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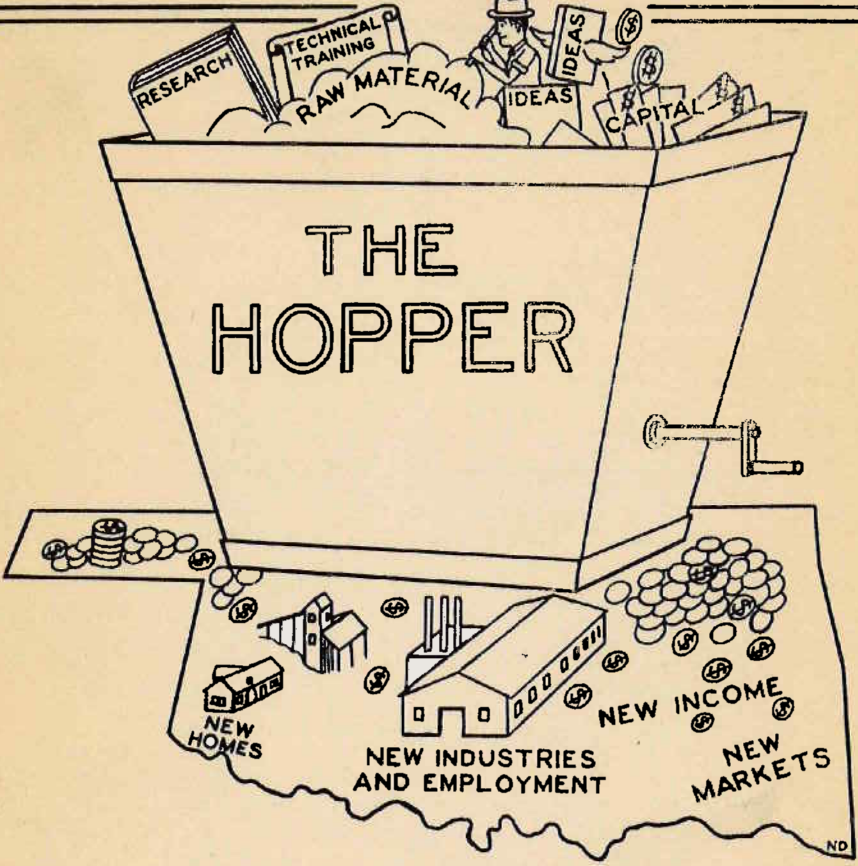

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THE LAKE SYSTEM OF NORTHEASTERN OKLAHOMA

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INTRODUCTION

The present lake system in northeastern Oklahoma was begun in 1922 by the construction of Spavinaw Lake, a reservoir designed to furnish a dependable supply of water for the City of Tulsa. Hydroelectric development and flood control program was started in 1935 by the creation of the Grand River Dam Authority by the Oklahoma Legislature. Financial support for this project was procured by a loan and grant agreement with the Public Works Administration of the United States Government, (Grand River Dam Authority, 1950). In 1937, The Chief of Engineers, Department of the Army, recommended a system of seven flood-control reservoirs in the Arkansas River Basin as part of the flood protection program for the Ohio and Lower Mississippi Rivers. The Flood Control Act of June 28, 1938, approved that system of reservoirs. Included were the Pensacola, Markham Ferry, and Fort Gibson Dams on the Grand River and Tenkiller Reservoir on the Illinois River. Actual construction of the Fort Gibson Dam and Reservoir was authorized by the Flood Control Act of 1941 and Tenkiller Ferry Dam was approved by Congress in the River and Harbor Act of 1946 (Corps of Army Engineers, 1946, 1948). The Pensacola, Fort Gibson, and Tenkiller Ferry projects have been completed; initial appropriations for construction of the Markham Ferry Dam were made this year.

GEOLOGICAL SETTING

Northeastern Oklahoma lies on the southwestern flank of the Ozark Uplift, a broad,

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asymmetrical dome which occupies an area of approximately 40,000 square miles in Missouri, Arkansas, and Oklahoma. Portions of Ottawa, Craig, Delaware, Mayes, Wagoner, Muskogee, Cherokee, Adair, and Sequoyah Counties are included.

The Ozark region can be divided into three physiographic provinces; the Salem Plateau carved on Ordovician and older rocks; the Springfield Structural Plain underlain largely by rocks of Mississippian age, and the Boston Mountains, a dissected plateau capped by resistant sandstone strata of early and middle Pennsylvanian.

The northern three-fourths of the Oklahoma Ozark Area is in the Springfield Structural Plain. Here the upland surface is formed on the cherts and limestones of the "Boone" or Osagean. The area is deeply dissected with flat divides and sharp, V-shaped valleys. A dendritic or branching drainage pattern is conspicuous. The approximate western boundary of the Springfield Plateau is the present position of the Spring and Grand Rivers.

South of the Springfield Structural Plain is a narrow belt of rugged topography of the Boston Mountain Plateau. Here a series of northeast-trending normal faults separate the area into prominent fault blocks whose dip slopes are capped by resistant sandstone. Dissection in this area is deep and valleys 300 to 500 feet are not uncommon.

The Oklahoma Ozark Area lies in the drainage basin of the Arkansas River. The northern portion is drained by the Grand River which enters the Arkansas near Fort Gibson. The southern part is drained by Bayou Manard, Boudinot Creek, Greenleaf Creek, Cedar Creek, Illinois River, Vian Creek, Sallisaw Creek, and Lee Creek.

SEQUENCE OF ROCK UNITS

The rocks exposed at the surface in the Oklahoma Ozarks range in age from pre-Cambrian to Middle Pennsylvanian. Locally these are overlain by a thin veneer of terrace gravels and alluvium. (See stratigraphic section, figure 1).

The pre-Cambrian Spavinaw granite is overlain by the Lower Ordovician Cotter dolomite in the vicinity of Spavinaw. In the southern part of the area, the Cotter is succeeded by the Burgen sandstone, Tyner shales and dolomite, Fite limestone, Fernvale limestone, and Sylvan shale of Ordovician age. Upper Ordovician Sylvan shale is overlain unconformably by the St. Clair limestone of Silurian age which is in turn succeeded by the Frisco limestone and the Sallisaw sandstone and chert of Devonian age.

Devonian, Silurian, and Ordovician units are beveled northward by unconformity and are overlapped by the Chattanooga black shale and the basal Sylamore sandstone member (Late Devonian or Early Mississippian) which lie on the Sallisaw formation near Marble City and on the Cotter near Spavinaw.

The succeeding Osagean Series, frequently referred to as the "Boone chert", includes the St. Joe, Reeds Spring, and Keokuk formations. The Osagean is overlain unconformably by the "Mayes" limestone which can be divided into several lithic units of Moorefield and Hindsville age. The Hindsville limestone is overlain by the Fayetteville black shale and Pitkin limestone of Upper Mississippian age. Lower Pennsylvanian strata include the Hale and Bloyd formations; the overlying Atoka is assigned to the Middle Pennsylvanian, Atoka Series. Succeeding units of Des Moinesian age truncate the Atoka northward in Mayes, Craig, and Ottawa Counties.

SYSTEM	SERIES	FORMATION	ROCK	FEET	CHARACTERISTICS AND FAUNA
PENNSYLVANIAN	DES MOINESIAN	"CHEROKEE"		0-300	Yellow brown shales and sandstone with Warner or Little Cabin sandstone at base.
	"ATOKAN"	ATOKA		0-600	Sequence of marine and non-marine shales and sandstones with occasional limestone. Best developed in Muskagee Porum District where it includes the Coody, Pope Chapel, Georges Fork, Dirty Creek, Webbers Falls, and Blackjack School members.
	MORROWAN	BLOYD		0-150	Blue-gray, fossiliferous limestone interbedded with gray, fissile shale. Abundant _Pentremites_. Thins northward to extinction in Yonkers area.
		HALE		0-140	Massive, blue-gray, sandy limestone and cross-bedded sandstone; weathers pitted and fluted. Conglomerate at base. Abundant _Pleurodictyum eugenae_.
MISSISSIPPIAN	CHESTERIAN	PITKIN		0-80	Gray-blue, rubbly-weathering limestone with _Archimedes_, _Diaphragmus_, _Eumetria_, _Torynifera_ Thins northward to extinction near Yonkers.
		FAYETTEVILLE		15-185	Black, fissile shale and thin interbedded blue-black limestone. Fossiliferous with _Eumetria_, _Diaphragmus_, _Spirifer increbescens_, _Linoproductus_.
		HINDSVILLE		0-65	Gray, oolitic limestone with _Spirifer leidyi_, _Agassizocrinus_, _Diaphragmus cestriensis_.
	MERAMECIAN	MOOREFIELD		0-35	Blue-yellow, calcareous siltstone and shale.
				0-8	Gray, granular limestone with chert fragments.
				0-65	Blue black to brown, argillaceous limestone; _Leiorhynchus carboniferum_, _Moorefieldella eurekensis_; grades eastward into glauconitic, gray limestone.
	OSAGIAN (BOONE)	KEOKUK		0-70	Massive, white to tan flecked, tripolitic chert and blue gray, crinoidal limestone.
		REEDS SPRING		0-150	Blue-white to tan, thin-bedded chert and limestone.
		ST. JOE		0-25	Gray, nodular weathering limestone and underlying green shale.
?	KINDERHOOKIAN	CHATTANOOGA		0-60	Black, fissile shale with basal Sylamore sandstone.
DEV.	ULSTERIAN	SALLISAW		0-25	Brown, calcareous sandstone and chert.
		FRISCO		0-8	Gray, coarsely crystalline limestone.
SIL.	NIAGARAN	ST CLAIR		0-100	Pinkish-white, coarsely crystalline limestone; absent north of Qualls.
ORDOVICIAN	CINCINNATIAN	SYLVAN		0-25	Yellow-brown to green, unfossiliferous shale.
		FERNVALE		0-25	Gray, coarsely crystalline limestone with abundant _Rhynchotrema capax_.
	MOHAWKIAN	FITE		0-8	Gray, lithographic, calcite-flecked limestone.
		TYNER		0-90	Bright green shales and thin, sandy, yellow dolomite.
	CHAZYAN	BURGEN		0-100	White to yellow, hard, massive sandstone with thin bed of sandy dolomite and green shale.
	CANADIAN	COTTER		±200	Gray to buff, finely crystalline dolomite with thin beds of white sandstone.
PRE-CAMBRIAN		SPAVINAW		?	Red, coarse-grained granite near Spavinaw

GENERALIZED COLUMNAR SECTION FOR NORTHEASTERN OKLAHOMA

Figure 1

(Reproduced from Okla. Geol. Survey Guidebook 1)

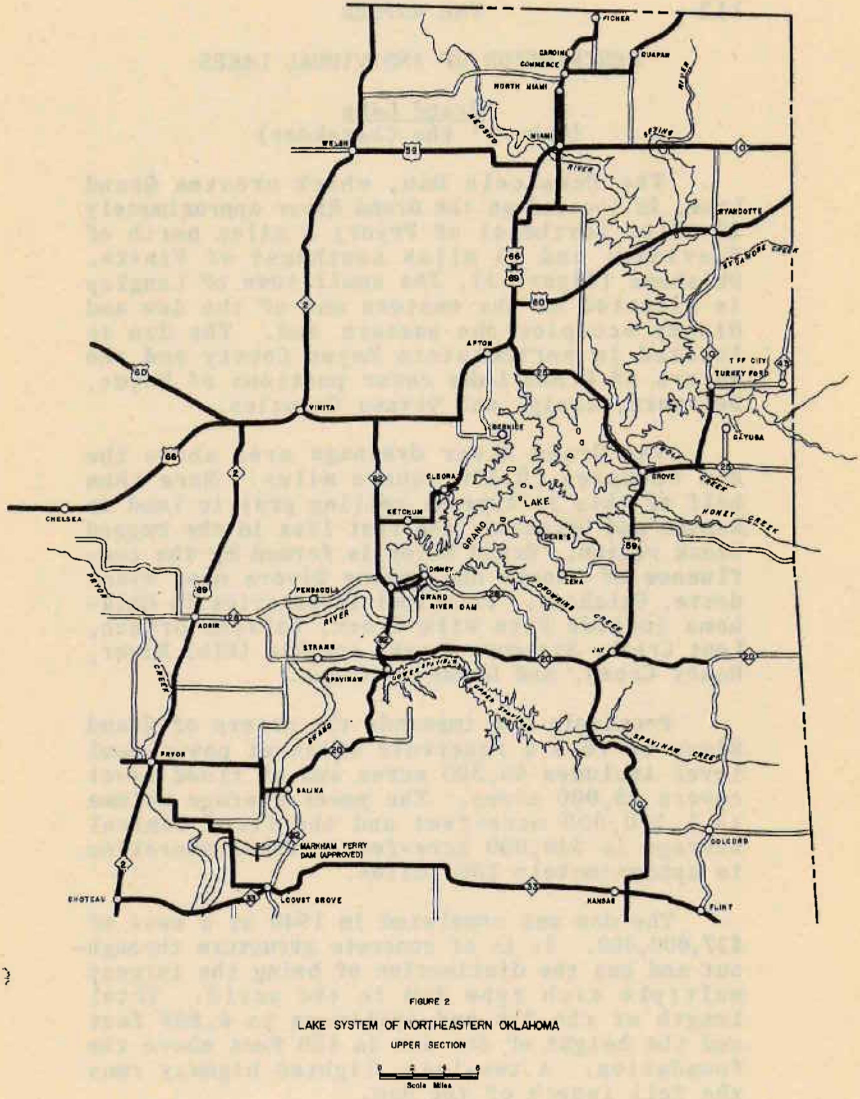

FIGURE 2

LAKE SYSTEM OF NORTHEASTERN OKLAHOMA

UPPER SECTION

Scale Miles

(Redrawn from Oklahoma Ozark Playgrounds Map)

DESCRIPTION OF INDIVIDUAL LAKES

Grand Lake
(Lake o' the Cherokees)

The Pensacola Dam, which creates Grand Lake, is located on the Grand River approximately 20 miles northeast of Pryor; 5 miles north of Spavinaw; and 16 miles southeast of Vinita, Oklahoma (figure 2). The small town of Langley is situated at the western end of the dam and Disney occupies the eastern end. The dam is located in northeastern Mayes County and the waters of Grand Lake cover portions of Mayes, Delaware, Craig, and Ottawa Counties.

The Grand River drainage area above the dam occupies 10,300 square miles. More than half of this is typical rolling prairie land in Kansas and Oklahoma; the rest lies in the rugged Ozark region. Grand River is formed by the confluence of Neosho and Spring Rivers near Wyandotte, Oklahoma. Principal tributaries in Oklahoma include Five Mile Creek, Warrens Branch, Lost Creek, Sycamore Creek, Cowskin (Elk) River, Honey Creek, and Drowning Creek.

Pensacola Dam impounds the waters of Grand River to form a reservoir which at power-pool level includes 46,300 acres and at flood level covers 55,000 acres. The power storage volume is 1,200,000 acre-feet and the flood control storage is 540,000 acre-feet. Total shoreline is approximately 1300 miles.

The dam was completed in 1940 at a cost of $27,000,000. It is of concrete structure throughout and has the distinction of being the largest multiple arch type dam in the world. Total length of the dam and spillways is 6,565 feet and the height of the dam is 150 feet above the foundation. A two-lane, lighted highway runs the full length of the dam.

Pensacola Dam was taken over by the Government in 1941, under Presidential Order to utilize its power for war effort. For approximately five years, it served the war plants located nearby, producing in that time over 350,000,000 kilowatt hours per year. It was returned to the Grand River Dam Authority and the State of Oklahoma in 1946 (Grand River Dam Authority, 1950).

The annual firm production of the Pensacola plant is 180,000,000 kilowatt hours. Secondary energy is 120,000,000 kilowatt hours. Five 20,000 horse power turbines have been in operation for several years and a sixth unit is being installed. Electric power is distributed through the Grand River Dam Authority to towns and cities throughout northeastern Oklahoma. The abundance of electric power and water makes this general region attractive for larger industries which are moving into the state.

Pensacola Dam is built on solid rock ledges of the Reeds Spring chert and limestone of Mississippian age. Upper portions of the valley walls near the dam are of white, massive, Keokuk chert. Nearly all of the reservoir is underlain by chert and limestone of Osagean age. Northwest of Miami, the Neosho River flows across the Hindsville limestone (Mississippian) and the soft, relatively non-resistant beds of the Hartshorne, McAlester, Savanna, and Boggy formations of Middle Pennsylvanian age. Tributary streams from the east rise in the chert hills and are clear and free of silt. The Neosho River and tributary streams entering from the west are muddy and heavily loaded with silt.

The beds in this area are essentially flatlying with local departure from horizontal along the flanks of the Horse Creek anticline and in proximity to the Seneca Graben which cuts across the spillway of the Pensacola Dam east of Disney.

The Spavinaw Lakes

The Spavinaw Lakes, located on Spavinaw Creek in Mayes and Delaware Counties, Oklahoma (figure 2) are artificial lakes built to provide an adequate supply of water for the City of Tulsa. The lower lake was completed in 1922 at an approximate cost of 8½ million dollars, (Wally Wallis, Daily Oklahoman, May 1955). Increased industrial demands following World War II led to the construction of the Upper Spavinaw Lake in 1952. The water is carried from Spavinaw to Tulsa through two large concrete aqueducts. Total cost of the entire project was about 20 million dollars.

The lower lake, located at Spavinaw, Oklahoma, covers approximately 1600 acres, is about 5 miles long, and impounds 31,000 acre-feet of water. The upper lake covers 3200 acres, is about 8 miles long and impounds 80,000 acre-feet of water.

Spavinaw Creek is floored by the Cotter dolomite of Ordovician age. This is overlain by the Chattanooga black shale, the St. Joe limestone, Reeds Spring and Keokuk cherts and limestones of Mississippian age. The sequence above the Cotter may be seen at the south end of the dam on the lower lake and this sequence of units may be traced almost continuously around the valley walls adjacent to the lakes. The Cotter dolomite and underlying Spavinaw granite (pre-Cambrian) are exposed along Spavinaw Creek west of the lower dam and in scattered crops throughout the western edge of Spavinaw.

The lower lake is serviced by the City of Spavinaw which is a typical resort town. Jay, located six miles northeast of the upper lake supplies fishing material and food for fishermen.

Fort Gibson Reservoir

Fort Gibson Dam is located on the Grand River in Wagoner and Cherokee Counties, Oklahoma, about 8 miles above its confluence with the Arkansas River (figure 3). The site is 5 miles north of Fort Gibson; 5 miles northeast of Okay; 12 miles northeast of Muskogee, and 10½ miles southeast of Wagoner, Oklahoma.

Fort Gibson Dam and Reservoir were constructed for flood control and hydroelectric power together with the development of the area for recreational purposes. The shore lands surrounding the lake will be developed for public parks and recreational purposes, and as a wildlife preserve. Sequoyah Lodge, now under construction east of Wagoner, will provide accommodations comparable to those at Lake Murray and Lake Texoma. Total cost of the project exceeds $25,000,000 for the dam and $1,300,000 for the lodge.

The Fort Gibson Reservoir is approximately 39 miles long and will cover approximately 51,000 acres. The reservoir, when full, will have a storage capacity of 1,287,000 acre-feet of which 365,000 acre-feet will be maintained for development of hydroelectric power and 922,000 acre-feet for flood control. Tributary streams which enter the Fort Gibson Reservoir include Pryor Creek, Chouteau Creek, Spring Creek, Flat Rock Creek, Clear Creek, Fourteenmile Creek, and Ranger Creek. In general, the tributaries from the east are spring fed and clear; those from the west are sluggish, intermittent in part, and heavily loaded with silt.

Fort Gibson Dam has an overall length of 2,850 feet of which 2,563 feet is of concrete construction and the remainder of earthen fill. The dam is 110 feet high (above the foundation) and the top has an elevation of 593 feet. A highway 22 feet wide has been constructed across

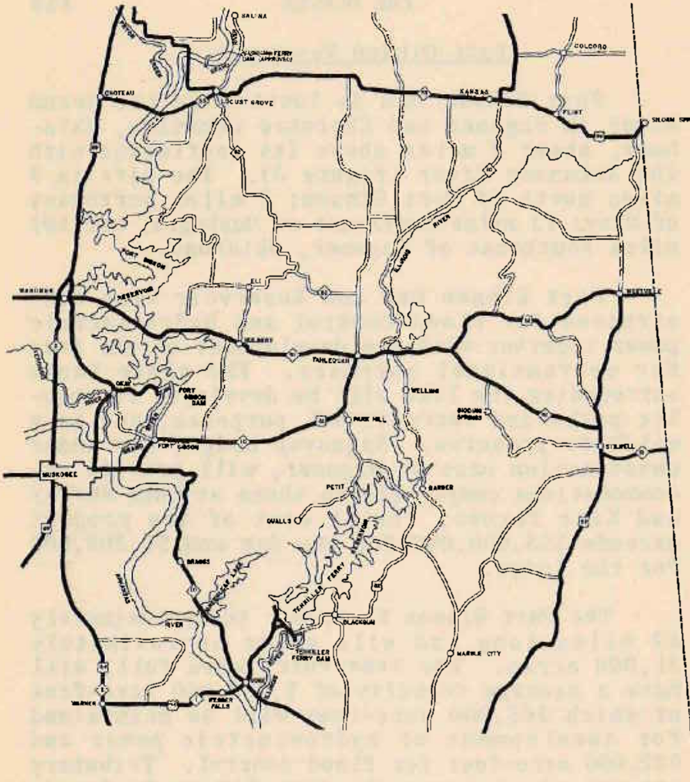

FIGURE 3

LAKE SYSTEM OF NORTHEASTERN OKLAHOMA

LOWER SECTION

Scale Miles

the dam. Complete installation of six 12,300 k.w. generators will provide an output of 180, 700,000 kilowatt-hours per year (data from Corps of Engineers, U.S. Army, 1946).

The Fort Gibson Dam is built on limestones of Mississippian age. The east end of the dam abuts against the Fayetteville black shale and thin, interbedded limestones. These are overlain by the Pitkin, Hale, Bloyd, and Atoka formations. The earthen embankment at the west end of the dam is attached to a wall of Upper Fayetteville and Pitkin. The prominent regional unconformity between the Upper Mississippian and the Lower Pennsylvanian, Morrow Series, is well displayed along the cliff at the west end of the dam where a good development of basal Hale conglomerate cuts across the Pitkin strata.

The oldest rocks present in the Fort Gibson Reservoir area are of Ordovician age. The Tyner shale crops out near the junction of Clear Creek and the Grand River where it is brought to the surface by anticlinal flexing. The Tyner is succeeded by the Chattanooga, St. Joe, Reeds Spring, and Keokuk formations at this locality. In the upper reaches of the reservoir, Meramec and Chester limestones and shales floor the valleys and form the lower portions of adjoining cliffs. Principal units include the Moorefield, Hindsville, and Fayetteville formations. The upper portions of the valley walls are formed by the resistant Hale and Atoka formations.

Greenleaf Lake

Greenleaf Lake (figure 3) is located on Greenleaf Creek in eastern Muskogee County near the town of Braggs. It can be reached by State Highway No. 10, which connects Gore, Oklahoma, and Fort Gibson.

This lake was created by an earthen fill dam with concrete and rock spillway. The lake is approximately 4½ miles long and has a maximum width of nearly 2 miles. During World War II, this lake was used for training amphibious landing forces (Wally Wallis, Daily Oklahoman, May 1955) stationed at Camp Gruber just north of Braggs, Oklahoma. Since cessation of hostilities and partial dismantlement of Camp Gruber, the lake has been returned to civilian use. Today it is used wholly for recreational purposes.

The dam and spillway are built on limestones of the Morrow Series of Lower Pennsylvanian age. Rock ledges in the spillway yield abundant blastoids of the Pentremites augustus type as well as fragments, plates, and occasional calyxes of crinoids. The precipitous cliffs which border Greenleaf Lake are composed of limestones, shales, and sandstones of the Fayetteville, Pitkin, Hale, Bloyd, and Atoka formations. Greenleaf Lake fault passes approximately three-fourths of a mile northwest of the dam, parallels the northwest lake shore for nearly two miles, then cuts across the lake, in Sec. 36, T. 14 N., R. 20 E.

Tenkiller Ferry Reservoir

Tenkiller Ferry Dam on the Illinois River was constructed about 13 miles above the confluence of the Illinois and Arkansas Rivers and 7 miles northeast of Gore, Oklahoma (figure 3). The reservoir, which at the top of flood-control level is 42 miles long and covers 21,000 acres, is located in the scenic Cookson Hills of Sequoyah and Cherokee Counties, Oklahoma.

The Illinois River rises in the Boston Mountains of western Arkansas, about 15 miles southwest of Fayetteville. Spring-fed tributaries, rising in the chert hills of northeastern Oklahoma and western Arkansas assure this lake a plentiful supply of clear, blue water which makes Tenkiller Lake perhaps the most beautiful of all lakes in this area. The main tributaries in Oklahoma are Flint Creek, Barren Fork, and Caney Creek.

The dam which creates Tenkiller Ferry Reservoir is an earthen fill type with a total length of 3000 feet, a maximum height of 190 feet, and a crest width of 25 feet. The dam was completed in 1953 at a total cost of $25,000,000.

The purposes of this dam are three-fold. The primary purposes are flood control and hydroelectric power. Flood protection is offered to over 3000 acres of land in the Illinois Valley below the dam as well as thousands of acres in the Arkansas River Valley below the mouth of the Illinois. The power plant will furnish about 107,000,000 kilowatt-hours of power each year through its two generating units. Storage volume of the power pool is 630,000 acre-feet; the total storage capacity is 1,230,000 acre-feet. The shorelines have been improved to provide public park and recreational facilities (data from Corps of Engineers, U.S. Army, 1948).

The geologic setting of this great dam is unique. It is located on a large bend in the Illinois River. The neck or spur of this bend forms a natural barrier which contains the tunnels and spillways and the earthen dam is attached to the rock wall of its southern terminus. Both ends of the dam abut against the heavy ledges of the Atoka formation. The Bloyd shale and limestones which underlie the Atoka are exposed just west of the dam on the lower or southern side. The Bloyd-Atoka contact dips beneath the floor of the reservoir. Minor faulting in the vicinity of the penstock tunnels created only slight engineering problems during construction.

Upstream the reservoir is traversed by several northeast trending faults. Rocks as old as Ordovician are brought to the surface on the upthrown blocks. Exposed rocks along the shores of Tenkiller Lake include the Tyner, Fite, Fernvale, and Sylvan of Ordovician age; the Chattanooga and Sylamore of Upper Devonian-Lower Mississippian; the St. Joe, Reeds Spring, Keokuk, Moorefield, Hindsville, Fayetteville, and Pitkin of Mississippian age; and the Hale, Bloyd, and Atoka formations of Pennsylvanian age.

Sources of Information

1. Fort Gibson Dam and Reservoir Project, Corps of Engineers, U.S. Army, Tulsa Engineer District, Tulsa, Oklahoma, 1946.

2. Huffman, George G. "Recent Investigations of Pre-Atokan Rocks in Northeastern Oklahoma". Tulsa Soc. Digest, Vol. XIX, 1951.

3. Huffman, George G. "Geology of the Ozark Uplift, Northeastern Oklahoma". Shale Shaker, November, 1951.

4. Huffman, George G. "Field Conference on Pre-Atoka Rocks in Western Part of the Ozark Uplift, Northeastern Oklahoma". Okla. Geological Survey Guidebook 1, 1953.

5. Tenkiller Ferry Dam and Reservoir, Illinois River, Arkansas River Watershed, Corps of Engineers, Tulsa District, Tulsa, Oklahoma, 1948.

6. The Grand River Project of Oklahoma, Grand River Dam Authority, 1950.

7. Wallis, Wally, Daily Oklahoman, Summer 1955.