72,665,603
Average					2,261.4		1,639,898

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Feb.	Available Flow CFS	Gross Head Ft.	Net Head Ft.	Flow For Generation CFS	Net Output One Unit KW	Number Units Operating	Month's Generation KWH
1935	1,800	27.0	26.7	1,740	1,620	2	2,177,772
1936	1,900	26.5	26.2	1,722	1,712	2	2,301,541
1937	5,000	26.0	24.9	1,679	2,848	2	3,827,605
1938	1,800	27.0	26.6	1,739	1,620	2	2,177,772
1939	4,000	22.0	21.0	1,544	2,216	2	2,979,046
1940	300	31.0	-	-	-	-	-
1941	400	31.0	-	-	-	-	-
1942	3,800	22.0	21.0	1,544	2,216	2	2,979,004
1943	3,000	25.0	24.1	1,654	2,548	2	3,424,651
1944	300	31.0	-	-	-	-	-
1945	600	30.5	-	-	-	-	-
1946	3,500	24.0	22.9	1,613	2,526	2	3,395,587
1947	2,200	26.0	25.5	1,701	1,935	2	2,600,643
1948	1,900	26.5	26.1	1,722	1,694	2	2,277,314
1949	7,600	27.5	26.3	1,727	3,096	2	4,162,158
1950	9,000	31.0	29.6	1,833	3,708	2	4,984,092
1951	3,500	24.0	22.9	1,613	2,526	2	3,395,587
1952	4,000	23.0	21.9	1,579	2,368	2	3,182,877
1953	300	31.0	-	-	-	-	-
1954	500	30.0	-	-	-	-	-
1955	1,900	25.5	25.1	1,689	1,629	2	2,190,281
1956	200	25.5	-	-	-	-	-
1957	1,800	26.0	25.6	1,706	1,576	2	2,118,737
1958	1,600	28.0	27.0	1,750	3,134	1	2,106,636
1959	2,800	25.0	24.2	1,657	2,436	2	3,274,573
1960	2,600	24.5	23.8	1,644	2,226	2	2,991,908
1961	600	30.5	-	-	-	-	-
1962	4,200	26.0	24.8	1,679	2,847	2	3,827,604
1963	300	31.0	-	-	-	-	-
1964	400	31.0	-	-	-	-	-
1965	900	30.0	29.6	1,834	1,783	1	1,198,225
1966	2,200	26.0	25.5	1,701	1,955	2	2,628,018
1967							
1968	7,000	16.0	15.3	1,317	1,373	2	1,846,512
1969	7,700	20.5	19.6	1,491	1,993	2	2,678,785
1970	2,600	16.5	15.8	1,340	1,434	2	1,928,188
1971	1,500	27.0	26.1	1,721	2,844	1	1,911,476
1972	3,800	20.0	19.1	1,473	1,921	2	2,583,109
1973	9,000	19.5	18.6	1,454	1,851	2	2,488,599
1974	9,500	25.0	23.9	1,646	2,684	2	3,608,306
1975	5,000	17.0	16.2	1,357	1,505	2	2,022,885
1976	2,600	20.5	19.8	1,500	7,486	2	2,515,330
1977	50	30.0	-	-	-	-	-
1978	200	31.0	-	-	-	-	-
TOTAL					136,011		85,784,821
Average					2,950		1,994,996

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Mar.	Available Flow CFS	Gross Head Ft.	Net Head Ft.	Flow For Generation CFS	Net Output One Unit KW	Number Units Operating	Month's Generation KWH
1935	2,300	26.5	26.0	1,717	2,102	2	3,128,840
1936	3,900	22.0	21.0	1,545	2,217	2	3,298,230
1937	4,000	25.0	23.9	1,647	2,685	2	3,994,910
1938	4,000	24.0	22.9	1,613	2,526	2	3,759,400
1939	5,000	18.0	17.2	1,396	1,638	2	2,438,614
1940	1,000	30.0	29.6	1,832	1,996	1	1,485,471
1941	400	30.0	-	-	-	-	-
1942	4,000	24.0	22.9	1,613	2,526	2	3,759,400
1943	2,600	24.5	23.8	1,644	2,226	2	3,312,470
1944	1,000	32.0	31.6	1,892	2,131	1	1,585,822
1945	3,900	27.0	25.8	1,711	3,012	2	4,482,622
1946	3,700	21.5	20.5	1,527	2,141	2	3,186,117
1947	1,000	30.0	29.6	1,832	1,996	1	1,485,471
1948	3,000	23.5	22.6	1,602	2,389	2	3,556,078
1949	6,000	26.0	24.8	1,679	2,847	2	4,237,705
1950	8,500	30.0	28.6	1,803	3,528	2	5,249,806
1951	4,000	26.0	24.8	1,679	2,847	2	4,237,705
1952	3,500	25.0	23.9	1,646	2,684	2	3,994,910
1953	2,000	26.5	26.1	1,720	1,798	2	2,676,054
1954	500	30.0	-	-	-	-	-
1955	3,300	22.5	21.5	1,561	2,291	2	3,409,250
1956	300	29.0	-	-	-	-	-
1957	2,000	25.5	25.1	1,687	1,729	2	2,573,545
1958	2,100	25.0	24.5	1,669	1,797	2	2,674,058
1959	3,800	24.0	22.9	1,613	2,526	2	3,759,400
1960	800	30.5	30.2	1,852	1,580	1	1,175,741
1961	2,300	26.5	25.9	1,716	2,102	2	3,128,840
1962	5,000	26.0	24.8	1,679	2,847	2	4,237,705
1963	3,700	22.5	21.5	1,561	2,291	2	3,409,250
1964	1,900	26.5	26.1	1,722	1,694	2	2,521,312
1965	1,000	30.0	29.6	1,832	1,996	1	1,485,471
1966	2,100	26.0	25.5	1,703	1,850	2	2,753,838
1967							
1968	2,800	11.5	10.9	1,116	-	-	-
1969	4,500	11.0	10.5	1,091	-	-	-
1970	1,400	18.0	17.2	1,398	805	2	1,198,108
1971	2,900	22.0	21.2	1,550	2,184	2	3,250,752
1972	1,000	26.0	25.6	1,703	1,763	1	1,312,400
1973	3,000	27.5	26.6	1,738	2,898	2	4,313,483
1974	10,000	23.5	22.4	1,596	2,446	2	3,639,796
1975	7,600	16.0	15.3	1,317	1,373	2	2,044,353
1976	3,400	19.0	18.1	1,435	1,779	2	2,647,537
1977	1,600	27.5	26.5	1,733	3,015	1	2,243,402
1978	4,200	23.0	21.9	1,579	2,368	2	3,523,899
TOTAL					154,769		115,171,765
Average					3,599.27		2,678,413

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Apr.	Available Flow CFS	Gross Head Ft.	Net Head Ft.	Flow For Generation CFS	Net Output One Unit KW	Number Units Operating	Month's Generation KWH
1935	2,000	28.5	28.1	1,785	1,936	2	2,788,134
1936	200	33.5	-	-	-	-	-
1937	3,500	25.0	23.9	1,647	2,685	2	3,866,042
1938	7,000	26.5	25.3	1,695	2,928	2	4,217,711
1939	5,000	25.0	23.9	1,646	2,684	2	3,866,042
1940	500	31.5	-	-	-	-	-
1941	800	31.0	30.7	1,867	1,606	1	1,156,610
1942	4,000	24.0	22.9	1,613	2,526	2	3,638,129
1943	1,800	28.0	27.6	1,772	1,681	2	2,420,730
1944	1,200	36.0	35.4	2,004	2,930	1	2,110,246
1945	7,000	17.5	16.7	1,570	1,572	2	2,263,991
1946	200	34.5	-	-	-	-	-
1947	3,400	19.0	18.1	1,435	1,779	2	2,562,132
1948	4,800	26.5	25.3	1,695	2,928	2	4,217,711
1949	4,000	28.0	26.7	1,742	3,181	2	4,582,000
1950	7,500	26.5	25.3	1,695	2,928	2	4,217,711
1951	4,000	28.0	26.7	1,742	3,181	2	4,582,000
1952	4,000	27.0	25.8	1,711	3,012	2	4,338,022
1953	1,000	33.0	32.6	1,934	2,198	1	1,583,223
1954	400	30.0	-	-	-	-	-
1955	300	31.0	-	-	-	-	-
1956	300	30.0	-	-	-	-	-
1957	4,200	23.0	21.9	1,579	2,368	2	3,410,225
1958	500	31.0	-	-	-	-	-
1959	3,300	24.5	23.4	1,631	2,609	2	3,757,572
1960	3,200	23.5	22.5	1,597	2,452	2	3,531,897
1961	1,300	31.0	30.3	1,855	2,775	1	1,998,379
1962	4,600	25.5	24.3	1,663	2,765	2	3,982,946
1963	400	33.0	-	-	-	-	-
1964	1,800	28.0	27.6	1,772	1,681	2	2,420,730
1965	700	31.0	-	-	-	-	-
1966	800	31.5	31.2	1,882	1,614	1	1,162,346
1967							
1968	2,000	13.5	13.1	1,218	-	-	-
1969	1,800	24.5	24.1	1,656	1,484	2	2,137,562
1970	400	31.0	-	-	-	-	-
1971	500	28.5	-	-	-	-	-
1972	100	33.0	-	-	-	-	-
1973	4,800	27.0	25.8	1,711	3,012	2	4,338,022
1974	6,600	19.7	18.8	1,461	1,878	2	2,704,986
1975	3,900	18.0	17.2	1,396	1,638	2	2,359,949
1976	1,200	25.5	24.9	1,682	2,106	1	1,516,543
1977	2,800	23.5	22.7	1,605	2,308	2	3,324,622
1978	7,800	21.5	20.5	1,527	2,141	2	3,083,339
TOTAL					127,943		92,139,552
Average					2,975.41		2,142,780.27

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May	Available Flow CFS	Gross Head Ft.	Net Head Ft.	Flow For Generation CFS	Net Output One Unit KW	Number Units Operating	Month's Generation KWH
1935	4,100	25.5	24.4	1,663	2,766	2	4,115,711
1936	900	32.0	31.7	1,896	1,903	1	1,415,951
1937	4,000	24.5	23.4	1,630	2,604	2	3,875,324
1938	4,100	26.5	25.3	1,695	2,928	2	4,358,301
1939	4,000	27.0	25.8	1,711	3,012	2	4,482,622
1940	2,100	28.0	27.5	1,768	2,016	2	3,000,360
1941	600	32.5	-	-	-	-	-
1942	2,000	28.0	27.6	1,769	1,881	2	2,800,029
1943	6,200	28.0	26.7	1,742	3,181	2	4,734,733
1944	4,500	26.0	24.8	1,679	2,847	2	4,237,705
1945	4,200	16.5	25.3	1,695	2,928	2	4,358,301
1946	4,000	25.0	23.9	1,646	2,684	2	3,994,910
1947	3,900	25.0	23.9	1,646	2,684	2	3,994,910
1948	4,000	25.0	23.9	1,646	2,684	2	3,994,910
1949	2,200	30.0	29.5	1,829	2,261	2	3,365,377
1950	4,000	25.0	23.9	1,646	2,684	2	3,994,910
1951	4,000	25.0	23.9	1,646	2,684	2	3,994,910
1952	3,300	26.5	25.4	1,699	2,894	2	4,307,660
1953	1,000	33.0	32.6	1,922	2,198	1	1,635,997
1954	400	30.0	-	-	-	-	-
1955	600	31.5	-	-	-	-	-
1956	400	31.0	-	-	-	-	-
1957	5,000	27.0	25.8	1,711	3,012	2	4,482,622
1958	1,800	28.0	27.6	1,772	1,681	2	2,501,421
1959	1,000	32.0	31.6	1,892	2,131	1	1,585,822
1960	2,000	28.5	28.1	1,785	1,915	2	2,850,744
1961	3,800	27.0	25.8	1,711	3,012	2	4,482,622
1962	3,800	24.0	22.9	1,613	2,526	2	3,759,400
1963	1,900	28.5	28.1	1,787	1,804	2	2,685,156
1964	3,000	26.5	25.6	1,705	2,790	2	4,151,627
1965	800	31.5	31.2	1,882	1,622	1	1,214,586
1966	4,000	24.0	22.9	1,613	2,526	2	3,759,400
1967	2,300	14.0	13.0	1,236	-	-	-
1968	700	25.0	24.8	1,677	1,120	1	833,843
1969	3,100	24.0	23.0	1,617	2,490	2	3,705,669
1970	7,600	25.0	23.9	1,646	2,684	2	3,994,910
1971	50	30.0	-	-	-	-	-
1972	2,600	27.5	26.8	1,744	2,480	2	3,691,419
1973	5,300	27.5	26.3	1,727	3,096	2	4,608,103
1974	2,700	24.5	23.8	1,642	2,330	2	3,467,249
1975	1,900	27.0	26.6	1,738	1,726	2	2,569,491
1976	50	29.0	-	-	-	-	-
1977	2,900	23.5	22.7	1,604	2,386	2	3,551,784
1978	3,200	25.5	24.5	1,667	2,731	2	4,063,756
TOTAL					172,838		128,622,245
Average					3,928.13		2,923,232

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Jun.	Available Flow CFS	Gross Head Ft.	Net Head Ft.	Flow For Generation CFS	Net Output One Unit KW	Number Units Operating	Month's Generation KWH
1935	4,200	26.5	25.3	1,695	2,929	2	4,217,711
1936	300	33.0	-	-	-	-	-
1937	1,800	29.0	27.8	1,774	1,685	2	2,426,794
1938	3,800	25.0	23.9	1,646	2,684	2	3,866,042
1939	1,400	31.5	30.7	1,866	3,058	1	2,202,138
1940	1,000	31.0	30.6	1,862	2,086	1	1,502,089
1941	1,000	32.0	31.6	1,892	2,131	1	1,534,666
1942	3,500	24.0	22.9	1,613	2,526	2	3,638,129
1943	6,500	30.0	28.6	1,803	3,528	2	5,080,457
1944	4,200	29.5	28.2	1,788	3,439	2	4,953,584
1945	5,200	26.0	24.8	1,679	2,847	2	4,101,005
1946	4,200	25.0	23.9	1,646	2,684	2	3,866,042
1947	3,900	25.0	23.9	1,646	2,684	2	3,866,042
1948	3,000	26.5	25.6	1,705	2,790	2	4,017,704
1949	800	33.5	33.2	1,942	1,717	1	1,236,695
1950	2,800	27.0	26.2	1,724	2,637	2	3,797,932
1951	2,000	29.5	29.1	1,816	1,983	2	2,856,942
1952	1,800	30.0	28.7	1,805	3,529	1	2,541,230
1953	700	33.5	-	-	-	-	-
1954	400	30.0	-	-	-	-	-
1955	1,200	30.0	29.4	1,827	2,460	1	1,771,573
1956	800	31.5	31.2	1,882	1,614	1	1,162,346
1957	6,100	29.0	27.7	1,773	3,354	2	4,830,385
1958	2,100	27.0	26.5	1,736	1,923	2	2,769,166
1959	600	32.5	-	-	-	-	-
1960	2,700	26.0	25.3	1,693	2,427	2	3,495,521
1961	4,800	26.5	25.3	1,695	2,928	2	4,217,711
1962	2,600	26.5	25.8	1,712	2,388	2	3,439,306
1963	700	32.5	-	-	-	-	-
1964	1,000	33.0	32.6	1,922	2,222	1	1,600,247
1965	1,800	28.0	27.6	1,776	1,681	2	2,420,730
1966	2,600	27.5	26.8	1,744	2,455	2	3,535,888
1967	1,500	17.5	17.2	1,400	883	2	1,272,678
1968	3,500	12.5	11.9	1,164	-	-	-
1969	1,200	28.0	27.4	1,764	2,317	1	1,668,479
1970	3,500	27.5	26.3	1,727	3,100	2	4,464,605
1971	50	32.0	-	-	-	-	-
1972	200	33.0	-	-	-	-	-
1973	4,100	27.5	26.3	1,727	3,096	2	4,459,455
1974	2,900	31.0	30.2	1,850	3,112	2	4,481,355
1975	1,100	30.5	30.0	1,845	2,276	1	1,638,726
1976	50	29.0	-	-	-	-	-
1977	300	33.0	-	-	-	-	-
1978	2,100	29.0	28.5	1,800	2,067	2	2,977,490
TOTAL					145,708		105,910,863
Average					3,266.09		2,407,065

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Jul.	Available Flow CFS	Gross Head Ft.	Net Head Ft.	Flow For Generation CFS	Net Output One Unit KW	Number Units Operating	Month's Generation KWH
1935	3,800	23.5	22.5	1,596	2,446	2	3,639,796
1936	400	33.0	-	-	-	-	-
1937	600	32.5	-	-	-	-	-
1938	1,800	29.0	27.7	1,774	1,685	2	2,507,687
1939	600	34.0	-	-	-	-	-
1940	300	32.0	-	-	-	-	-
1941	400	33.0	-	-	-	-	-
1942	4,000	25.0	23.9	1,646	2,684	2	3,994,910
1943	5,000	28.0	26.7	1,742	3,181	2	4,734,733
1944	2,200	36.0	35.5	2,007	2,636	2	3,922,523
1945	5,200	28.0	26.7	1,742	3,181	2	4,734,733
1946	2,100	30.0	29.5	1,831	2,117	2	3,150,854
1947	3,900	26.0	24.8	1,679	2,847	2	4,237,705
1948	1,800	29.0	27.7	1,774	1,667	2	2,480,723
1949	900	33.0	32.6	1,925	1,941	1	1,444,746
1950	2,500	27.0	26.4	1,730	2,321	1	3,454,418
1951	4,000	27.0	25.8	1,711	3,012	2	4,482,622
1952	1,800	30.0	28.7	1,805	3,529	1	2,625,938
1953	800	33.5	33.2	1,942	1,717	1	1,277,918
1954	400	30.0	-	-	-	-	-
1955	1,200	30.0	29.4	1,827	2,460	1	1,771,573
1956	1,600	29.0	28.0	1,782	3,250	1	2,418,670
1957	8,100	30.5	29.1	1,819	3,618	2	5,384,775
1958	3,000	25.5	24.6	1,671	2,681	2	3,909,772
1959	200	33.5	-	-	-	-	-
1960	4,000	25.0	23.9	1,646	2,684	2	3,994,910
1961	2,200	29.0	28.5	1,798	2,162	2	3,217,562
1962	900	32.0	31.6	1,895	1,903	1	1,415,950
1963	800	32.5	32.2	1,912	1,684	1	1,253,432
1964	400	34.0	-	-	-	-	-
1965	900	31.0	30.6	1,865	1,843	1	1,371,278
1966	400	32.0	-	-	-	-	-
1967	1,600	20.0	19.6	1,497	1,077	2	1,603,984
1968	1,600	22.0	21.7	1,570	1,174	2	1,747,481
1969	2,200	25.5	25.0	1,684	1,917	2	2,852,618
1970	4,000	25.0	23.9	1,646	2,684	2	3,994,910
1971	1,900	28.5	28.1	1,787	1,804	2	2,685,156
1972	300	33.0	-	-	-	-	-
1973	4,800	26.0	24.8	1,679	2,847	2	4,237,705
1974	4,500	28.0	26.7	1,742	3,181	2	4,734,733
1975	800	31.5	31.2	1,882	1,632	1	1,214,586
1976	50	29.0	-	-	-	-	-
1977	700	32.0	-	-	-	-	-
1978	2,600	26.0	25.3	1,695	2,342	2	3,485,214
TOTAL					129,534		98,063,615
Average					2,943.95		2,228,718

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<u>Aug.</u>	<u>Available Flow CFS</u>	<u>Gross Head Ft.</u>	<u>Net Head Ft.</u>	<u>Flow For Generation CFS</u>	<u>Net Output One Unit KW</u>	<u>Number Units Operating</u>	<u>Month's Generation KWH</u>
1935	300	33.0	-	-	-	-	-
1936	500	32.0	-	-	-	-	-
1937	200	33.5	-	-	-	-	-
1938	800	32.5	32.2	1,912	1,684	1	1,253,432
1939	1,800	30.0	28.6	1,805	3,529	1	2,625,938
1940	200	32.5	-	-	-	-	-
1941	500	33.0	-	-	-	-	-
1942	3,800	24.0	22.9	1,613	2,526	2	3,759,400
1943	4,000	24.5	23.4	1,630	2,604	2	3,875,324
1944	300	35.0	-	-	-	-	-
1945	2,800	27.0	26.2	1,724	2,610	2	3,884,888
1946	2,200	28.0	27.5	1,766	2,086	2	3,104,802
1947	1,800	29.0	27.7	1,774	1,685	2	2,507,687
1948	500	33.0	-	-	-	-	-
1949	600	34.0	-	-	-	-	-
1950	300	33.0	-	-	-	-	-
1951	3,500	26.0	24.8	1,679	2,847	2	4,237,705
1952	400	34.0	-	-	-	-	-
1953	300	34.0	-	-	-	-	-
1954	400	30.0	-	-	-	-	-
1955	1,000	31.0	30.6	1,862	1,997	1	1,486,110
1956	400	32.0	-	-	-	-	-
1957	7,000	28.5	27.2	1,758	3,269	2	4,865,177
1958	4,000	24.5	23.4	1,630	2,604	2	3,875,324
1959	900	32.0	31.6	1,895	1,903	1	1,415,950
1960	2,100	29.0	28.5	1,800	2,045	2	3,044,353
1961	1,800	29.0	27.7	1,774	1,685	2	2,507,687
1962	600	33.0	-	-	-	-	-
1963	700	32.5	-	-	-	-	-
1964	400	34.0	-	-	-	-	-
1965	400	32.0	-	-	-	-	-
1966	500	32.0	-	-	-	-	-
1967	1,200	20.5	19.9	1,504	1,718	1	1,278,932
1968	800	26.5	26.2	1,725	1,386	1	1,031,697
1969	1,800	21.5	21.1	1,550	1,328	2	1,976,124
1970	400	32.5	-	-	-	-	-
1971	1,200	30.0	29.4	1,827	2,486	1	1,849,695
1972	300	33.5	-	-	-	-	-
1973	3,700	24.5	23.4	1,630	2,604	2	3,875,324
1974	4,200	25.5	24.3	1,663	2,765	2	4,115,711
1975	400	32.5	-	-	-	-	-
1976	50	29.0	-	-	-	-	-
1977	500	32.5	-	-	-	-	-
1978							
TOTAL					76,019		56,571,260
Average					1,767.88		1,315,610.69

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<u>Sep.</u>	<u>Available Flow CFS</u>	<u>Gross Head Ft.</u>	<u>Net Head Ft.</u>	<u>Flow For Generation CFS</u>	<u>Net Output One Unit KW</u>	<u>Number Units Operating</u>	<u>Month's Generation KWH</u>
1935	400	33.0	-	-	-	-	-
1936	400	32.0	-	-	-	-	-
1937	300	33.0	-	-	-	-	-
1938	200	33.5	-	-	-	-	-
1939	200	34.5	-	-	-	-	-
1940	300	32.0	-	-	-	-	-
1941	300	33.0	-	-	-	-	-
1942	100	33.0	-	-	-	-	-
1943	200	33.5	-	-	-	-	-
1944	400	33.0	-	-	-	-	-
1945	600	34.0	-	-	-	-	-
1946	200	33.5	-	-	-	-	-
1947	300	33.0	-	-	-	-	-
1948	200	33.5	-	-	-	-	-
1949	700	33.5	-	-	-	-	-
1950	900	32.0	31.6	1,895	1,903	1	1,370,274
1951	600	34.0	-	-	-	-	-
1952	400	34.0	-	-	-	-	-
1953	400	33.0	-	-	-	-	-
1954	400	29.0	-	-	-	-	-
1955	500	32.0	-	-	-	-	-
1956	500	32.0	-	-	-	-	-
1957	4,200	26.5	25.3	1,695	2,928	2	4,217,711
1958	3,000	26.5	25.6	1,705	2,790	2	4,017,704
1959	600	33.0	-	-	-	-	-
1960	200	33.5	-	-	-	-	-
1961	400	33.0	-	-	-	-	-
1962	300	33.0	-	-	-	-	-
1963	300	33.0	-	-	-	-	-
1964	400	34.0	-	-	-	-	-
1965	900	31.0	30.6	1,865	1,843	1	1,327,043
1966	500	32.0	-	-	-	-	-
1967	200	23.0	-	-	-	-	-
1968	300	25.0	-	-	-	-	-
1969	1,600	19.5	19.2	1,478	1,050	2	1,512,980
1970	100	34.0	-	-	-	-	-
1971	50	33.5	-	-	-	-	-
1972	700	32.0	-	-	-	-	-
1973	2,100	27.0	26.5	1,736	1,923	2	2,769,166
1974	4,000	23.5	22.4	1,596	2,446	2	3,522,383
1975	600	31.7	-	-	-	-	-
1976	50	29.0	-	-	-	-	-
1977	600	31.5	-	-	-	-	-
1978							
TOTAL					42,252		18,737,261
Average					982.6		435,758.25

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<u>Oct.</u>	<u>Available Flow CFS</u>	<u>Gross Head Ft.</u>	<u>Net Head Ft.</u>	<u>Flow For Generation CFS</u>	<u>Net Output One Unit KW</u>	<u>Number Units Operating</u>	<u>Month's Generation KWH</u>
1935	500	32.0	-	-	-	-	-
1936	300	32.0	-	-	-	-	-
1937	700	32.5	-	-	-	-	-
1938	300	33.0	-	-	-	-	-
1939	400	33.0	-	-	-	-	-
1940	400	31.5	-	-	-	-	-
1941	1,000	32.0	31.6	1,892	2,131	1	1,585,822
1942	200	32.5	-	-	-	-	-
1943	400	33.0	-	-	-	-	-
1944	599	33.0	-	-	-	-	-
1945	1,800	30.0	28.7	1,805	3,529	1	2,625,938
1946	300	33.0	-	-	-	-	-
1947	300	33.0	-	-	-	-	-
1948	300	33.0	-	-	-	-	-
1949	2,600	27.5	26.8	1,744	2,480	2	3,691,419
1950	500	33.0	-	-	-	-	-
1951	500	33.0	-	-	-	-	-
1952	400	33.0	-	-	-	-	-
1953	400	33.0	-	-	-	-	-
1954	300	29.0	-	-	-	-	-
1955	500	32.0	-	-	-	-	-
1956	400	32.0	-	-	-	-	-
1957	900	32.0	31.6	1,895	1,903	1	1,415,950
1958	600	32.0	-	-	-	-	-
1959	400	33.0	-	-	-	-	-
1960	200	33.5	-	-	-	-	-
1961	400	33.0	-	-	-	-	-
1962	500	33.0	-	-	-	-	-
1963	300	33.0	-	-	-	-	-
1964	400	33.0	-	-	-	-	-
1965	900	31.0	30.6	1,865	1,843	1	1,371,278
1966	400	32.0	-	-	-	-	-
1967	50	23.0	-	-	-	-	-
1968	800	21.0	20.7	1,534	1,132	1	842,564
1969	1,700	22.0	21.7	1,569	1,258	2	1,872,321
1970	200	33.0	-	-	-	-	-
1971	50	33.0	-	-	-	-	-
1972	900	31.5	31.1	1,880	1,873	1	1,393,614
1973	500	32.5	-	-	-	-	-
1974	1,800	28.5	28.1	1,787	1,711	2	2,546,578
1975	600	32.0	-	-	-	-	-
1976	50	29.0	-	-	-	-	-
1977	1,900	28.0	27.6	1,771	1,772	2	2,637,489
1978							
TOTAL					26,853		19,982,973
Average					624.48		464,720.3

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Nov.	Available Flow CFS	Gross Head Ft.	Net Head Ft.	Flow For Generation CFS	Net Output One Unit KW	Number Units Operating	Month's Generation KWH
1935	400	32.0	-	-	-	-	-
1936	1,000	32.0	31.6	1,893	2,154	1	1,551,169
1937	400	33.0	-	-	-	-	-
1938	300	33.0	-	-	-	-	-
1939	500	33.0	-	-	-	-	-
1940	400	31.0	-	-	-	-	-
1941	500	34.0	-	-	-	-	-
1942	1,900	28.5	28.1	1,787	1,804	2	2,598,538
1943	400	32.0	-	-	-	-	-
1944	500	33.0	-	-	-	-	-
1945	1,200	33.0	32.4	1,918	2,682	1	1,931,683
1946	4,000	23.0	21.9	1,579	2,368	2	3,410,225
1947	300	33.0	-	-	-	-	-
1948	2,100	28.0	27.5	1,768	2,016	2	2,903,574
1949	500	34.0	-	-	-	-	-
1950	1,500	30.0	29.1	1,817	3,139	1	2,260,133
1951	2,000	29.5	29.1	1,816	1,983	2	2,856,942
1952	500	33.0	-	-	-	-	-
1953	500	32.0	-	-	-	-	-
1954	300	29.0	-	-	-	-	-
1955	600	31.0	-	-	-	-	-
1956	1,800	28.0	27.6	1,772	1,681	2	2,420,730
1957	1,200	30.0	29.4	1,827	2,460	1	1,771,573
1958	1,200	30.0	29.4	1,827	2,460	1	1,771,573
1959	800	32.5	32.2	1,912	1,666	1	1,199,521
1960	300	32.0	-	-	-	-	-
1961	1,200	31.0	30.4	1,858	2,544	1	1,831,721
1962	700	32.5	-	-	-	-	-
1963	300	33.0	-	-	-	-	-
1964	400	33.0	-	-	-	-	-
1965	400	32.0	-	-	-	-	-
1966	700	31.5	-	-	-	-	-
1967	50	23.5	-	-	-	-	-
1968	400	21.0	-	-	-	-	-
1969	3,100	16.0	15.3	1,317	1,373	2	1,978,406
1970	50	33.5	-	-	-	-	-
1971	50	33.5	-	-	-	-	-
1972	2,600	30.0	29.3	1,824	2,684	2	3,865,082
1973	700	32.0	-	-	-	-	-
1974	1,400	30.0	29.2	1,820	2,909	1	2,094,687
1975	1,000	31.0	30.6	1,862	2,064	1	1,486,110
1976	50	29.0	-	-	-	-	-
1977	1,800	28.5	28.1	1,787	1,693	2	2,437,931
1978							
TOTAL					53,282		38,369,598
Average					1,239.11		892,316.23

CITY OF CARLYLE, ILLINOIS - MUNICIPAL ELECTRIC UTILITY

Table No. 6. 44 Year Summary of Pro Forma Hydroelectric Output of Conceptual Design

Year	January Generation KWH	February Generation KWH	March Generation KWH	April Generation KWH	May Generation KWH	June Generation KWH	July Generation KWH	August Generation KWH	September Generation KWH	October Generation KWH	November Generation KWH	December Generation KWH	Annual Total Generation KWH
1935	3,075,304	2,177,772	3,128,840	2,788,134	4,115,711	4,217,711	3,639,796	-	-	-	-	2,521,312	25,664,580
1936	-	2,301,541	3,298,230	-	1,415,951	-	-	-	-	-	1,551,169	2,411,105	10,977,996
1937	3,875,324	3,827,605	3,994,910	3,866,043	3,875,324	2,426,794	-	-	-	-	-	3,674,800	25,540,799
1938	1,501,444	2,177,772	3,759,400	4,217,711	4,358,301	3,866,042	2,507,687	1,253,432	-	-	-	2,778,563	26,420,352
1939	-	2,979,046	2,438,614	3,866,042	4,482,622	2,202,138	-	2,625,938	-	-	-	1,535,647	20,130,047
1940	-	-	1,485,471	-	3,000,360	1,502,089	-	-	-	-	-	-	5,987,920
1941	-	-	-	1,156,610	-	1,534,666	-	-	-	1,585,822	-	3,523,899	7,800,997
1942	-	2,979,004	3,759,400	3,638,129	2,800,029	3,638,129	3,994,910	3,759,400	-	-	2,598,538	3,759,400	30,926,959
1943	3,759,400	3,424,651	3,312,470	2,420,730	4,734,733	5,080,457	4,734,733	3,875,324	-	-	-	1,485,471	32,827,969
1944	-	-	1,585,822	2,110,246	4,237,705	4,953,584	3,922,523	-	-	-	-	1,175,741	17,985,621
1945	-	-	4,482,622	2,263,991	4,358,301	4,101,005	4,734,733	3,884,888	-	2,625,938	1,931,683	3,196,990	31,580,151
1946	3,298,230	3,395,587	3,186,117	-	3,994,910	3,866,042	3,150,854	3,104,802	-	-	3,410,225	3,075,304	30,482,071
1947	2,753,838	2,600,643	1,485,471	2,562,132	3,994,910	3,866,042	4,237,705	2,507,687	-	-	-	2,463,482	26,471,910
1948	2,411,105	2,277,314	3,556,078	4,217,711	3,994,910	4,017,704	2,480,723	-	-	-	2,903,574	1,617,670	27,476,789
1949	3,298,230	4,162,158	4,237,705	4,582,000	3,365,377	1,236,695	1,444,746	-	-	3,691,419	-	3,882,825	29,901,155
1950	4,991,398	4,984,092	5,249,806	4,217,711	3,994,910	3,797,932	3,454,418	-	1,370,274	-	2,260,133	3,023,538	37,344,212
1951	2,647,537	3,395,587	4,237,705	4,582,000	3,994,910	2,856,942	4,482,622	4,237,705	-	-	2,856,942	3,625,421	36,917,371
1952	2,438,614	3,182,877	3,994,910	4,338,022	4,307,660	2,541,230	2,625,938	-	-	-	-	-	23,429,251
1953	-	-	2,676,054	1,583,223	1,635,997	-	1,277,918	-	-	-	-	-	7,173,192
1954	-	-	-	-	-	-	-	-	-	-	-	-	-
1955	-	2,190,281	3,409,250	-	-	1,771,573	1,771,573	1,486,110	-	-	-	1,636,971	12,265,758
1956	-	-	-	-	-	1,162,346	2,418,670	-	-	-	2,420,730	2,676,054	8,677,800
1957	-	2,118,737	2,573,545	3,410,225	4,482,622	4,830,385	5,384,775	4,865,177	4,217,711	1,415,950	1,771,573	3,409,250	38,479,950
1958	3,523,899	2,106,636	2,674,058	-	2,501,421	2,769,166	3,989,772	3,875,324	4,017,704	-	1,771,573	3,510,976	30,740,529
1959	1,768,473	3,274,573	3,759,400	3,757,572	1,585,822	-	-	1,415,950	-	-	1,199,521	2,647,885	19,409,196
1960	2,325,157	2,991,908	1,175,741	3,531,897	2,850,744	3,495,521	3,994,910	3,044,353	-	-	-	1,326,606	24,756,837
1961	-	-	3,128,840	1,998,379	4,482,622	4,217,711	3,217,562	2,507,687	-	-	1,831,721	3,639,796	25,024,318
1962	3,409,252	3,827,604	4,237,705	3,982,946	3,759,400	3,439,306	1,415,950	-	-	-	-	1,535,647	25,607,810
1963	-	-	3,409,250	-	2,685,156	-	1,253,432	-	-	-	-	1,693,350	9,041,188
1964	-	-	2,521,312	2,420,730	4,151,627	1,600,247	-	-	-	-	-	-	10,693,916
1965	-	1,198,225	1,485,471	-	1,214,586	2,420,730	1,371,278	-	1,327,043	1,371,278	-	2,521,312	12,909,923
1966	2,074,431	2,628,018	2,753,838	1,162,346	3,759,400	3,535,888	-	-	-	-	-	3,298,230	19,212,151
1967	-	-	-	-	-	1,272,678	1,603,984	1,278,932	-	-	-	3,298,230	7,453,824
1968	1,647,537	1,846,512	-	-	833,843	-	1,747,481	1,031,697	-	842,564	-	-	7,949,654
1969	1,035,942	2,678,785	-	2,137,562	3,705,669	1,668,479	2,852,618	1,976,124	1,512,980	1,872,321	1,978,406	1,162,365	22,581,851
1970	-	1,928,188	1,198,108	-	3,994,910	4,464,605	3,994,910	-	-	-	-	-	15,580,721
1971	1,924,876	1,911,476	3,250,752	-	-	-	2,685,156	1,849,695	-	-	-	2,548,155	14,170,110
1972	2,875,324	2,583,109	1,312,400	-	3,691,419	-	-	-	-	1,393,614	3,865,082	4,865,177	20,586,125
1973	1,608,103	2,488,599	4,313,483	4,338,022	4,608,103	4,459,455	4,237,705	3,875,324	2,769,166	-	-	4,070,699	39,768,659
1974	4,734,733	3,608,306	3,639,796	2,704,986	3,467,249	4,481,355	4,734,733	4,115,711	3,522,383	2,546,578	2,094,687	2,755,235	42,405,752
1975	1,948,969	2,022,885	2,044,353	2,359,949	2,569,491	1,638,726	1,214,586	-	-	-	1,486,110	3,438,819	18,723,888
1976	3,030,238	2,515,330	2,647,537	1,516,543	-	-	-	-	-	-	-	-	9,709,648
1977	-	-	2,243,402	3,324,622	3,551,784	-	-	-	-	2,637,489	2,437,931	3,994,910	18,190,138
1978	3,708,245	-	3,523,899	3,083,339	4,063,756	2,977,490	3,485,214	-	-	-	-	-	20,841,943
TOTAL	72,665,603	85,784,821	115,171,765	92,139,552	128,622,245	105,910,863	98,063,615	56,571,260	18,737,261	19,982,973	38,369,598	97,780,835	929,800,391
Mo. KWH Avg.	1,689,898	1,994,996	2,678,413	2,142,780	2,923,232	2,407,065	2,228,718	1,315,610	435,758	464,720	892,316	2,273,972	21,447,380
Mo. KW Avg.	2250	2950	3600	3000	3900	3350	2950	1750	600	624	1200	3050	2450

CITY OF CARLYLE, ILLINOIS - MUNICIPAL ELECTRIC UTILITY

PRO FORMA FREQUENCY DISTRIBUTION OF
HYDROELECTRIC OUTPUT OF SELECTED CONCEPTUAL DESIGN

TABLE NO. 5
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<u>Dec.</u>	<u>Available Flow CFS</u>	<u>Gross Head Ft.</u>	<u>Net Head Ft.</u>	<u>Flow For Generation CFS</u>	<u>Net Output One Unit KW</u>	<u>Number Units Operating</u>	<u>Month's Generation KWH</u>
1935	1,900	26.5	26.2	1,722	1,694	2	2,521,312
1936	1,800	27.0	26.7	1,740	1,620	2	2,411,105
1937	3,000	24.5	23.7	1,637	2,470	2	3,674,800
1938	2,000	27.5	27.1	1,753	1,867	2	2,778,563
1939	1,000	31.0	30.6	1,862	2,004	1	1,535,647
1940	400	31.0	-	-	-	-	-
1941	4,000	23.0	21.9	1,579	2,368	2	3,523,899
1942	4,000	24.0	22.9	1,613	2,526	2	3,759,400
1943	1,000	30.0	29.6	1,832	1,996	1	1,485,471
1944	800	30.5	30.2	1,852	1,580	1	1,175,741
1945	2,400	26.0	25.4	1,698	2,148	2	3,196,990
1946	3,800	21.0	20.0	1,509	2,066	2	3,075,304
1947	1,700	28.5	27.4	1,762	3,311	1	2,463,482
1948	1,900	27.5	27.1	1,755	1,759	2	1,617,670
1949	3,300	24.5	23.4	1,631	2,609	2	3,882,825
1950	2,200	27.0	26.5	1,734	2,031	2	3,023,538
1951	2,800	25.0	24.2	1,657	2,436	2	3,625,421
1952	700	30.5	-	-	-	-	-
1953	600	31.0	-	-	-	-	-
1954	300	29.0	-	-	-	-	-
1955	1,100	29.5	29.0	1,814	2,200	1	1,636,971
1956	2,000	26.5	26.1	1,720	1,798	2	2,676,054
1957	3,300	22.5	21.5	1,561	2,291	2	3,409,250
1958	2,800	24.0	23.2	1,623	2,359	2	3,510,976
1959	2,000	26.5	26.1	1,720	1,779	2	2,647,885
1960	900	30.0	29.6	1,834	1,783	1	1,326,606
1961	3,300	23.5	22.4	1,596	2,446	2	3,639,796
1962	1,000	31.0	30.6	1,862	2,064	1	1,535,647
1963	1,100	30.5	30.0	1,845	2,276	1	1,693,350
1964	700	31.5	-	-	-	-	-
1965	1,900	26.5	26.1	1,722	1,694	2	2,521,312
1966	4,000	22.0	21.0	1,544	2,216	2	3,298,230
1967	3,700	22.0	21.0	1,544	2,216	2	3,298,230
1968	500	21.0	-	-	-	-	-
1969	1,200	18.5	17.9	1,426	1,562	1	1,162,365
1970	700	31.5	-	-	-	-	-
1971	1,600	30.5	29.5	1,829	3,424	1	2,548,155
1972	3,600	28.5	27.2	1,758	3,269	2	4,865,177
1973	3,000	26.0	25.1	1,688	2,735	2	4,070,699
1974	3,300	19.5	18.6	1,454	1,851	2	2,755,235
1975	2,900	23.0	22.2	1,586	2,311	2	3,438,819
1976	50	29.0	-	-	-	-	-
1977	3,500	25.0	23.9	1,646	2,684	2	3,994,910
1978							
Total					132,686		97,780,835
Average					3,085.7		2,273,972

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generation over the entire 44 year period of recorded data. Table No. 6 specifically shows that an average annual production of 21,447,000 kilowatt hours could have been expected over the past 44 years. It is believed that a similar production can be experienced by this proposed facility in the future. In fact, it is believed that a production in excess of this can even be expected, since this table is missing five months of data in 1967 and five months of data in 1978. Table No. 6 also has the advantage, in that it represents the fluctuations in the annual production from the proposed project. For example, for the period 1953 through 1957 the proposed project would have failed to produce even the average production. Not only are there fluctuations in the proposed project's output from year to year, there are also fluctuations from month to month. Figure No. 11, entitled Corrolation of Hydroelectric Output Fluctuations to Carlyle's Load Range, indicates that the average output from the proposed project ranges from a high in May to a low in October.

During this feasibility study, it became necessary to correlate the fluctuations in the proposed project's output to the fluctuations which are experienced in the electric loads on both the Carlyle Municipal Electric Utility and the Breese Municipal Electric Utility. Figure No. 12 consists of another twelve pages (one for each month of the year), showing the monthly electric load durations for the Carlyle utility as well as for Carlyle and Breese combined. From these figures, it is apparent how much energy would be available for which utility during that month of the year. For example, during April, 1978, the proposed project would have produced sufficient power to meet the entire

MONTHLY LOAD DURATION
FEBRUARY 1978

V-106
KW x 1000

Figure No. 12
Page 2 of 12

MONTHLY LOAD DURATION
APRIL 1978

V-108
KW x 1000

Figure 4
Page 4 of 12
No. 12

0 100 200 300 400 500 600 700
HOURS

BREESE AND CARLYLE (ESTIMATED)

CARLYLE

3000
HYDRO

0 100 200 300 400 500 600 700
HOURS

MONTHLY LOAD DURATION
JUNE 1978

0001 x kW
V-1110

Figure No. 12
Page 6 of 12

MONTHLY LOAD DURATION
JULY 1978

0000 KW x 1000
V-1111

Figure No. 12
Page 7 of 12

MONTHLY LOAD DURATION
AUGUST 1978

0001 x MW-112

Figure No. 12
Page 8 of 12

MONTHLY LOAD DURATION
SEPTEMBER 1978

0001 x MW V-113

Figure No. 12
Page 9 of 12

MONTHLY LOAD DURATION
OCTOBER 1978

V-114

Figure No. 12
Page 10 of 12

MONTHLY LOAD DURATION
NOVEMBER 1978

0001 x KW
V-1115

Figure No. 12
Page 11 of 12

MONTHLY LOAD DURATION
DECEMBER 1978

0001 x MW
V-116

BREESE AND CARLYLE (ESTIMATED)

3050
HYDRO

CARLYLE

0 100 200 300 400 500 600 700
HOURS

load requirements for the Carlyle Municipal Electric Utility, as well as transmitt up to a maximum of 1300 kilowatts of hydro power to the Breese Municipal Electric Utility. Similarly, a maximum of approximately 1200 kilowatts could have also been transmitted to Illinois Power Company in April, 1978.

The information as graphically represented on Figure No. 12, was projected for the period 1980 through 1990, and those projections were the basis for the distribution of energy from the proposed hydroelectric facility which were used in developing Table No. 10 in Section VII, which discusses the project's feasibility. Correlating these load fluctuations with the proposed project's output fluctuations yielded for the fiscal year ended April 30, 1985, approximately 18,466,600 kilowatt hours of hydroelectric generation could be used by Carlyle, approximately 2,284,831 kilowatt hours of hydroelectric generation could be used by Breese and approximately 748,565 kilowatt hours of hydroelectric generation could be used by the Illinois Power Company. Again, it must be emphasized, that for the purposes for this study, averages have been used and, that during the project's development, certain provisions should probably be made to take into consideration periods of high and low output from the proposed project.

SECTION VI - PRELIMINARY ENVIRONMENTAL ASSESSMENT

The location and general description for Carlyle Reservoir was provided in earlier sections of the report and specific data regarding areas of pool storage, elevation, structure description and operation are summarized in Appendix A. The following section is intended to review the project as conceptually designed in relationship to the impact it would have on the environment of Carlyle Reservoir during construction and operation of this proposed facility.

A. PROJECT DESCRIPTION

Section V described in detail the site and layout for the proposed hydroelectric power plant to be reviewed at this time for possible environmental impacts. Summarizing, that facility will be located immediately west of and adjacent to the present spillway structure with penstocks bored through the existing non-overflow dam identified as monolith 2D. This site was selected out of three possible sites on the dam. The other two possibilities were in the embankment and in an existing tainter gate. Another design selection made was to utilize horizontal shaft, axial flow hydraulic flow equipment in this facility. This proposed facility will generally have its greatest output in the month of March, April and May and its least output during August, September, October and November. It is very possible that during the months of low flow, this facility will not be able to operate. These conditions of operation are dictated by the St. Louis District Office of the U. S. Corps of Engineers and their Reservoir Regulation Plan VII. This project is not proposing to modify that reservoir regulation to provide for project power storage.

B. GENERAL DESCRIPTION OF PROJECT'S ENVIRONMENTAL SETTING

Carlyle Reservoir has a normal pool elevation of 445.0 ft. MSL. At that elevation its flat water surface area is approximately 26,000 acres. This quantity of water in southern Illinois has become an attraction for considerable recreation. Public access areas have been developed by both the Corps of Engineers and the Illinois Department of Conservation. These areas presently total approximately 3,300 acres. Some of the recreational opportunities include sites for picnicing, camping, swimming, comfort stations, boat launching, car and boat trailer parking, boat docks, sales and service areas, organized game units, nature study areas and casual game areas.

The lake has a distinctive characteristic in that it is divided approximately in the middle by a line of the Burlington Northern Railroad. The area which is north of this railroad is approximately 16,000 acres and is under intensive wildlife management by the Illinois Department of Conservation. North of this railroad, the vegetation was not removed during construction of the reservoir in order to provide for an improved wildlife habitat. At this time, the reader is referred to the publication prepared by the St. Louis District Office of the U.S. Corps of Engineers entitled Environmental Statement for Carlyle Lake, Illinois. On pages 8-20, this document provides considerable description of the environmental setting for Carlyle Reservoir. For the reader's convenience, those pages have been reproduced and included in this report as Appendix X. Such topics which are specifically discussed include the area's geology, mineral resources, climate, hydrological elements, biological elements, cultural elements, and the reservoir in relation with other projects in the Kaskaskia Watershed. This description will be incorporated by

reference only, in that the environmental setting which will be directly affected by this proposed project is believed to consist of that area described earlier as west of and immediately adjacent to the spillway channel. In other words, because the operation of the plant will follow Regulation Plan VII, the plant's operation will have no greater impact on the environmental setting for the reservoir than is presently being experienced as a result of reservoir operation.

C. PROBABLE ENVIRONMENTAL IMPACT

The development of hydroelectric generation at Carlyle Reservoir will reduce the requirement for coal-fired generation which is presently being purchased by the Carlyle Municipal Electric System from the Illinois Power Company. There should be no significant improvement in ambient air quality, however, due to the small scale which this project represents in comparison to the coal-fired generation for the area. The present ambient air monitoring for Air Quality Control Region 70 which covers Clinton County and Carlyle, Illinois is primarily in the major metropolitan St. Louis area. Since there is not any monitoring conducted immediately in the area of the proposed project, the ambient air quality is not specifically known. It is believed, however, to be below the primary standard with respect to total suspended particulates, sulfur dioxide, nitrogen dioxide, ozone and carbon monoxide.

This project's impact on public facilities, primarily recreational facilities, in the proposed project area is believed to be identical to that impact already being experienced as a result of reservoir regulation. This, again, is assured by the fact that the project's operation is to comply with the Reservoir Regulation Plan VII.

The operation of this proposed facility should not effect the present water quality of the reservoir or the lower Kaskaskia River in any manner, other than the present effect resulting from regulation of Carlyle Reservoir. During construction, on the other hand, precautions will be made in order to avoid sedimentation or run-off during that period. Excavated material will be placed at approximate elevation 435 south of the present dam embankment and west of the spillway channel. This elevation is above normal high water which is at elevation 427 ft. MSL. Cofferdams will be constructed and braced on the upstream side of the spillway as well as downstream during construction of inlets and tailrace, respectively. The design developed in Section V has taken several precautions to avoid any erosion of downstream features which could also result in the loss of water quality.

The noise level in the vicinity of the spillway is believed to be within the standards established by the Illinois Pollution Control Board, however, with operation of a hydroelectric power plant for a considerable time of the year, this present noise would even be reduced. This is because the proposed facility would be releasing that water in a submerged condition through turbines, rather than over the present ogee crest of the spillway. Plant noise from the facility is very nominal and should certainly not be heard outside the limits of the plant structure. Operation for the hydraulic turbines is intended to be below the limit at which cavitation would result in considerable noise and vibration. A safe elevation at this time has been selected at 418.5 ft. MSL for preliminary development of the conceptual design. Detail design should confirm the actual turbine centerline elevation. Noise during

construction, on the other hand, could result from earth-moving equipment, drilling equipment, blasting for rock and concrete removal or other phases of construction. Due to the temporary nature of this type of noise, it is felt that this condition will also prove to be environmentally tolerable.

Preliminary conferences with the Illinois Department of Conservation have presented at least two questions regarding the operation of this proposed facility which would have an impact on the biological environment. First of which is whether or not the project will impinge fish on any of its inlet structures. As proposed in Section V, the inlet trash racks are constructed of half-inch bars spaced three inches on centers at a distance of approximately 12 feet from the penstock inlets. At this point, the water velocity is believed to be less than 6-1/2 ft. per second at maximum plant operation. It is believed that most adult fish in Carlyle Reservoir can reach escape speeds exceeding that velocity for brief periods of time. It is believed that fish which are not able to escape impingement would pass through the turbine or at least at no greater rate of loss than is presently being experienced by releases through tainter gates. The reference for this observation is Chapter 25, Fisheries Handbook of Engineering Requirements and Biological Criteria, U.S. Corps of Engineers, Portland, Oregon, February 1973. The second inquiry posed by the Illinois Department of Conservation was whether or not the project would draw oxygen off the surface of the pool to create a fish kill. Referring to the conceptual design developed in Section V, the passage of the water through the inlet of the proposed facility can be described as initially entering a rectangular basin

before entering the two 12-1/2 ft. inside diameter bell mouth inlets to the penstocks. The water first passes over the existing approach wall of the spillway channel which is at elevation 435.0 ft. MSL. Since the pool elevation will be a minimum of 443 ft. MSL, this gives a water depth over this approach wall of at least 8 ft. With this minimum depth over the approach wall and an invert elevation for the penstocks of approximately 423.0 ft. MSL, the submergence is believed to be sufficient to minimize oxygen removal from the surface of the reservoir and thus avoid significant impacts on aquatic life.

In summary, the condition of fish impingement under the proposed facility is very similar to that condition under which the present tainter gates are operated and thus an additional impact is not anticipated in this regard. Concerning the prospect of oxygen draw-off, this project will remove water from a higher elevation than the present tainter gate operation but should not pose a significant adverse impact on present aquatic life.

The site for the project, as presently proposed next to the existing spillway, is one which should not effect any possible archeological site. This is an area which has already been disturbed during the construction of the reservoir and thus does not require further survey. Downstream of the proposed site is located the General Dean Suspension Bridge, which is listed on the National Register of Historic Places. This historic structure should not be affected in any way by the proposed facility, in that the project does not propose any modification of the existing river channel in the vicinity of that structure. A minimum amount of channel modification will be required in order to tie the

tailrace of the proposed facility into the exit channel from the existing spillway structure. This modification will be approximately 3,000 ft. from the General Dean Bridge. Similarly, there should not be any adverse impact on architectural plans for the area (of which there are none believed to be in existence) since the majority of the proposed facility will be located below nominal ground level at 435 ft. MSL. Appendix N developing the conceptual plant design shows the top of the powerhouse structure at elevation 440 ft. MSL with respect to the site's topography.

The project, as presently proposed, should not have any adverse impact on the following socio-economic factors.

1. Population.
2. Migration Trends - People Relocations.
3. Population Distribution.
4. Economic Patterns.
5. Employment or Occupational Distribution.
6. Income Levels.
7. Land Values.
8. Tax Levels.
9. Housing Types or Occupancy.
10. Health Services.
11. Social Services.
12. Educational Services.
13. Transportation Services.
14. Alignment of Railroads or Highways.
15. Lifestyles or Attitudes.
16. Community Cohesion.
17. Religious Patterns.
18. No Disruptions of Unique Areas Such as Cemeteries.

There will be a change in two socio-economic factors. Those are conservation of natural resources, specifically fossil fuels used in generating electricity and reservoir operation will be enhanced to include the production of electric energy. During construction, the proposed project would have a temporary effect on employment in the area, however this effect should probably be considered as favorable, while the proposed project would have an unfavorable impact during

construction on the recreational area located on the west side of the exit channel from the spillway. It is pointed out again, however, that this is temporary and that access will remain to the recreational area which is on the east side of the present exit channel from the spillway.

In the vicinity of the tailrace of the proposed project, the Illinois Department of Transportation is planning on constructing Federal Access Primary (FAP) Route 409 with a centerline alignment which will be parallel to and 401 ft. south of the axis of the embankment for the dam. Depending on the final design of both the proposed power plant and the proposed highway, there may be some interference between the tailrace of the plant and the bridge structure over the spillway exit channel. This interference is not expected to be significant to the point that an adverse impact will result on either of the two proposed projects. Appendix Y in the back of this report is a status report on Highway 409 indicating that final plans for this section of highway near Carlyle Reservoir have not been completed, or even funded, although the project has been authorized by the State of Illinois. Work has already begun on sections of the highway east of Carlyle, Illinois near Lebanon, Illinois.

D. ALTERNATIVE TO PROJECT

Since this project is not intended to increase the capacity of the Carlyle Municipal Electric System, but rather to take advantage of available water power, there is only one alternate to the proposed project. This alternate would be to not construct the facility at all. The impacts on the environment which result from the present reservoir regulation are almost identical to the impacts which are believed to

result from operation of a hydroelectric power plant on the reservoir. Therefore, the alternate of not constructing the project in order to avoid any adverse environmental impact which would result from the proposed facility would probably not be a valid concern. A favorable impact, on the other hand, could possibly result from implementing the project by fixing energy costs and taking advantage of a renewable power supply as well as off-setting cost escalations and supply reductions in fossil fuel reserves presently being used for generating electricity.

E. SUMMARY OF PRELIMINARY ENVIRONMENTAL ASSESSMENT

In summary, this preliminary project review indicates that there is no probable adverse impact which would result from implementation of this proposed hydroelectric power plant. This contention is based on the facts as follows:

1. The project is to be constructed on a site which has already been disturbed during construction of the present spillway structure.
2. The proposed project will operate under present conditions of reservoir regulation.
3. The project will not substantially degrade the environment in any manner.
4. The proposed project should enhance both the short-term uses of man's environment as well as the long-term productivity resulting from conserved natural resources.

This assessment of the impact resulting from this proposed facility has been developed on a preliminary basis and is not intended to be a comprehensive review of all possible impacts. In any preliminary assessment, it is conceded that as various special interests are contacted regarding the proposed facilities, certain specifics will be presented requiring further attention. At this time, however, there does not

appear to be any restrictions on an environmental plane which could not be solvable and thus prevent development of the proposed project.

SECTION VII - ECONOMIC FEASIBILITY

A. OPERATION AND MAINTENANCE COST

The hydroelectric power plant as outlined in Section V of this report, will integrate into the existing Carlyle Municipal Electric Utility without a noticable affect on procedures for day-to-day operation of the utility and specifically their municipal power plant. The Carlyle System presently purchases the majority of their energy requirements and uses its own generation for covering periods of peak loading conditions. With the availability of supplemental hydroelectric energy, the Carlyle system requirements would be met first by utilizing as much hydroelectric energy as possible, then by purchasing a block of firm power and finally by utilizing the power plant's internal combustion engines to carry those peak loads which will not be served by either the hydroelectric facility or the firm capacity purchases.

A projection has been made to determine the future costs of fuel and purchased power which can reasonably be expected by the Carlyle Municipal Electric Utility. Table No. 4 found in Section III of this report, has been prepared using six (6) years of historic data on the Carlyle, Illinois Municipal Electric Utility. For the fiscal year ending April 30, 1974 through 1979, the generating costs and purchased power costs are reflected on Table No. 4. A review of these costs indicates trends which are escalating at a rate which is believed to be exaggerated because of the national situation regarding supplies of fuel oil and natural gas and their respective pricing levels. Summarizing that table, it appears that Carlyle's generating costs over the past five years have escalated approximately 16.6% compared to an annual

increase of 9.3% in purchased power costs. These combined costs result in an increase in average fuel and purchased power costs of 14.8% since the beginning of fiscal year 1975. It is believed that these escalation rates will not be maintained in the future, and thus for the projected period shown on Table No. 4 from 1980 to 1990, the generating costs are projected at an 8% per year increase and the purchased power costs are projected at an annual increase of 6%. The combination of these two costs results in an overall annual increase in fuel and purchased power cost of 6.4%.

A similar determination to that for the fuel and purchased power costs has been made for all operating expenses of the Carlyle Municipal Electric Utility. Table No. 7, entitled Projected Utility Performance Based On Present Operating Conditions, attempts to determine the future operating expenses by observing the trends in annual increases experienced from the period 1974 to 1979. Specifically, the historic information for total operating income for the utility shows an annual increase averaging 14.7% compared to an annual increase of 20% in operating expenses. Again, these are trends which are believed to be exaggerated as a result of conditions which were beyond the control of the utility. While operating expenses are not expected to go down, these exorbitant increases are not expected to continue. For the projected period of 1980 to 1990, the total operating income is projected to increase approximately 4.2% per year, compared to an annual increase of 5% per year in total operating expenses.

The incorporation of supplemental hydroelectric generation into the operation of the Carlyle Municipal Electric Utility has been summarized

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TABLE NO. 7. PROJECTED UTILITY PERFORMANCE BASED ON PRESENT OPERATING CONDITIONS (1)

Fiscal Year Ending April 30	Electric Energy Sales KWH	Total Operating Income (3,4)	Purchased Power (3,5)	Fuel	Salaries & Wages	Materials and Supplies	Repairs and Maint.	Public Utility Tax	Insurance	Employee Retire.	Prof. Services	Utility & Misc.	Total Operating Expenses	Net Operating Income
1974	21,331,400	\$484,693	\$ 7,987	\$142,551	\$ 87,233	\$12,006	\$ 2,957	\$21,654	\$17,553	\$15,435	\$11,759	\$2,280	\$321,415	\$159,108
1975	19,943,580	605,405	43,843	235,265	113,379	10,300	5,870	23,850	11,781	19,030	19,708	3,235	486,261	111,659
1976	21,107,800	722,630	237,440	66,775	122,009	40,071	60,752	32,997	23,233	21,292	8,254	1,906	614,730	101,651
1977	21,586,000	777,792	350,059	56,246	133,485	29,357	12,218	34,568	27,887	23,202	4,642	2,737	674,401	99,297
1978	23,242,000	1,058,244	442,862	138,386	149,266	25,482	10,709	50,018	23,310	25,315	6,577	4,257	876,182	173,259
1979 (2)	23,250,000	1,051,211	482,600	81,523	165,000	30,000	12,000	47,000	26,000	27,500	5,000	3,500	880,123	171,088
PROJECTED:														
1980	24,589,074	1,149,900	525,444	103,569	178,900	34,700	13,900	51,400	26,000	30,400	5,400	3,700	973,413	176,487
1981	25,600,508	1,250,500	579,237	116,539	193,400	38,000	14,500	55,900	26,500	32,900	5,700	4,000	1,066,676	183,824
1982	26,653,546	1,360,400	641,034	130,832	207,800	41,400	15,100	60,800	27,000	35,300	6,100	4,300	1,169,666	190,734
1983	27,749,899	1,476,700	706,934	147,452	222,200	44,700	15,734	66,000	27,500	37,800	6,500	4,600	1,279,420	197,280
1984	28,891,349	1,601,400	779,593	165,686	236,600	48,100	16,400	71,500	28,000	40,200	7,000	4,900	1,397,979	203,421
1985	30,079,750	1,732,500	859,553	186,145	251,000	51,400	17,100	77,400	28,500	42,700	7,500	5,300	1,526,598	205,902
1986	31,317,035	1,883,100	950,021	209,530	265,300	54,700	17,800	84,100	29,000	45,100	8,000	5,600	1,669,151	213,949
1987	32,605,214	2,039,300	1,046,477	235,579	279,700	58,000	18,500	91,100	29,500	47,500	8,600	6,000	1,820,956	218,344
1988	33,946,379	2,210,400	1,154,951	264,517	294,100	61,400	19,200	98,800	30,000	50,000	9,200	6,500	1,991,668	218,732
1989	35,342,712	2,398,900	1,276,501	297,727	308,400	64,700	20,000	107,200	30,500	52,400	9,800	6,900	2,174,128	224,772
1990	36,796,481	2,601,900	1,409,180	334,414	322,800	67,100	20,900	116,200	31,000	54,900	10,500	7,400	2,374,394	227,506

NOTES:

- (1) Information is from annual audits except where noted.
- (2) Unaudited, 3 months estimated.
- (3) Purchase power income and expenditures associated with Breese, Ill. have been excluded based on unaudited monthly bill calculations.
- (4) Does include non-operating income such as interest earned on investments and 50% of the income item marked "miscellaneous" in the Audit.
- (5) Notes of the Table of "Projected Fuel and Energy Costs Based on Present Operating Conditions" is applicable here also.

on Table No. 8, entitled Pro Forma Energy Supply Using Supplemental Hydroelectric Energy, and Table No. 9, entitled Pro Forma Utility Performance Using Supplemental Hydroelectric Energy. For ease of comparison, these tables attempt to follow the format of Tables No. 4 and No. 7 with the incorporation of hydroelectric power. It is assumed in this analysis that the proposed facility is producing at its average production determined earlier in this study. This hydroelectric energy would be first utilized by Carlyle and the excess would be used by Breese, as much as possible, and any remaining power would be utilized by the Illinois Power Company. Referring to Table No. 8, it is seen that the total fuel and purchased power costs would be reduced approximately 52% in 1980 and approximately 48.5% in 1990, with the utilization of supplemental hydroelectric energy. This table was intended to show what might be expected should the proposed facility be available in 1980. This, of course, is a hypothetical situation since the study has previously indicated that the earliest the project could be completed is approximately December of 1982. Table No. 9 incorporates those costs reflected on Table No. 8 into the projected costs anticipated for the Carlyle Electric Utility to determine the effect on Net Operating Income. It is believed that the operating expenses for salaries, materials and supplies, and repairs would be the same for the Carlyle Municipal Electric Utility when operating the proposed hydroelectric plant as would be experienced by that utility, were they operating under present conditions.

The contention that non-fuel operating expenses will not change is justified on the basis that the proposed project would not require any additional operating personnel for the Carlyle Municipal Power Plant.

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TABLE NO. 8. PRO FORMA ENERGY SUPPLY USING SUPPLEMENTAL HYDROELECTRIC ENERGY

Fiscal Yr. Ending April 30	Carlyle's Peak Load KW	System Energy Requirement KWH	Hydroelectric Generation KWH	Load On Peak From Hydro KW (2)	Purchased Power KWH	Load on Peak From IP KW (1)	Purchased Power Cost	Unit Purchased Power Cost \$/KWH	Engine Generation KWH	Peak Load On Engines KW (3)	Fuel Cost (5)	Total Fuel & Purchased Power Cost	Average Energy Cost
1980	7,387	24,589,074	17,105,900	2,800	7,420,700	4,275	\$299,500	\$.0404 (4)	62,474	1,675	\$1,624	\$301,124	\$.0122
1981	7,691	25,600,508	17,369,800	2,800	8,075,700	4,275	332,500	.0412	155,008	1,785	4,356	336,856	.0132
1982	8,007	26,653,546	17,637,700	2,800	8,788,600	4,750	369,200	.0420	227,246	1,900	6,886	376,086	.0141
1983 (6)	8,336	27,749,899	17,909,800	2,800	9,564,300	4,750	409,900	.0429	275,799	2,026	9,046	418,946	.0151
1984	8,679	28,891,849	18,186,100	2,800	10,408,600	4,750	455,000	.0437	296,649	2,159	10,501	465,501	.0161
1985	9,036	30,079,750	18,466,600	2,800	11,373,100	5,250	505,200	.0444	240,050	2,300	9,170	514,370	.0171
1986	9,408	31,317,035	18,712,200	2,800	12,301,100	5,250	565,200	.0459	303,735	2,465	12,544	577,744	.0184
1987	9,795	32,605,214	18,961,100	2,800	13,304,900	5,250	632,300	.0475	339,214	2,641	15,129	647,429	.0199
1988	10,198	33,946,379	19,213,300	2,800	14,390,600	5,750	707,300	.0492	342,479	2,830	16,464	723,764	.0213
1989	10,617	35,342,712	19,468,800	2,800	15,564,900	5,750	791,300	.0508	309,012	3,033	16,069	807,369	.0228
1990	11,054	36,796,481	19,723,700	2,800	16,832,800	6,250	885,100	.0526	239,981	3,250	13,464	898,564	.0244

Notes:

- (1) Assumes a power factor of .95 at peak load on the electrical interconnection with IP
- (2) There is a reasonable possibility of producing 2800 KW of Hydro power at the time of Carlyle's Peak Load in July. This must not be assumed to be firm power, however.
- (3) This peak load is greatest on the engines when the hydro capacity is not available.
- (4) Purchased Power Costs are higher primarily because of unfavorable utilization factors.
- (5) Engine unit fuel costs are identical to those costs projected on Table No. 4 of this report.
- (6) Hydroelectric energy production from this proposed facility should not be anticipated prior to Dec. 1, 1982.

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TABLE NO. 9. PRO FORMA UTILITY PERFORMANCE USING SUPPLEMENTAL HYDROELECTRIC ENERGY

<u>Fiscal Yr. Ending April 30</u>	<u>Electric Energy Sales</u>	<u>Total Operating Income</u>	<u>Purchased Power</u>	<u>Fuel</u>	<u>Salaries & Wages</u>	<u>Materials and Supplies</u>	<u>Repairs and Maint.</u>	<u>Public Utility Tax</u>	<u>Insurance</u>	<u>Employee Retire.</u>	<u>Prof. Services</u>	<u>Utility & Misc.</u>	<u>Total Operating Expenses</u>	<u>Net Operating Income</u>
<u>PROJECTED:</u>														
1980	24,589,074	\$1,149,900	\$299,500	\$1,624	\$178,900	\$34,700	\$13,900	\$51,400	\$26,000	\$30,400	\$5,400	\$3,700	\$645,524	\$504,376
1981	25,600,508	1,250,500	332,500	4,356	193,400	38,000	14,500	55,900	26,500	32,900	5,700	4,000	707,756	542,744
1982	26,653,546	1,360,400	369,200	6,886	207,800	41,400	15,100	60,800	27,000	35,300	6,100	4,300	774,186	586,214
1983	27,749,899	1,476,700	409,900	9,046	222,200	44,700	15,734	66,000	27,500	37,800	6,500	4,600	843,980	632,720
1984	28,891,349	1,601,400	455,000	10,501	236,600	48,100	16,400	71,500	28,000	40,200	7,000	4,900	918,201	683,199
1985	30,079,750	1,732,500	505,200	9,170	251,000	51,400	17,100	77,400	28,500	42,700	7,500	5,300	995,270	737,230
1986	31,317,035	1,883,100	565,200	12,544	265,300	54,700	17,800	84,100	29,000	45,100	8,000	5,600	1,087,344	795,756
1987	32,605,214	2,039,300	632,300	15,129	279,700	58,000	18,500	91,100	29,500	47,500	8,600	6,000	1,186,329	852,971
1988	33,946,379	2,210,400	707,300	16,464	294,100	61,400	19,200	98,800	30,000	50,000	9,200	6,500	1,295,964	914,436
1989	35,342,712	2,398,900	791,300	16,069	308,400	64,700	20,000	107,200	30,500	52,400	9,800	6,900	1,407,269	991,631
1990	36,796,481	2,601,900	885,100	13,464	322,800	67,100	20,900	116,200	31,000	54,900	10,500	7,400	1,529,364	1,072,536

The materials and supplies which would have been consumed for engine generation under present conditions are still believed to be required expenditures for the proposed hydroelectric power plant although they will be expenditures for different purposes. Summarizing Table No. 9, the use of supplemental hydroelectric energy between 1980 and 1990 could conceivably allow the Carlyle Municipal Electric Utility to reduce their total operating expenses between 34 and 36%.

B. DEBT SERVICE

Section V of this report developed a project cost of approximately \$7,550,000. Appendix Z of this report indicates that the outstanding debt requirements for the Carlyle Municipal Electric Utility as of May 1, 1978 was \$1,135,000. During the study of this proposed project, it was learned, from bond consultants for the Carlyle Municipal Electric Utility on previous issues, that because of the magnitude of the project costs, parity bonds could probably not be issued, and thus the proposed project would have to refund the outstanding debt. Other provisions were suggested by the bond consultants for the City in order to assure payment of interest during low production years of the project resulting from lack of water. For the purposes of this study, it will be assumed that the project will produce at its average level, and that no provisions will be made for meeting interest requirements during low production years. This assumption is believed warranted, in that some type of reserve fund or special provision should be specifically developed for this project, and correlated with the debt service schedule which would eventually be required. To avoid possible default, this aspect should be looked at very carefully.

For the purposes of this study, bond consultants for the City of Carlyle advised that a 35 year serial maturity bond issue should be used for preliminary study purposes. The recommendation of a 35 year maturity made by the City's bond consultant is believed necessary to improve the saleability of this bond issue, even though the expected project life is believed to be 50 years. Another assumption made for the purposes of preliminary study, is that the interest rate for this issue would be 7.5%.

The proposed project should experience revenue from surplus hydroelectric energy sales to either the Breese Municipal Electric Utility or the Illinois Power Company. Table No. 10, entitled Pro Forma Statement of Funds Available for Hydroelectric Debt Service, indicates that the funds available for debt service would range from a low of \$573,000 in 1980 to \$1,140,000 in 1990. These figures were determined based on the net operating income for the Carlyle Utility determined on Table No. 9, in combination with expected revenues from Breese, Illinois and the Illinois Power Company. Table No. 10 assumes that a charge of 65% of projected fuel and purchased power costs would be an appropriate charge for supplemental hydroelectric energy and would be sufficient incentive for Breese, Illinois to take advantage of this power. Similarly for the Illinois Power Company, the proposed charges have been assumed to be at a level equivalent to the projected Cost of Power Adjustment Factor which that utility would be charging its wholesale customers under "Partial Requirements" contracts. Again, it must be emphasized on Table No. 10 that an average annual production has been assumed and that this will probably not be the actual case, since there will be years of greater production and less production in reality.

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TABLE NO. 10. PRO FORMA STATEMENT OF FUNDS AVAILABLE FOR HYDROELECTRIC DEBT SERVICE

Fiscal Yr. Ending April 30	Carlyle's Pro Forma Net Operating Income	Hydro Generation Used By Carlyle KWH (3)	Hydro Capacity On Peak For Carlyle KW	Hydro Generation Used By Breese KWH (3)	Peak Hydro To Breese KW	Proposed Unit Cost Of Hydro To Breese \$/KWH (1)	Revenues From Breese	Hydro Generation Used By IP KWH (3)	Peak Hydro To IP KW	Proposed Unit Cost Of Hydro To IP \$/KWH	Revenues From IP	Total Hydro Generation Utilized KWH	Funds Available For Debt Service
1980	\$504,376	17,105,900	2,800	3,417,944	1,900	\$.0166	\$56,738	976,156	2,500	\$.0046	\$4,490	24,500,000	\$565,604
1981	542,744	17,369,800	2,800	3,195,307	1,880	.0177	56,557	934,893	2,450	.0057	5,329	21,500,000	604,630
1982	586,214	17,637,700	2,800	2,970,689	1,860	.0189	56,146	891,611	2,350	.0070	6,241	21,500,000	648,601
1983	632,720	17,909,800	2,800	2,744,068	1,840	.0200	54,883	846,132	2,250	.0087	7,361	21,500,000	694,964
1984	683,199	18,186,100	2,800	2,515,368	1,820	.0213	53,577	798,637	2,150	.0107	8,545	21,500,000	745,321
1985	737,230	18,466,600	2,800	2,284,831	1,800	.0226	51,637	748,565	2,050	.0132	9,881	21,500,000	798,748
1986	795,756	18,712,200	2,800	2,155,272	1,790	.0241	51,942	632,528	1,950	.0150	9,488	21,500,000	857,186
1987	852,971	18,961,100	2,800	2,009,296	1,780	.0255	51,237	529,604	1,850	.0170	9,003	21,500,000	913,211
1988	914,436	19,213,300	2,800	1,860,377	1,770	.0272	50,602	426,323	1,650	.0194	8,271	21,500,000	973,309
1989	991,631	19,468,800	2,800	1,671,565	1,760	.0289	48,308	359,635	1,450	.0220	7,912	21,500,000	1,047,851
1990	1,072,536	19,723,700	2,800	1,485,190	1,750	.0308	45,744	291,110	1,250	.0250	7,278	21,500,000	1,125,558

Notes:

- (1) Proposed charges are assumed to be 65% of average fuel and purchased power costs determined in Table No. 4 - Projected Fuel and Energy Costs Based on Present Operating Conditions.
- (2) Proposed charges are assumed to be the same as the average Cost of Power Adjustment factor used in IP billings to wholesale customers under "Partial Requirements" Contracts.
- (3) Hydroelectric generation assumes an average year's water flow and maximum utilization by Carlyle first, then Breese, then Illinois Power Company.

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TABLE NO. 11
CITY OF CARLYLE, ILLINOIS - MUNICIPAL ELECTRIC UTILITY
PROPOSED CAPITAL IMPROVEMENT PAYMENT PLAN
NEW ISSUE; 35 YEAR; 7½%

\$7,550,000 Project Cost
1,095,000 Refunding
- 150,000 Less Existing Funds
\$8,495,000 TOTAL ISSUE

Fiscal Yr. Ending April 30	Carlyle Operating Funds Available For Debt Service	Project Expenditures	Remaining Amount of Issue Invested (3)	Interest Earned	Total Funds Available For Debt Service	Principal and Interest Payment For a Serial Issue	Pro Forma Annual Surplus Funds	Pro Forma Cumulative Surplus	Projected Cumulative Surplus Based On Present Oper. Cond.
1980 (1)	\$176,487	\$1,477,000	\$7,168,000	\$645,120	\$821,607	\$692,197	\$129,410	\$129,410	176,487
1981 (1)	183,824	261,400	6,906,600	621,594	805,418	692,197	113,221	242,631	360,311
1982 (1)	190,734	3,125,500	3,781,100	340,299	531,003	692,197	(161,164)	81,467	551,045
1983 (2)	573,000	3,781,100	0	0	573,000	692,197	(119,197)	(37,730)	748,325
1984	745,321	0	0	0	745,321	692,197	53,124	15,394	951,746
1985	798,748	0	0	0	798,748	692,197	106,551	121,945	1,157,648
1986	857,186	0	0	0	857,186	692,197	164,989	286,934	1,371,597
1987	913,211	0	0	0	913,211	692,197	221,014	507,948	1,589,941
1988	973,309	0	0	0	973,309	692,197	281,112	789,060	1,808,673
1989	1,047,851	0	0	0	1,047,851	692,197	355,654	1,144,714	2,033,445
1990	1,125,558	0	0	0	1,125,558	692,197	433,361	1,578,075	2,260,951
1991	1,125,558	0	0	0	1,125,558	692,197	433,361	2,011,436	2,488,457
1992	1,125,558	0	0	0	1,125,558	692,197	433,361	2,444,797	2,715,963
1993	1,125,558	0	0	0	1,125,558	692,197	433,361	2,878,158	2,943,469
1994	1,125,558	0	0	0	1,125,558	692,197	433,361	3,311,519	3,170,975
1995	1,125,558	0	0	0	1,125,558	692,197	433,361	3,744,880	3,398,481
1996	1,125,558	0	0	0	1,125,558	692,197	433,361	4,178,241	3,625,987
1997	1,125,558	0	0	0	1,125,558	692,197	433,361	4,611,602	3,853,493
1998	1,125,558	0	0	0	1,125,558	692,197	433,361	5,044,963	4,080,999
1999	1,125,558	0	0	0	1,125,558	692,197	433,361	5,478,324	4,308,505
2000	1,125,558	0	0	0	1,125,558	692,197	433,361	5,911,685	4,536,011
2001	1,125,558	0	0	0	1,125,558	692,197	433,361	6,345,046	4,763,517
2002	1,125,558	0	0	0	1,125,558	692,197	433,361	6,778,407	4,991,023
2003	1,125,558	0	0	0	1,125,558	692,197	433,361	7,211,768	5,218,529
2004	1,125,558	0	0	0	1,125,558	692,197	433,361	7,645,129	5,446,035
2005	1,125,558	0	0	0	1,125,558	692,197	433,361	8,078,490	5,673,541
2006	1,125,558	0	0	0	1,125,558	692,197	433,361	8,511,851	5,901,047
2007	1,125,558	0	0	0	1,125,558	692,197	433,361	8,945,212	6,128,553
2008	1,125,558	0	0	0	1,125,558	692,197	433,361	9,378,573	6,356,059
2009	1,125,558	0	0	0	1,125,558	692,197	433,361	9,811,934	6,583,565
2010	1,125,558	0	0	0	1,125,558	692,197	433,361	10,245,295	6,811,071
2011	1,125,558	0	0	0	1,125,558	692,197	433,361	10,678,656	7,038,577
2012	1,125,558	0	0	0	1,125,558	692,197	433,361	11,112,017	7,266,083
2013	1,125,558	0	0	0	1,125,558	692,197	433,361	11,545,378	7,493,589
2014	1,125,558	0	0	0	1,125,558	692,197	433,361	11,978,739	7,721,095

COVERAGE RATIO: $\frac{\text{Total Funds Available for Debt Service}}{\text{Total Principal and Interest}} = \frac{\$36,205,634}{\$24,226,895} = 1.49$

Notes:

- (1) Anticipated funds available for debt service under present method of operation.
- (2) Anticipated operating funds available for debt service based on placing proposed plant in operation December 1, 1982.
- (3) Bond funds invested at 9% for fiscal years 1980, 1981 and 1982.

TABLE NO. 12 SAVINGS IN NON-RENEWABLE FUELS

Fiscal Year Ending April 30	Carlyle's Reduced Fuel Oil Consumption (Gal.)	Carlyle's Reduced Power Purchases (Ton of Coal)	Breese's Reduced Fuel Oil Consumption (Gal.)	IP's Reduced Coal Consumption (Tons)	Total Reduction in Fuel Oil Consumption (Gal.)	Total Reduction in Coal Consumption (Tons)
1980	266,065	5,219	263,893	386	529,958	5,605
1981	270,904	5,295	248,785	370	519,689	5,665
1982	277,578	5,362	233,543	352	511,121	5,714
1983	286,336	5,419	218,165	335	504,501	5,754
1984	297,469	5,463	202,646	316	500,115	5,779
1985	314,373	5,476	187,003	296	501,376	5,772
1986	323,653	5,519	178,211	250	501,864	5,769
1987	335,406	5,549	168,306	209	503,712	5,758
1988	349,928	5,564	158,201	169	508,129	5,733
1989	367,549	5,562	145,388	142	512,937	5,704
1990	388,214	5,543	132,741	115	520,955	5,658
Average					510,380	5,719

The above table has been calculated from the previous determinations of energy supply for the various utilities involved, under projected present operations and also pro forma operations using supplemental hydroelectric energy. The estimates of savings in fuel oil consumption are based on engine generation at the Carlyle Power Plant as well as the Breese Power Plant at a gross heat rate of 9500 BTUs per kilowatt hour, and a heating value of 140,000 BTUs per gallon of fuel oil. Similarly, the coal consumption saved is strictly for the Illinois Power Company at a gross heat rate of 9500 BTUs per kilowatt hour, and a heating value for coal of 12,000 BTUs per pound. This table was not intended to indicate that the utilities of Carlyle and Breese will be consuming coal, but rather that the reduction in power purchases of those utilities will result in a corresponding reduction in coal consumption by the larger utility.

SECTION VIII - CONCLUSIONS

Based on the foregoing examinations and study, several conclusions have been reached concerning implementation of hydroelectric power generation on Carlyle Reservoir. These conclusions are listed as follows:

1. Carlyle Reservoir is in close proximity to the Carlyle, Illinois Municipal Power Plant. The present methods of operating the reservoir would allow for the production of electric energy without effecting the authorized functions of the reservoir and without a major modification in the present operating procedures for the Carlyle Utility. Because of this situation, it is felt that the Carlyle Municipal Electric System is the most obvious organization to construct a hydroelectric Power Plant on Carlyle Reservoir.
2. Under present methods of operation, the average unit cost for retail electric energy in Carlyle, Illinois is expected to escalate at approximately 4.2% per year from 4.7¢/KWH in 1980 to 7.1¢/KWH in 1990. These figures are believed to also be appropriate for Breese, Illinois, based on similarities in the present operations of both utilities.
3. An acceptable engineering design for generation facilities appears to be available without endangering the structural integrity of the present gated spillway and embankment. The proposed construction can be accomplished with a structural integrity at least as great as that for the existing features. An estimated project cost of approximately \$7,550,000 is anticipated.

4. The development of hydroelectric power facilities for Carlyle Reservoir should take approximately forty-five (45) months, of which, the first twenty-four (24) months are for developing an acceptable engineering design and for obtaining a Federal Energy Regulatory Commission (FERC) license.
5. The proposed project should utilize two (2) hydraulic turbines of the horizontal shaft, adjustable blade, fixed vane propeller type with an operating range of 14.5 ft. to 36.0 ft. of net head. The turbines are to be connected through speed increasing gear boxes to take advantage of reduced diameter generators. The proposed plant has a probable maximum output of 7400 KW from two (2) generators of 4375 KW nameplate each, and an average annual production of between 21,500,000 and 22,000,000 KWH based on the 44 year period of historic flow data for the Kaskaskia River.
6. The proposed facility's operation under present reservoir regulation procedures will result in a range of annual production from no production to a high of 42,000,000 KWH. The possible fluctuation in annual production over a wide range of outputs will require some type of regulation in funding procedures since regulation of reservoir storage for power generation is not anticipated.
7. Based on average production from the proposed facility and projections of present operating costs, the Carlyle Municipal Electric System would normally be expected to expend sufficient funds in future fuel costs to fund the proposed project. The

biggest problem would be the magnitude of the expenditure, in relation to the present size of the Carlyle Municipal System.

8. The proposed project should have a minimum service life of fifty (50) years, however for bond marketability, it has been recommended that debt retirement be limited to a thirty-five (35) year term, should private financing be attempted.
9. All production from the proposed project can be utilized by the already existing facilities of any or all of the following load centers; Carlyle, Illinois Municipal Electric Utility, Breese, Illinois Municipal Electric Utility and the Illinois Power Company.
10. The proposed project's impact on the environment and socio-economic factors should not vary by a significant amount from that impact already being experienced as a result of either present reservoir or present utility operation. Temporary impacts will be experienced during construction but are not expected to warrant non-implementation of the project.
11. The project as proposed is compatible with present plans for area improvements such as Highway FAP 409.
12. The Federal, state and local agencies affected by this proposed project should be contacted as soon as practical to avoid delays in obtaining their authorizations for the project, should the project be authorized.

13. Monthly averages of pool stages and flow releases have been utilized in the attached feasibility study. Computer analysis of the daily readings should be obtained to confirm these preliminary designs.

SECTION IX - RECOMMENDATIONS

We offer the following recommendations based on the attached feasibility study. These recommendations are listed as follows.

1. It is feasible for the City of Carlyle, Illinois to consider developing hydroelectric power at Carlyle Reservoir, and to try to develop the means required for this development.
2. Investigation should begin to determine provisions for meeting debt service requirement during low production years.
3. The City of Carlyle, Illinois should officially contact the District Engineer of the St. Louis District Office of the U.S. Corps of Engineers to obtain interim authorization for this project subject to ultimate development of an acceptable engineering design and subject to that agency's review and approval of that engineering design.
4. Application for license from the Federal Energy Regulatory Commission should begin as soon as possible if there is to be any hope of receiving a license prior to the expiration of Carlyle's present preliminary permit on April 30, 1980. Certain federal, state and local agencies should be advised of this project's status whether or not an application for licenses is prepared.
5. The cooperating utilities of Dreesse, Illinois and Illinois Power Company should be contacted as soon as practical so that they may be advised of the specifics of their roles in the proposed project's development and operation and the necessary contractual agreements worked out.

6. The City of Carlyle, Illinois should request a legal interpretation of Title 18 of the U.S. Code of Federal Regulations with respect to project licenses to determine whether the interim authorization mentioned in Recommendation Number 3 is suitable to meet license application requirements.

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10. U.S. Corps of Engineers, Chapter 25, Fisheries Handbook of Engineering Requirements and Biological Criteria, Portland, Oregon, February, 1973.
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14. U.S. Department of Interior, Design of Small Dams, 1960.
15. U.S. Department of Interior, Design Standard Number Six Turbines and Pumps, February 2, 1960.
16. U.S. Department of Interior, Bureau of Reclamation, Engineering Monographs No. 27, Moments and Reactions for Rectangular Plates.

APPENDIXES

Table No. 11, entitled Proposed Capital Improvement Payment Plan, takes the funds available for debt service determined from Table No. 10, and uses those funds to retire an \$8,495,000 bond issue over a 35 year, 7.5% serial maturity payment schedule. Summarizing Table No. 11, the total funds available for debt service appears to be \$36,600,000 as compared to \$24,200,000 of principal and interest payments which results in a coverage ratio of approximately 1.49. It is pointed in the early years of the project, the lack of operating income from the project has been offset by interest earned on bond issue funds. This is believed to be an allowable procedure for a period of up to three years during the construction of the project. Again, it must be emphasized that this payment plan does not take into consideration the fact that annual production will fluctuate from this project. This is a further detailed determination which will have to be made before a decision can be made as to whether the proposed project can be implemented. It is a determination which can be made while various approvals are being obtained during the proposed project's early development.

C. SAVINGS IN NON-RENEWABLE FUELS

It is believed that the feasibility of the City of Carlyle, Illinois pursuing the proposed project, is best represented by the discussion of revenue expenditures in the previous sections.

The project's contribution to the national goal of energy conservation can best be summarized in terms of reduced consumption in fossil fuels which would result from the proposed project's production offsetting that consumption. Table No. 12 summarizes those reduced consumptions, which would be expected during the period 1980 to 1990 for each of the three utilities involved in utilizing energy from this proposed project.

PERTINENT DATA SUMMARY
CARLYLE LAKE

<u>ITEM</u>	<u>UNIT</u>	
<u>DRAINAGE AREA</u>	sq.mi.	2,680
<u>INACTIVE STORAGE POOL</u>		
Elevation	m.s.l.	429.5
Area	acres	7,100
Storage	acre-feet	50,000
Storage (runoff)	inches	0.35
<u>JOINT-USE POOL</u>		
Elevation	m.s.l.	429.5-445.0
Area	acres	24,580
Storage	acre-feet	233,000
Storage (runoff)	inches	1.63
Regulated Outflow (min)	c.f.s.	50
Regulated Outflow (max)	c.f.s.	4,000
<u>FLOOD CONTROL</u>		
Elevation	m.s.l.	445.0-462.5
Area	acres	58,440
Storage	acre-feet	699,900
Storage (runoff)	inches	4.89
Regulated Outflow (min)	c.f.s.	50
Regulated Outflow (max)	c.f.s.	10,000
<u>INDUCED SURCHARGE</u>		
Elevation	m.s.l.	462.5-465.5
Area	acres	65,000
Storage	acre-feet	184,000
Storage (runoff)	inches	1.29
Outflow (max)	c.f.s.	149,000
<u>SURCHARGE POOL (TOTAL)</u>		
Elevation	m.s.l.	462.5-467.2
Area	acres	69,400
Storage	acre-feet	304,000
Storage (runoff)	inches	2.13
Outflow (max)	c.f.s.	160,000

FREEBOARD

Elevation	m.s.l.	467.2-472.0
Area	acres	111,600
Storage	acre-feet	409,000
Storage (runoff)	inches	2.71
Height	feet	4.8

STANDARD PROJECT FLOOD

Peak Inflow	c.f.s.	104,550
Peak Outflow	c.f.s.	7,000
Design Storm	inches	11.54
Runoff (includes base flow)	acre-feet	1,157,321
Runoff (includes base flow)	inches	8.10

DAM

Elevation, Top of Dam	m.s.l.	472.0
Height above Streambed	feet	67
Length of Crest	feet	6,610

SPILLWAY

Width		
Gross	feet	179
Net	feet	152
Elevation of Crest	m.s.l.	425
Tainter Gates		
Number	each	4
Size	feet	38ft.W x 39ft.H
Top elevation, Closed	m.s.l.	463.5

OUTLET STRUCTURE

Number of Sluices	each	1
Size	inches	30 and 24 diameter conduits joined by a Venturi tube and a regulating valve
Intake Invert Elevation	m.s.l.	417.0
Outlet Invert Elevation	m.s.l.	404.0

1" Runoff Equals 142,933 Acre Foot

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

PRELIMINARY PERMIT

City of Carlyle, Illinois) Project No. 2806

ORDER ISSUING PRELIMINARY PERMIT

(Issued November 16, 1978)

The City of Carlyle, Illinois, (Applicant) filed on July 22, 1977, an application for preliminary permit 1/ for the proposed Carlyle Project, FERC No. 2806. 2/ The proposed hydroelectric project would be located in the City of Carlyle, near the City of Breese, Clinton County, Illinois, on the Kaskaskia River. The project would affect navigable waters and the existing Carlyle Dam of the United States Corps of Engineers.

The proposed run-of-river Carlyle Project would consist of a powerhouse and appurtenant facilities to be constructed adjacent to the spillway channel immediately downstream of the existing Carlyle dam. The powerhouse would have either one or two generating units with a total nameplate rating of 8,000 kW.

Public notice of the filing of the application was given with March 17, 1978, as the last date for filing of protests or petitions to intervene. No protests, notices of intervention, or petitions to intervene were received.

Comments were solicited from interested Federal, State, and local agencies, and comments were received from the Department of the Interior, the Corps of Engineers, the Department of Agriculture (Forest Service), the Environmental Protection Agency, the Advisory Council on Historic Preservation, the Illinois Department of Conservation, and Clinton County, Illinois.

1/ This proceeding was commenced before the Federal Power Commission (FPC). By the joint regulation of October 1, 1977 (10 CFR 1000.1), it was transferred to the Federal Energy Regulatory Commission (FERC). The term "Commission," when used in the context of action taken prior to October 1, 1977, refers to the FPC; when used otherwise, the reference is to the FERC.

2/ Authority to act on this matter is delegated to the Director, Office of Electric Power Regulation, under section 3.5(g) of the Commission's regulations, 18 CFR 3.5(g) (as amended August 14, 1978).

DC-A-19

APPENDIX B

Project No. 2806

The Corps of Engineers (Corps) reported in its letter dated February 7, 1978, that it had no objection to the issuance of a preliminary permit. The Corps noted that the proposed power plant would affect the authorized functions of the Carlyle Lake, and Congressional approval will be required for any modification. The Corps added that it is studying the physical potential for hydroelectric power development in the Kaskaskia River Basin and that it is studying Carlyle Lake to determine the economic, engineering, and environmental feasibility of adding hydro-power to the existing Carlyle Dam. The Corps also asked that any permit clearly state that studies by the permittee would be at the permittee's risk. This, of course, is so; a license, if applied for, may or may not be granted. The Corps asked further that the permittee be required to coordinate its studies with the District Engineer, St. Louis, Missouri. This is provided for by Article 10 of the permit.

The Environmental Protection Agency (EPA) reported in its letter of February 25, 1978, that it did not object to the issuance of a preliminary permit; EPA then stated that mitigative measures would be necessary during construction of the hydroelectric facilities to prevent possible adverse impacts upon Carlyle Lake and the public water supply. EPA also expressed concern over the possible adverse impacts from anticipated flow reductions or fluctuations in the river during construction and installation of the facilities. Included in this permit are Special Articles 7 and 10 which require the Applicant to study the possible effects of the proposed project on fish and wildlife, land and land use, water quality and use, recreational resources, and cultural resources.

The other agencies which commented on this application all reported that they had no objections to the issuance of a preliminary permit.

On November 20, 1973, the Federal Power Commission issued a preliminary permit to the Cities of Breese and Carlyle, Illinois, as joint permittees to study the proposed Carlyle Project. ^{3/} Studies made under the previous permit revealed that State legislative action would be required before the two municipalities could undertake the proposed joint venture;

^{3/} Order Issuing Preliminary Permit to the Cities of Breese and Carlyle, Illinois, FPC Project No. 2728, issued November 20, 1973.

Project No. 2806

Applicant reported that the State of Illinois assembly did not complete the necessary legislation. Consequently, it was not possible for the joint permittees to complete the studies needed for an application for license. Applicant now desires to make the studies needed for filing its application for license as a single entity and not as a joint applicant with the City of Breese.

The studies which must be conducted under this permit include an assessment of the economics of the project in light of Applicant's individual financial resources and market for power. Technological and environmental matters studied during the term of the previous joint permit may require updating supplements or new studies altogether. The circumstances of this case, coupled with Applicant's previous good-faith efforts, warrant the issuance of a preliminary permit for a period of 18 months.

This preliminary permit does not authorize any construction. The preliminary permits maintains for the Permittee priority of application for license. Issuance of a preliminary permit is not a major Federal action significantly affecting the quality of the human environment. An environmental impact statement is not, therefore, required.

It is ordered that:

(A) This preliminary permit is issued to the City of Carlyle, Illinois, for Carlyle Project No. 2806 located near the City of Carlyle in Clinton County, Illinois, on the Kaskaskia River, affecting a Government dam, lands of the United States, and navigable waters, for a period of 18 months, effective as of the first day of the month in which this order is issued, subject to the terms and conditions of the Federal Power Act, which is incorporated by reference as part of this permit, and subject to the Commission's Rules and Regulations under the provisions of the Act.

(B) This permit is also subject to the terms and conditions set forth in Form P-1, entitled "Terms and Conditions of Preliminary Permit," (Revised October, 1975) which terms and conditions (designated as Articles 1 through 6) are attached to this order and made a part of it; and subject further, to the following special conditions set forth as additional articles:

Project No. 2806

Article 7. Permittee, in the interest of protecting and developing the natural resources and other environmental values of the project area shall consult with the appropriate Federal, State, and local agencies in their fields of responsibility and expertise, shall conduct its project investigations in a manner which protects the environmental integrity of the area, and shall fully explore all feasible alternatives to the project and alternative project designs which would avoid damage or destruction of natural resources and other environmental values. These resources and values include, but are not limited to, forests, land management and treatment, fish, wildlife, recreation and public use, water and air quality (waste treatment and disposal), public health and safety, archaeology, historical and cultural sites, and scenic and esthetic values. The Permittee shall initiate and conduct at its expense such studies as may be necessary to determine the impact of the construction and operation of the proposed project on these natural resources and values and any measures needed to protect and develop them or to provide for their mitigation or replacement, including alternative designs and operational measures; and shall utilize the results of such studies in the preparation of Exhibits H, R, S, V, and W to accompany any application for a license to construct and operate the project.

Article 8. The Permittee shall submit at the close of each six-month period, from the effective date of this permit, to the Regional Engineer, Federal Energy Regulatory Commission, Chicago, Illinois, and to the Director, Office of Electric Power Regulation, or to such other officer as the Commission may designate, accurate statements of the work accomplished during the period and of work contemplated under this permit for the ensuing period.

Article 9. The Permittee shall, for the purpose of assuring the cooperation required by the terms of the permit, designate a liaison officer to act for the Permittee in keeping appropriate Federal, State, and local agencies specified in Article 7 of this permit currently informed as to the progress of investigations throughout the term of the permit, and the liaison officer shall communicate with those agencies within 30 days from the date of issuance of this permit.

Article 10. Permittee shall coordinate the studies for the proposed project required by this permit with the Corps of Engineers, District Engineer, St. Louis, Missouri.

Project No. 2806

(C) This order shall become final 15 days from the date of its issuance unless a petition appealing it to the Commission is filed under section 1.7(d) of the Commission's regulations, 18 CFR 1.7(d) (as amended, August 14, 1978). Failure of the Licensee to file such a petition shall constitute acceptance of this order.

(S E A L)

William W. Lindsay
Director, Office of Electric
Power Regulation

Attachment:
P-1 Form

CHAPTER V - WATER CONTROL PLAN

5-01. SUMMARY OF PLAN

a. General Objectives.

The objective is to regulate the project to provide flood control to downstream local interests and to maintain the pool at seasonal pool elevation as set by the Schedule of Release in PLATE 28 at all times, thus providing water storage for water supply, pollution abatement, fish and wildlife conservation, recreation, and navigation on the lower Kaskaskia River.

b. Major Constraints.

The downstream channel capacity restricts non-damaging releases to 4,000 c.f.s. or less during growing season (1 May through harvest). Releases are made in excess of 4,000 c.f.s. when the pool level exceeds elevation 450. The summer pool stage frequency curve is presented as PLATE 17. Reservoir fluctuations from the period of record routings are presented in the Master Regulation Manual.

c. Overall Plan for Water Control.

(1) Growing Season. Growing season shall be considered to exist from 1 May to completion of harvest, the earliest possible date that this might occur would be in October. Beginning 1 May, the rule curve elevation is raised from the winter drawdown level of 443.0 to 445.0. If on 1 May, the pool is above elevation 445.0, ground conditions are wet from very recent rains and the rate of release is above 4,000 c.f.s., these release rates may be maintained up to 7 May. This 1-week extension of above 4,000 c.f.s. rates of release should be exercised for the sole purpose of evacuating the flood storage to provide greater protection to the agricultural interests after the crops have been planted. If on 1 May, the pool level is between 443.0 and 445.0, the rate of release should be reduced to permit the regaining of summer pool level (50 c.f.s. minimum). The rate at which releases are made during the month of May will have very little effect on peak pool stages as a result of subsequent rainfall during the following months. If rainfall occurs at a significant rate early in May, the summer level of 445.0 will be gained rapidly. The chances of gaining full summer pool level by 1 June is about 65 percent and by 1 July, 75 percent. Recreational boating, fishing, and other recreational endeavors on Carlyle Lake can function at a moderate degree of satisfaction at elevation 443.0, therefore, the date at which elevation 445.0 is gained is not critical. When runoff occurs to the extent that the pool tends to exceed elevation 445.0, downstream conditions should be checked to determine the maximum rate of release that would be non-damaging (See paragraph 4-02a(2)). The release rate would then be increased at a rate (normally not to exceed 300 c.f.s. per hour) considered appropriate for the conditions. The maximum rate of release is dependent on rate of inflow and the pool elevation in addition to downstream flows. The reason for this dependency is that the rate that releases are reduced is restricted so as

not to cause bank sloughing, yet the release rate must equal the inflow rate when the pool reaches elevation 445.0. Consult TABLE 8, the Table of Critical Releases, to determine the rate of release recommended for a given pool elevation. Releases are limited to 4,000 c.f.s. for a pool elevation not exceeding 450.0 feet m.s.l. For pool elevations exceeding 450.0 feet m.s.l., releases will be made according to the Schedule of Releases (See PLATE 28), that is, the release rate will increase as the pool level increases reaching a maximum rate of 10,000 c.f.s. at elevation 462.5 feet m.s.l.

(2) Dormant Season. The dormant season shall be considered to exist from the date that the harvest is completed (the earliest possible date occurring in October) through April. During this period, the release rate may reach the maximum of 10,000 c.f.s. independent of pool elevation. Rate of release shall match rate of inflow as nearly as possible up to 10,000 c.f.s. and be maintained at this rate until the storm inflow is depleted or the pool approaches its lower limits. TABLE 10 should be adhered to as the pool reaches its lower limits so as to obtain gate closure without causing bank sloughing. On 1 December, the rule curve elevation is lowered from 445.0 to 443.0. The rate of release to accomplish the drawdown should be in the range of 3,000 to 4,000 c.f.s. The importance of the winter drawdown has diminished considerably with the inception of the winter-dump plan, its greatest benefit now being in the ability to store spring runoff after 1 May during regaining of elevation 445.0, thus improving agricultural conditions.

d. Water Control Plan for Low Flow Regulation.

When the pool recedes below the rule curve elevation, a minimum release of 50 c.f.s. will be maintained at all times. These water quality releases must be supplemented to provide adequate water for the Kaskaskia navigation project when natural downstream flow is insufficient. The release required is a function of natural flow downstream and number of lockages. Detailed procedures for determining these releases are presented in the Kaskaskia River Navigation Project, Appendix C, Master Reservoir Regulation Manual. The regulation of the reservoir during low inflow periods requires a detailed accounting of water quality releases, navigation releases, water supply withdrawals, reservoir inflow, precipitation on reservoir surface, and evaporation from reservoir surface. The low flow accounting is accomplished by computer program on a monthly basis (a printout is presented as PLATE 29). The productivity of the joint-use storage allocations will be shared between the federal government and the State of Illinois, based on the proportionate shares in joint-use storage allocations. At no time, however, shall the water in storage in either joint-use water account exceed the allocated storage. Water in excess of the allocated storage shall be credited to the other joint-use account if available storage still exists. The proportionate shares shall be as follows for the Carlyle Lake:

Total joint-use storage (acre feet)	233,000
Federal storage (acre-feet)	200,000
Federal proportion (percent)	85.8
State of Illinois storage (acre-feet)	33,000
State of Illinois proportion (percent)	14.2

e. Water Control Plan for Surge Regulation (Pool above 462.5).

Should the pool level exceed elevation 462.5, all flood control storage will have been utilized. It will now be necessary to pass the inflow at whatever rate it may be up to the spillway capacity. Reservoir regulation curves (PLATE 13) are provided for determining release rate versus pool elevation and/or rate of inflow.

f. Standing Instructions to Reservoir Personnel.

(1) General. All regulating instructions shall be furnished by the Regulation Office (Reservoir Regulation Section, Hydrologic and Hydraulics Branch, Engineering Division). Only in the event of a disaster which renders all communication systems unusable are the reservoir personnel authorized to operate the tainter or sluice gates without specific instructions from the Regulation Office. (See EXHIBIT C for emergency contact list.) Reservoir personnel shall carry out all gate instructions issued from the Regulation Office. This may occasionally require overtime work. To assure the availability of someone to make gate changes during off-duty hours, the Regulation Office should be advised as to whom to contact at all times (an on-duty or on-call person).

(2) Routine Reporting. Reservoir personnel shall prepare, and forward to the Regulation Office for permanent storage, LMS FORM No. 89 (See EXHIBIT B1), containing that data pertinent to Carlyle Lake. They shall gather basin precipitation and local stream gage data as required (See paragraph 3-02) and shall communicate said data by telephone or radio to the Regulation Office for use in real-time regulation of Carlyle Lake.

(3) Reporting Unusual Occurrences. Unofficial reports of heavy rainfall in addition to official reports shall be reported to the Regulation Office immediately. Unexpected or unusual fluctuations of the pool level should be reported as well as any other occurrences that might affect the regulation of the reservoir. Local flooding of roads, ice or log jams, drownings, or other mishaps fall in the above category. See EXHIBIT C for emergency contact list.

(4) Emergency Regulating Instructions. In the event communications cannot be established with the Regulation Office as per paragraph 5-01f(1), reservoir personnel are authorized to regulate the gates according to the following instructions. Maintain at least 50 c.f.s. water quality release at all times. For the months May through

November, if within the flood control pool (elevation 445.0 to 462.5), refer to EXHIBIT D1 for gate setting instructions. For the months December through April, refer to EXHIBIT D2 for gate setting instructions when the pool is within the limits of 443.0 to 462.5. In the event the pool level should exceed 462.5, refer to EXHIBIT D3.

5-02. FLOOD CONTROL

a. Objectives.

The objective of flood control is to limit losses resulting from high water to a minimum. Flood protection benefits extend to that portion of the Middle Mississippi River Basin located between Chester and Cairo, Illinois, as well as the lower Kaskaskia River Basin.

b. Regulation Procedure.

Following completion of the crop harvest, through April, overtopping of the downstream low flood plains is permitted so as to provide maximum flood protection when the planting season arrives. During this time period, the inflow is passed through the reservoir up to a maximum rate of 10,000 c.f.s. After 1 May, maximum flood protection is provided to downstream agricultural interests until the pool exceeds elevation 450.0, thereafter, downstream water damages are shared on a 50-50 basis with losses occurring within the flood control pool, i.e., to recreation and lake perimeter agriculture. Releases are limited to a maximum of 5,000 c.f.s. when the pool level is below elevation 455.6 and flooding is eminent on the reach of the Mississippi River between Chester and Cairo, Illinois.

5-03. NAVIGATION

a. Objectives.

The lower 50 miles of the Kaskaskia river were canalized and shortened to 36 miles, a lock and dam was constructed at river mile 0.8. Joint use water from Carlyle Lake and Lake Shelbyville is designated for the purpose of maintaining navigation on this segment of the river during low flow periods.

b. Regulation Procedure.

Joint use water will be released from Carlyle Lake allowing appropriate travel time (See PLATE 23) to provide for the required number of lockages. Refer to Kaskaskia River Navigation Project, Appendix C, Master Reservoir Regulation Manual to determine rate of release to satisfy lockage requirements.

5-04. WATER QUALITY

a. Objectives.

Water quality releases are made to maintain the dissolved oxygen level in the downstream channel suitable for aquatic habitat.

b. Regulation Procedure.

A minimum release of 50 c.f.s. is required at all times to maintain good downstream water quality.

5-05. WATER SUPPLY

a. Objective.

The State of Illinois has contracted with the United States Government for joint use water to be utilized as water supply (see EXHIBIT E1). Water supply withdrawal up to 1,100 gallons per minute (GPM) for the City of Salem, 100 GPM for the City of Keyesport, and 180,000 (42-gallon) barrels per day averaged over a 30-day period for Texaco, Inc., shall be considered riparian water rights and shall be debited against the Federal storage. The contract with Texaco, Inc., is presented as EXHIBIT E2.

b. Regulation Procedure.

The State of Illinois shall provide a letter request to the Regulation Office for water to be taken from the State water supply account. All water taken directly from the reservoir shall be metered and a monthly accounting forwarded to the Regulation Office. The Regulation Office will maintain records of joint use storage water released through the spillway gates in addition to the metered readings.

5-06. FISH AND WILDLIFE

a. Objectives.

Enhancement of fish and wildlife is one of the goals in the regulation of the reservoir.

b. Regulation Procedures.

The Regulation Office cooperates with the Fisheries Biologist, Illinois Department of Conservation to provide optimum fish spawning conditions each spring. The pool is maintained at the summer level of 445.0 until 1 December to provide the best waterfowl habitat possible during the fall migratory season.

5-07. RECREATION

a. Objectives.

It is the goal of the Regulation Office to provide the best possible water conditions to support recreational activities such as boating, swimming, fishing, hunting, camping, etc.

b. Regulation Procedures.

The Regulation Office is required to maintaining the pool at rule curve elevation as nearly as possible at all times. At the established winter drawdown pool level of 443.0 all phases of recreation can function to a degree of satisfaction. The winter dump plan reduces significantly the high pool levels during the winter and spring that hindered recreation prior to the incorporation of this feature in the regulation plan.

ELEVATIONS WERE PROVIDED BY COURTESY OF THE U.S. CORPS OF ENGINEERS AND ARE FROM ACTUAL READINGS TAKEN APPROXIMATELY 1969.

CARLYLE DAM - CORPS OF ENGINEERS
FLOWS AND HEADS - FROM HYDROGRAPHS PRESENTED

H₁ = Pool Elevation
H₂ = Tailwater Elevation

YEAR	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
	FLOW CFS	H ₁	H ₂	FLOW CFS	H ₁	H ₂	FLOW CFS	H ₁	H ₂	FLOW CFS	H ₁	H ₂	FLOW CFS	H ₁	H ₂	FLOW CFS	H ₁	H ₂	FLOW CFS	H ₁	H ₂	FLOW CFS	H ₁	H ₂	FLOW CFS	H ₁	H ₂	FLOW CFS	H ₁	H ₂	FLOW CFS	H ₁	H ₂			
THEORETICAL																																				
1935	3900	444.0	423.0	1800	444.0	417.0	2300	445.0	418.5	2000	446.0	417.5	4100	449.0	423.5	4200	450.0	423.5	3800	446.5	423.0	300	446.0	413.0	400	446.0	413.0	500	445.0	413.0	400	445.0	413.0	1900	444.0	417.5
1936	400	444.0	413.0	1900	444.0	417.5	3900	445.0	423.0	200	446.0	412.5	900	446.0	414.0	300	446.0	413.0	400	446.0	413.0	500	445.0	413.0	400	445.0	413.0	300	445.0	413.0	1000	446.0	414.0	1800	444.0	417.0
1937	4100	448.0	423.5	5000	451.0	425.0	4000	448.0	423.0	3500	447.0	422.0	4000	447.5	423.0	1800	446.0	417.0	600	446.0	413.5	200	446.0	412.5	300	446.0	413.0	700	446.0	413.5	400	446.0	413.0	3000	445.0	420.5
1938	1000	444.0	414.0	1800	444.0	417.0	4000	447.0	423.0	7000	453.0	426.5	4100	450.0	423.5	3800	448.0	423.0	1800	446.0	417.0	800	446.0	413.5	200	446.0	412.5	300	446.0	413.0	300	446.0	413.0	2000	445.0	417.5
1939	500	444.0	413.0	4000	445.0	423.0	5000	443.0	425.0	5000	450.0	425.0	4000	450.0	423.0	1400	447.0	415.5	600	447.0	413.0	1800	447.0	417.0	200	447.0	412.5	400	446.0	413.0	500	446.0	413.0	1000	445.0	414.0
1940	200	444.0	412.5	300	444.0	413.0	1000	444.0	414.0	500	444.5	413.0	2100	446.0	418.0	1000	445.0	414.0	300	415.0	413.0	200	445.0	412.5	300	445.0	413.0	400	444.5	413.0	400	444.0	413.0	400	444.0	413.0
1941	600	444.0	413.5	400	444.0	413.0	400	443.0	413.0	800	444.5	413.5	600	446.0	413.5	1000	446.0	414.0	400	446.0	413.0	500	446.0	413.0	300	446.0	413.0	1000	446.0	414.0	500	447.0	413.0	4000	446.0	423.0
1942	500	444.0	413.0	3800	445.0	423.0	4000	447.0	423.0	4000	447.0	423.0	2000	445.5	417.5	3500	446.0	422.0	4000	448.0	423.0	3800	447.0	423.0	100	445.0	412.0	200	445.0	412.5	1900	446.0	417.5	4000	447.0	423.0
1943	4000	447.0	423.0	3000	446.0	421.0	2600	444.0	419.5	1800	445.0	417.0	6200	454.0	426.0	6500	456.0	426.0	5000	453.0	425.0	4000	448.0	423.5	200	446.0	412.5	400	446.0	413.0	400	445.0	413.0	1000	444.0	414.0
1944	400	444.0	413.0	300	444.0	413.0	1000	446.0	414.0	1200	451.0	415.0	4500	450.0	424.0	4200	453.0	423.5	2200	454.0	418.0	300	448.0	413.0	400	446.0	413.0	500	446.0	413.0	500	446.0	413.0	800	444.0	413.5
1945	300	444.0	413.0	600	444.0	413.5	3900	450.0	423.0	7000	444.0	426.5	4200	450.0	423.5	5200	451.0	425.0	5200	453.0	425.0	2800	447.0	420.0	600	447.0	413.0	1800	447.0	417.0	1200	448.0	415.0	2400	445.0	419.0
1946	3900	445.0	423.0	3500	446.0	422.0	3700	444.0	422.5	200	447.0	412.5	4000	448.0	423.0	4200	449.0	424.0	2100	448.0	418.0	2200	446.0	418.0	200	446.0	412.5	300	446.0	413.0	4000	446.0	423.0	3800	444.0	423.0
1947	2100	444.0	418.0	2200	444.0	418.0	1000	444.0	414.0	3400	417.0	422.0	3900	448.0	423.0	3900	448.0	423.0	3900	449.0	423.0	1800	446.0	417.0	300	446.0	413.0	300	446.0	413.0	300	446.0	413.0	1700	445.0	416.5
1948	1800	444.0	417.0	1900	444.0	417.5	3000	444.0	420.5	4800	451.0	424.5	4000	448.0	423.0	3000	447.0	420.5	1800	446.0	417.0	500	446.0	413.0	200	446.0	412.5	300	446.0	413.0	2100	446.0	418.0	1900	445.0	417.5
1949	5000	417.0	425.0	7600	454.0	426.5	6000	452.0	426.0	4000	451.0	423.0	2200	448.0	418.0	800	447.0	413.5	900	447.0	414.0	600	447.0	413.0	700	447.0	413.5	2600	447.0	419.5	500	447.0	413.0	3300	446.0	421.5
1950	6500	455.0	426.0	9000	458.0	427.0	8500	457.0	427.0	7500	453.0	426.5	4000	448.0	423.0	2800	447.0	420.0	2500	446.0	419.0	300	446.0	413.0	900	446.0	414.0	500	446.0	413.0	1500	446.0	416.0	2200	445.0	418.0
1951	3000	444.0	421.0	3500	446.0	422.0	4000	449.0	423.0	4000	451.0	423.0	4000	448.0	423.0	2000	447.0	417.5	4000	450.0	423.0	3500	448.0	422.0	600	447.0	413.0	500	446.0	413.0	2000	447.0	417.5	2800	445.0	420.0
1952	3500	444.0	422.0	4000	446.0	423.0	3500	447.0	422.0	4000	450.0	423.0	3300	448.0	421.5	1800	447.0	417.0	1800	447.0	417.0	400	447.0	413.0	400	447.0	413.0	400	446.0	413.0	500	446.0	413.0	700	444.0	413.5
1953	300	444.0	413.0	300	444.0	413.0	2000	444.0	417.5	1000	447.0	414.0	1000	447.0	414.0	700	447.0	413.5	800	447.0	413.5	300	447.0	413.0	400	446.0	413.0	400	446.0	413.0	500	445.0	413.0	600	444.0	413.0
1954	400	444.0	413.0	500	443.0	413.0	500	443.0	413.0	400	443.0	413.0	400	443.0	413.0	400	443.0	413.0	400	443.0	413.0	400	443.0	413.0	400	442.0	413.0	300	442.0	413.0	300	442.0	413.0	300	442.0	

CARLYLE DAM - CORPS OF ENGINEERS

FLOWS, NET EFFECTIVE HEADS AND ESTIMATED USEABLE RESERVOIR POTENTIAL ENERGY (MM-HR)

Ho: Net Head (Ft.) = $H_1 - H_2$

(No provision for plant losses or efficiencies)

YEAR	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER			TOTAL
	FLOW CFS	Ho Ft.	MW-HR	FLOW CFS	Ho Ft.	MW-HR	FLOW CFS	Ho Ft.	MW-HR	FLOW CFS	Ho Ft.	MW-HR	FLOW CFS	Ho Ft.	MW-HR	FLOW CFS	Ho Ft.	MW-HR	FLOW CFS	Ho Ft.	MW-HR	FLOW CFS	Ho Ft.	MW-HR	FLOW CFS	Ho Ft.	MW-HR	FLOW CFS	Ho Ft.	MW-HR	FLOW CFS	Ho Ft.	MW-HR				
THEORETICAL																																					
1935	3900	16.0	3,929	1800	26.0	2,661	2300	24.5	3,548	2000	27.0	3,290	4100	19.0	4,905	4200	20.5	5,246	3800	18.5	4,426	300	33.0	623	400	33.0	804	500	32.0	1,007	400	32.0	780	1900	25.5	3,050	34,269
1936	400	31.0	781	1900	25.0	2,701	3900	17.0	4,174	200	33.0	402	900	29.5	1,672	300	23.0	420	400	33.0	831	500	32.0	1,007	400	32.0	780	300	32.0	604	1000	31.5	1,919	1800	26.0	2,947	18,238
1937	4100	18.0	4,647	5000	17.5	4,976	4000	20.0	5,037	3500	21.0	4,478	4000	19.0	4,785	1800	28.0	3,071	600	32.0	1,209	200	33.0	416	300	33.0	603	700	32.0	1,410	400	33.0	804	3000	21.5	4,061	35,497
1938	1000	29.0	1,826	1800	26.0	2,661	4000	19.0	4,785	7000	18.0	7,678	4100	20.5	5,292	3800	20.0	4,631	1800	28.0	3,173	800	32.0	1,612	200	33.0	402	300	33.0	623	300	33.0	603	2000	26.0	3,274	36,560
1939	500	30.5	960	4000	16.5	3,753	5000	14.0	4,408	5000	17.0	5,179	4000	21.5	5,415	1400	30.5	2,602	600	33.5	1,266	1800	29.0	3,287	200	34.0	414	400	33.0	831	500	32.5	990	1000	30.5	1,920	31,025
1940	200	31.0	390	300	30.5	520	1000	29.5	1,857	500	32.0	975	2100	24.5	3,239	1000	29.5	1,797	300	32.0	604	200	32.0	403	300	32.0	585	400	31.0	781	400	31.0	756	400	31.0	781	12,688
1941	600	30.0	1,133	400	30.5	694	400	29.5	743	800	29.5	1,438	600	22.0	831	1000	31.5	1,919	400	32.5	819	500	32.5	1,023	300	33.0	603	1000	31.5	1,983	500	34.0	1,036	4000	20.0	5,037	17,259
1942	500	30.5	960	3800	17.0	3,674	4000	19.0	4,785	4000	19.0	4,631	2000	26.5	3,337	3500	20.0	4,265	4000	20.0	5,037	3800	19.0	4,546	100	33.0	201	200	32.0	403	1900	27.0	3,126	4000	21.0	5,289	40,254
1943	4000	19.0	4,785	3000	22.0	3,753	2600	21.0	3,438	1800	27.0	2,961	6200	19.5	7,612	6500	21.5	8,515	5000	19.5	6,139	4000	19.0	4,785	200	33.0	402	400	33.0	831	400	32.0	780	1000	29.5	1,857	45,858
1944	400	30.5	768	300	30.5	520	1000	29.5	1,857	1200	25.5	1,864	4500	19.0	5,383	4200	23.5	6,014	2200	34.5	4,779	300	35.0	661	400	33.0	804	500	33.0	1,039	500	33.0	1,005	800	30.0	1,511	26,205
1945	300	30.5	576	600	30.0	1,024	3900	22.0	5,402	7000	9.5	4,052	4200	20.5	5,421	5200	17.5	5,545	5200	19.5	6,385	2800	24.0	4,231	600	33.5	1,225	1800	29.0	3,287	1200	32.5	2,376	2400	24.0	3,627	43,151
1946	3900	17.0	4,174	3500	20.0	3,981	3700	17.0	3,960	200	35.0	427	4000	20.0	5,037	4200	19.0	4,862	2100	28.5	3,768	2200	26.0	3,601	200	33.0	402	300	33.0	623	4000	18.0	4,387	3800	16.0	3,828	39,050
1947	2100	24.5	3,239	2200	24.0	3,003	1000	29.5	1,857	3400	19.0	3,936	3900	20.0	4,911	3900	20.0	4,753	3900	21.0	5,157	1800	28.0	3,173	300	33.0	603	300	33.0	623	300	33.0	603	1700	27.5	2,944	34,802
1948	1800	26.0	2,947	1900	25.0	2,701	3000	20.5	3,872	4800	18.5	5,411	4000	20.0	5,037	3000	23.5	4,296	1800	28.0	3,173	500	32.5	1,023	200	33.0	402	300	33.0	623	2100	26.5	3,390	1900	26.0	3,110	35,985
1949	5000	13.5	4,250	7600	19.0	8,212	6000	17.5	6,611	4000	23.0	5,605	2200	28.0	3,878	800	33.0	1,609	900	32.5	1,842	600	33.5	1,266	700	33.0	1,408	2600	25.0	4,093	500	34.0	1,036	3300	20.5	4,259	44,069
1950	6500	20.5	8,390	9000	22.5	11,516	8500	21.5	11,507	7500	19.0	8,683	4000	20.0	5,037	2800	24.0	4,095	2500	25.0	3,935	300	33.0	623	900	31.5	1,727	500	33.0	1,039	1500	29.0	2,651	2200	25.0	3,463	62,666
1951	3000	20.0	3,778	3500	20.0	3,981	4000	21.0	5,289	4000	25.0	6,093	4000	20.0	5,037	2000	28.0	3,412	4000	22.0	5,541	3500	22.0	4,848	600	33.5	1,225	500	33.0	1,039	2000	28.0	3,412	2800	22.0	3,878	47,533
1952	3500	18.0	3,967	4000	17.5	3,981	3500	21.0	4,628	4000	24.0	5,849	3300	22.5	4,675	1800	29.0	3,180	1800	29.0	3,287	400	34.0	856	400	34.0	829	400	33.0	831	500	33.0	1,396	700	30.0	1,322	34,801
1953	300	30.5	576	300	30.5	520	2000	25.0	3,148	1000	32.5	1,980	1000	32.5	2,046	700	33.0	1,408	800	33.0	1,662	300	34.0	642	400	33.0	804	400	33.0	831	500	32.0	975	600	31.0	1,171	15,763
1954	400	30.5	768	500	30.5	867	500	29.5	929	400	30.0	731	400	30.0	756	400	30.0	731	400	30.0	756	400	30.0	756	400	29.0	707	300	29.0	548	300	29.0	530	300	29.0	548	8,627
1955	200	25.0	315	200	25.0	284	300	28.5	538	300	30.0	548	400	31.0	781	800	31.0	1,511	1600	28.0	2,821	400	32.0	806	500	32.0	975	400	32.0	806	1800	27.0	2,961	2000	25.0	3,148	15,494
1956	500	29.5	929	1900	24.0	2,593	3300	19.0	3,948	300	30.0	548	600	31.0	1,171	1200	29.5	2,157	1000	30.5	1,920	1000	29.5	1,857	500</												

CITY OF CARLYLE, ILLINOIS - MUNICIPAL ELECTRIC UTILITY
1978 HOURLY LOAD READINGS

Load KW	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Load KW
7000													2	7000
6950						2							2	6950
6900						4							4	6900
6850						1							1	6850
6800						5	1						6	6800
6750						1							1	6750
6700							1						1	6700
6650						3	2	1					6	6650
6600						3	1	2					6	6600
6550							1						1	6550
6500						6	3	1					10	6500
6450						2	3						5	6450
6400						5	1						6	6400
6350						1	2	1					4	6350
6300						3	2						5	6300
6250						1	1	3					5	6250
6200						2	1	3					6	6200
6150						2	2	1					5	6150
6100						2	8	1					11	6100
6050						2	1	2					5	6050
6000						2	2	1					5	6000
5950						1	3						4	5950
5900						2	9	4					15	5900
5850							5	2					7	5850
5800						2	6	1					9	5800
5750						3	5	2					10	5750
5700							3	2					5	5700
5650							3	1	1				5	5650
5600							11	1	2				14	5600
5550						1	5	1					7	5550
5500						1	8	2	3				14	5500
5450							4						4	5450
5400						5	5	6	2				18	5400
5350							3	2	2				7	5350
5300							7	2	3				12	5300
5250							4		1				5	5250
5200							9	10	3				22	5200
5150						1		3					4	5150
5100					2	2	9	3	4				20	5100
5050							1		1				2	5050
5000					2	2	22	8	4				38	5000
4950							1	5					6	4950
4900						1	4	10	6				21	4900
4850						1	1	1					3	4850
4800					2	4	14	16	9				45	4800
4750						3	1	2	1				7	4750
4700					1	4	17	6	6				34	4700
4650					1				1				2	4650
4600					2	7	10	14	7				40	4600
4550					1			4	2				7	4550
4500					3	3	13	10	3				32	4500
4450					1		3	1	1				6	4450
4400	1				2	8	19	17	9				56	4400
4350							2	2	3				7	4350
4300					3	5	10	13	8				39	4300
4250						2		2	1				5	4250
4200	5				7	8	14	19	20				73	4200
4150	1	1				1	2	5	3				13	4150
4100	1				1	2	7	3	8				22	4100
4050		3						1					4	4050
4000	7	1			8	16	21	25	9			1	88	4000
3950	1	6				4	1	1	5				18	3950
3900	8	4			5	2	9	6	5			2	41	3900
3850	3	5			1		1	4	1				15	3850
3800	17	12			5	7	19	16	22			4	102	3800
3750		8	1		1	1			3			1	15	3750
3700	8	10	1		3	7	7	10	6			1	55	3700
3650	5	5				2			1				13	3650
3600	38	22	2		4	12	18	14	15			1	126	3600
3550	2	26	3		1	1		3	4			3	43	3550
3500	22	19	7		4	6	14	17	7			4	100	3500
3450	11	17	5		5	1		1	3			4	45	3450
3400	45	38	26		4	16	18	17	14			11	189	3400
3350	4	19	5		4	3	2	2				1	40	3350
3300	20	23	13		2	10	10	9	10		3	11	111	3300
3250	10	27	8		2		1				2	6	56	3250
3200	92	25	25		8	21	28	15	13		12	29	265	3200
3150	3	18	10		3	5		4	2		2	13	60	3150
3100	34	17	24		1	8	16	6	8		8	19	141	3100
3050	20	14	4			3	1	3			2	12	59	3050
3000	68	23	43	2	7	38	39	28	16		27	64	355	3000
2950	2	14	8		5	9	4	2	1		3	9	57	2950
2900	19	14	19	4	12	11	12	10	5	1	16	32	155	2900
2850	7	13	20	2	1	3	2	2			6	6	62	2850
2800	52	32	46	9	19	24	23	30	16	3	33	51	338	2800
2750	9	9	19		4	3	1	1	1		5	11	63	2750
2700	21	15	19	8	9	19	18	16	12	11	16	31	195	2700
2650	6	10	12	3	5		1		1		8	10	56	2650
2600	48	35	25	28	35	32	25	25	29	29	32	52	395	2600
2550	2	14	27	2	11	7			3	2	13	5	86	2550
2500	31	29	14	39	35	24	18	15	17	25	31	34	312	2500
2450	14	15	15	6	5	6	2		3	5	6	3	80	2450
2400	35	43	45	67	61	37	27	24	40	64	52	45	540	2400
2350	1	9	16	4	15	3			6	5	10	4	73	2350
2300	17	21	32	37	29	19	17	16	13	44	22	35	302	2300
2250	1	10	9	16	6	4		1		9	7	4	67	2250
2200	16	16	48	61	57	27	21	27	35	54	45	40	447	2200
2150		14	12	6	4	1			2	3	6	3	51	2150
2100	4	5	16	20	19	10	16	14	20	23	23	32	202	2100
2050	4	3	9	5	2	1			1	23	7	6	61	2050
2000	20	5	31	56	36	30	20	35	45	67	38	60	443	2000
1950		3	12	3	2	1	1		1	3	17	12	55	1950
1900	2		17	21	15	7	5	22	18	16	16	21	160	1900
1850	1		14	4	3	1			1	11	3	1	39	1850
1800	5		25	30	23	19	15	25	28	52	45	20	287	1800
1750			6	1	5		2		3	2	14	6	39	1750
1700	1		7	22	27	18	9	23	28	25	37	10	207	1700
1650			3	3		1			1	6	9		23	1650
1600			19	64	35	31	10	22	32	46	46	8	313	1600
1550			3	1	7				1	4	12	1	29	1550
1500			9	29	30	30	5	16	15	70	22	4	230	1500
1450			1		9		2		2		2		16	1450
1400			7	69	54	26	7	18	24	54	23	1	283	1400
1350			2		4	2	1	2	1		4		16	1350
1300				51	37	12	3	13	20	39	17		192	1300
1250					3	1		4	6		7		21	1250
1200				34	25	19		3	21	42	8		152	1200
1150											2		2	1150
1100				13	1	3			9	6	1		33	1100
1050									1				1	1050
1000														1000
	744	672	744	720	744	720	744	744	720	744	720	744		

Robert A. Meissner, Treasurer

ALDERMEN

Robert Berndsen
Jerry Holzinger
Donald Maue
Jupe Perkes
James Reilmann
James Schlueter
Gene Schurman
Donald Toennies

1979 FEB 14 10:00
Wilfrid C. Hilmes, Mayor
Robert J. Venhaus, City Clerk

City of Breese

Member of Illinois Municipal League

OFFICE OF THE CITY CLERK

BREESE, ILLINOIS 62230
618-526-7731

Feb. 13, 1979

Martin Johnson
Supt. of Utilities

Al Gebke
Chief of Police

Laurell Wuest
Asst. Chief of Police

Robert Dumstorff
Fire Chief

Bernard Heiligenstein
Corporation Counsel

Mr. Randal B. Thomas
Barnes, Henry, Meisenheimer & Gende, Inc.
Consulting Engineers
4658 Gravois Ave.
St. Louis, Mo. 63116

Dear Mr. Thomas:

In response to your Feb. 12, 1979 letter, this is to advise that the City of Breese, Illinois, would be interested in receiving power from the proposed hydroelectric power plant being studied by the City of Carlyle, Illinois, provided such power could be used and justified on an economic basis.

Very truly yours,

Wilfrid C. Hilmes
Mayor
City of Breese

cc: Hon. J. Leo Davis, Mayor
City of Carlyle
City of Breese-file

REC'D JAN 1 1979

ILLINOIS POWER COMPANY

500 SOUTH 27TH STREET, DECATUR, ILLINOIS 62525

December 28, 1978

Mr. Randal B. Thomas
Barnes, Henry, Meisenheimer
and Gende, Inc.
Consulting Engineers
4658 Gravois Avenue
St. Louis, Missouri 63116

Dear Mr. Thomas:

In response to your December 20, 1978 letter this is to advise that Illinois Power Company would be interested in receiving power from the proposed hydroelectric power plant being studied by the City of Carlyle, Illinois, provided such power could be used and justified on an economic basis.

Very truly yours,

H. G. Goers

/ldh

cc: Hon. J. Les Davis, Mayor, City of Carlyle
Mr. B. L. Hantle, P-10
Mr. J. M. Williams, A-10

APPENDIX I

AGREEMENT FOR PURCHASE OF POWER

BY

THE CITIES OF BREESE & CARLYLE, ILLINOIS

FROM

ILLINOIS POWER COMPANY

CONTENTS

<u>SECTION</u>	<u>PAGE NO.</u>
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APPENDIX

Wholesale Electric Service for Resale
to Cities of Breese & Carlyle, Illinois Exhibit A

One-Line Diagram of Facilities at the
Point of Delivery Exhibit B

Facilities Rental Agreement Exhibit C

AGREEMENT FOR PURCHASE OF POWER
FROM ILLINOIS POWER COMPANY

This is an agreement dated this 19, between ILLINOIS POWER COMPANY ("Utility" or "Company"), and the CITIES OF BREESE & CARLYLE, ILLINOIS ("CUSTOMER").

Utility is an Illinois corporation with its business office at 500 South 27th Street in Decatur, Illinois, is engaged in the generation, transmission, distribution and sale of electric energy to the public in various municipalities and areas in the State of Illinois, and is a public utility within the meaning of an Act entitled "An Act Concerning Public Utilities," approved June 29, 1921, as amended, set forth in Chapter 111-2/3, Section 1 et seq. of the Illinois Revised Statutes, and now in force.

Customer owns and operates an electric generating and distribution facility and provides electric public utility service to customers located in and about Carlyle & Breeze, Illinois.

Customer desires to purchase electric energy for municipal uses and for resale to its customers, and Utility desires and is willing and able to supply Customer with electric energy for these purposes, on the terms and conditions hereinafter set forth.

In consideration of the mutual agreements herein contained, the parties agree as follows:

I. General Terms

Utility shall supply electric energy and Customer shall accept and pay for service rendered under the terms of Exhibit A, attached hereto, entitled Wholesale Electric Service for Resale to Cities of Breeze & Carlyle, Illinois. Agreement shall control if there is any conflict between the provisions hereof and the provisions of Exhibit A, except for the determination of contract capacity.

II. Conditions of Service

1. Customer requires and Utility agrees to supply a minimum amount of capacity according to the following five year schedule, beginning with commencement of the Agreement under Section X.

	<u>CARLYLE</u>	<u>BREESE</u>	<u>TOTAL</u>
1st year	<u>4,500 Kva</u>	<u>3,500 Kva</u>	<u>8,000 Kva</u>
2nd year	<u>4,500 Kva</u>	<u>3,500 Kva</u>	<u>8,000 Kva</u>
3rd year	<u>5,000 Kva</u>	<u>4,000 Kva</u>	<u>9,000 Kva</u>
4th year	<u>5,000 Kva</u>	<u>4,000 Kva</u>	<u>9,000 Kva</u>
5th year	<u>5,000 Kva</u>	<u>4,000 Kva</u>	<u>9,000 Kva</u>

This capacity will be the initial "contract capacity" governed by the provisions of Section 5(a) of Exhibit A. At the expiration of each year, Customer will specify a new contract capacity for the fifth year following. In the absence of such specification, the contract capacity specified for the fourth year shall carry over to become the contract capacity for the fifth year.

2. Customer shall provide a 69,000 volt substation at the point of delivery to transform energy received from Utility at 69,000 volts to the 69,000 volts required by Customer. (See Exhibit B.)
3. Utility requires a circuit switcher or oil circuit breaker and lightning arresters at the point of delivery to protect its system from any faults on Customer's system. Customer elects to install at its expense a 69 Kv oil circuit breaker satisfactory to Utility. Utility shall control, operate, and maintain such oil circuit breaker to assure satisfactory operation with its electric system. Customer shall pay Utility the non-salvable cost of installing such lightning arresters plus a monthly rental for the salvable cost of the lightning arresters, all as provided in Exhibit C.
4. Utility shall extend its line to the point of delivery to Customer and shall furnish and install meters, recording devices and other apparatus necessary for the purpose of measuring the energy received by Customer at the point of delivery. The point of delivery shall be at the 69 Kv bus installed in the 69 Kv substation referred to in the preceding paragraph 3 located on Customer's property.
5. Customer agrees that any existing towers, poles, wires or equipment placed by Utility on the streets, avenues, alleys and public places in the Cities of Breeze & Carlyle shall be exempt from any special tax assessments, license or rental fee to Customer during the term of this Agreement.

6. Customer agrees to use reasonable care to design its circuits so that loads of the individual phases on its lines at the point of delivery will be balanced as nearly as practicable.
7. Customer and Utility agree to maintain and operate their systems in accordance with sound utility practices, so as to minimize the likelihood of a disturbance in either system which might cause impairment of service to the other party's system.

III. Rates and Charges

1. Customer agrees to pay Utility monthly for electric service rendered during the preceding month at the rates and charges due and payable therefor as provided in Exhibit A, attached, or as subsequently revised under Section X, paragraph 3.
2. Utility shall add to all charges under this Agreement and those provided for in Exhibit A the amount of any tax or charge of any kind levied, assessed, or charged by any municipal, state, or federal government, or authority becoming effective after the execution date of this Agreement, measured by but not included in the purchase price paid or revenues received by Utility on account of the service rendered under this Agreement.

IV. Meter Reading and Billing

1. Utility shall read meters and render bills monthly. Bills will be rendered at a gross charge using the rates and charges contained in Exhibit A in effect at the time, including other charges in this Agreement increased by two percent. Payment shall be due thirty days from the date of rendering the bill, and if made within that period, Customer shall be entitled to a two percent prompt payment discount from the gross charge. The gross charge shall be payable with respect to each bill paid after the due date.
2. Should either over-billing or under-billing occur due to causes other than inaccurate meter registration, it shall be corrected by proper allowance or payment upon written notice by either party to the other, by mail or by personal delivery, provided that such notice must be given within one year following the date on which the bill to be corrected is rendered.

3. If Customer has failed to pay any bill accruing under this Agreement on or before the thirtieth day after day of billing, Utility may discontinue delivery of electric energy provided at least fifteen days prior written notice has been given to Customer. Utility will not be liable in any manner for any loss or damage arising from such discontinuance of electric service.

V. Metering, Testing and Billing Adjustments

1. Utility shall own and maintain the number of meters and related metering equipment necessary to measure the demand and energy delivered to Customer by Utility at the point of delivery.
2. Utility shall test and calibrate the meters by comparison with accurate standards at approximately twelve month intervals.
3. Utility shall make special meter tests at the request of Customer. If a special test made at Customer's request shall disclose that meters are registering within 2 percent of 100 percent accuracy, Customer shall bear the expense of the test; otherwise, the cost of such test shall be borne by Utility. Utility shall give Customer three days advance notice of its intention to test and calibrate meters when requested in writing by Customer and Customer shall be permitted to witness any meter tests made by Utility.
4. Meters found by test to be registering inaccurately shall be restored to a condition of accuracy. If the inaccuracy exceeds two percent, the meter readings taken during the period of 90 days preceding (or during such shorter period as may have intervened since the previous test) shall be corrected by the percentage of inaccuracy found by the test and payment adjusted accordingly. No prior readings will be corrected.

VI. Rights of Access

Duly authorized representatives of either party hereto shall be permitted reasonable access to the premises of the other party if required to carry out the provisions of this Agreement. Each party shall have access to the facilities of the other party at a mutually agreed-upon time for the purpose of removing its own facilities from the facilities of the other party where such removal is permitted under this Agreement.

VII. Continuity of Service

1. Utility agrees to provide adequate and reliable service to Customer. However, Utility shall not be liable to Customer for interruption or inadequacy of service, loss or damage to property, or injury (including death) to any person caused by act of God, public enemy, vandalism, strikes and other labor troubles or their equivalent, legal process, state, municipal or other governmental regulation, windstorm, flood, fire or explosion, or other matter or thing beyond Utility's control, whether the same shall affect or occur in connection with the operations or property of Customer, Utility or any other person.
2. Utility shall not be responsible in damages for any failure to supply electricity, or for interruption, or reversal of the supply, if such failure, interruption, or reversal is without willful default or negligence on its part, nor for interruptions, by underfrequency relays or otherwise, to preserve the integrity of Utility's system or interconnected systems.
3. Utility may interrupt service to make necessary repairs or to make changes in equipment or to install new equipment; but only for such reasonable times as may be unavoidable. If the nature of the situation permits, reasonable advance notice of these interruptions shall be given by Utility.

VIII. Liability

Customer shall not be liable for and Utility shall save Customer harmless against any and all claims, damages, liability or expense, resulting from or occasioned by the presence, use or maintenance of any electrical conductor or other type of equipment owned or maintained by Utility or Customer or by the escape of electric energy in or from any such conductor or equipment, provided that such claims, damages, liability or expense shall be caused by Utility's negligence or misconduct. Utility shall not be liable for the Customer shall save Utility harmless against any and all claims, damages, liability or expense resulting from or occasioned by the presence, use or maintenance of any electrical conductor or other type of equipment owned or maintained by Utility or Customer, or by the escape of electric energy in or from any such

conductor or equipment, provided that such claims, damages, liability or expense shall be caused by Customer's negligence or misconduct. Negligence or misconduct, as used herein, shall include but not be limited to failure to comply with all General Orders of the Illinois Commerce Commission applicable to the furnishing of electric service by Utility or Customer, all regulations of the United States Occupational Safety and Health Administration and the Structural Work Act of the State of Illinois, or failure to meet any standard of care derived from any of such orders, regulations or statute.

IX. Annexed Areas and Other Services

1. Utility shall be permitted to continue to provide retail electric service on a non-exclusive basis to its existing customers or existing customers' premises served by Utility within the city limits as of the effective date hereof.
2. Whenever, after the date of this Agreement, Customer annexes an area in which Utility is providing electric service, the parties shall meet and shall negotiate in good faith as to the party to provide and the manner of providing electric service to present and future electric customers in the annexed area. Such negotiations shall be conducted by the parties in the light of all relevant matters, and any agreements made and procedures established by them shall be in the public interest and in accordance with then prevailing law and applicable regulatory authority.
3. Neither party to the detriment of the other party shall require any person to take electric service from it as a condition to, or in combination with, any other commodity or service, including but not limited to gas, sewer, water, or any other municipal or utility service.

X. Term of Agreement

1. This Agreement shall be for a term of five years commencing on the first date that Utility completes construction and installation of facilities necessary to provide service contracted for in Section II, paragraph 1, which is estimated to be
Such date shall be stated in a letter of understanding to be effected between the parties after service is commenced. The Agreement shall continue thereafter from year to year unless cancelled by either party at the expiration of the primary or extended term upon not less than two years prior written notice.

2. All provisions of this Agreement which are obligatory upon or shall inure to the benefit of Utility shall inure to the benefit of all successors and assigns of Utility.
3. Any existing or future Agreement required hereunder to be entered into or entered into between Utility and Customer for electric service shall be amended from time to time to incorporate any revisions and changes herein or in any rate, charge, or term or condition of service when such revision, change or substitution shall be approved or permitted to go into effect under the Illinois Public Utilities Act, the Federal Power Act, or other applicable federal law, or as otherwise provided by law as they may be applicable. Nothing contained herein shall be construed as affecting in any way the right of either party under this Agreement to unilaterally make application to the Federal Energy Regulatory Commission or any successor agency for a change in rates under Section 205, or any similar provision, of the Federal Power Act and pursuant to the Commission's Rules and Regulations promulgated thereunder or under any other applicable federal law or commission.

IN WITNESS WHEREOF, the parties hereto have duly entered into this Agreement the day and year first above mentioned.

ILLINOIS POWER COMPANY CITY OF BREESE, ILLINOIS

By _____ By _____

Title _____ Title _____

Date _____ Date _____

Attest: _____ Attest: _____

As to Illinois Power Company: As to City of Breese, Illinois
(Secretary) (City Clerk)

CITY OF CARLYLE, ILLINOIS

By _____

Title _____

Date _____

Attest: _____

Wholesale Electric Service
For Resale to-the Cities of Breese & Carlyle, Illinois

1. Availability

Service hereunder is available to the Cities of Breese & Carlyle Illinois ("Customer") subject to the following conditions:

- a. That Customer is engaged in the distribution and sale of electricity to the general public within the service territory served by Utility;
- b. That Customer is located adjacent to Utility's lines having a capacity adequate to supply Customer's requirements in addition to the requirements of other customers already receiving service from such lines or that Utility shall have sufficient time before Customer shall require service to construct such lines. Prior to commencement of service hereunder, Utility will construct additional facilities to provide service to Customer, provided the cost of such facilities does not exceed one and one-half times annual revenue estimated by Utility to be received from Customer. Any costs in excess of one and one-half times this estimated annual revenue shall be paid by Customer to Utility;
- c. That prior to the commencement of service hereunder, Customer shall execute and shall thereafter keep in full force and effect a written agreement with Utility with a primary term of five years.

2. Conditions of Service

Service hereunder shall be provided to Customer subject to the following conditions:

- a. Should Customer desire to receive electric energy from any source other than capacity owned and operated by Customer and to operate in parallel with the power supplied by Utility to Customer under this schedule, it shall, in the absence of existing arrangements with Utility for the delivery of such power, give the Utility reasonable notice of such desire, specifying the requirements involved and the date when it desires such transfers to commence. Reasonable notice shall be defined as notice sufficient to allow Utility to continue safe and efficient operation of its system and shall be interpreted in an engineering context considering the facilities and requirements involved;

- b. Utility shall be reimbursed for any expenses incurred by it by reason of the transfer of electric energy requirements referred to in subsection 2(a):
- c. Service hereunder will be initially delivered to Customer from a 69,000 volt three phase electric line having capacity sufficient to serve the Customer's energy requirements. Utility retains discretion to select the supply line or lines from which service will be rendered to Customer. The supply line selected shall be the best available source with adequate capacity based on good engineering practices. Utility also retains discretion to change such supply line or lines and to change the voltage of the supply line or lines or other conditions of service. If such change is initiated by Utility, the cost of providing service under the new conditions including the cost of transformation shall be borne by Utility. In all other cases, except for changes caused by an increase in Customer's electric energy requirements which shall be governed by subsection 1(b), costs of changes shall be borne by Customer;
- d. Customer shall provide and maintain all transformers and related facilities necessary for handling and utilizing the energy delivered hereunder;
- e. Utility will provide and maintain one three phase voltage connection, provided Customer will make available, without charge to Utility, space required for Utility's lines and delivery facilities, and;
- f. Utility will provide and maintain one point of delivery and metering equipment therefor. Such metering equipment shall be located on the high voltage side of Customer's transformation. Utility, at its discretion, may elect to install such metering equipment on the low voltage side of transformation (whether or not for the convenience of Utility or Customer) and in such case, both the demand and energy consumption will be increased to compensate Utility for transformer losses as measured by such metering equipment, or in the absence of such measurement, by computing such losses based on the manufacturer's data pertaining to the specific transformers installed.

3. Rates and Charges

The gross charge shall equal the sum of the charges below and any other applicable charges increased by two percent.

- a. Customer Charge:

<u>Delivery Voltage</u>	<u>Charge</u>
4160 or 12,470 volts	\$ 80.00 per month
34,500 or 69,000 volts	\$110.00 per month
- b. Demand Charge:

<u>Delivery Voltage</u>	<u>Charge per Kva of Billing Demand in Any One Month</u>
4160 or 12,470 volts	\$3.73 per Kva
34,500 or 69,000 volts	\$3.18 per Kva
- c. Energy Charge: 1.25¢ per Kwh for all Kwh delivered by Utility in any one month
- d. Cost of Power Adjustment:

(1) A Cost of Power Adjustment (CPA) will be applied to each Kwh of energy billed hereunder during the "billing period" as defined herein.

$$(2) \text{ CPA} = \frac{(\text{FCCG} + \text{ECPP} + \text{ECIP} - \text{FCIS}) \times 100}{(\text{CG} + \text{PP} + \text{IP} - \text{IS}) \times \text{LF}} = .834\%$$

Where:

CPA = Cost of Power Adjustment. The amount rounded to the nearest .001¢ per Kwh to be charged for each Kwh billed hereunder during any monthly "billing period" as defined herein.

FCCG = Fuel Cost of Company Generation. The cost of fossil fuel as included in Account 151 and the cost of nuclear fuel as included in Account 518, according to the FPC Uniform System of Accounts, consumed in "Company's plants" during the "determination period."

ECPP = Energy Cost of Purchased Power. The net energy cost of energy purchased on an economic dispatch basis from other utilities under purchased power agreements during the "determination period," exclusive of capacity or demand charges. Otherwise, the actual identifiable fuel cost associated with such energy purchased.

ECIP = Energy Cost of Interchange Purchases. The net energy cost of energy purchased on an economic dispatch basis from other utilities during the "determination period" under interchange or interconnection agreements irrespective of the designation assigned to such transactions. Otherwise, the actual identifiable fuel cost associated with such energy purchased.

FCIS = Fuel Cost of Interchange Sales. The cost of fuel consumed in "Company's plants" to generate energy sold to other utilities during the "determination period" through all inter-system sales.

CG = Company Generation. All Kwh generated during the "determination period" in Company's plants.

PP = Purchased Power. All Kwh purchased, except interchange purchases, from other utilities during the "determination period" irrespective of the designation of such purchases.

IP = Interchange Purchases. All Kwh purchased or received from other utilities during the "determination period" under interchange or interconnection agreements irrespective of the designation of such purchases.

IS = Interchange Sales. All Kwh generated in "Company's plants" which were sold or furnished to other utilities during the "determination period" through all inter-system sales.

LF = Loss Factor. The estimated ratio of Kwh sales at the average delivery voltage of wholesale sales for resale to the Kwh generated for such sales. This ratio is .97.

(3) Definitions

- (a) The "determination period" is defined as the calendar month immediately preceding the billing month.
- (b) The "billing period" is defined as the period beginning with the 4th billing cycle of the month following the "determination period" and ending with the 3rd billing cycle of the next month.
- (c) "Company's plants" is defined as Company's fossil and nuclear generating plants and Company's share of any jointly owned or leased fossil and nuclear generating plants.

4. Determination of Demands

- a. Maximum kilovolt ampere (Kva) demand will be the highest number of Kva delivered during any fifteen minute period.
- b. Billing demand for any billing month shall be the greater of:
 - (1) 50% of the maximum Kva demand measured for the billing month, or
 - (2) the contract capacity

5. Additional Conditions and Contract Provisions

- a. A capacity (called "contract capacity" herein) shall be as provided in Article II, Section 1 of the Agreement. In the event the Customer's maximum Kva demand during the 13 consecutive hours of 10:00 a.m. through 11:00 p.m. on weekdays occurring during the period June 15 through September 14, in any one year, exceeds the contract capacity in effect at that time during any 3 fifteen minute intervals, no two of which shall be selected in any one calendar day, the contract capacity shall be increased, without notice or other action, by the amount by which the average of the three highest measured Kva demands exceeds the then existing contract capacity, and any existing contract shall be deemed to have been amended to include such increased capacity.
- b. Customer may reduce Customer's contract capacity upon providing Utility with twelve months' prior written notice. However, in no event shall Customer be permitted to reduce Customer's contract capacity to a level below that specified under Article II, Section 1 of the Agreement.
- c. If Customer requires service at the delivery point specified herein for existing, new or added capacity of 500 Kva or more in excess of the contract capacity which requires Utility to install special apparatus, Customer shall execute and keep in full force and effect a written contract with Utility for service which shall specify a contract capacity and other terms and conditions of service not inconsistent with those provided for herein. The primary term for such written agreement shall be five years.

Illinois Power Company
Partial Requirements Service Agreement
Proposal Submitted December 6, 1978
Exhibit A
Page 6 of 6

- d. The primary or extended term of any agreement provided for herein shall be automatically extended from year to year with the privilege of either party to terminate the agreement at the end of the primary term, or any extended term, on not less than two years' prior written notice.
- e. Nothing contained herein shall be construed as affecting in any way the right of either party under this rate schedule to unilaterally make application to the Federal Energy Regulatory Commission or any successor agency for a change in rates under Section 205, or any similar provision, of the Federal Power Act and pursuant to the Commission's Rules and Regulations promulgated thereunder or under any other applicable federal law or commission.

HOURLY FUEL AND ENERGY QUOTATIONS FOR ILLINOIS POWER COMPANY (1)

[illegible]

NOTES: (1) Quotations do not include demand related charges.
(2) Price Quotations are artificially high as a result of the 1978 strike of the United Mine Workers.

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

7 FEB 1978

REPLY TO
ATTENTION OF:
DAEN-CWE-HY

Honorable Charles B. Curtis, Chairman
Federal Energy Regulatory Commission
Washington, DC 20426

RECEIVED
OFFICE OF THE
SECRETARY
FEB 14 10 03 AM '78
FEDERAL
POWER COMMISSION

**DO NOT UNSTAPLE AND DO
NOT REMOVE FROM OPI**

Dear Mr. Chairman:

This is in reply to the Commission's letter dated 22 November 1977 about an application for a preliminary permit filed by the City of Carlyle, Illinois, for Carlyle Project No. 2806. The project is considered for location on Kaskaskia River, Illinois.

The applicant proposes to study the feasibility of installing hydro-electric power adjacent to the spillway channel immediately downstream of the existing Corps of Engineers Carlyle dam.

The Corps' comments and recommendation concerning the proposed study for Project No. 2806 are as follow:

Please advise the applicant that to the extent the proposed power plant would affect the authorized functions of the Carlyle Lake, Congressional approval will be required for any modification.

Corps of Engineers Authorized Studies. The Corps under the authority of Section 167 of the 1976 Water Resources Development Act is studying the physical potential for hydroelectric power development in the United States. This study will include the potential for hydro-power in the Kaskaskia River Basin. Also, the Corps St. Louis District has a new-start survey study for the Carlyle Lake and Shelbyville Lake projects in Illinois, to determine the economic, engineering and environmental feasibility of adding hydro-power to these existing projects.

Effect of Proposal on the Corps' Existing Project. The Corps of Engineers Carlyle Lake project provides for flood control, water supply, navigation releases, recreation and fish and wildlife

DAEN-CWE-HY

Honorable Charles B. Curtis

7 FEB 1978

conservation. The Corps will have to determine the physical, environmental and economic effects of proposed hydro-power development on the present authorized uses at the Carlyle project. The design, construction and operation of the proposed power plant will be subject to approval by the Corps of Engineers.

Department of the Army Permit Requirements. Please advise the applicant that pursuant to Section 404 of the Federal Water Pollution Control Act, a Department of the Army permit is required for any discharge of dredged or fill material into the waters of the United States and/or wetland of the project site. This includes placement of any fill material necessary to site investigation and to the subsequent construction of the project. Applicant should contact the District Engineer, St. Louis, Missouri, about requirements for a Department of the Army permit.

Others. The Congressional report referenced in Exhibit C of the application is in error and should be corrected to read "House Document No. 232, 85th Congress, 1st Session, 23 August 1957."

Recommendation. In view of the matters discussed above, we recommend that a preliminary permit, if issued, clearly state that the applicant undertakes the proposed study at his own risk. We further recommend that any permit issued requires the applicant to coordinate his studies for Project No. 2806 closely with the District Engineer, St. Louis, Missouri.

Sincerely,

DRAKE WILSON

Brigadier General, USA

Deputy Director of Civil Works

ALTERNATE A

KEYWORD DESCRIPTION: 5000 Kw; Horizontal Units; tainter gate penstock, bypass over-tops plant, no upstream cofferdam, no downstream modification

TURBINE LOCATION: Inside West Tainter Gate Opening

TURBINE CAPACITY: Approximately 2500 KW Allis Chalmers

NUMBER OF TURBINES: 2

TURBINE CONFIGURATION: Horizontal water passage over fixed-vane, adjustable blade runner; centerline El. 419.5 or less.

INLET CONFIGURATION: Penstock installed over and tied to existing ogee crest with existing tainter gate maintained in operation with an elevated gate sill at approximate El. 435'

UPSTREAM COFFERDAM: None. Use existing stop logs for construction to elevation 450'

DOWNSTREAM COFFERDAM: Individual cells approx. 32' x 12' x 25' high counter balanced externally for stability. Construct downstream walls in sections and dewater after closing in. Then construct plant and set equipment

BYPASS FOR EMERGENCY RELEASES: Through plant and over-top plant (Ballpark estimate) 5000-7000 cfs bypass capacity

UPSTREAM WATERSTOP: 10.5' butterfly valve for individual units, existing stop logs for both units simultaneously and to dewater joint-use penstock

TAILWATER CHANNEL: Two (2) straight through 12' x 16' draft tubes discharging downstream and in west tainter gate opening. No tailrace channel modification.

MODIFICATIONS TO EXISTING CONCRETE STRUCTURE: Minimum; anchor to existing; breech training wall for manway access to power plant.

MODIFICATIONS TO EXISTING EMBANKMENT: None

PENSTOCK SURGE PROTECTION: None

SECONDARY FACILITIES EFFECTED: Relocate existing observer parking located west of west retaining wall. This area to be used for maintenance and power plant equipment service area with traveling rail crane

NOTEABLE PLANT FEATURES: Large access hatches for equipment removal. Construction will utilize the post-tensioning technique to assure positive anchorage of plant spillway.

REVISIONS DATE OCT 1978 DRAWN BY G.P.R. CHECKED BY R.B.T. SCALE 1/8" = 1'-0" Missouri	
Barnes, Henry, Meisenheimer & Gende, Inc. Consulting Engineers St. Louis	
BH&G	
CITY OF CARLYLE, ILLINOIS MUNICIPAL ELECTRIC SYSTEM IMPROVEMENTS PROPOSED HYDROELECTRIC INSTALLATION - 5000 KW. ALTERNATE A	
JOB NO. B79295 SHEET NO. M2	

ALTERNATE B

KEYWORD DESCRIPTION: 8000 KW; Horizontal Units; tainter gate penstock; partial capacity bypass sluice; no upstream cofferdam, breach training wall twice, plant beside spillway

TURBINE LOCATION: Beside stilling basin west of existing west retaining wall.

TURBINE CAPACITY: Largest Allis Chalmers tube unit available.
Approx. 4000 KW Allis Chalmers

NUMBER OF TURBINES: 2

TURBINE CONFIGURATION: Horizontal water passage over fixed vane; adjustable blade runner; Centerline El. 419.5 or less.

INLET CONFIGURATION: Penstock installed over and tied to existing ogee crest with existing tainter gate maintained in operation with an elevated gage sill (i.e. crest) at approx. El. 455 plus (2) 12.4' elbow penstocks through training wall.

UPSTREAM COFFERDAM: None. Use existing stop logs for construction to El. 450'

DOWNSTREAM COFFERDAM: Individual cells approx. 32' x 12' x 25' high counter balanced externally for stability. Construct downstream walls in sections and dewater after closing in. Construct plant west of west retaining wall and then cut through retaining wall after penstock is dewatered.

BYPASS FOR EMERGENCY RELEASES: 2 sluice gates approx. 17' x 20' openings. No overflow (Ballpark estimate 20,000 to 23,000 for bypass capacity)

UPSTREAM WATERSTOP: 12.5' butterfly valve for individual units. Existing stop logs for both units simultaneously and to dewater penstock.

TAILWATER CHANNEL: Curved and extended 15' x 20' draft tubes (2) to enter existing improved channel downstream at approx. center of 50' R curved portion of west retaining wall. Rip rap from outlets below stilling basin sill if necessary

MODIFICATIONS TO EXISTING CONCRETE STRUCTURES: Breach existing west training wall for 2-12.5' ID penstocks and 2-15' x 20' draft tube outlets. Anchor to existing

MODIFICATIONS TO EXISTING EMBANKMENT: Excavate behind west retaining wall and replace with power plant structure.

PENSTOCK SURGE PROTECTION: May be necessary.

SECONDARY FACILITIES EFFECTED: Relocate existing observer parking located west of west retaining wall. May conflict with proposed FAP 409 bridge over the channel 401' parallel to and south of axis of dam.

PLAN

ELEVATION - SECTION 'A-A'

Min TW 414.2 at 1000 cfs
 El 405 Bottom of Exit Channel

REVISIONS			
DATE	BY	CHECKED BY	SCALE
NOV. 1978	R.B.T.	R.B.T.	1/32" = 1'-0"

Barnes, Henry, Meisenheimer & Gende, Inc.
 Consulting Engineers
 St Louis
 Missouri

CITY OF CARLYLE, ILLINOIS
 MUNICIPAL ELECTRIC SYSTEM IMPROVEMENT
 PROPOSED HYDROELECTRIC INSTALLATION - 8000 KW.
 ALTERNATE B

JOB NO.
 879295

Sheet No.
M4

ALTERNATE C

KEYWORD DESCRIPTION: 8000 KW; Horizontal Units; in embankment; long penstock, pressure surge protection, extensive upstream cofferdam; discharge to old River Channel. Plant 1800' east of Spillway

TURBINE LOCATION: In earth embankment approx. 1800' east of centerline of spillway in vicinity of original river channel.

TURBINE CAPACITY: Approx. 4000 KW

NUMBER OF TURBINES: 2

TURBINE CONFIGURATION: Horizontal water passage over fixed vane, adjustable blade runner; centerline El. 419.5 or less.

INLET CONFIGURATION: Lengthy penstock (200') approximately 22' x 23' constructed in an open cut excavation breaching entire width of embankment.

UPSTREAM COFFERDAM: 5 unit cellular cofferdam 60' DD x 50' tall.

DOWNSTREAM COFFERDAM: None required. After construction of the plant, the downstream channel can be constructed by dragline and rip rap as needed.

BYPASS FOR EMERGENCY RELEASES: None needed. Spillway release capacity is actually increased by 3200 cfs with this alternative.

UPSTREAM WATERSTOP: 12.5' ID Butterfly valve for individual units. Combination trash rack and inlet headgate structure will stop water for both units simultaneously.

TAILWATER CHANNEL: Open channel flow with box culvert type of passage under existing tailwater access road with discharge into original river channel. Dredge and rip rap old river channel as necessary. Confusion regarding bridge responsibility under the proposed FAP 409 located 401' parallel to and south of axis of dam.

MODIFICATION TO EXISTING CONCRETE STRUCTURES: None

MODIFICATION TO EXISTING EMBANKMENT: Open or shored and crossbraced excavation breaching entire width of embankment. 40'-50' minimum width of bottom of excavation.

PENSTOCK PRESSURE SURGE PROTECTION: Will most likely be required

SECONDARY FACILITIES EFFECTED: FAP 409. Minimum flow must be maintained in spillway tailrace to prevent stagnation. East spillway access road.

NOTEABLE PLANT FEATURES: Piling driven parallel to axis of dam as a permanent water stop to cut off seepage in backfill of disturbed embankment.

REVISIONS			
DATE	BY	CHKD BY	SCALE
NOV. 1978	G.P.R.	H.B.T.	1"=50'-0"

Barnes, Henry, Meisenheimer & Gende, Inc.
 Consulting Engineers
 St. Louis
 Missouri

CITY OF CARLYLE, ILLINOIS
 MUNICIPAL ELECTRIC SYSTEM IMPROVEMENTS
 PROPOSED HYDROELECTRIC EMBANKMENT
 INSTALLATION ALTERNATE C

3020
 879295

M6

ALTERNATE D

KEYWORD DESCRIPTION: 4000 KW; Vertical Unit, tainter gate open flume, sluice gate bypass; no upstream cofferdam; extensive removal of existing structure.

TURBINE LOCATION: Inside west tainter gate opening.

TURBINE CAPACITY: Approximately 4000 KW; Leffel

NUMBER OF TURBINES: 1

TURBINE CONFIGURATION: Vertical water passage; 0-100% flow wicket gate distributor submerged gate position operator; fixed blade runner.

INLET CONFIGURATION: Open flume installed in tainter gate to hold flood control pool 462.5' El. with top slap.

UPSTREAM COFFERDAM: None. Use existing stop logs for construction to elevation 450'.

DOWNSTREAM COFFERDAM: Cellular cofferdam required downstream for construction of draft tube discharge and open flume inlet with sluice gate bypass. Cofferdam will essentially render the 2 west gates unusable during construction.

BYPASS FOR EMERGENCY RELEASES: Bypass; sluice gate openings 2 - 17.5' x 33' should pass required gate design capacity of 40,000 cfs, but some reduction because of channel ogee.

UPSTREAM WATERSTOP: Existing tainter gate is removed. Turbine wicket gates are positive shutoff under flow. Existing stop logs are available to dewater to 450' El.

TAILWATER CHANNEL: One (1) vertical elbow single pin draft tube opening approximately 30' x 13' discharging downstream and in line with west tainter gate opening.

MODIFICATIONS TO EXISTING CONCRETE STRUCTURES: Stilling Basin slabs 1S and 6S will have to be removed and the footings of training wall monoliths 1T and 2T will have to be removed to excavate for a lower discharge and construct new draft tube discharge channel. Toe of ogee crest to be removed. Three baffles will be removed. Anchors to existing remaining structures will be required.

MODIFICATIONS TO EXISTING EMBANKMENT: None apparent

PENSTOCK SURGE PROTECTION: None

SECONDARY FACILITIES EFFECTED: None apparent

NOTABLE PLANT FEATURES: Extremely long shaft between generator and turbine will require centering bearing to be tied to three sides of the open flume. Power Plant is above flume.

M8

SHEET NO

JOB NO.
B79295

CITY OF CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC SYSTEM IMPROVEMENTS
PROPOSED HYDROELECTRIC INSTALLATION - 4000 KW.
ALTERNATE D

Barnes, Henry, Meisenheimer & Gende, Inc.
Consulting Engineers
St Louis
Missouri

REVISIONS			
DATE	DEC. 1978	DRAWN BY	R. B. T.
		CHECKED BY	R. B. T.

ALTERNATE E

KEYWORD DESCRIPTION: 8000 KW; Vertical Units; tainter gate open flume; sluice gate bypass; no upstream cofferdam; breech training wall twice; plant beside spillway

TURBINE LOCATION: Beside stilling basin west of existing west training wall.

TURBINE CAPACITY: Approximately 4000 KW, Leffel

NUMBER OF TURBINES: 2

TURBINE CONFIGURATION: Vertical water passage; 0-100% flow wicket gate distributor; fixed blade runner.

INLET CONFIGURATION: Open flume installed in tainter gate to top of monoliths 3D and 4D El. 467' with top slab to achieve the additional structural strength of a box. Penstock inlets breech west retaining wall.

UPSTREAM COFFERDAM: None. Use existing stop logs for construction to elevation 450'.

DOWNSTREAM COFFERDAM: Individual cells approx. 32' x 12' x 25' high counter balanced externally for stability. Construct downstream walls in sections with sluice gates and dewater after closing in.

BYPASS FOR EMERGENCY RELEASES: Bypass through sluice gate openings 2-17.5' x 33' should pass required gate design capacity of 40,000 cfs. Even increase max. possible discharge some.

UPSTREAM WATERSTOP: Existing tainter gate is removed. Turbine wicket gates are positive shutoff under flow. Existing stop logs are available to dewater to 450' Elevation.

TAILWATER CHANNEL: Two (2) vertical single pier elbow draft tubes discharging downstream to enter existing improved channel below stilling basin and training wall. Drag line and rip rap.

MODIFICATIONS TO EXISTING CONCRETE STRUCTURES: Anchor new to existing, breech training wall for penstock inlets 2-30' x 15.5'. Remove for 3 manholes for dewatering behind west training wall. May lose two baffles and 50'R of training wall.

MODIFICATIONS TO EXISTING EMBANKMENT: Extensive excavation behind west retaining wall and replace with power plant structure.

PENSTOCK SURGE PROTECTION: Should not be required

SECONDARY FACILITIES EFFECTED: Relocate existing observation parking located west of west retaining wall. May conflict with proposed FAP 409 bridge over the channel 401 ft. south of and parallel to axis of dam.

CITY OF CARLYLE, ILLINOIS
 MUNICIPAL ELECTRIC SYSTEM IMPROVEMENTS
 PROPOSED HYDROELECTRIC INSTALLATION - 8000 KW.
 ALTERNATE E

JOB NO.
 879295

SHEET NO.

M 10

Barnes, Henry, Meisenheimer & Gande, Inc.
 Consulting Engineers
 St. Louis
 Missouri

DATE	DRAWN BY	CHECKED BY	SCALE
DEC., 1978	C. E. D.	R. B. T.	1/8" = 1'-0"

REVISIONS

ALTERNATE F

KEYWORD DESCRIPTION: 8000 KW, Vertical units; in embankment; approach channel; wide bank excavation; extensive upstream cofferdam, discharge to old river channel; Plant 1800 feet east of spillway.

TURBINE LOCATION: In earth embankment approx. 1800' east of center-line of spillway in vicinity of original river channel.

TURBINE CAPACITY: Approximately 4000 KW - Leffel

NUMBER OF TURBINES: 2

TURBINE CONFIGURATION: Vertical water passage; 0-100% flow wicket gate distributor; fixed blade runner.

INLET CONFIGURATION: Open channel with approach walls to 2-30' x 15.5' x 57' long single pier penstocks. Constructed in an open cut excavation breaching entire width of embankment.

UPSTREAM COFFERDAM: Several unit, cellular cofferdam 60'OD x 50' tall.

DOWNSTREAM COFFERDAM: None required. After construction of the plant, the downstream channel can be constructed by dragline and rip rap as needed.

BYPASS FOR EMERGENCY RELEASES: None needed. Spillway release capacity is actually increased by 3200 cfs with this alternate.

UPSTREAM WATERSTOP: Turbine wicket gates. Stop logs and trash racks at inlet to penstock. The approach channel cannot be dewatered.

TAILWATER CHANNEL: Open channel flow with box culvert type of passage under existing tailwater access road with discharge into original river channel. Dredge and rip rap old river channel as necessary. Confusion regarding bridge responsibility under the proposed FAP 409 located 401' parallel to and south of axis of dam.

MODIFICATIONS TO EXISTING CONCRETE STRUCTURE: None

MODIFICATIONS TO EXISTING EMBANKMENT: Extremely large open cut excavation breaching entire width of embankment. 100-125' minimum width of bottom of excavation. 500' width at top of excavation.

PENSTOCK PRESSURE SURGE PROTECTION: Probably not required unless penstocks are extended.

SECONDARY FACILITIES AFFECTED: FAP 409 minimum flow must be maintained in spillway tailrace to prevent stagnation.

NOTEABLE PLANT FEATURES: Piling driven parallel to axis of dam as a permanent water stop to cut off seepage in backfill of disturbed embankment. Excessively high and long retaining walls would be a significant feature of this alternate.

M12

JOB NO.
B79295

SHEET NO.

CITY OF CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC SYSTEM IMPROVEMENTS
PROPOSED HYDROELECTRIC INSTALLATION - 8000 KW.
ALTERNATE F

Barnes, Henry, Meisenheimer & Gende, Inc.
Consulting Engineers
St Louis
Missouri

REVISIONS			
DATE	NOV. 1978	DATE	NOV. 1978
DRAWN BY	R.B.T.	CHECKED BY	R.B.T.
SCALE	1"=20'-0"		

ALTERNATE G

KEYWORD DESCRIPTION: 8000 KW; Horizontal Units; through non-overflow wall; upstream cofferdam; new approach channel; breech retaining wall, plant beside spillway.

TURBINE LOCATION: Beside stilling basin west of existing west retaining wall.

TURBINE CAPACITY: 2-4000 KW Allis Chalmers. Largest A-C tube unit available.

NUMBER OF TURBINES: 2

TURBINE CONFIGURATION: Horizontal water passage over fixed vane; adjustable blade runner; centerline EL. 419.5 or less.

INLET CONFIGURATION: Excavate with a dragline the west approach embankment in front of the west non-overflow wall. Construct another approach wall for bank retention rip rap new approach channel as necessary. Bore or drill and blast 12.5-13' penstocks through non-overflow wall; line with steel tubes.

UPSTREAM COFFERDAM: Sheeting cofferdam tied into embankment required for construction of approach and breeching non-overflow wall.

DOWNSTREAM COFFERDAM: Details would be similar to upstream cofferdams.

BYPASS FOR EMERGENCY RELEASES: None needed. Spillway release capacity is actually increased bt 3200 cfs.

UPSTREAM WATERSTOP: 12.5' butterfly valve for individual units. Upstream stop logs would have to be fabricated for mounting on face of non-overflow wall

TAILWATER CHANNEL: 2-15' x 20' draft tubes to enter an open channel outlet from the power plant. Channel is to breech retaining wall in the vicinity of the 50' R section. Rip rap existing channel below this confluence as necessary.

MODIFICATIONS TO EXISTING CONCRETE STRUCTURES: 2-13' ID Holes breeching non-overflow wall; 2-15' x 20' openings breeching west retaining wall. Existing west approach wall is abandoned.

MODIFICATIONS TO EXISTING EMBANKMENT: Permanent excavation upstream of non-overflow wall and redesign approach bank. Excavate downstream of non-overflow wall and behind west retaining wall and replace with power plant structure.

PENSTOCK SURGE PROTECTION: Probably not necessary.

SECONDARY FACILITIES EFFECTED: Relocate existing observer parking located west of west retaining wall. Discharge channel may conflict with proposed FAP 409 bridge over the channel 401' parallel to and south of axis of dam.

GEOTECHNICAL CONSIDERATIONS FOR DESIGN ALTERNATIVES

ALTERNATIVE A. Adaptation of the existing west spillway gate for construction of Alternative A would involve constructing a downstream cofferdam on the spillway basin floor. As proposed by Barnes, Henry, Meisenheimer, and Gende, Inc., it is probable that an internally and externally braced structural steel, rectangular box-like cofferdam could be constructed and the walls of the power plant in the spillway constructed in segments. After construction of a segment, the cofferdam could be moved to the next locations. No upstream cofferdam would be required since the existing stop logs could be utilized.

Construction would effect the spillway monoliths and spillway slab. The new structure would impose additional loads on the structures and the capacity of the foundation to support the loads would require investigation. Also the possibility of overturning of the monoliths because of construction would require attention as well as uplift imposed on the spillway floor. However, since this alternative was not selected, these investigations were not accomplished.

ALTERNATIVE B. Alternative B would not require an upstream cofferdam, however, a moveable downstream cofferdam similar to the one described for Alternative A would be required to construct the walls of the plant. As for Alternative A, the new structure would be partially constructed on the existing spillway and spillway slab thus imposing new loads on the foundations of these structures. The power plant, however, would be constructed immediately adjacent to the west face of the west training wall requiring a braced

excavation. The capacity of the existing monoliths and spillway to resist new loads is unknown and would require additional investigation; however, since this alternative was not the prime alternative, these investigations were not made.

ALTERNATIVE C. Alternative C would require construction through the existing dam embankment in the area of the old river channel. For construction it would be necessary to install an upstream cofferdam consisting of large diameter circular cofferdams and breaching of the embankment to construct the penstocks. Excavation for placement of the penstocks would require an open cut or a braced excavation that could compromise the integrity of the dam unless special precautions are undertaken to insure that no seepage paths are created by the construction of the penstocks or placement of the sheeting and bracing. The plant would be constructed on the downstream face of the dam.

ALTERNATIVE D. Alternative D would essentially require construction of a box-like sluice structure founded below the spillway slab downstream of the monoliths. Construction of the new plant would require excavation below the elevation of the existing structure, and preservation of the integrity of the existing structure would be difficult. A downstream cofferdam similar to Alternative A would be required so the plant could be constructed segmentally. Since the water elevation in the sluice would be maintained at the same level as the lake, additional loads would be imposed on the spillway structure.

ALTERNATIVE E. Alternative E would be a variation of Alternatives B and D and would involve construction of the sluice box similar to that for Alternative D with the plant to the west of the existing west

training wall as for Alternative B. Comments regarding construction on the existing spillway and to the sides of the training wall are as previously noted in Alternatives B and D.

ALTERNATIVE F. Alternative F is about the same as Alternative C and would be constructed in the embankment near the old channel. The configuration of the plant would involve a substantial upstream cellular cofferdam and either a braced or open cut excavation through the embankment. The plant would be located near the axis of the dam with open approach and discharge channels which would require extremely high upstream and downstream retaining walls.

ALTERNATIVE G. The plant proposed in Alternative G is located adjacent to the west approach and training walls with tunnels for the penstocks through the non-overflow monoliths. This alternative has been chosen as the prime alternative and is discussed in more detail in subsequent sections. Briefly, the main problems associated with construction of this alternative will be the cofferdams which will retain both earth and soil, associated with construction of the plant and intake and excavation into the rock below the elevation of the existing spillway slab.

MISCELLANEOUS COMMENTS

- ALTERNATE A - 1. Difficult to keep plant dry when over-topping during emergency bypassing-
2. Close overhead clearances inside plant.
3. A lowered turbine centerline would apparently require some degree of stilling basin removal.
4. A post tensioned design.
- ALTERNATE B - 1. Gate portion of penstock is same size as Alt. A, therefore velocities are greater likewise head losses are greater.
2. A post tensioned design.
3. Possible change in stability of west non-overflow wall because of excavation downstream to set power plant.
- ALTERNATE C - 1. Construct on rock.
- ALTERNATE D - 1. Tainter gate is not operable and therefore must be removed.
2. Extra long shaft appears to be an alignment problem.
3. Structural design heavily dependant on post tensioning which may please the Corps.
- ALTERNATE E - 1. Do the sluice gates have to have their track installed above 433' before they can be set or can we set the gates and then complete the box above 433'.
2. Channelization is believed to be accomplishable by drag line.
3. Structural design based on extensive post tensioning which may please the Corps.
4. Possible stability change in west non-overflow wall because of extensive excavation downstream for power plant.
5. This alternative has least reduction in spillway capacity for all alternatives not requiring an upstream cofferdam.
6. Not exactly sure how new downstream channel will be tied to existing. Will cofferdam be required?
- ALTERNATE F - 1. Construct on rock.

PLAN - TRASH RACKS AND GUIDE RAILS FOR STOP GATES

1" = 5'-0"

SECTION 7

1" = 5'-0"

DETAIL "A"

N.T.S.

DETAIL "B"

N.T.S.

SECTION 1

1" = 10'-0"

REVISIONS DATE FEB-79 DRAWN BY C.E.D. CHECKED BY D.J.Mc Missouri	Barnes, Henry, Meisenheimer & Gende, Inc. Consulting Engineers St Louis	BH&G	CITY OF CARLYLE, ILLINOIS MUNICIPAL ELECTRIC SYSTEM EXTENSION PROFILE AND DETAILS
			JOB NO. B79295
			SHEET NO. 0

SECTION 2
1" = 5'-0"
5 4 3 2 1 0 5

SECTION 4
1" = 5'-0"
5 4 3 2 1 0 5

SECTION 3
1" = 10'-0"
10 5 0 10

SECTION A
3/4" = 1'-0"
1' 9' 6' 3' 0' 1'

SECTION 5
1" = 10'-0"
10 5 0 10

DATE	REVISIONS
FEB 79	
DRAWN BY	C.E.D.
CHECKED BY	D.J.Mc

Barnes, Henry, Meisenheimer & Gende, Inc.
Consulting Engineers
St Louis
Missouri

CITY OF CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC SYSTEM EXTENSION
SECTIONS AND DETAILS

JOB NO.
B79 295
SHEET NO.

ELEVATION OF UPSTREAM COFFERDAM

1" = 10'-0"
10 8 6 4 2 0 5 10

PLAN OF UPSTREAM COFFERDAM

1" = 10'-0"
10 8 6 4 2 0 5 10

NOTES:

1. THIS PLATE PREPARED BY SHANNON & WILSON, INC.
2. SEE PLATE N FOR LOCATION OF INTAKE STRUCTURE AND PLAN LOCATION OF PILING.
3. ALL STEEL ASTM A-36, 36,000 PSI YIELD STRENGTH UNLESS NOTED OTHERWISE.
4. BRACING SYSTEM INSTALLED AND EXCAVATION MADE WITH WATER. AT MAXIMUM LEVEL OF EL. 442. AFTER INSTALLING STRUT AT EL. 432, EXCAVATION CAN PROCEED WITH WATER LEVEL AT TOP OF SHEET PILING.
5. COFFERDAM DESIGN PREPARED FOR COST ESTIMATING PURPOSES. USE FOR CONSTRUCTION WOULD REQUIRE FURTHER INVESTIGATION, ANALYSIS, AND DETAILING.
6. SUPPORT BRACKETS AND STIFFENER PLATES SHOULD BE PROVIDED AS REQUIRED FOR STRUTS AND WALES.

PLAN OF DOWNSTREAM COFFERDAM

1" = 10'-0"
10 8 6 4 2 0 5 10

NOTES:

1. THIS PLATE PREPARED BY SHANNON & WILSON, INC.
2. SEE PLATE N FOR LOCATION OF DOWNSTREAM COFFERDAM.
3. COFFERDAM DESIGN PREPARED FOR COST ESTIMATING PURPOSES. USE FOR CONSTRUCTION WOULD REQUIRE FURTHER INVESTIGATION, ANALYSES, AND DETAILING.
4. SUPPORT BRACKETS AND STIFFENER PLATES SHOULD BE PROVIDED AS REQUIRED FOR STRUTS AND WALES.

CITY OF CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC SYSTEM EXTENSION

PLAN OF DOWNSTREAM COFFERDAM

JOB NO.

SHEET NO.

R

Barnes, Henry, Meisenheimer & Gende, Inc.
Consulting Engineers

St Louis

Missouri

DATE	REVISIONS
DRAWN BY P.J.D.	CHECKED BY R.M.E.

ELEVATION OF DOWNSTREAM COFFERDAM

ELEVATION OF DOWNSTREAM COFFERDAM (CONT'D.)

NOTES:

1. THIS PLATE PREPARED BY SHANNON & WILSON, INC.
2. SEE PLATE N FOR LOCATION OF STRUCTURES AND PLAN LOCATION OF PILING
3. ALL STEEL ASTM A-36, 36,000 PSI YIELD STRENGTH UNLESS NOTED OTHERWISE.
4. BRACING BELOW EL. 425 INSTALLED WITH MAXIMUM WATER LEVEL AT EL. 425.
5. COFFERDAM DESIGN PREPARED FOR COST ESTIMATING PURPOSES. USE FOR CONSTRUCTION WOULD REQUIRE FURTHER INVESTIGATION, ANALYSES, AND DETAILING.
6. SUPPORT BRACKETS AND STIFFENER PLATES SHOULD BE PROVIDED AS REQUIRED FOR STRUTS AND WALES.

- NOTES:**
1. THIS PLATE PREPARED BY SHANNON & WILSON, INC.
 2. SEE PLATE N FOR LOCATION OF SECTIONS.
 3. SEE PLATES Q, R, AND S FOR MORE DETAIL.
 4. COFFERDAM DESIGN PREPARED FOR COST ESTIMATING PURPOSES. USE FOR CONSTRUCTION WOULD REQUIRE FURTHER INVESTIGATION, ANALYSES AND DETAILING.
 5. SUPPORT BRACKETS AND STIFFENER PLATES SHOULD BE PROVIDED AS REQUIRED FOR STRUTS AND WALES.

DATE	REVISIONS
	DRAWN BY P.J.D.
	CHECKED BY R.M.E.

Barnes, Henry, Meisenheimer & Gende, Inc.
Consulting Engineers
St Louis
Missouri

CITY OF CARLYLE, ILLINOIS
MUNICIPAL ELECTRIC SYSTEM EXTENSION
COFFERDAM AT SECTION 2, 5, AND 6

JOB NO.
SHEET NO.

T

CITY OF CARLYLE, ILLINOIS
 MUNICIPAL ELECTRIC SYSTEM IMPROVEMENTS
POWER TRANSMISSION FACILITIES

DATE
 1/25/58
 SHEET NO.
 15

✓

Barnes, Henry, Meisenheimer & Gende, Inc.
 Consulting Engineers
 St. Louis
 Missouri

REVISIONS			
DATE	BY	CHECKED BY	REVISIONS
1/25/58	J.C.D.	R.D.R.

NOTE: LOCK OF FIELD RELAY (40 DEVICE) IS LOCATED AT REAR OF PANEL

ELEVATION - EQUIPMENT LOCATED AT HYDRO PLANT
SCALE: 3/32" = 0'-1"

- LEGEND**
- D.C. VOLTMETER
 - D.C. AMMETER
 - A.C. AMMETER
 - POWER FACTOR METER
 - STATOR TEMP. METER
 - BLADE ANGLE INDICATOR
 - VALVE POSITION INDICATOR
 - WATT METER
 - KILOWATT RECORDER
 - RATE OF FLOW RECORDER
 - CONTROL MODE SWITCH (VOLTAGE REGULATOR)
 - AUTO VOLT ADJUST SWITCH
 - AMMETER SWITCH
 - VOLTMETER SWITCH
 - STATOR TEMP SWITCH
 - GOVERNOR SWITCH
 - LOCKOUT RELAY
 - SYNCHRONIZING SWITCH
 - UNIT PARALLEL SWITCH
 - AIR CIRCUIT BREAKER SWITCH
 - DIFFERENTIAL RELAY
 - REVERSE POWER RELAY
 - WATTHOUR METER
 - SYNCHRONIZING RELAY
 - OVERCURRENT W/VOLT REG. RELAY
 - UPPER POOL ELEVATION INDICATOR
 - TAIL WATER ELEVATION INDICATOR
 - A.C. VOLTMETER (INCOMING UNIT)
 - A.C. VOLTMETER (BUS)
 - SYNCHROSCOPE W/LIGHTS
 - FREQUENCY METER
 - EXCITER FIELD RHEOSTAT
 - VALVE POSITION INDICATOR SWITCH
 - RATE OF FLOW INDICATOR
 - ANNUNCIATOR
 - KW. TOTAL INDICATOR
 - A.C. VOLTMETER SWITCH (BUS)
 - OVERCURRENT RELAY (NEUTRAL)
 - OVER/UNDER VOLTAGE RELAY
 - LOCKOUT RELAY TO LOCK OF FIELD RELAY

ELEVATION - EQUIPMENT LOCATED AT CARLYLE POWER PLANT
SCALE: 3/32" = 0'-1"

- LEGEND**
- METERS**
- A AMMETER
 - EXC. REG. EXCITER REGULATOR
 - F.F. FREQUENCY METER
 - F.R. FIELD RESISTOR
 - K.W. KILLO WATT METER
 - K.W.H. KILLO WATTHOUR METER
 - P.F. POWER FACTOR METER
 - P.F.T. POWER FACTOR TRANSFORMER
 - SS SYNCHRO-SCOPE
 - V VOLT METER
 - WT WATT TRANSFORMER
- PROTECTIVE DEVICES**
- 29 SYNCHRONIZING RELAY
 - 32 DIRECTIONAL POWER RELAY
 - 40 LOCK OF FIELD RELAY
 - 51 A.C. TIME OVERCURRENT RELAY
 - 51N A.C. TIME OVERCURRENT RELAY (NEUTRAL)
 - 52 AIR CIRCUIT BREAKER
 - 27/59 OVER/UNDER VOLTAGE RELAY
 - 87 DIFFERENTIAL RELAY
 - 86 LOCKOUT RELAY

REVISIONS

DATE FEB. 1979

DESIGNED BY G. P. R.

CHECKED BY R. D. R.

Barnes, Henry, Meisenheimer & Gende, Inc.

Consulting Engineers

Missouri

St. Louis

BH&G

CITY OF CARLYLE, ILLINOIS

MUNICIPAL ELECTRIC SYSTEM IMPROVEMENTS

PROPOSED HYDROELECTRIC PLANT - ONE LINE DIAGRAM & CONTROL PANELS

JOB NO. 879295

SHEET NO. W

1.71 Operation and maintenance of the dam, outlet structure, and subimpoundment pumping stations, in accordance with the approved regulation plans.

1.72 Operation, development, and maintenance of recreational facilities, roads, and grounds by utilization of resident personnel and contractual services. Services include mowing, trash removal, cleaning, safety patrol, and vector control.

1.73 Removal and disposal of drift from the lake.

1.74 Development of resource management programs that enhance the environment through reforestation, brush control, and wildlife habitat improvement.

1.75 Pumping and treatment or disposal of sewage from vault toilets, marine toilets, flush toilets, fish cleaning stations, and trailer dumping stations.

2. ENVIRONMENTAL SETTING OF THE PROJECT.

2.1 General. Carlyle Lake, with its 26,000 acres of water, at normal pool elevation 445.0 feet m. s. l., provides a tremendous potential for recreation. Six public access areas have been developed by the Corps of Engineers totaling 880 acres, and four areas by the Illinois Department of Conservation encompassing 2,400 acres. Most of the State land will be a major State Park on the west shore of the lake.

The Corps sites provide picnic and camping areas, including swimming beaches, tables, barbecue braziers, comfort stations, boat launching ramps, car and boat trailer parking, boat docks, sales and service areas. The State areas provide picnic areas, boat launching ramps with car and boat trailer parking areas, boat docks, sales and service areas, camping areas, organized game units, nature study area, and casual game areas. In 1973, 2,535,000 people visited these facilities at Carlyle Lake.

The upper portion of the lake above the Burlington Northern Railroad, an area of approximately 16,000 acres of project land and water, has been licensed to the Illinois Department of Conservation for intensive wildlife management purposes.

There were 37,159 acres of fee land and 25,279 acres of easement land purchased for the project. Of this 62,438 acres, 57,500 acres will be flooded at flood control pool elevation of 462.5 feet.

2.2 Geological Elements.

2.21 Geology.

2.211 A thin veneer of glacial drift blankets the upland, which, in turn, is generally overlain by three to seven feet of loess (except where removed by erosion).

2.212 The flood plain of the Kaskaskia varies in width from 1/2 mile to 3 miles, and stands 15 to 20 feet above low-water stages. The drainage basin is long, narrow, and shallow. The river is a slow, turbid, meandering stream which has an average fall of less than one foot per mile. Tributaries are few and small, and the uplands are mainly undissected. Remnants of terrace deposits, which are very similar in composition to the recent alluvium, are scattered along the valley.

2.213 The Glacial Drift of Illinoian Age which blankets most of the uplands and forms the drift hills consists of an intimate mixture of clay with pebbles and a few cobbles. Most of the pebbles are less than one inch in diameter, and there are few boulders larger than one-half cubic foot. Occasional sand and gravel lenses are encountered, particularly in the drift hills. The pebble mineralogy is predominantly silicate, with some carbonate rocks and a varied suite of igneous types.

2.214 Soils in the Carlyle Lake Area are formed mainly in loess and the underlying glacial till. Internal drainage ranges from poor to moderate and in some level areas poor drainage is a distinct problem. Most soils in the area have slowly permeable subsoils that present moderate to severe limitations for recreational uses. The project also lies almost in the center of a zone of problem solonchic soils peculiar to this part of the State. These soils have a high content of sodium which creates unfavorable conditions for tree growth. It is possible that some of these solonchic soils may be present on project lands.

2.22 Mineral Resources.

2.221 Oil and Gas - Three oil fields, namely Boulder, Fairman, and Patoka West, were affected by the lake. The Boulder Oil Field in Clinton County, which was discovered in 1941 and which had a proved area of 720 acres, lied entirely within the flood control reservoir, near the eastern side, opposite river miles 113 to 115.

The Patoka West Oil Field in Fayette County, which was discovered in 1950 and which had a proved area of 2,500 acres, lied along the eastern shore of the lake opposite approximate river mile 138. The Fairman Oil Field in Clinton and Marion Counties, which was discovered in 1939 and which had a proved area of 460 acres, lied in an area adjacent to the east fork of the Kaskaskia River and the county line between Clinton and Marion Counties. The St. Louis District purchased rights in all oil producing properties at Carlyle Lake in April 1963, under agreements which permitted the owners to continue operations to 1 October 1964. Upon completion of production all equipment was removed and all wells capped or plugged in accordance with the laws of the State of Illinois. As of 1 January 1974 there were no gas or oil wells on Federal properties at Carlyle Lake. Any future development of gas or oil wells on Federal fee lands would be handled under Section 19 of ER 405-1-830 Department of the Army, through the Department of the Interior. At this time there are no plans for the reopening of the old oil fields which are presently considered depleted or any new ones on Federal land.

2.222 Coal - No coal mines are operating, and, so far as the file records of the Illinois State Geological Survey show, none have ever operated at locations within the lake area. There are strong indications that the entire pool area is underlain with No. 6 coal resources.

2.23 Topography. The topography of the lake area consists of gently rolling land with alluvial valleys and terrace developed along the Kaskaskia River. The lake area is one of moderately low relief. The highest point is some four miles southwest of the Town of Carlyle, and is approximately 580 feet in elevation; while the lower portions of the Kaskaskia River Valley have elevations near 400 feet. The uplands are generally flat, except where interrupted by occasional drift hills. Elevations of these uplands range between 450 and 550 feet, with the drift hills standing 30 to 50 feet higher.

2.24 Climate.

2.241 Temperature - Occasional temperatures of 100°F or higher have been experienced. The winters are usually short and moderate, although temperatures below zero are occasionally experienced. The average annual temperature in this area is about 55°F, and the average monthly temperature ranges from a maximum of 78°F during July to a minimum of 30°F in January. An extreme low of minus 34°F was recorded in Lincoln, Illinois, in January 1927, and minus 28°F was recorded in Morrisonville, Illinois, just outside the basin boundary.

The maximum observed temperature of 115°F occurred at Centralia, Illinois, on 22 July 1901, and again at Greenville, Illinois, on 12 July 1936.

2.242 Wind - The maximum wind movement occurs in March, and the minimum average occurs in August. The average annual wind velocity is about 10.3 miles per hour. The prevailing winds over the basin are from the south.

2.243 Humidity - The mean relative humidity varies from about 59 to 86 percent in the winter and from 51 to 89 percent during the other seasons of the year.

2.244 Precipitation - The average annual precipitation over the drainage area is 38.6 inches of which about 22 percent falls in May and June. Although rainstorms are frequent in the spring, local cellular storms also occur in July and August. Snowfall is usually limited to the period from October through April and seldom covers the ground for more than a few days at a time. The average annual snowfall amounts to about 20 inches.

2.3 Hydrological Elements.

2.31 Existing Water Resources. The lake, at joint-use pool elevation 445.0, will have a water surface of 26,000 acres and contain 233,000 acre-feet of joint-use storage above elevation 429.5 for water supply, navigation, recreation, and fish and wildlife purposes. A minimum downstream release of 50 c.f.s. is assured and is an improvement over the historically recorded minimum of 11 c.f.s.. The pool, at elevation 445.0, extends upstream from the dam approximately 15 miles, and varies in width at this elevation from 1 to 3-1/2 miles. The average water depth throughout the lake at joint-use pool elevation is approximately 25 feet. Depths along the western shore are greater than along the eastern shore and in the upper reaches. Maximum depths of 40.0 feet are along the old river bed and at several of the bottom-land lake sites which existed prior to inundation. The 83 miles of shoreline of the lake at the joint-use pool elevation are rather regular. At elevation 462.5 feet water is backed up approximately 25 miles from the dam and will have a water surface area of 57,500 acres. An additional 700,000 acre-feet of flood storage capacity are provided at this elevation.

The major tributary is the Kaskaskia River. Also providing inflows directly to the lake are the East Fork Kaskaskia River, Hurricane

Creek, Coles Creek, Allen Branch, and numerous smaller tributaries. Nearly all water in the lake is derived from surface runoff since springs are sparse in this area. The drainage area upstream from the dam site comprises 2,680 square miles. Stream flows at the dam site during a period between 1930 and 1954 averaged 1,872 c.f.s. Maximum flow of 54,400 and a minimum flow of 11 c.f.s. were recorded during that period.

2.32 Water Quality. Minor sources of pollution exist in some of the tributary streams, but these are quickly assimilated and the Kaskaskia River and Carlyle Lake are still considered relatively free of pollution. Potential sources of pollution which could have considerable effect upon water quality in Carlyle Lake include wastewater from surrounding communities and runoff from agricultural land. Because of this, the U. S. Army Corps of Engineers will cooperate within the limits of its authority with local Soil and Water Conservation Districts in promoting an accelerated land treatment program throughout the watershed to reduce erosion sedimentation and water pollution.

The water quality of the Basin has been neither degraded nor improved due to the impoundment of the stream. The temperatures of the stream below the dam outfall were as follows: 9 June (23°C), 6 July (28°C), 4 August (24°C), 31 August (28°C), 28 September (21°C), 26 October (18°C). The temperature profile for the lake is shown in Appendix D. The lake is eutrophic and in the summer, water below 12 to 15 feet deep, frequently becomes de-oxygenated. Terrain and the physical shape of the lake do not hinder frequent high winds and waves which often keep the lake water mixed and eliminate any prolonged thermal stratification.

Water quality conditions below the dam have shown higher dissolved oxygen concentrations and lower turbidity than water entering the lake. These improvements are primarily due to turbulence created in the stilling basin and entrapment of sediment behind the dam, respectively. The water quality in Carlyle Lake is of suitable quality for use as a water supply, primary and secondary contact recreation, and for support of desirable biological communities.

2.4 Biological Elements.

2.41 Vegetation. Prior to the construction of the reservoir, about 60 percent of the present fee-owned project acreage was forested. The majority of these lands was located below the normal pool elevation and was inundated by the reservoir.

In the low, poorly drained areas of the Kaskaskia bottoms are found the palustrine oak-hickory-maple forests. This major plant community is variable in the nature and type of plant associations, largely as a result of minor differences in the amount of drainage and the periodicity of inundation.

A climax growth of this major plant community was observed in the swamps of the lake basin before clearing. Here the dominant trees were pin oak, cottonwood, pignut hickory, and soft maple. Overcup-oak occurred in reduced numbers. The undergrowth was largely young pin oak and pignut hickory, while the ground cover was composed of sedges and minor associations of grass. Remnants of this forest-type can still be found along the uncleared stream channel and in the subimpoundment areas.

Along the upper portions of the Kaskaskia Valley, in well-drained soils and gentle slopes, the upland oak-hickory forests are the climax growth.

The upland oak-hickory forest community is dominated by several species of the red oaks, bur oak, and shagbark hickory. The overstory in its natural form was dense and allowed only occasional light to penetrate below. This substratum consists largely of the young of the dominant trees. Surface cover is essentially non-existent, the ground being covered with a heavy matting of small twigs and leaves. On the edges of small sunbreaks in the upper stratum, grasses may be found as ground cover; grapes and other lianas may cover the adjacent growth.

Minor floral associations which occur within the upland oak-hickory forest are largely the result of variations in the amount of drainage and disruptions in the density of the upper stratum. For example, in more open areas where lumbering has been carried out, minor plant associations occur dispersed within the upland forest proper. In some broken spots, the surface cover may be largely grasses, particularly brooms-edge and young cottonwood, hickory, and locust. These lower trees may be covered with lianas of both summer and frost grape. Along the edges of the forest proper, in the transitional zones between the forests and the agricultural land, blackberry and dewberry are abundant, as well as sassafras, black cherry, many lianas of summer and frost grape, virginia creeper, and several species of greenbrier. Various sedges and grasses are also characteristic of the transitional zones.

Since project completion, two distinct areas of vegetative cover can be described on the project. One area lies above the Burlington Northern Railroad embankment; the other area lies below the railroad embankment.

The timbered area lying north of the embankment is devoted to management for wildlife habitat and public hunting. There are several units which have been enclosed in levees and which will be managed as "green tree" reservoirs. The remainder of this area, which has a substantial forest cover, is either inundated or subject to inundation. Most of the trees in this area are dead or dying, and it is expected that many of the remaining live trees will also die over the next ten years. There will probably be some scattered stands which will survive because they occupy higher ground, or islands created by the reservoir. Most of the timber in this area had been heavily cut and high-graded prior to acquisition for the project.

The project lands below the Burlington Northern embankment contain scattered stands of timber which are the remnants of former farm woodlots. These stands are generally low in quality and have less than desirable species composition as a result of past management practices by private owners.

2.42 Animal Life. Located in the 37,159 acres of the Carlyle Lake Area are numerous species of wildlife - most notable among these are deer, bobwhite quail, dove, fur bearers of several varieties, such as mink, muskrat, raccoon, opossum, and red and grey fox, and a large variety of non-game birds. During the migratory season, all varieties of waterfowl indigenous to this flyway are represented. Among these are Canada geese, blue and snow geese, mallard, black duck, baldpate, pintail, gadwall, blue and green wing teal, scaup, ring-neck duck, canvasback, and several of the mergansers. Wood ducks, which nest here during the year and utilize the flooded timber areas for rearing young, are a species which greatly benefit from the reservoir environment. In addition to these spectacular forms of wildlife, there are a large number of songbirds which utilize this vast acreage. The lake area contains heron and egret rookeries, and numerous species of shore-birds, including snipe, yellow legs, and sandpipers. Carlyle Lake does not provide important habitat for any endangered species. Biologists of the Illinois Department of Conservation believe that the Federally-owned land around Carlyle Lake is increasingly productive in terms of wildlife abundance and diversity because much of this area has been retired from intensive agricultural production and allowed to

return to more favorable habitat conditions. It is estimated that from October to April, 100,000 to 250,000 waterfowl visit the project area. The number of birds attracted is dependent on the food supply and the water level. The fur bearers are numerous throughout the area and one needs only navigate the area in a boat and note signs that are left by mink, muskrat, raccoon, and opossum. Carlyle Lake has a high wildlife habitat potential, and it is, at the present time, being developed at a rapid rate by the Corps of Engineers and by the Department of Conservation. Many of the practices that are being inaugurated now will further benefit this wildlife potential and will benefit most forms of wildlife.

2.43 Aquatic Life. The fish population of Carlyle Lake and its tailwater is typical of midwestern waters. Major sport, commercial, and forage species are white and black crappie, bluegill, green sunfish, yellow bass, long-ear sunfish, warmouth, yellow and black bullhead, channel and flathead catfish, largemouth bass, freshwater drum, carp, numerous species of buffalo fishes, suckers, and carpsuckers, bowfin, gizzard shad, brook silversides, and many species of minnow, shiners and darters. All totaled, there are approximately 50 species of fish found in this area. An overall listing of fish species sampled at Carlyle is presented in Appendix A.

The water of the lake and tailwater also has many diverse forms of phytoplankton, zooplankton, aquatic insects, crustaceans, and mollusks. All, in one stage or another, are an integral part of the food chain, necessary to sustain life of the lake organisms. The food supply of the fishes is supplemented also by numerous terrestrial forms, particularly during periods of rainfall or windy days. Maintenance of good water quality (free of inorganic or organic pollutants) is also necessary for the well-being of the diverse aquatic populations.

While presently not abundant, several species of semi-aquatic plants (smartweed, arrowhead, water willow, cattail) are established and contribute to the aquatic communities as a source of nesting, feeding, and protective cover.

2.5 Cultural Elements.

2.51 Archaeological Studies. A report on the survey of archaeological sites in the Carlyle Lake Basin was accomplished in 1960 through a contract awarded to Melvin L. Fowler, Southern Illinois University, by

the U. S. Department of the Interior, National Park Service (Contract No. 14-10-529-1983). Although it was previously known that this area contained aboriginal sites, it was not known how numerous or extensive these sites were. Only minimal archaeological work had been accomplished in this area prior to the above survey. Eighty-three sites were identified as possibly having archaeological significance. On the basis of the survey, it was strongly recommended that salvage operations be undertaken at selected sites so that a greater understanding of the aboriginal occupants could be achieved. Subsequent salvage studies carried out through cooperative agreements with the National Park Service (Contract No. 14-10-529-1984, No. 14-10-529-1993, and No. 14-10-529-2487) reported on specific salvage operations. Contract No. 14-10-529-2877 entitled "Carlyle Reservoir Archaeology: Final Session," was authored by Frank Rackerby and published in April 1968.

Three cultural groups were identified in the studies as a result of finds in the work areas. They were the Archaic, Woodland, and Mississippian groups or periods. No sites attributed to historic Indian groups were located in the area. The Carlyle Project cast no light on this shadow zone between the archaeological past and written history. A considerable amount of data collected still requires analysis, interpretation, and then publication.

2.52 Area History. The first white-man activity in the Carlyle Area dates back over a century and a half when, in the latter part of 1808, a wagon road was laid out through what is now Clinton County. This road extended east and west and was part of what was known as the Vincennes - St. Louis road. It ran along the site which is now Fairfax Street in Carlyle.

In 1812, the settlement of Carlyle began with John Hill, who built a log fort and block house as a means of protection against the war-like Indians at a site six blocks east of the present courthouse square. Hill established a ferry for crossing the Kaskaskia River, and built a small shelter at the river which served as a toll house. This toll house and block house were the first buildings in Carlyle, and probably the first in Clinton County. Those to follow Hill and continue the settlement of the area were of English birth or parentage, hence the name they gave it - Carlyle - was in honor of Sir Thomas Carlyle, who figured so prominently in Eighteenth Century English literature.

It was in 1824, six years after Illinois was granted statehood, that Clinton County was formed out of Washington, Bond, and Fayette Counties. Covington, which had been the County Seat, was situated in Washington County; therefore, the question of a new County Seat for Clinton County arose. Charles Slade, a prominent Carlyle citizen, in order to secure the Seat for Carlyle, made a grant of 20 acres on the condition that Carlyle would be selected. The present courthouse square is part of that grant.

In 1825, Charles Slade erected a toll bridge across the Kaskaskia River to replace the ferry which had been the only means of crossing the river. The bridge served the travelers on the Vincennes - St. Louis road until 1860 when a suspension bridge, one of the earliest in the mid-west, was constructed at a cost of \$45,000. In 1946, the Carlyle Suspension Bridge Restoration Association was formed to restore this picturesque structure which was deteriorating rapidly. Twenty thousand dollars was appropriated in 1951 by the State Legislature for the restoration of the bridge because of its historical importance. When the restoration was completed, it was decided to name the bridge in honor of General William Dean, hero of the Korean War. On 11 November 1953, General Dean came to Carlyle to dedicate the bridge.

2.53 Population Trends. The area of immediate impact from Carlyle Lake is defined as Bond, Clinton, Fayette, and Marion Counties. Total population of the area fell steadily from 114,500 in 1940, to 99,400 in 1960. The declining population trend was reversed during the 1960's and increased to 102,000, as reported in the 1970 census. Nearly 87 percent of the increase occurred in Clinton County. The increase was diffused over 10 communities which are on or very near U. S. Highway 50 or Illinois Highway 161.

The Office of Business Economics (OBE) projections for the Kaskaskia River Water Resources Planning Area (WRPA)*, 17 March 1969, indicate an increase in population beginning with 1980 and averaging almost 7.5 percent per decade thereafter. Positive rates of growth during the 1960's resulted in the 1970 Kaskaskia population exceeding the projected population for 1980. Since the Carlyle Area has maintained a population in proportion to the Kaskaskia River Water Resources Planning Area since 1950, a population increase

*The Kaskaskia River WRPA is composed of Monroe, Randolph, Washington, Clinton, Bond, Fayette, Marion, Montgomery, Shelby, and Moultrie Counties.

of about 7.5 percent per decade should be expected to approximate the next 20 or 30 years growth of the Carlyle Area.

2.54 Present Economic Conditions. In 1960, median family income for the State of Illinois was \$6,566; in the Carlyle Area, median family income ranged from a low of \$3,806 in Fayette County to a high of \$4,808 in Clinton County. In 1950, median family income in the Carlyle Area was \$2,580 or 81 percent of that for the State (\$3,163); in 1960, it had declined to 66 percent. Therefore, even though the area increased its median family income by 68 percent between 1950 and 1960, it became less wealthy relative to the rest of the State. Although 1970 census figures on family income are not yet available, some indication that a disparity still exists is provided by a comparison of per employee quarterly taxable payrolls for the State of Illinois and the Carlyle Counties from County Business Patterns (CBP) 1970. The average quarterly payroll per employee for the State of Illinois was \$1,803, while that for the Carlyle Area was \$1,303; or 72 percent of the State average and OBE per capita income projections for the Kaskaskia show per capita income in the WRPA increasing to only 82 percent of the average per capita income for the U. S. by 2020.

The Carlyle Area in some ways reflects national trends in economic conditions. For example, employment is generally expanding in the retail trade and services sectors, but continues to decline in agriculture. Some of this increase reflects new opportunities to provide sales and services which are related to recreation activities at the lake. It is not yet evident from County Business Patterns (CBP) what proportion is related to Carlyle Lake. Contrary to national trends, however, is the slow increase in median family income. In this category, the Carlyle Area is not holding its own, and continues to lag behind average family income for the State of Illinois. Although 1970 quarterly payroll per employee was below average for the Carlyle Area, it has been increasing at a rate of over eight percent per year since 1968. If, as projected, population begins to increase in the other three counties during the 1970's, income may also begin to rise.

Clinton County does show evidence of benefit from Carlyle Lake. Sales tax revenues are up in the area and several new bait shops, marinas, and private campgrounds have been opened. The economic value of sport fishing at Carlyle Lake has been estimated to be nearly \$750,000 annually by Mr. Arnold Fritz, State Reservoir Fishery Biologist at Carlyle (based on a value of \$5.00 per fisherman day

taken from "1970 Economic Survey of Daily Expenditures Made by Carlyle Lake and Tailwater Anglers"). While much of this expenditure is non-local travel expense (only 23.3 percent of the fishermen at Carlyle Lake live within a 25-mile radius), significant amounts are spent locally for food, beverages, gasoline, and bait. Employment in retail sales has risen in all but Fayette County since 1967 with Clinton County having an increase from about 800 to nearly 1,000 in 1970. Extrapolating from the present growth in retail and some services employment would not be sufficient to predict future growth without a detailed examination of the area.

2.55 Socio-Economic Patterns. The area is heavily German in ethnic background, but significant numbers of the foreign-born population are English, Welsh, Czech, Polish, and Italian. In 1970, approximately two percent of the Carlyle Area population was Negro and less than one percent of the remainder was non-white. The median age (31.5) is somewhat higher than the median age for the State of Illinois (28.6). About 30 percent of the population was under age 18 in the four counties, which is also lower than the State's 34.2 percent.

The median age in Clinton County is significantly lower (24) than in the remaining counties (32-33) and also lower than the State (28.6). This is probably due in part to the increased attraction to young people of staying in this area after high school due to the proximity of the St. Louis Metropolitan Area expansion directly to the west in St. Clair County and the construction of Carlyle Lake and the resulting recreational industry growth surrounding it.

The Carlyle Area, traditionally agricultural, is undergoing a change as the labor force no longer needed in agriculture either seeks employment in the expanding St. Louis Metropolitan Area or turns to new local activities, such as services generated by the growing fishing and boating opportunities at Carlyle Lake.

It is projected that future growth in the area will center in Centralia and in the communities between Carlyle Lake and St. Clair County on Highways 50 and 161. These communities have grown significantly in comparison to the other communities in the four county area, and they are expected to continue the trend for the same reasons they have grown in the past.

2.56 Recreation Activity Trends and Projections. Trends in outdoor recreation activities at Carlyle Lake are expected to reflect the

broad trends observed at facilities within reach of the St. Louis Area. There appears to be a declining trend for sightseeing, driving for pleasure, and picnicking at facilities in close proximity to major metropolitan areas. In contrast, the preference for water-based recreation activities appears to be increasing. Boating, in particular, has shown a marked increase in recent years, and this general trend is expected to continue at Carlyle Lake. The demand for swimming has also increased greatly on the project with near capacity use being experienced on the beaches presently in operation. Fishing also has shown an increase, but less marked, and it is concentrated in the upper reaches above the Burlington Northern embankment and in the area immediately below the spillway. Projections for visitor days at the lake are expected to show a steady increase, reaching the annual design load capacity of 4,886,000 by 1986.

The upward trend in campground use at Carlyle Lake is particularly interesting. More and more families are purchasing equipment to enable them to spend weekends at lake projects instead of making day visits. Many of this new breed of campers require sophisticated equipment so the comforts of home can be carried to the outdoor setting. Tents are giving way to tent campers and travel trailers. More campers request electric service, water and sewer hookups, and they expect flush toilets and shower facilities. Greater security is necessary for the camper, and the campers have exhibited a willingness to pay for these services and extra facilities. It is expected that the Corps will develop campgrounds for youth groups, primitive overflow areas for families that find campgrounds full, and isolated primitive campgrounds for the tenter and boater that find the major campgrounds too modern.

2.6 Interrelation of Other Projects in Kaskaskia Watershed.

2.61 Lake Shelbyville. Lake Shelbyville is an 11,000-acre, at normal pool elevation 599.7 feet m.s.l., multi-purpose lake which was brought into operation for the first time in 1970. It was formed by the construction of a dam across the Kaskaskia River approximately 116 miles above Carlyle Dam, and regulates the runoff from 1,030 square miles of drainage area. There are 180,000 acre-feet of storage in the joint-use pool to meet the project purposes, which include a minimum downstream release of 10 c.f.s. - a distinct improvement over the natural flows which were reported as low zero flow in the past. Lake Shelbyville will release water to replenish Carlyle Lake during periods of low flow when Carlyle Lake makes releases to meet navigation deficiencies at the Kaskaskia Navigation Lock and Dam.

2.62 Kaskaskia Lock and Dam. Located approximately 107 miles downstream of Carlyle Dam, the Kaskaskia Navigation Lock and the Dam are essentially completed. It was authorized by Public Law 87-874, 87th Congress, 23 October 1962, and provides for navigation on the lower portion of the Kaskaskia River. The authorized plan consists of a navigation channel nine-feet deep and 200-feet wide from the mouth of the Kaskaskia River to Fayetteville, Illinois, by enlarging the present channel where required, making overbank cuts to eliminate sharp bends, and constructing a single lock and dam at river mile 0.8.

2.63 Levee District No. 21 (Vandalia). The Vandalia Levee, located on the left bank of the Kaskaskia River between miles 155.5 and 172.0 in Fayette County, Illinois, lies between Carlyle Lake and Lake Shelbyville. The existing levee offers only partial protection to 11,430 acres, of which 9,530 acres are cleared. The proposed levee will reduce the plain area's total need for rural flood damage prevention on 33,000 acres by its project area of 11,430 acres. Improvement of this levee is an essential element in the comprehensive plan of development of the Kaskaskia River Basin. The improved levee would provide flood protection benefits amounting to \$344,700 annually.

2.64 Dively Drainage and Levee District. The Dively Levee District is located about 12 miles upstream from Vandalia, Illinois, on the east bank of the Kaskaskia River. The existing levee provides partial protection for 1,415 acres of productive agricultural land. With the recommended alinement, the protected area remains about the same. The improvements would afford protection to the levee district against a flood having a frequency of about once in 50 years. The existing levee provides protection against a flood having a frequency of about once in 30 years.

3. THE ENVIRONMENTAL IMPACT OF PROGRAMMED OPERATION AND MAINTENANCE ACTIVITIES.

3.1 Local Development as a Result of the Project. As a result of Carlyle Lake being constructed and operated, several pertinent situations have developed which to some extent affect the environment of the project area. The Corps can control some of these situations, but others are less appropriate, particularly where the philosophy of providing a shoreline as natural as possible is important to the experience received by the recreationist.

REC'D DEC 23 1978

Illinois Department of Transportation

Division of Highways/District 8
9300 St. Clair Avenue/Fairview Heights, Illinois/62208

December 22, 1978

RE: FAP 409

Mr. Randal B. Thomas
Barnes, Henry, Meisenheimer
and Gende, Inc.
4658 Gravois Avenue
St. Louis, Missouri 63116

Dear Mr. Thomas:

The Environmental Impact Study and the Design Report for FAP-409 have been approved by the Federal Highway Administration from Illinois Route 158 to US Route 51 north of Sandoval, on October 18, 1978. During FY-79 we are concentrating our effort on a two lane portion between Illinois Route 4 and US-50 around Lebanon.

Except for the portion on the FY-79 program, no other work is being done on the remaining portions of FAP-409. Final plans for the remainder of the route have not been completed.

When funds become available we will program the remainder of the route for construction, however we have no idea when these funds will become available.

Thank you for your interest. If you have any questions please contact this office.

Sincerely,

Dale L. Klohr
District Engineer

Kent L. Muskopf
District Planning Engineer

FDB/lw

CITY OF CARLYLE, ILLINOIS

MUNICIPAL ELECTRIC UTILITY

Summary of Present Debt Service Requirements

\$820,000 Electric System Improvement
and Refunding Revenue Bonds
Dated May 1, 1963 at 3-3/4% (\$40,000 Unissued)

\$530,000 Electric System Revenue Bonds
Dated May 1, 1969 at 6%

\$150,000 Electric System Revenue Bonds
Dated Nov. 1, 1974 at 6-3/4%

Fiscal Yr. Ending April 30	Maturing May 1	Principal Outstanding	Principal Payment	Interest Payment	Principal and Interest	Principal Outstanding	Principal Payment	Interest Payment	Principal and Interest	Principal Outstanding	Principal Payment	Interest Payment	Principal and Interest	Total Principal and Interest
1967	1966	\$750,000	\$ 15,000	\$ 28,125	\$ 43,125									\$ 43,125
1968	1967	735,000	15,000	27,562	42,562									42,562
1969	1968	720,000	15,000	27,000	42,000									42,000
1970	1969	705,000	20,000	26,437	46,437									46,437
1971	1970	685,000	20,000	25,687	45,687	\$530,000	--	\$ 31,800	\$ 31,800					77,487
1972	1971	665,000	20,000	24,937	44,937	530,000	--	31,800	31,800					76,800
1973	1972	645,000	20,000	24,187	44,187	530,000	\$ 5,000	31,800	36,800					80,987
1974	1973	625,000	20,000	24,437	44,437	525,000	5,000	31,500	36,500					80,937
1975	1974	605,000	25,000	22,687	47,687	520,000	--	31,200	31,200					78,887
1976	1975	580,000	25,000	21,750	46,750	520,000	--	31,200	31,200	\$150,000	\$ 15,000	\$ 5,062	\$ 20,062	98,012
1977	1976	555,000	25,000	20,812	45,812	520,000	--	31,200	31,200	135,000	10,000	9,112	19,112	96,124
1978	1977	530,000	25,000	19,875	44,875	520,000	5,000	31,200	36,200	125,000	10,000	8,437	18,437	99,512
1979	1978	505,000	25,000	18,937	43,937	515,000	5,000	30,900	35,900	115,000	10,000	7,762	17,762	97,599
1980	1979	480,000	30,000	18,000	48,000	510,000	--	30,600	30,600	105,000	10,000	7,087	17,087	95,687
1981	1980	450,000	30,000	16,875	46,875	510,000	--	30,600	30,600	95,000	15,000	6,412	21,412	98,887
1982	1981	420,000	30,000	15,750	45,750	510,000	--	30,600	30,600	80,000	15,000	5,400	20,400	96,750
1983	1982	390,000	30,000	14,625	44,625	510,000	5,000	30,600	35,600	65,000	15,000	4,387	19,387	99,612
1984	1983	360,000	30,000	13,500	43,500	505,000	5,000	30,300	35,300	50,000	15,000	3,375	18,375	97,175
1985	1984	330,000	35,000	12,375	47,375	500,000	--	30,000	30,000	35,000	20,000	2,362	22,362	99,737
1986	1985	295,000	35,000	11,062	46,062	500,000	5,000	30,000	35,000	15,000	15,000	1,012	16,012	97,074
1987	1986	260,000	35,000	9,750	44,750	495,000	5,000	29,700	34,700					79,450
1988	1987	225,000	30,000	8,437	38,437	490,000	10,000	29,400	39,400					77,837
1989	1988	195,000	30,000	7,312	37,312	480,000	15,000	28,800	43,800					81,112
1990	1989	165,000	30,000	6,187	36,187	465,000	15,000	27,900	42,900					79,087
1991	1990	135,000	30,000	5,062	35,062	450,000	15,000	27,000	42,000					77,062
1992	1991	105,000	35,000	3,937	38,937	435,000	15,000	26,100	41,100					80,037
1993	1992	70,000	35,000	2,625	37,625	420,000	15,000	25,200	40,200					77,825
1994	1993	35,000	35,000	1,312	36,312	405,000	20,000	24,300	44,300					80,612
1995	1994					385,000	55,000	23,100	78,100					78,100
1996	1995					330,000	60,000	19,800	79,800					79,800
1997	1996					270,000	60,000	16,200	76,200					76,200
1998	1997					210,000	65,000	12,600	77,600					77,600
1999	1998					145,000	70,000	8,700	78,700					78,700
2000	1999					75,000	75,000	4,500	79,500					79,500
Summary of Current Debt as of May 1, 1978			\$505,000	\$165,746	\$670,746									
							\$515,000	\$546,900	\$1,061,900					
										\$115,000	\$37,797	\$152,797		\$1,885,443