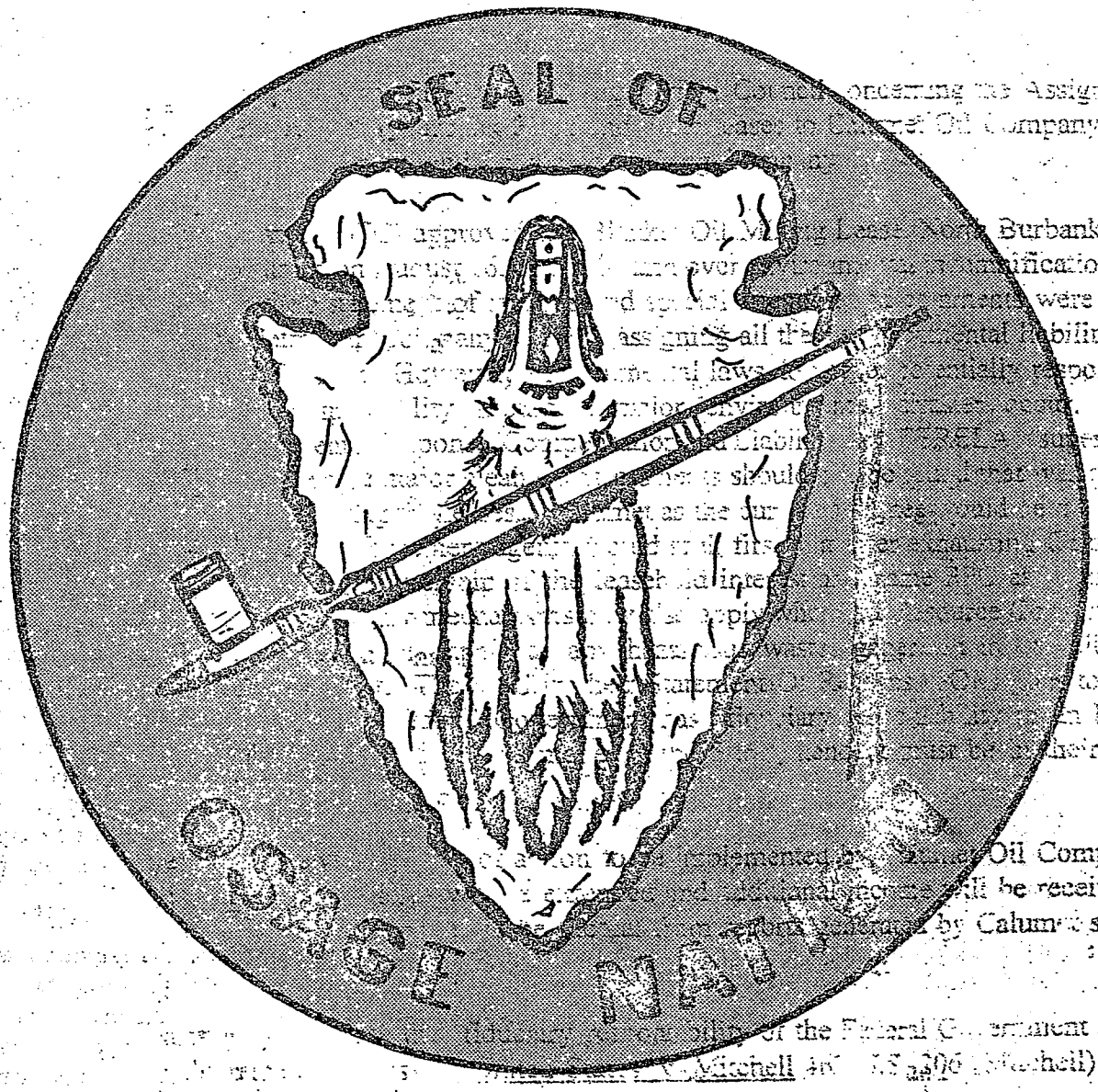
ENVIRONMENTAL ASSESSMENT



US Department of Interior
Bureau of Indian Affairs
Muskogee Area Office
Muskogee, Oklahoma 74401

REALTY

United States Department of the Interior

BUREAU OF INDIAN AFFAIRS
MUSKOGEE AREA OFFICE
MUSKOGEE, OKLAHOMA 74401

IN REPLY REFER TO:
Real Prop. Mgmt.
Environmental Quality

MAY 30 1979

Honorable H. Dale Cook
U. S. District Court Judge
Norther District of Oklahoma
Federal Bldg.
Tulsa, OK 73104

Dear Judge Cook:

The general purpose of this Project is to provide an Oil and Gas Leasing Program for the Osage Indian Tribe in Osage County, Oklahoma, in strict compliance with existing Federal Regulations of the Bureau of Indian Affairs, Department of the Interior.

The total area to be affected by this Project includes the total area of Osage County, which consists of a total of 1,476,480 acres.

There are no known threatened or endangered species of flora or fauna within the Project area. However, should any be encountered during any phase of these Projects; measures will be taken in accordance with the Endangered Species Act of 1973. There is no record of Archaeological or Historical resources within any Project areas. The Project contains a clause requiring that work cease should any heretofore unknown historic, cultural, archaeological resources eligible for inclusion on the National Register of Historic places be encountered at anytime. If any resources are encountered the advisory council on Historic preservation will be informed. Protective measures are being carried out in accordance with the existing Federal Regulations to prevent existing fresh water zones from being contaminated as a result of this program. These protective measures will continue to be in force and effect.

The review process indicated that significant enviromental impacts would not result from the proposed action. Consequently the decision has been made to issue this notice of intent not to prepare an Environmental Impact Statement. This action is taken on the basis of a careful review of the environmental assessment, and other supporting data, which are on file in the above Office.

The following Laws have been considered in making this Declaration:

National Environmental Policy Act (NEPA), P. L. 91-190
Clean Air Act, as amended 1977
Federal Water Pollution Control Act Amendments, P..O. 92-500 & 95-217
Noise Control Act of 1972, P. L. 92-574

Federal Insecticide, Fungicide, and Rodenticide Act, as amended, P. L. 92-156
Resource Conservation and Recovery Act of 1976, P. L. 94-580
Toxic Substances Control Act, P. L. 94-469
Safe Drinking Water Act, P. L. 93-523
Marine Protection, Research and Sanctuaries Act of 1972, P. L. 92-532
Rivers and Harbors Act of 1899
Historic Preservation Act of 1966, P. L. 89-665
Archaeological and Historical Preservation Act of 1974, P. L. 93-291
National Flood Disaster Protection Act of 1973, P. L. 93-234
Flood Control Act of 1970, P. L. 91-611
Flood Insurance Act of 1968, P. L. 90-448 and 92-213
Coastal Zone Management Act, P. L. 92-583
The Housing and Community Development Act of 1974, P. L. 93-383
Fish and Wildlife Coordination Act of 1958, P. L. 85-624
Endangered Species Act of 1969 and 1973, P. L. 91-135 and 93-205
Marine Mammal Protection Act, P. L. 92-522
Wild and Scenic Rivers Act of 1968, P. L. 90-542
Water Resources Planning Act of 1965, P. L. 89-80
Reservoir Salvage Act of 1960, P. L. 86-523

Alterative Discontinue the production of oil and gas in Osage County.

Sincerely yours,

Thomas J. Ellison

Area Director

ENVIRONMENTAL ASSESSMENT FOR THE OIL AND GAS LEASING PROGRAM OF THE OSAGE INDIAN TRIBE, OSAGE COUNTY, OKLAHOMA

US Department of Interior
Bureau of Indian Affairs
Muskogee Area Office
Muskogee, Oklahoma 74401

May, 1979

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

LIST OF TABLES

LIST OF TABLES (cont'd)

LIST OF FIGURES

I. DESCRIPTION OF THE OSAGE COUNTY, OKLAHOMA OIL AND GAS LEASING PROGRAM

The purpose of this environmental assessment is to describe and evaluate all aspects of the oil and gas leasing program in Osage County as it is supervised under existing regulations by the Bureau of Indian Affairs (BIA). The assessment is comprised of four chapters which provide: (1) a description of the on-going oil and gas leasing program and its operational components, (2) a description of existing environmental conditions and probable future conditions (with future projections made to varying times for various sections). (3) an evaluation of actual or potential environmental impacts related to the oil and gas leasing program, and (4) a list and summary of the consultations and coordination carried out with Federal, State, local and private groups or agencies during the preparation of the report.

A. LOCATION AND SUMMARY OF PROGRAM

Osage County, the study area for the program considered herein, is the largest of 77 counties in Oklahoma, encompassing a total of 1,476,480 acres. As shown in Figure 1, it is located in the northeastern portion of the State. Osage County is bordered by Kansas on the north, the Arkansas River on the southwest, Tulsa County on the southeast, and Washington County on the east. Pawhuska, the county seat, is centrally located. Although the majority of the study area is sparsely populated, an extension of metropolitan Tulsa has produced an urban area at the far southeastern corner of the county. Except for large flood plains along the Arkansas River and several other major streams, the topography of the county is characterized by gently rolling hills. These hills are generally covered by native grassland and wooded lands and are used primarily for cattle grazing.

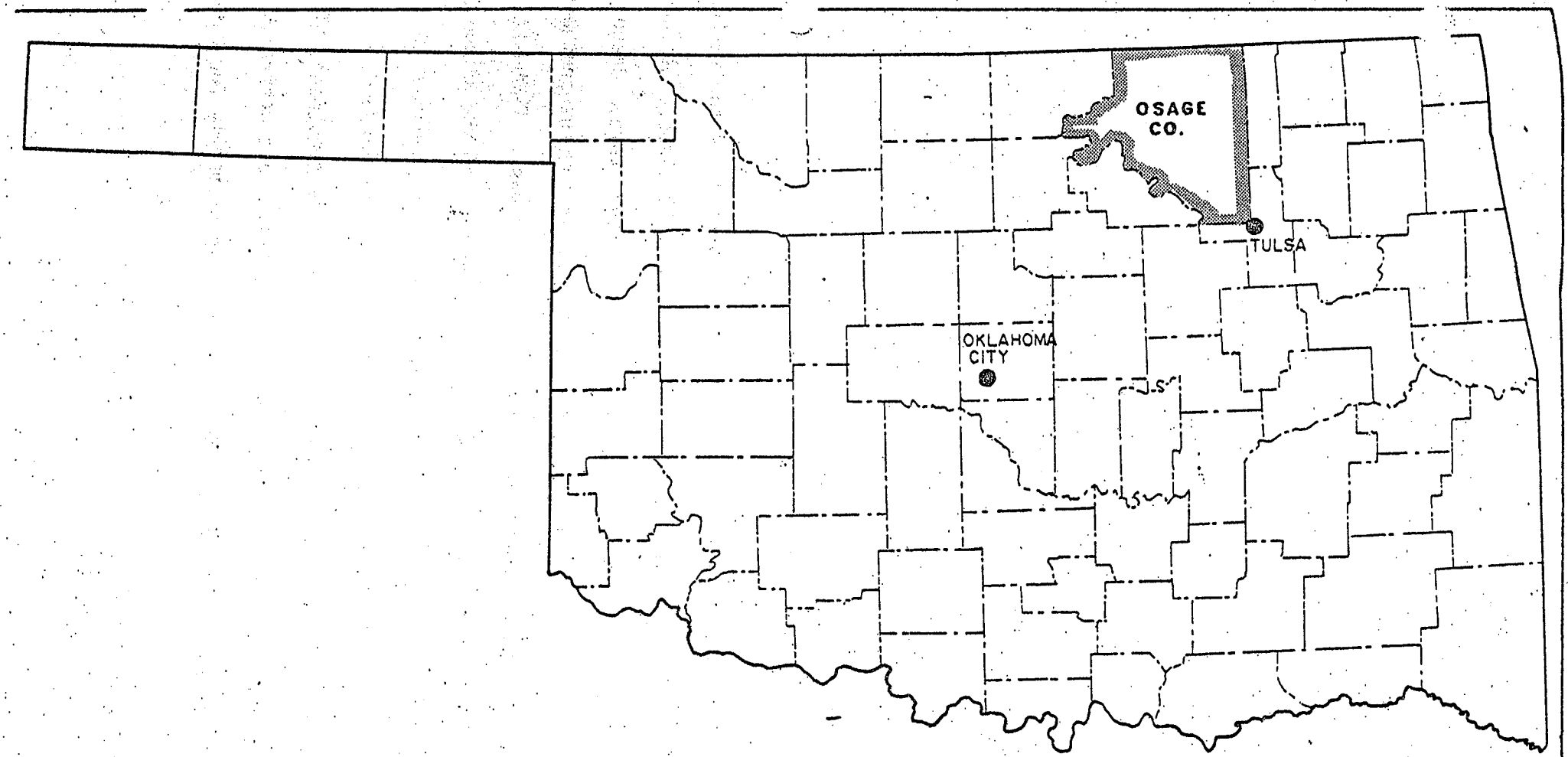


Figure 1. General location of Osage County, Oklahoma study area.

In the late 1800's, to satisfy the need for a permanent homeland, the Osage Indians purchased 1,469,077 acres of Oklahoma Territory land at about $0.70 per acre from the Cherokee Indians. A Congressional Act of June 16, 1906, which granted statehood to Oklahoma, provided that the Osage Indian Reservation would be established as a separate county of the state. Although this legislation incorporated most Osage Nation affairs with Oklahoma State government, an Act of June 28, 1906 (as amended), specifically placed mineral management and development and its financial control under Federal jurisdiction.

Oil and gas development began in the county on March 16, 1896 when the first oil and gas lease was obtained by Edwin B. Foster of Rhode Island. That lease covered all of the Osage Indian's mineral reserve and was for a duration of 10 years. This initial lease was extended for an additional 10 years, but then covered only the eastern half of the county. Starting on April 20, 1916, leases were sold at public auctions, which now are held three times annually. Tracts could then be leased either for oil or gas. Combination oil and gas leasing began in October of 1974. The first oil well was completed in Osage County in March 1897 as a dry hole. The first producing oil well was brought in on October 28, 1897, and the first oil from the well was sold in May 1900. About 34,000 wells have been completed in Osage County since oil and gas development began.

Since 1906, responsibility for the Osage oil and gas leasing program has been defined through a sequence of Federal legislation. Currently, the US Department of Interior, Bureau of Indian Affairs, supervises the leasing program through its Muskogee Area office. Daily operations are conducted by the Osage Agency at Pawhuska, Oklahoma. The Secretary of Interior, or his authorized

representive, is ultimately responsible for approval of leases. The Superintendent of the Osage Agency is the BIA employee with this delegated authority.

The Federal involvement with the Osage oil and gas leasing program has been deemed a Federal action requiring compliance with the National Environmental Policy Act (1969). Judge H. Dale Cook, US District Court, Northern Oklahoma District, ruled on May 4, 1977, that the BIA was responsible as the lead agency for producing an environmental assessment of the program for consideration in matters pending in that court.

B. PROGRAM BACKGROUND

The structure and magnitude of the present oil and gas leasing program in Osage County results from a secuence of legislative decisions, the availability of energy resources in the county, the national demand for energy, and the improvement of petroleum extraction technologies. Historically, these factors have combined to make Osage one of the leading oil and gas producing counties in Oklahoma.

1. Establishment of Osage Ownership and Authority

The purchase of their current land holdings in Oklahoma from the Cherokee Nation was transacted by the Principal Chief of the Osage Indians on June 14, 1883. A June 14, 1906, Congressional Act incorporated the Osage Reservation into a county of the new State of Oklahoma.

On June 28, 1906, another Act of Congress provided that "the oil, gas, coal, or other minerals covered by the lands for the selection and division of which provision is herein made are hereby reserved to the Osage tribe for a period of twenty-five years from and after the eighth day of April, nineteen hundred and six . . . ." It further authorized and directed that a roll of the Osage Tribe be established to record the legal membership thereof. It provided for allotment of all lands belonging to the Osage Tribe (with certain exceptions) to the 2,229 Osage Indians enrolled at that time. It reserved from allotment oil, gas, coal, and other minerals, but directed that the royalties received from mineral production be distributed to the membership of the Osage Tribe in accordance with the legal roll. The Act provided that the lands, moneys, and

mineral royalties of deceased Osage Indians should be equally divided among their legal heirs.

On March 3, 1921, Congress passed an Act which reserved mineral interests to the Osage Tribe until April 7, 1946; provided that all valid existing oil and gas leases on April 7, 1931 (25 years after the initial period, beginning April 8, 1906) would be reviewed upon the same terms and extended, subject to all other provisions of the Act of 1906, until the date of April 8, 1946, or as long thereafter as oil or gas is found in paying quantities. An amendment of the Act of 1906 on March 2, 1929 extended the mineral estate reserved to the Osage Indians until April 8, 1958. Another amendment of June 24, 1938 extended the mineral estate reserved to the Osage Indians until April 8, 1983.

On October 21, 1978, Congress again amended the original Act of 1906, but instead of granting another extension of 25 years or less, the latest amendment extended Federal trust supervision over the Osage mineral estate in perpetuity (that is, for an indefinite period, an annuity payable forever). The US Department of Interior is forever vested with complete supervision and management of the Osage mineral estate.

Although the original Act of 1906 and its amendments have contained variations in wording, the State of Oklahoma was authorized to tax income from the Osage mineral estate. The gross production tax on oil and gas going to the State from royalties to the Osage Tribe is currently 5 percent annually, which is the legal limit. Presently, the gross production tax for operators in Osage County and throughout the remainder of the State is 7 percent annually. The Oklahoma Tax Commission is the responsible State Agency which collects the gross production tax.

2. History of Oil and Gas Field Development and Production

Edwin B. Foster, a railroad contractor in Kansas, suspected that the southern Kansas oil fields extended further south into Indian Territory. In 1896, his third exploratory well struck oil. It was located near the eastern boundary of Osage County and originally yielded about 20 barrels of oil per day. Because of the lack of transportation, development of a market for this Oklahoma crude oil had to await construction of a railroad spur line to Bartlesville and construction of a pipeline from the well to the railhead. This construction was finished in 1900 and the first oil was sold for $1.25 per barrel.

During the first complete fiscal year (ending with June 30, 1901), Osage County produced 10,536 barrels of oil. By 1903, annual production was over 50,000 barrels. One million barrels production was reached by 1905 and 5,000,000 barrels was reached by 1907. Between 1911 and 1919, annual production remained fairly steady at around 10,000,000 barrels annually. A peak was reached in 1923 when over 40,000,000 barrels of oil were produced. This was followed by a decline to less than 10,000,000 barrels annually by 1933. A large peak in oil production in Osage County also occurred in 1959 at 28,105,000 barrels annually. This production increase came with the advent of widespread waterflooding. Beginning in 1974 and continuing to the present, another increase in production is evident because of increased exploration and improved recovery methods encouraged by high oil prices. The historical trend in oil production from Osage County is shown in Figure 2. Projected production also is shown for three possible scenarios to the year 2000.

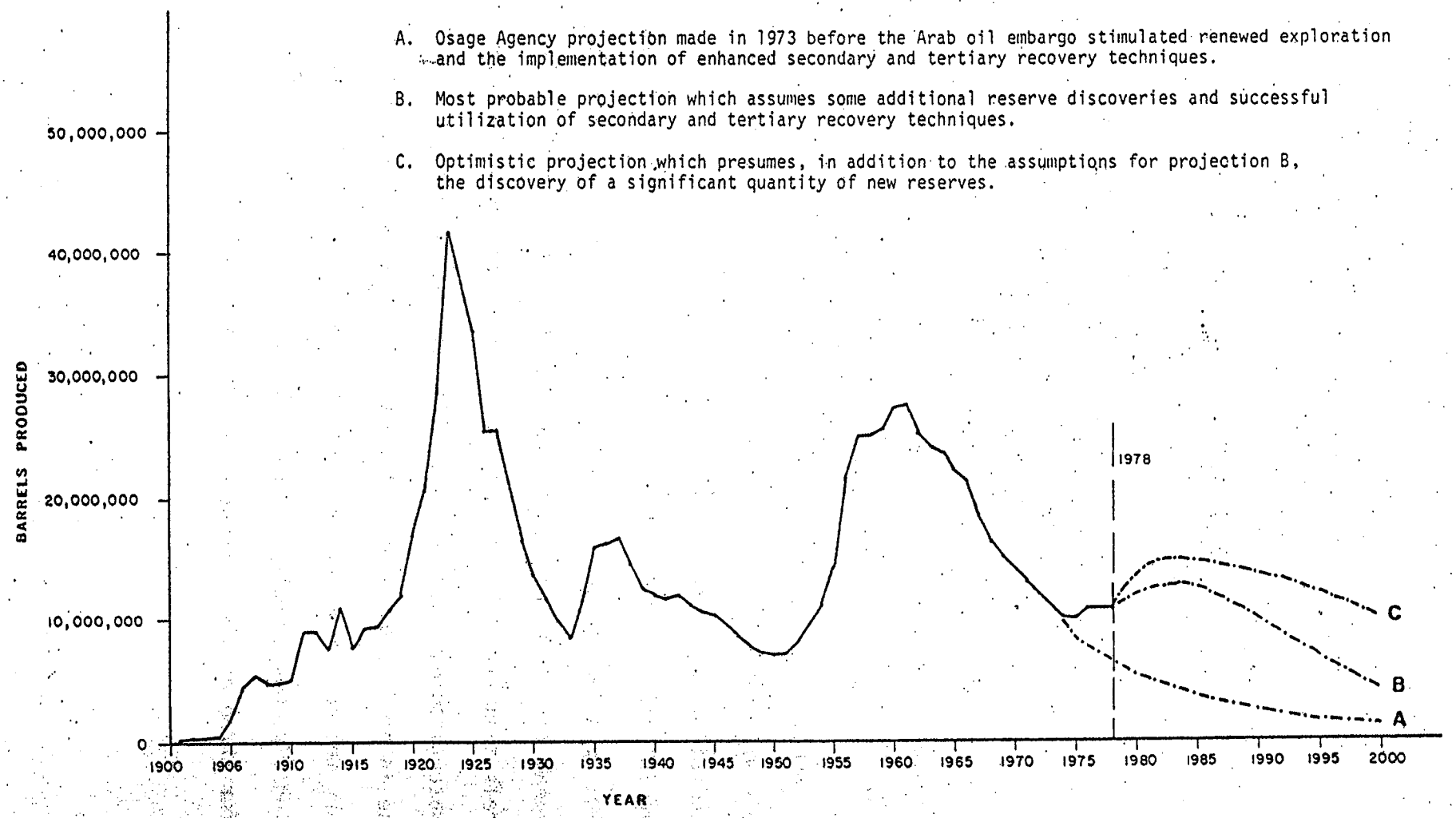


Figure 2. Total oil produced from Osage County by year (1900-1978), and projected to the year 2000.

and oil production in Osage County is from paleozoic, sedimentary rocks. Above the crystalline rocks that form the basement in Osage County is a sequence of sedimentary rocks whose thickness ranges from about 2,000 feet over peaks of pre-Cambrian rocks in the southeastern part of the county to about 5,000 feet in the western part. The lowermost 1,400 feet of the sedimentary rocks is composed mainly of limestone and dolomite, ranging in age from Cambrian to Mississippian. Oil and gas are produced from several zones in these beds. The succeeding 3,000 feet of strata is composed mainly of shale, but contains some beds of sandstone and limestone and, in its uppermost part, some beds of redrock. The age of most of this sequence is Pennsylvanian, although the uppermost part is Permian. The Pennsylvanian series in Osage County includes 14 zones that are oil- or gas-bearing, and some of these zones contain several oil- or gas-bearing sands. Of the 14 zones, the Bartlesville and Burbank sands, in the Cherokee shale, have produced most of the oil and gas.

Development of oil production in Osage County has placed comparatively modest demands on drilling technology throughout the history of the field. The bedrock is comparatively easy to drill and oil is found at relatively shallow depths with generally low reservoir pressures. These conditions were very favorable for the cable-tool drill rigs used during the early phases of the petroleum era. In this method the well is formed by repeated percussion of a tool bit which is raised and lowered by a cable from the surface. This type of rig was used universally throughout the Osage County area during the development period and the high production era of the 1920's. The favorable drilling conditions and reduced field activity during the 1930's and 1940's kept cable-tool drilling in general use in Osage County well past the introduction of rotary drilling in many other areas. A few wells are still being drilled by cable-tool each year in Osage County. During the early period of production

there was little control of surface field management. Spillage of oil and surface discharge of brine were common.

The typical well being drilled in Osage County at present is 2,000 to 2,500 feet deep using 4.5 and 5.5 inch casing. It is drilled by a rotary rig which is transported to the site by truck in knocked down configuration. Each drilling operation may occupy as much as one and one-half acres. This includes the actual working space, temporary pits for the storage of drilling fluids, and auxiliary equipment.

During the early stages of the production in the County, and extending through World War II, wells were operated by natural flow or pumping for as long as they produced enough to make a profit. When production declined to an uneconomic level a well was abandoned. As general production decreased throughout the area, secondary production techniques came into use. These methods stimulate recovery of oil by using some of the wells to re-inject fluids into the reservoir formations in order to move or displace oil toward other wells. The brine which is unavoidably produced with oil is frequently used as the re-injected fluid. Acid treatment or mechanical fracturing of the rock around wells also can be used to restore or maintain production by increasing the premeability so that oil can flow more easily into the well.

At present, two groups in the county (Phillips Petroleum Company, and Kewanee Petroleum--now owned by Gulf Oil) are experimenting with chemical treatment of the re-injected fluid in order to enhance its ability to mobilize remaining oil within the reservoir formation and to move oil more effectively to a producing well. These tertiary recovery techniques are expensive and are only in the experimental stage in several parts of the country, If oil prices remain high or increase further, they may become economically feasible methods for oil recovery.

C. PROGRAM OPERATIONS

The oil and gas leasing program in Osage County is operated by the Superintendent of the Osage Agency. Primary components of the program operations include geophysical exploration, leasing procedures, well drilling, energy production, well abandonment, transportation systems, and safety and environmental controls.

1. Program Operational Responsibility and Procedures

The Superintendent of the Osage Agency has the delegated responsibility to manage oil and gas operations on the Osage Reservation. This responsibility includes, but is not limited to: (1) approval of all oil and/or gas mining leases; (2) approval of drilling, workover, and plugging operations; (3) maintaining accurate records of all production and income received; (4) appraising damages and collection of compensation for damages on restricted Indian lands; (5) reviewing all incoming well records to ensure that they comply with Agency standards; (6) monitoring overall lease operations to ensure that lessees do not cause pollution (surface or subsurface); and (7) ensuring that lessees carry out lease operations in a prudent manner. The Superintendent also is responsible for managing all aspects of other mining and mineral operations on the Osage Reservation, which include, but are not limited to: sandstone, gravel, clay, sand, and limestone mining permits. A complete list of the responsibilities of the Superintendent of the Osage Agency is presented in the Code of Federal Regulations, Title 25, Indians, Chapter 1, Bureau of Indian Affairs, Part 183, Leasing of Osage Reservation Lands for Oil and Gas Mining (July 22, 1974) and amendments (effective dates: November 17, 1976 and February 28, 1978), and 25 CFR 175, Leasing of Osage Reservation Lands for Mining of Minerals Other than Oil and Gas.

As of late 1978, the Minerals Branch of the Osage Agency had a staff of thirteen (13) employees; nine BIA employees and four Tribal employees, engaged in the accounting and field operations.

2. Geophysical Exploration

Although fields of major drilling activity and production are fairly well known in Osage County, some areas are relatively less explored. Likewise, some geological strata and formations have received more attention than others. Since the Arab oil embargo in 1973, exploration and subsequent leasing, drilling and production have all increased. The Superintendent oversees and approves oil and gas geophysical and geological exploration.

During recent years, including 1978, about 25 geophysical exploration permits have been issued each year. In most cases, existing county and lessees' access roads are used, but in some instances equipment is transported over pastures or wooded land without constructing roads (in fair weather). Approximately 500 shot holes are drilled annually to conduct the required seismic surveys. A county-wide total of about 50 acres is required annually for this activity. A commencement fee of $25 per seismic shot must be paid to the surface owner.

After surveys are completed, shot holes are filled and each area is leveled and returned to as near original condition as feasible as soon as all work is done. Damages are paid to the surface landowner for all geophysical work conducted on his property. Within the last few years, damages paid per shot hole have ranged from as low as nothing paid to as much as $50. It is anticipated

that geophysical exploration will continue at about the same pace in the foreseeable future.

Leasing Procedures

A lease can be obtained for oil, gas or for a combination of oil and gas mining. A prospective lessee (any individual person, a firm, or a corporation) must nominate a specific tract of land for the type of lease desired. The nominations take place about two months prior to each sale. The nominated tracts (generally quarter sections, or 160 acres) are put up for auction at publicly advertised sales which take place three times annually, the third Wednesday of each February, June and October. The auctions take place on the grounds of the Osage Agency, Pawhuska, Oklahoma. A nominating bid must accompany each tract nomination before the tract is considered for listing at the sale. Each nominating bid is reviewed by the Osage Agency Minerals Branch staff and, if the nominating bid is considered to be an equitable amount, the tract is advertised for sale. An oral auction is conducted at each lease sale and the highest bidder is awarded an oil, gas, or combination oil and gas lease on the tract in question.

After successful bidders are determined for each tract, the bidder must obtain a performance bond and file other necessary papers before the lease is approved. Successful bidders must deposit with the Superintendent on the day of the sale a check or cash in an amount not less than 25 percent of the cash bonus offered as a guaranty of good faith. Bonuses are money offered by prospective bidders to enhance acceptability of their bids. Within 20 days after notification of being a successful bidder, the bidder must submit to the Superintendent the

balance of the cash bonus, a $10 filing fee, and the lease in completed form. The Superintendent may grant time extensions for completion and submission of lease forms, but no extension can be granted for remitting the balance of moneys due. If the lease is not completed or the lease is rejected through no fault of the Osage Tribal Council or Superintendent, the 25 percent of the cash bonus bid is forfeited to the Osage Tribe. The Superintendent may reject a lease made on an accepted bid upon evidence satisfactory to him of collusion, fraud, or other irregularity in connection with the notice of sale.

The Osage Tribal Council now establishes the term of each lease which is published with each sale notice. A primary term of 3 years was used in the February 1979 lease sales. Regardless of the length of the primary term, a lessee must complete a well producing and selling oil and/or gas in paying quantities within 12 months of the date of approval or pay rental, or the lease will terminate.

The most recent lease sale (Sale No. 197) took place on February 21, 1979, and included the sale of 14 gas leases, 96 oil and gas leases and 33 oil leases, all but seven of which comprised 160-acre tracts. Up until combination leases became available two years ago, sales have included mostly oil leases. As of October 1978, there were 4,549 active oil, gas or combination leases in Osage County. Figure 3 shows the geographical distribution of these leases which cover 1,170,493 acres or about 80 percent of the county. Approximately 600 leases were sold in 1977 and this trend is expected to continue for the next several years. Table 1 gives an indication of the increase in number of leases which has occured since 1970.

On many occasions, tracts, which have been leased in the past, but on which few or no producing oil or gas wells (in paying quantities) were brought in,

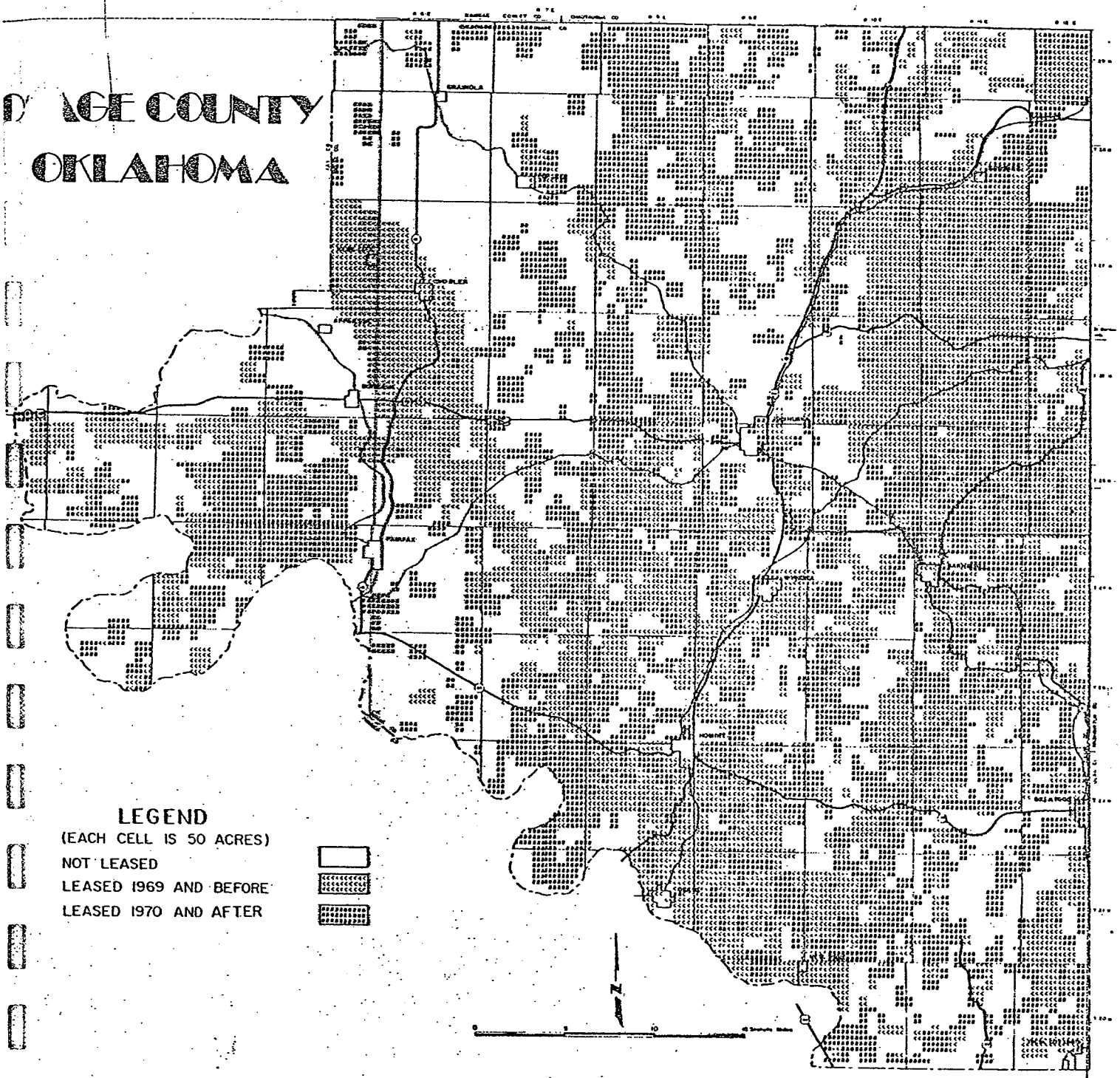


FIGURE 3. LEASED AREAS AS OF OCTOBER 30, 1978

Table 1. Number of subsurface leases in effect and acreage in Osage County, Oklahoma (Osage Reservation Lands).

Date (ending)	Number of subsurface leases			Acreage		
	Oil/gas or combination	Other minerals	Total	Oil/gas or combination	Other minerals	Total
June 30, 1970	2,418	6	2,422	509,729	688	510,417
June 30, 1971	2,318	6	2,322	484,686	718	485,404
June 30, 1972	2,361	7	2,368	454,385	868	455,253
June 30, 1973	2,559	10	2,569	503,083	1,288	504,371
June 30, 1974	3,108	9	3,117	632,253	1,618	633,871
June 30, 1975	3,793	12	3,805	1,096,444	3,118	1,099,562
Sept. 30, 1976	4,307	15	4,322	1,141,114	3,268	1,144,332
Sept. 30, 1977	4,612	10	4,622	1,185,657	2,528	1,188,185
Sept. 30, 1977	4,549	18	4,567	1,170,493	2,547	1,173,040

Source: U.S. Department of Interior, Bureau of Indian Affairs, 1970-1978 Annual Reports of Mineral Leasing Activities. Branch of Real Property Management

have been leased a second time. Virtually the entire County has been repetitively leased, parts of it more than four or five times. This phenomenon has seen an upsurge since the 1973 Arab oil embargo as more emphasis has been placed on secondary or tertiary petroleum recovery methods. Several large tracts of land are under blanket leases for gas production. These leases are held by larger companies for indefinite periods until production ceases.

Although many leases have been sold in Osage County for modest amounts, several have brought over $1 million. The first million dollar total lease sale was in 1916 under a large elm tree on the Osage Agency grounds. This tree is now an Oklahoma Historic Site known as the Million Dollar Elm (Wright et al, 1976). The first sale of a quarter section (160 acres) for over $1 million was in 1922. Several other tracts sold for over $1 million between 1922 and 1928 and in later years. The range in price for leases on individual tracts has ranged from as low as $0.87/acre on an oil tract in 1939 to as high as $6,000/acre on oil tracts in the 1920's.

Both unitizing (merging) and transferring of leases is permitted under proper conditions. Many leases have been unitized in Osage County since the mid-1930's. As of the end of 1977, approximately 150 cooperative agreements had been in effect at one time or another. Those agreements involved about 860 tracts (most of which were 160-acres each) and, excluding blanket leases, comprised about 100,000 surface acres. A small percentage of these unitizations have been terminated since they were initially formed. Transfer requires qualification of the new owner, a satisfactory performance bond and approval by the Superintendent.

4. Drilling Activity

A lessee must submit to the Osage Agency a permit application to drill each we Upon approval, the Superintendent issues the lessee a drilling permit (Figure 4) Prior to filing an application to drill, the lessee must contact the surface landowner and discuss the route of ingress and egress to the proposed well site. The only activities which may take place prior to the meeting of lessee and landowner are surveying and staking of well sites. At the meeting, in additio to discussing the route of ingress and egress, the lessee must give the landowner the name and address of the representative upon whom the surface owner must serve any claim for damage which he may sustain from mineral operations. If the drilling is to be on restricted Indian land, the meeting takes place with the Indian land owner. The Superintendent furnishes such services as may be necessary to handle damage claims on restricted Indian lands.

Lessees or their authorized representatives have the right to use as much of the surface of the land within the Osage Mineral Estate as may be reasonable for operations and marketing, and the right-of-way for ingress and egress to any point of operations. If lessees and surface owners cannot agree on the routing of the items mentioned above, the route is established by the Superintendent. Before commencing a drilling operation, lessees must pay to surface owners commencement money in the amount of $300 for each well, after which lessees are entitled to immediate possession of the drilling sites. Regulations state that "a drilling site shall be held to the minimum area essential for operations and shall not exceed one and one-half acres in area unless authorized by the Superintendent." Acceptance of commencement money on the part of a surface landowner in no way affects his future right to damage compensation occasioned by the drilling and completion of the well for which it is paid.

DRILLING PERMIT

Date_____
Well No. _____
____Sec.____Twp.____Rge.__

This drilling permit shall terminate six (6) months from the date of approval unless d ling operations have commenced and are thereafter continued with due diligence. This permit is approved under the following conditions:

1. That the requirements set out in 25 CFR 183.18 are complied with before entry. (You are advised to assure that the owner of livestock on the land is also made aware of the commencement of operations on the lease).
2. That this office be informed at least one day in advance of the day drilling is to start.
3. That surface pipe is set below all fresh water and cemented from bottom to top. If mechanical logs indicate depth of surface pipe was insufficient to protect all fresh water zones, cement will be circulated to surface on production string, or a D.V. Tool will be run in the production string to a depth of 50 feet below all fresh water zones and cement will be circulated to surface to protect all fresh water.
4. (a) That the production string of casing be 4-1/2" or larger in diameter. The production string will be cemented with sufficient cement to cover all potential productive zones to isolate same and prevent migration of oil and/or water from one zone to another zone. (b) If cable tools, sufficient casing will be set adequately to protect all potential producing formations penetrated. (Any variation from the casing program required by conditions 3 and 4 will be allowed only after prior approval by this office.)
5. That the mud pits will not be used for the storage of BS or salt water after the completion of the well, unless specifically authorized by the Superintendent or his authorized representative. Pits must be fenced.
6. A mechanical log shall be made of this well and a finished copy furnished this office. (Gamma, electrical, etc.)
7. That within 10 days after completion of the well a satisfactory completion report shall be submitted on Osage Form 208 and shall be accompanied by a copy of each cementing service ticket, core analysis, and drillstem, wire line, etc., test information.
8. That the well and tank battery are marked with a permanent descriptive sign as soon as the well is completed as provided by 25 CFR 183.34.
9. If proper authority is obtained, other than under 25 CFR 183.24, and water from restricted land is used for the drilling of this well, payment must be made to this office for the account of the surface owner.
10. Accurate testing and reporting of initial oil, gas, and water production potential is expected for each newly completed well. A production test of the subject well, to be witnessed by an Agency representative, may be required.
11. An accurate survey of the location and elevation of this well shall be run and shown on the completion report with the name of surveyor.
12. Control devices. In drilling operations in "wildcat" territory, or in a gas or oil field where high pressures are known to exist, the lessee shall have on such leased premises an approved gate valve or other approved controlling device in proper condition for use until the well is completed as provided by 25 CFR 183.36.
13. SPECIAL INSTRUCTIONS:

Checked by: _____ Date _____

Chief, Branch of Minerals
Auth: F. R. 15812

Figure 4. Sample copy of the drilling permit issued by the Osage Agency.

Lessees may not drill wells within 300 feet of the boundary line of a leased parcel of and, nor may they locate a well or tank within 200 feet of any public hig way, established watering place, or building used as a dwelling, granary or barn, except with the written permission of the Superintendent. No limits n well spacings within leases exist.

One use f property during drilling operations is the requirement for mud pi s. These pits are leveled as soon as possible after completion of operati ns unless otherwise requested by the surface owner or user. Pits must be "c nstructed and maintained so as to prevent pollution of surface and subsur ace fresh water," and they must be fenced off with at least four strands of barbed wire unless the surface owner, user, or Superintendent gives cons nt otherwise. The pits also must be of adequate size to contain mud or del terious substances extracted from wells, and must have sufficient storage to contain a supply of mud to be used in emergencies. No earthern pit, excep those used for drilling, completion, recompletion, or workover of a well can be constructed, enlarged, reconstructed, or used without the approval o the Superintendent. Furthermore, unlined pits cannot be used for the contin ed storage of salt water or other deleterious substances. These substances must be placed in properly lined receptacles and not be permitted to escape. Where existing facilities for disposal of such substances are inadequate the Superintendent gives instructions as to their disposal.

During dri ling and other operations, lessees are required to keep accurate and comp e e records on all wells. These records must show the formations penetrated the content and character of oil, gas, or water in each formation; and the ki d, weight, size, landed depth, and cement record of casing used in

drilling each well. Lessees are required to protect all freshwater zones from the surface downward: "Lessee shall, to the satisfaction of the Superintendent, take all proper precautions and measures to prevent damage or pollution of oil, gas, fresh water, and other mineral bearing formations" (25 CFR, 183.35).

Since drilling began in Osage County over 34,000 wells have been completed. The distribution and density of wells drilled through 1969 are shown in Figure 5. This date was used to display the regional pattern of drilling which had evolved prior to the passage of the National Environmental Policy Act (1969). The total well count for all types of actively operating wells in Osage County in October 1978 was as follows:

Type	Number
Oil	9,702
Gas	489
Oil/Gas Combination	52
Water input	2,553
Salt water disposal	1,148
Gas Repressure	74
Water supply	141
Hazardous Material Disposal	1
Total	14,160

Figure 6 shows the locations of various operating wells and locations of dry holes and abandoned wells through 1969, including only those wells drilled prior to NEPA.

Fiscal Year (ending)	Number of Oil and Gas Wells Completed	Number of Dry Holes
June 30, 1970	165	68
June 30, 1971	125	56
June 30, 1972	157	47
June 30, 1973	102	41
June 30, 1974	229	82
June 30, 1975	311	227
September 30, 1976	409	137
September 30, 1977	417	137
September 30, 1978	449	55

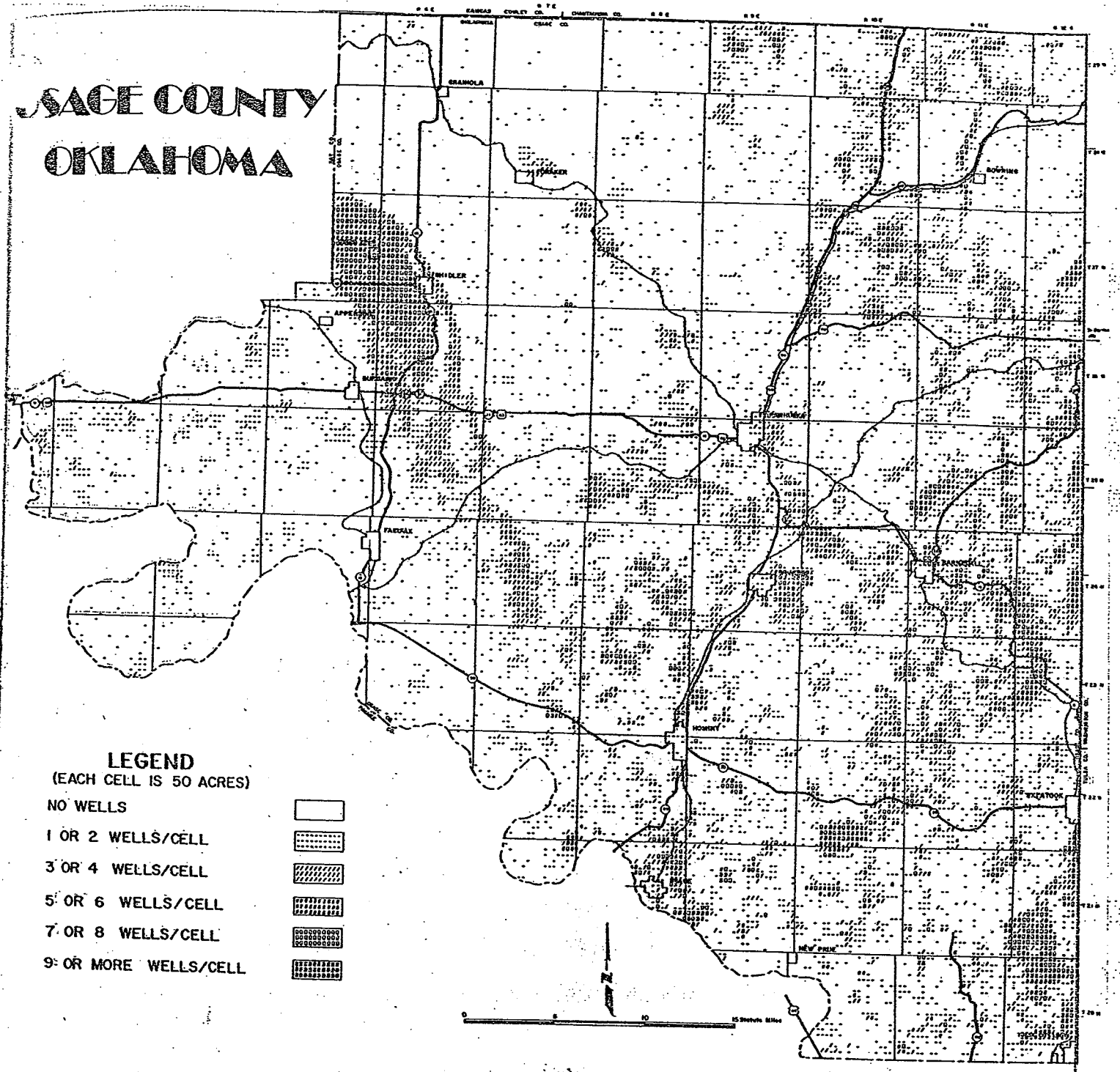


FIGURE 5. WELL DENSITY AND DISTRIBUTION

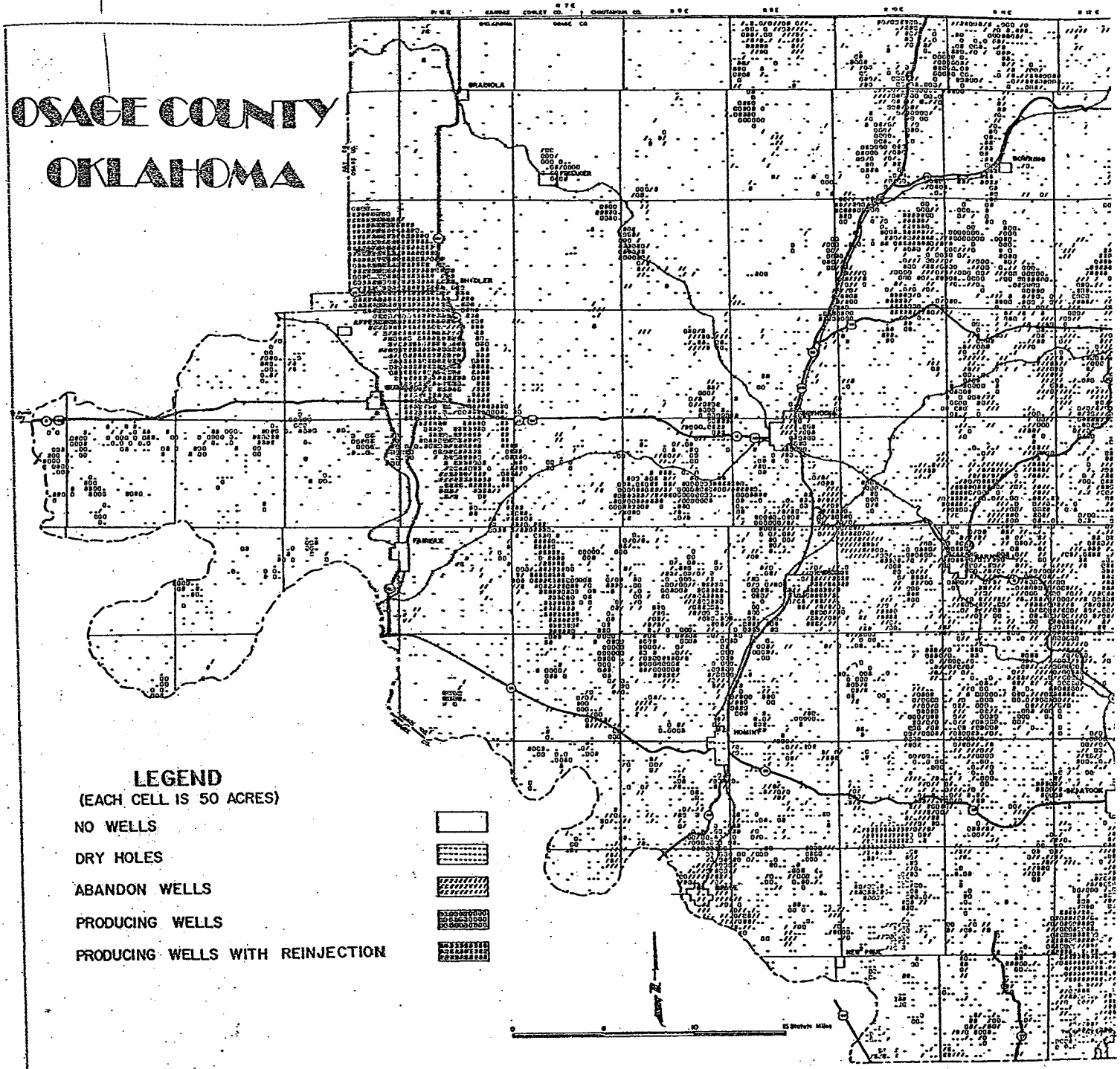


FIGURE 6. WELL TYPE AND DISTRIBUTION

As noted from recent plugging records, a total of 192 wells in Osage County were plugged in 1977 and 160 wells were plugged in 1978. This trend is not expected to change significantly in the foreseeable future.

During the last several years, approximately 650 drilling permits have been issued annually by the Osage Agency. Of those, an average of about 75 percent of all wells drilled are completed as oil wells, about 5 percent are completed as gas wells, and about 20 percent are completed as dry holes and are plugged and abandoned.

It appears that current pricing of oil, heavy reliance on importing petroleum, and the general energy shortage will continue to influence the increased amount of drilling, exploration, and workover of wells in Osage County, at least at the present level. Drilling rigs are currently being used at full capacity and a waiting list exists for the northeastern Oklahoma area, as well as for many other areas of the country. In October 1978, about 20 producing wells were being completed weekly in Osage County; this number could increase if additional drilling rigs became available (personal communications, David Baldwin, Superintendent, Osage Agency, October 19, 1978).

5. Production

Oil and gas production in Osage County can certainly be termed the major economic development factor for the county since the first oil was sold in 1900. The industry has had three development peaks: (1) 1920-1925 (discovery and development of the Burbank field in the northwestern part of the county, (2) 1950-1960 (an era with extensive development of waterflood recovery in various county fields), and (3) 1974-present (an increase in production due primarily to the

increase in oil prices). The present productivity level for oil should continue for many years because of petroleum demands, advances in recovery technology, and more exploration. Gas production has also increased strongly in Osage County in recent years.

Since oil production began in Osage County in 1897 through September 1978, a total of 1,095,851,806 barrels of oil and billions of cubic feet of gas have been produced. Current rates of production are approximately 11.0 million barrels of oil and 8.6 billion cubic feet of gas annually. Accurate historical records of gas production have not been kept since, in decades past, gas was considered a waste product and often was burned at the wells. With the added importance of gas to industries in recent years, accurate gas production records are being kept, and gas activity is expected to increase more rapidly than oil production, probably by 20 percent per year for the next several years. As of October 1978, a total of 489 gas wells were producing in Osage County.

Several fields in Osage County have historically produced more oil than others. In 1978, typical production levels ranged from as low as less than one barrel of oil per day per well to as high as 150 barrels per day. As of October 1978, the county-wide production from about 9,600 wells was averaging slightly less than 3.5 barrels per day.

When completing an oil well (or several closely grouped wells) for production, several types of associated equipment are needed; naturally, access roads are maintained for producing wells. Tank batteries are set up for individual or grouped wells. Lessees must pay fees for tank sites (not to exceed 50 feet square) at the rate of $40 per tank or other vessel. No fee is due for a tank temporarily set up for drilling, completing or testing a well. For tanks

occupying more than 50 feet square, fees are agreed upon between surface owners and lessee or are fixed by arbitration. Pipelines, electrical lines, and associated appliances also are a necessity for each set of wells and tank batteries. Lessees and surface owners must meet and agree to routing of these lines and tank locations or the routes are set by the Superintendent. No fees are required for placement of the lines, but damages may be claimed for their installation.

Formation water is produced along with the oil. The water is generally high in dissolved salts, especially sodium chloride, and is usually disposed of by reinjecting it through nearby wells into the formation from which it is derived. The amount of formation water produced at most wells is around 40 barrels of water to each barrel of oil, and the total amount produced in 1977 has been estimated to be about 410,000,000 barrels. The surface disposal of deleterious formation water in watercourses such as streams or freshwater ponds is prohibited.

Reworking of old oil wells to increase production can include acid treating, redrilling, hydro-fracturing, or otherwise improving well productivity. Reworking of wells is common in Osage County, but carrying out these operations requires approval of the Osage Agency. Figure 7 presents a copy of the workover permit application which must be completed and approved.

Production royalties from oil, gas or combination oil/gas wells is one of the primary sources of income for the Osage Mineral Estate. The royalty on oil is generally 16 2/3 percent of the gross proceeds from sales after deducting the oil used for development and operation on the lease. In cases where oil production is more than 100 barrels per day on all wells within any one quarter section or portion thereof, the oil royalties are not less than 20 percent. With

WORKOVER PERMIT

Date_____
Well No. _____
____Sec.____Twp.____Rge.____

Approved under the following conditions:

1. That within 10 days after completion of work done, a supplemental report on Form No. _____ will be submitted to this office showing what was done, and the results thereof.

2. The report shall show whether any cementing was done and by whom (and shall be accompanied by copies of any invoices covering cementing services performed).

3. Should a mechanical log (Gamma, electrical, etc.) be made of this well in the performance of work done, a copy shall be furnished this office.

4. Special instructions: A packer shall be run on tubing water injection string and set inside casing within 75' of top of injection interval. The tubing-casing annular space shall be tested to 500 psi to assure packer is set and casing is in satisfactory condition. Tubing-casing annular space will be left open to atmosphere to detect possible packer or tubing failure.

A downhole diagram of the injection or disposal well shall be submitted, after completion indicating the following information: (1) casing sizes and depths, (2) cemented intervals on outside of casing, (3) tubing size and depth, (4) packer setting depth, (5) injection interval, (6) name of injection sand, and (7) proposed injection rate and pressure.

_____
Chief, Branch of Minerals

_____
Checked by: Date

gure 7. Sample copy of the workover permit issued by the Osage Agency.

advanced recovery methods in use for additional oil recovery, a revised royalty rate of not less than 12 1/2 percent can be authorized by the Osage Tribal Council with the approval of the Superintendent. All gas royalty money is collected on the basis of not less than 16 2/3 percent of the market value per 1000 cubic feet. The Council has also negotiated royalties in excess of 16 2/3 percent.

Table 2 summarizes the annual royalties received from the oil and gas leasing program in Osage County from 1970 to the present. It is projected that the current annual royalties of about $25 million will continue to increase for several years at the anticipated rate of new drilling, production, and secondary or tertiary recovery implementation. As of September 1978, total lease, bonus, fee and royalty money generated for the Osage Tribe since leasing began is $617,751,543.06.

6. Well Abandonment and Plugging Procedures

Both dry holes and old wells which are no longer economically productive must be plugged. Prior to abandonment, a plugging permit (Figure 8) is required from the Osage Agency. In all cases, lessees are required to plug and fill holes in a manner which confines a fluid (fresh water, oil, gas, salt water) to its own formation, and prevents the transmission of fluids between formations. Mud-laden fluid, cement, and other plugs must be used to fill each hole from bottom to top unless satisfactory agreements are reached between lessees and surface owners (subject to approval by the Superintendent). Within 10 days after plugging, lessees must file a complete report with the Superintendent regarding the plugging of each well. When any well is plugged as a dry hole or abandoned as a producer and plugged, the casing must be cut off three feet below ground level and lessees are allowed 90 days to clean up the area surrounding the well site to the satis-

Table 2. Summary of total annual Osage Indian mineral estate royalties received from the oil and gas production in Osage County, Oklahoma (1970-1978).

Time period	Total moneys received
Year ending June 30, 1970	$6,600,647.70
Year ending June 30, 1971	$6,378,785.14
Year ending June 30, 1972	$6,090,325.44
Year ending June 30, 1973	$5,818,116.08
Year ending June 30, 1974	$9,656,242.45
Year ending June 30, 1975	$14,039,860.37
Year ending Sept. 30, 1976	$22,683,080.30
Year ending Sept. 30, 1977	$21,839,563.78
Year ending Sept. 30, 1978	$25,408,211.36

Source: U.S. Department of Interior, Bureau of Indian Affairs, 1970-1978 Annual Reports of Mineral Leasing Activities. Branch of Real Property Management.

PLUGGING PERMIT

Approval date _____
Well No. _____
___1/4 Sec.___Twp___Rge____

Approved under the following conditions:

1. Plugging will not commence until 20 days following approval date and this office must be notified at least 24 hours before work is to start. We may have an Inspector present to supervise and give special instructions.

2. A plugging report shall be submitted to this office within 10 days after completion of the work. The report shall state whether any cementing was done and by whom and shall be accompanied by copies of any cementing service tickets covering cement used.

3. As casing is removed the well shall be kept full of mud. No surface pipe is to be pulled without instructions from the Superintendent or his authorized representative.

4. Upon plugging completion the location will immediately be cleared of all hazards to livestock or property, and within 90 days the location will be placed in a physical condition satisfactory to the Superintendent.

5. Cement plugs will be spotted:

   (a) To isolate all formations bearing oil or gas, or which communicate with formations bearing oil or gas in the same general vicinity.

   (b) To protect all fresh water zones.

If surface casing is already cemented through all fresh water a plug not less than 40 feet long shall be set half below and half above the casing point. If adequate cemented surface casing has not been set, one plug not less than 40 feet long shall be set immediately below all fresh water.

A 20 foot plug will be set from a depth of 30 feet to 10 feet below surface. The top 10 feet of hole will be filled with soil.

6. Place a readily removable heavy duty steel cap on surface pipe 3 feet below ground level unless otherwise approved by Field Inspector.

7. Offset lessees must be notified by you in writing of intent to plug.

8. Special instructions:

Chief, Branch of Minerals
Auth: 34 F.R. 15812

Checked by: _____ Date _____

ure 8. Sample copy of the plugging permit issued by the Osage Agency.

faction of the Superintendent. After all of the above actions have taken place, landowners can make claim to lessees for alleged damages, and all damages are settled in accordance with 25 CFR 183.

Each application for plugging must be accompanied by a fee of $15. For failure to notify the Superintendent before plugging or abandoning any well, a fine of $200 can be imposed. For failure to file plugging reports a fine of $10 per day for each violation until compliance is met can be levied.

Approximately 175 wells have recently been plugged and abandoned each year in Osage County. It is anticipated that this same level of activity will continue into the foreseeable future. During 1978, the cost of plugging a dry hole or non-productive well was about $4,000. This has increased substantially from a cost of about $2,000 or less in the mid-1950's.

I. Transportation and Transmission

In Osage County there are currently about 2,000 miles of paved highways which are maintained by district offices of the Oklahoma State Department of Transportation, Division of Highways. Several new roads are currently funded for pending construction. In addition, about 3,000 miles of oil company roads are maintained by lessees for day-to-day operations of their properties. Approximately 150 miles of unpaved gravel roads are constructed annually to carry out new oil and gas field operations.

In all, about 13,500 wells in the county are checked on a scheduled basis by oil field pumpers who normally make their rounds in pickup trucks. Workover units, drilling rig vehicles, cementing trucks, logging trucks, acidizing trucks and

other vehicles also use the roads in drilling about 500 wells and reworking about 3,000 wells annually. Oil trucking firms also use the roads to deliver oil from tank batteries to gathering points or refineries. These companies presently truck about 6 percent of all oil produced in Osage County, and normally carry 160 to 200 barrels of oil per load. Most of the oil is presently trucked to Cushing and Tulsa, Oklahoma for refining or redistribution. Pipelines also run to these refining centers. The major mode of movement of gas, oil, formation water and secondary recovery chemicals is by pipeline.

Several major interstate pipelines cross Osage County. The inside diameters (ID) of the largest crude oil lines are 24" (ARCO). The largest natural gas lines are several Cities Service lines with 16" ID. Many interstate product lines also cross the county, with the majority of those converging at Barnsdall. Except for activities involving locating interstate pipelines on restricted Indian lands in Osage County, neither the Osage Agency, the Osage Tribe, nor the U.S. Department of Interior has any regulatory authority over interstate pipeline operations (including spill prevention or cleanup). The Superintendent of the Osage Agency must approve route locations of interstate lines on restricted Indian lands.

In addition to the major interstate lines, about 94 percent of all oil and essentially all of the natural gas is piped to tank batteries or gathering centers through lines ranging in size from 2" ID to 6" ID. It is estimated that several hundred miles of pipelines used for brine disposal or injection are presently in use in the county. The countywide total estimate (Osage Agency, 1978) for all major oil, gas or saltwater lines used to deliver products to their proper location for sale or disposal is about 8,000 miles of pipelines. Approxi-ately 150 to 200 miles of new pipelines are being installed annually (1978 rate)

due to new oil and gas operations. This level of activity is not expected to change in the foreseeable future.

8. Safety and Environmental Controls

The oil and gas leasing program in Osage County is subject to numerous Federal and Osage Agency regulations which guard personal safety and environmental conditions. As in other parts of the country where oil and gas drilling and production are taking place, the rules of the Occupational Safety and Health Administration (OSHA, US Department of Labor) are in effect in Osgae County. These rules apply primarily to workers at industrial sites and include such protection as specifying hardhats in drilling areas, ear protection when working around machinery with high noise levels, and so forth.

The US Environmental Protection Agency is the regulatory agency which is charged with enforcement of the Oil Spill Pollution Prevention regulations (40 CFR, Part 112; Federal Register, December 11, 1973). These regulations were enacted to control oil spills with regard to non-transportation related onshore and offshore activities. The inspection process put forth in these regulations has been in effect in Osage County. Fresh water is further protected under Federal regulations of the Safe Drinking Water Act (1974, amended 1977) and the Clean Water Act (1972, amended 1977), which are administered by the Environmental Protection Agency.

To bring the Osage Agency, the Bureau of Indian Affairs, and the Department of Interior into conformity with the purposes, intent and procedures set forth in the National Environmental Policy Act (NEPA, 1969), Section 516 was added to the Department Manual (dealing with environmental quality) on September 17, 1970

(revised September 27, 1971). In addition, the Bureau of Indian Affairs' environmental guidelines (Interim Guidelines, Environmental Quality Handbook, 30 BIAM, Supplement 1) were promulgated in August 1973. Environmental regulations specific to Osage Agency operations for oil and gas mining were revised effective July 22, 1974 (amended 1976 and 1978), and include environmental considerations.

It should be noted, however, that specific sections dealing with environmental protection have been incorporated into Osage Agency regulations since at least 1932. Regulations and permit requirements of the Osage Agency have therefore stressed safety and environmental protection since long before NEPA came into effect. The 1932 regulations, for example, included the following controls: when drilling in wildcat territory or known high pressure fields, a lessee must have an approved control device installed to protect against blowouts; all pollution is specifically prohibited with respect to surface water, mudpits and plugging (subsurface formations protected); and, with respect to surface operations and possible damage to streams, ponds, soil and vegetation, all salt water and other deleterious substances must be contained in appropriate receptacles and properly disposed.

Under current regulations, all well drilling, reworking and plugging must be accomplished in a manner that will prevent migration of oil, gas, saltwater, or other substance from one subsurface stratum to another, including any fresh-water-bearing formation. These requirements are specifically noted in the drilling permits and plugging permits which are issued by the Osage Agency. Since these permit's came into effect much in advance of the effective date of the Oil Spill Pollution Prevention regulations (40 CFR, Part 112), it is obvious that management of the Osage Mineral Estate has been conscientiously working to maintain an unpolluted environment in Osage County for many decades.

In the event of accidents, fires, brine or oil spills, or other problems at well sites in Osage County, a lessee is required to file a report with the Osage gency. If a surface landowner has a grievance as a result of any oil and gas activity, as soon as possible after the discovery of any damages, he must serve a written notice to the appropriate lessee or his representative. This notice must contain the nature and location of alleged damages, the date of occurrence, the names of the parties causing the damages, and the amount of damages. If arbitrated settlement cannot be made, action may be brought in court against the alleged party causing the damages.

The Osage Agency can levy fines on lessees or operators for not properly adhering to environmental regulations. For failure to construct and maintain mudpits as required, a fine of $10 per day of operations after commencement can be levied on any well until compliance is mot. For failure to have a proper valve or other blowout control device installed at each drilling, a fine of $100 can be levied. For failure to properly care for and dispose of sludge, saltwater or other deleterious substance, a fine of $100 per day can be levied and, in the event of failure to comply within 5 days, a fine of $500 per day can be levied until compliance is met.

II. DESCRIPTION OF EXISTING AND PROJECTED ENVIRONMENTAL CONDITIONS IN OSAGE COUNTY, OKLAHOMA

A. REGIONAL LAND USE

Historically, the dominant land use in Osage County has been agricultural. Excellent natural rangeland has made the region an important cattle grazing area. As shown in Figure 9 and Table 3, rangeland, native and tame (bermuda/fescue) pastureland and cropland comprise about 81 percent of the county. Native wooded lands cover about 15 percent of the county, mostly in the eastern half and along major streams. The remaining 4 percent of the county contains urban areas, mines and gravel pits, oil waste land and surface water (US Soil Conservation Service, 1974). This picture has changed little in the past few years except that more of the eastern upland blackjack and postoak areas have been sprayed with defoliants to convert them to open rangeland. Also, minor expansion of urban areas, especially around Tulsa, continues at a steady pace. Cropland acreage also has decreased in the past decade.

From about 1910 to 1930, most of the floodplains in the county were cleared of trees and brush along the Arkansas River and major streams. At that time, vast acreages were planted in corn, oats or wheat. With the Dust Bowl of the 1930's, farmers abandoned their croplands and sold much of the property to large cattle ranchers. Many of the fields lay idle for years and upland soils became severely eroded. Bermuda grass was brought into the county in the 1940's to help control erosion. Since then about 80,000 acres (or 5.4 percent) of the county has been planted in tame bermuda grass pasture (US Soil Conservation Service, in press).

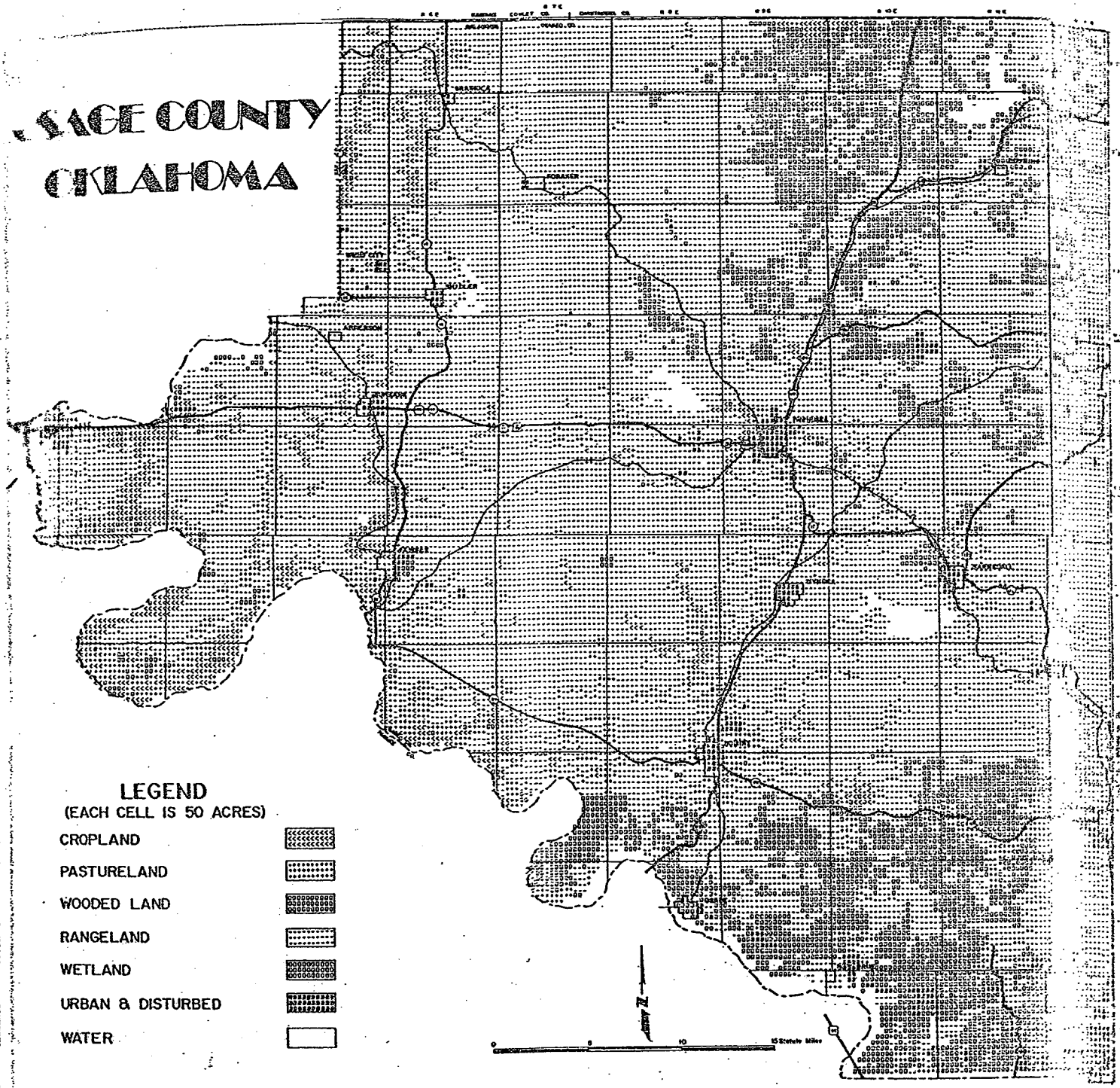


FIGURE 9. LAND USE (GROUND COVER)

Table 3. Present and projected land use (in acres) for Osage County, Oklahoma.

Land use category	Present acreage[a]	Percent cover	Projected year 2000 acreage[b]	Percent cover
Wooded land	220,000[c]	14.90	205,000	13.89
Rangeland	926,617	62.76	912,744	61.82
Pasture land	184,820	12.52	222,400	15.06
Cropland & orchards	82,000	5.55	60,000	4.07
Wetland	3,855	0.26	3,700	0.25
Urban & built up[d]	16,130	1.09	18,820	1.27
Paved highways & county roads	13,318	0.90	14,773	1.00
Stripmines & gravel pits	670	0.05	800	0.05
Oil waste land	2,000	0.14	2,544[e]	0.24
Confined feedlot operations	160	0.01	200	0.01
Water	26,910	1.82	34,500	2.34
Total	1,476,480	100.00	1,476,480	100.00

[a] Based on US Soil Conservation Service (1974), but modified for more correct estimates of surface water, urban areas, roads, oil waste land and other categories for 1978 status.

[b] Based partially on projected trends as outlined by the Osage County Conservation District (1973), INCOG 208 Areawide Water Quality Management Plan (1978), State Department of Transportation (personal communication), and estimates of water coverage assuming all proposed Corps of Engineers reservoirs are completed.

[c] Commercial forest = 70,000 acres (1972), according to Osage County Conservation District

[d] Includes city street mileage.

[e] Assumes historical average (1970-1978) of 164 spills per year with average area of 15.58 acres degraded per spill, and no natural revegetation or reclamation of existing oil waste land.

Prior to about 1960, most of the cattle grazing in the county was done by bringing steers in by rail, fattening them, and shipping them to northeastern markets. Now most ranches are self-sustaining, year-round operations. The average size of an operational ranch in Osage County is 1,209 acres, but several ranches cover tens of thousands of acres. Approximately 990 ranches or farms are now operating in Osage County.

With respect to future land use in the county, two groups have published data. The Osage County Conservation District (1973) data indicates that by 1982 slight reductions will occur in rangeland, wooded land and cropland, while increases of tame pasture, urban areas and surface water acreage will take place. Most of these changes will result from urban growth and completion of Skiatook Reservoir. The INCOG 208 Areawide Water Quality Management Plan also forecasts increases in urban areas to the year 2000 based on population and employment growth as well as on physical environmental, socio-economic and political constraints. Table 3 depicts present and projected land use to the year 2000 for Osage County; data used are modified from existing and projected conditions as described by the Soil Conservation Service (1974), the Osage County Conservation District (1973) and INCOG (1978).

Among the general assumptions that guided formulation of the INCOG projections are the following:

i. the City of Tulsa will continue to be the regional center;

ii. most intensive development in Osage County will occur adjacent to the City of Tulsa;

iii. southeastern Osage County will receive development expansion from Tulsa, Sperry, Skiatook, and Sand Springs;

iv. areas outside of the Tulsa metropolitan area will continue to be rural in character, with increased growth in the range of 0 to 1.5 percent per annum;

v. areas of severe soil limitations are not considered as part of the available supply of land, but constraints include: wetlands, steep slopes with erodible soils, and bedrock;

vi. prime agricultural land (as determined by soils analysis) should be protected from development pressures and not considered in the supply of land for urban development; and

vii. only land which can be economically sewered to meet demand should be considered in the supply of land for urban development.

With these assumptions in mind and population and industrial growth taken into account, the INCOG 208 Plan identified several areas in Osage County subject to urban growth. The Plan stated that residential development for the industrial community of Sand Springs (along the Arkansas River) would extend northward into Osage County as a result of improved sewage collection and treatment facilities; however, water supply there would be a problem affecting short-term growth. The Plan also noted that the majority of new growth in Skiatook would occur in Osage County due to the expanse of the Bird Creek floodplain in Tulsa County. Furthermore Skiatook Reservoir (under construction) and the proposed Osage Expressway (from Tulsa to Skiatook) would influence Skiatook's growth patterns. The 208 Plan concludes that the area "outside the Tulsa Metropolitan area will retain its rural character and there will be few major changes in land use." In addition to the expansion of Tulsa, Sand Springs and Skiatook, the projected land use map for the year 2000 in the 208 Plan shows one new industrial area in far southeast Osage County on Flat Rock Creek.

B. PHYSICAL CHARACTERISTICS

1. Physiography and Topography

Osage county is situated in the Interior Plains division of the Central Lowlands physiographic province. The northwestern part of the county is in the Northern Limestone Cuesta Plains subdivision while the southeastern portion is in the Eastern Cuesta Plains subdivision. The terrain of the region is characterized by gently rolling to rocky hills dissected by lowlands of the Arkansas River and its major tributaries. As shown in Figure 10, the average elevation in the county is about 860 feet, and ranges from a maximum of 1,407 feet at one point a few miles northeast of Foraker to around 590 feet. The normal power pool level of Keystone Reservoir, at the southern boundary, is 722 feet (mean sea level). Most slopes are in the range of 0 to 15 percent.

2. Geology

Osage County is situated in a region of mid-continental Paleozoic rocks on the western flank of the Ozark Uplift. Structurally, the entire area is part of a regional homocline which dips gently to the west. Bedrock formations are typically intermixed sequences of sandstone, shale and thin limestones in the eastern two-thirds of the county. For the most part, the entire county is considered to be an outcrop of Upper Pennsylvanian aged structures. However, rocks of Lower Permian age produce outcrops in a few extreme western areas of the county. The rolling hills are virtually all grass covered because of the high calcium content of the soils derived from the parent rocks of high carbonate content.

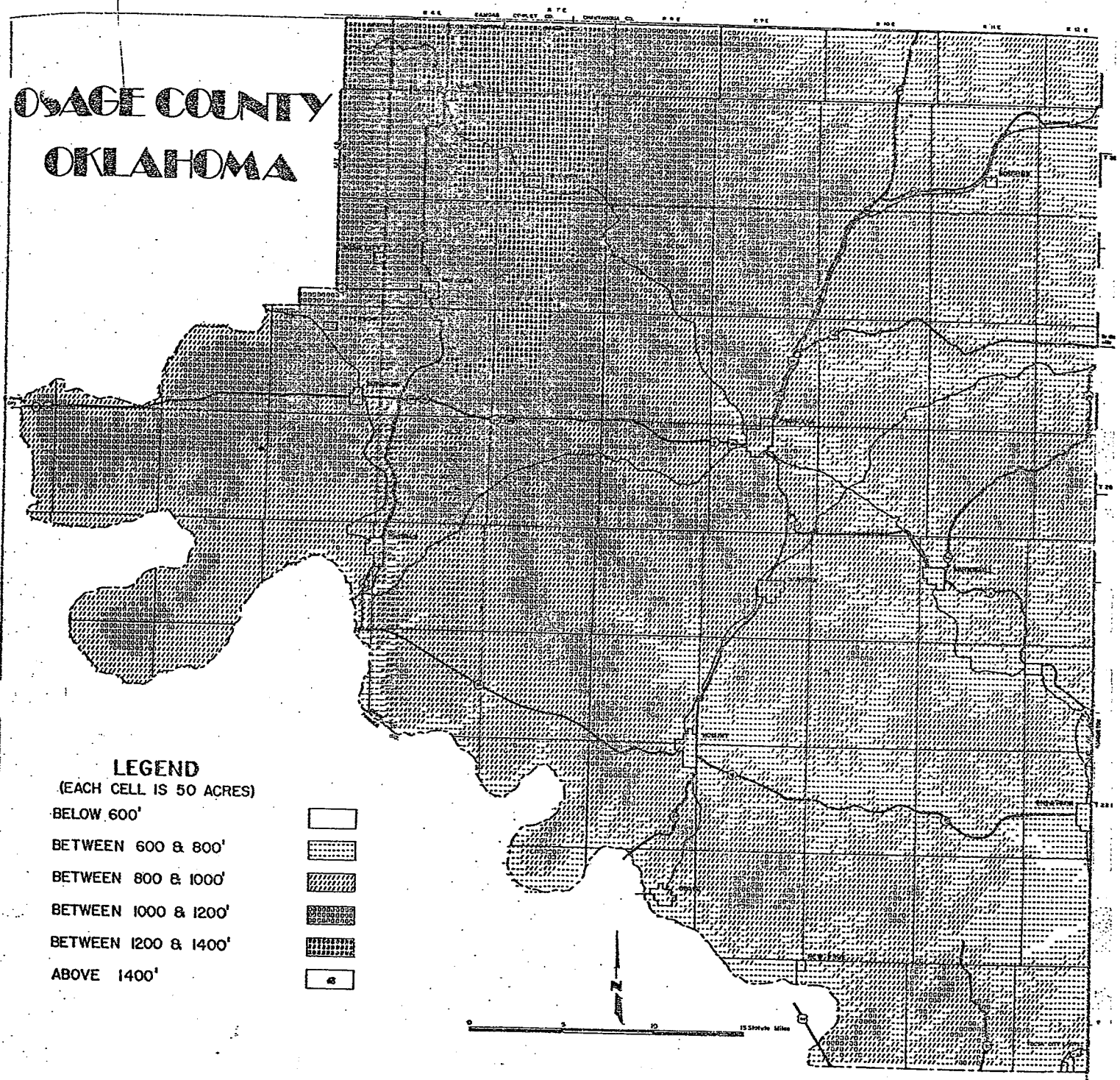


FIGURE 10. ELEVATIONS

Oil and gas production in the county comes mainly from formations at depths between 200 and 3,000 feet. The Burbank Sand, Oswego Lime, Arbuckle Sand and Mississippi Chat are among the formations from which oil and gas have been produced. In general, production comes from shallow formations in the eastern portion of the county and from deeper formations to the west. A stratigraphic section typical of the major Burbank field is shown in Figure 11 . Shale and limestone quarrying are carried out at some surface outcrops of these rocks. Sand and gravel are recovered from alluvial deposits along the Arkansas River and the major tributary streams.

3. Soils

A complete and very detailed soil survey of Osage County recently has been produced (U.S. Soil Conservation Service, in press). Figure 12 depicts the distribution of four major soil groupings which incorporate 70 individual soils as determined from this survey. The twelve soil associations can be categorized into three major groups. One group, the Verdigris-Mason-Wynona and Kiomatia-Mason-Roebuck Associations are comprised of soils which are deep, loamy sands found primarily on wooded floodplains. These two associations cover 14 percent of Osage County, and are used mainly for field crops and tame pasture. Uncleared areas of these soils support bottomland hardwoods with an understory of native tall grasses.

The second group is comprised of seven soil associations which cover about 50 percent of the county supporting the prairie-covered uplands. These seven associations are the Dennis-Parsons-Bates, Steedman-Coweta-Bates, Apperson-Wolco-Dwight, Shidler-Summit-Foraker, Grainola-Shidler-Stoneburg, Corbin-Pawhuska, and Norge-Vanoss. The soils in these associations are used mainly for native

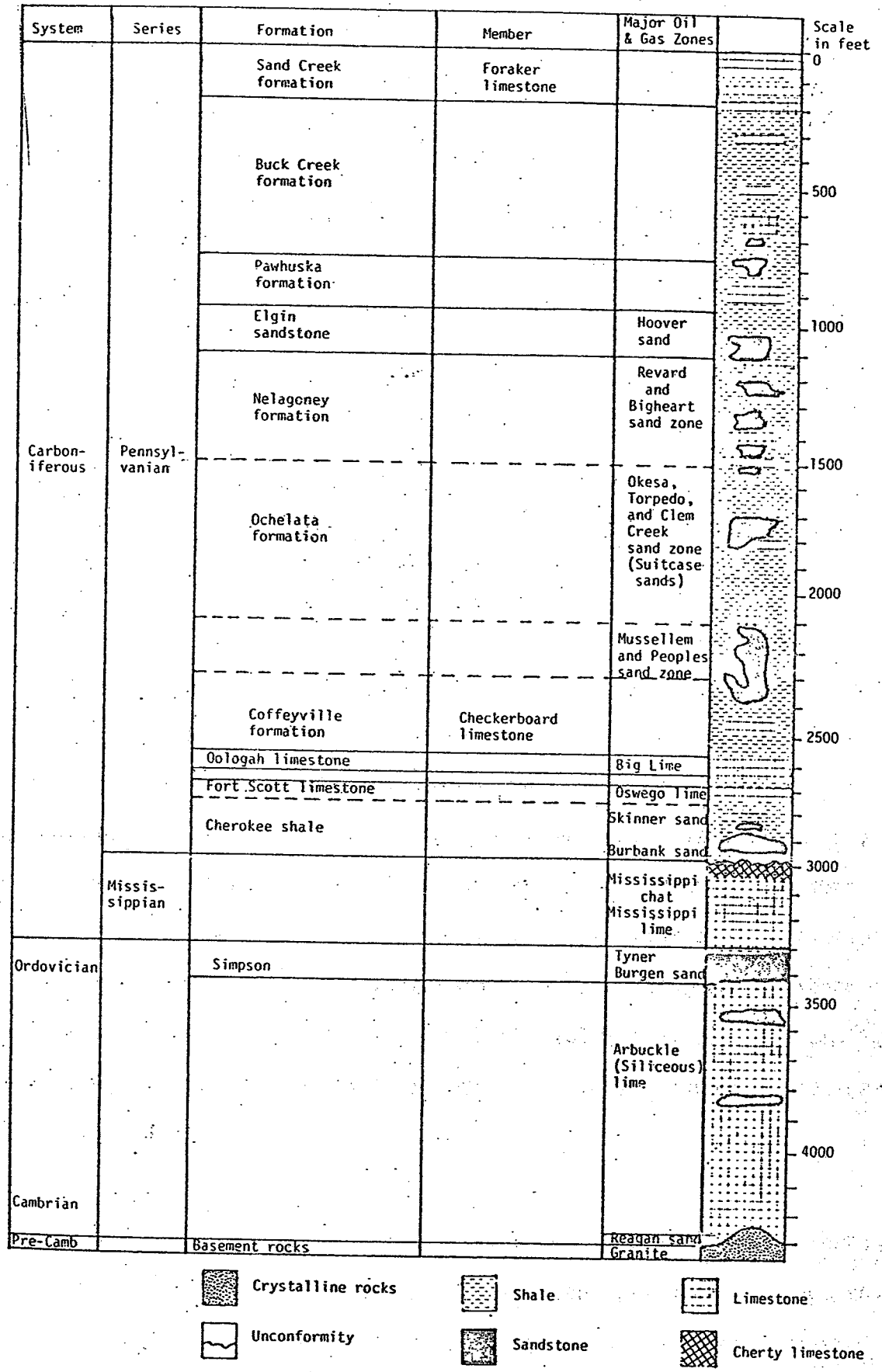


Fig. 11. Stratigraphic column showing geological formations in area of Osage County near Burbank oil field.

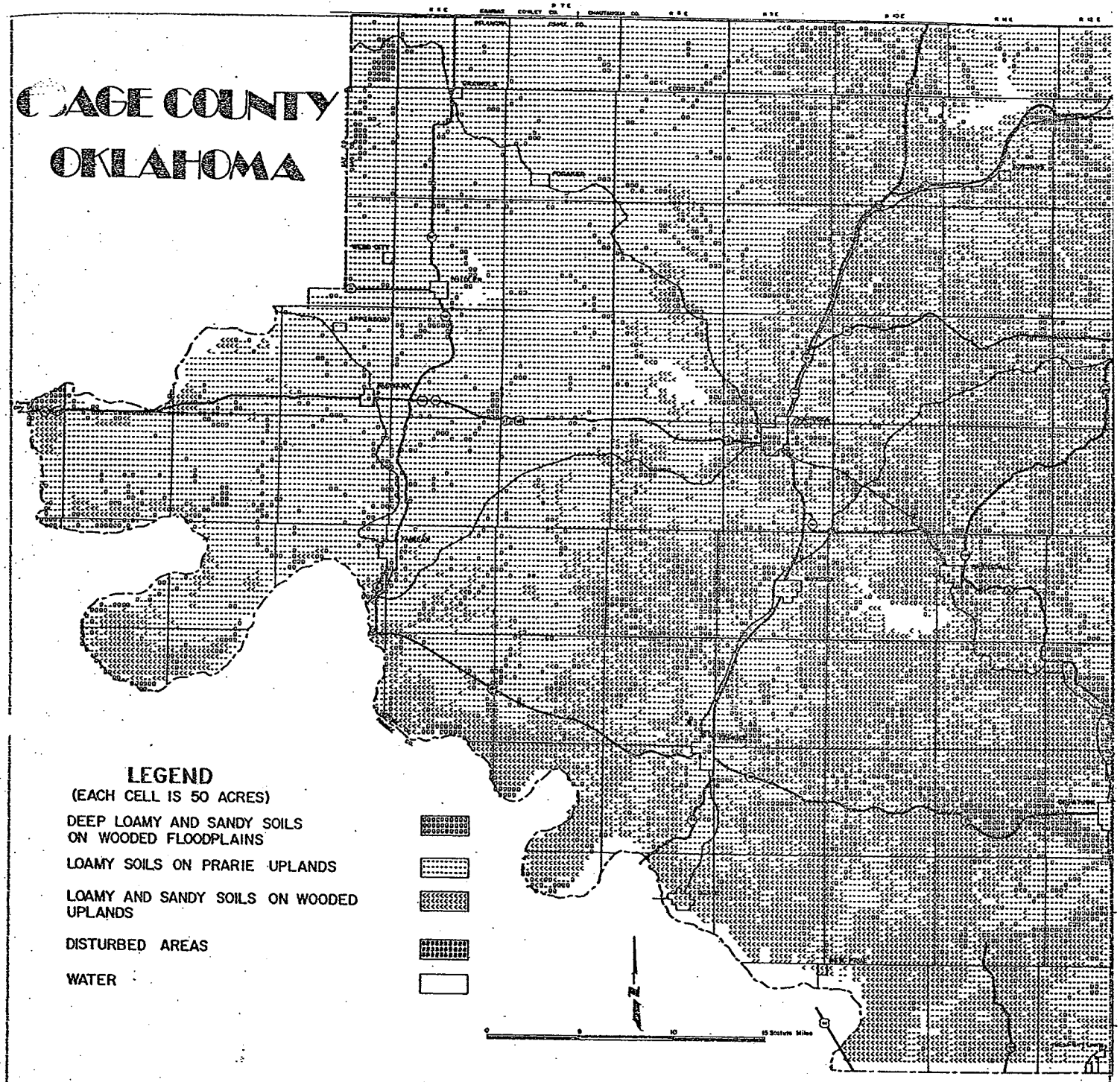


FIGURE 12. SOIL TYPE AND DISTRIBUTION

range, native hay meadows and tame pasture. Native vegetation consists mostly of tall grasses. Soils that are free of stones and on level to gently sloping topography are suitable for cultivation. In some areas containing these soils, limestone is quarried.

The remaining group of three associations is comprised of the following: Niotaze-Darnell, Dougherty-Eufaula, and Darnell-Stephenville Associations. This group covers about 34 percent of the county. The soils are shallow to deep, loamy or sandy, and are found on wooded uplands. Some of the deeper soils are cultivated to small grains, cotton, or grain sorghum. Native vegetation is mostly postoak, blackjack oak, and hickory, with an understory of native tall grasses.

Generally, the soils in Osage County are a constraint to both mechanized agricultural production and urban and industrial development. Soil erosion is a major problem for cropland or other exposed surfaces on slopes greater than 2 percent. Most soils present moderate to severe limitations to recreational use, shallow excavations, basement construction, road bases, septic tank fields, sewage lagoons and sanitary landfills. Consequently, over 70 percent of the county remains in native grassland or partially wooded rangeland.

4. Climate

Osage County lies in a mid-temperate climatic zone of the United States. No mountain ranges or large bodies of surface water are found nearby which influence the local climate. At a latitude just north of 36^{o}, the area is far enough north to escape long periods of summer heat, yet sufficiently southerly to miss the extreme cold of winter. The influence of warm moist air from the Gulf of Mexico is often noted as high humidity, but the climate is essentially continental, characterized by fairly rapid temperature changes.

The growing season in the county ranges from about 201 days (northwest) to 16 days (southeast). At Pawhuska, in the central part of the county, the average date of the last freeze in spring is April 12. Usually, the first freeze in fall is around October 24. The average number of days with freezing temperatures at Pawhuska is 102 days. With regard to high temperatures, Osage County experiences a yearly average of 87 days with temperatures of 90^{o} or higher. The record high temperature at Pawhuska was 116^{o} F on July 18, 1936; the record low was -26^{o} F on January 22, 1930. The mean annual temperature is 60^{o}F.

Precipitation varies from about 30 inches annually in the northwestern portion of the county to 40 inches in the southeast. The average at Pawhuska is about 36 inches per year. Approximately 61 percent of all precipitation comes during spring and summer. Winter is the driest season, and yields only about 12 percent of the annual precipitation. The driest and wettest years, respectively, were 957 (19 inches) and 1915 (58 inches). Precipitation of more than one-tenth of an inch normally occurs in the county on about 53 days each year. Total annual snowfall averages 10 inches.

Except during January and February, when winds are mostly from the north, prevailing winds in Osage County are southerly. The annual average wind speed is about 12 miles per hour (mph), but monthly averages vary from 9 mph in July and August to 14 mph in March. Relative humidity is usually moderate throughout the year, but varies daily from about 80 percent in early morning hours to around 45 percent in afternoon hours. Annual evaporation in Osage County ranges from 53 inches in the east to 57 inches in the west.

5. Air Quality

Osage County is in a 14-county area of Oklahoma designated by the EPA as the Northeastern Oklahoma Intrastate Air Quality Control Region (AQCR). It includes the following counties: Craig, Creek, Delaware, Mayes, Muskogee, Nowata, Okmulgee, Osage, Ottawa, Pawnee, Rogers, Tulsa, Wagoner, and Washington. The Tulsa Metropolitan Area and Muskogee are totally within the Region (AQCR No. 186). The EPA's attainment status of Federal Standards for AQCR No. 186 as of March 3, 1978 are shown on Table 4 . . In particular, parts of Tulsa County have been designated as non-attainment areas for ozone (exceeds 0.2 parts per million standard), for carbon monoxide, and for total suspended particulates. Portions of nearby Washington County are the only areas in AQCR 186 which are designated as non-attainment areas for sulfur dioxide. EPA Region VI indicates that the non-attainment status of AQCR 186 with regard to the categories of pollutants mentioned above is not related to the overall oil and gas leasing and production programs in the area (personal communicaion, Mr. Jerry Stubberfield, EPA, December 6, 1978), but is most likely due to automobile and industry emissions.

Overall, air quality in Osage County is quite good. The Osage County Conservation District (1973) noted that smoke from a few industrial areas and occasional grass fires were the most significant air pollutants. Several studies performed by the US Army Corps of Engineers (1972-1975) concluded that stagnant meteorological conditions which lead to air pollution episodes are unlikely to occur in Osage County.

6. Noise

Background noise is not usually apparent in rural areas. Throughout most of Osage County, daytime noise from automobile traffic, farm equipment, wind, insects,

Table 4. Status of EPA's Air Quality Control Region Number 186 for air emission pollutants. (Sections 107, 301 of the Clean Air Act, as amended--42 U.S.C. 7407, 7601).

Pollutant Classification	Does not meet primary standards	Does not meet secondary standards	Cannot be classified	Better than national standards	Cannot be classified or is better than national standards
Total Suspended Particulates (TSP)					
Portions of Tulsa Co.	X				
Protions of Tulsa Co.			X		
Portions of Muskogee Co.			X		
Mayes Co.	X*				
Remainder of AQCR				X	
Ozone (Ox)					
Tulsa Co.	X				
Remainder of AQCR					X
Carbon Monoxide (CO)					
Portion of Tulsa Co.	X*				
Remainder of AQCR					X
Sulfur Dioxide (SO_2)					
Portion of Washington Co.	X*				
Remainder of AQCR				X	
Nitrogen Dioxide (NO_2)					
AQCR 186					X

*EPA designation replaces state designation.

Source: EPA Regulations Designating Air Quality Control Regions (40 CFR 81.337, November, 1971, as amended, 1978).

birds, airplanes, and so forth, is usually in the range of 35 to 40 dBA. Rural noise levels at night range from 20 to 30 dBA. These measurements are representative of a quiet and tranquil environment.

Exceptions to the typical quiet conditions in Osage County are the noise levels associated with urban and highway traffic and oil/gas production activities. These activities, especially oil pumping, are carried on around the clock every day of the week. Noise level data were taken during a spot check of several representative areas in Osage County on November 9 and 10, 1978. These data are not intended to give a thorough analytical picture of existing noise conditions in the county, but simply reflect the circumstances encountered. In general, urban noise was dominated by automobile traffic in the various communities; sound levels there ranged up to 65 dBA. In areas of active drilling or pumping, noise was at a much higher level than in the urban or rural settings. In one instance, a noise level (exceeded 10 percent of the time) of 92 dBA was measured at the boundary of a well drilling site. In close proximity (within 50 feet) of large gas-powered pumps, pulse noise was at high levels, in some instances over 100 dBA. At present, the general industry standards of OSHA (Section 1910.95) indicate that the noise level, on an 8-hour time-weighted average, should be no greater than 90 dBA and on a 2-hour average should be no greater than 100 dBA. Several pumping stations and work areas which were investigated during field reconnaissance in Osage County for this study displayed signs which warned that protective devices for the ears were required if a person had to work in the area for more than 4 hours.

7. Surface Water Resources

a. Sources and Use

All of Osage County is within the Arkansas River drainage basin. The Arkansas River forms the southern boundary for the county, and those streams not draining directly into it flow to the Caney River, one of the Arkansas' large tributaries. In addition to the Arkansas and Caney rivers, there are 116 permanent or intermittent streams wholly or partially within Osage County (Osage County Conservation District, 1976). Among the major streams are Birch Creek, Bird Creek, Candy Creek, Hominy Creek, Salt Creek, Sand Creek, Pond Creek, and Mud Creek. Because of the moderate rainfall and hilly topography over much of the county, the majority of the 116 streams only flow intermittently during most years. Figure 13 shows the major surface water resources of Osage County.

Hulah Reservoir and Birch Reservoir are the only completed and filled Army Corps of Engineer reservoirs totally within Osage County, although four others are proposed or under construction. Keystone Reservoir, whose dam is approximately 11 miles west of Tulsa on the Arkansas River, forms much of the southern boundary of the county. A small area of the Kaw Reservoir flood pool, also on the Arkansas River, extends into the western portion of the county. In addition to the major bodies of water discussed above, 47 lakes of between 10 acres and 800 acres in size also are located in the county (Oklahoma Water Resources Board, 1976b).

Soil Conservation Service flood retarding or stock watering structures are mostly less than 10 acres in size in Osage County. To date the SCS has given technical

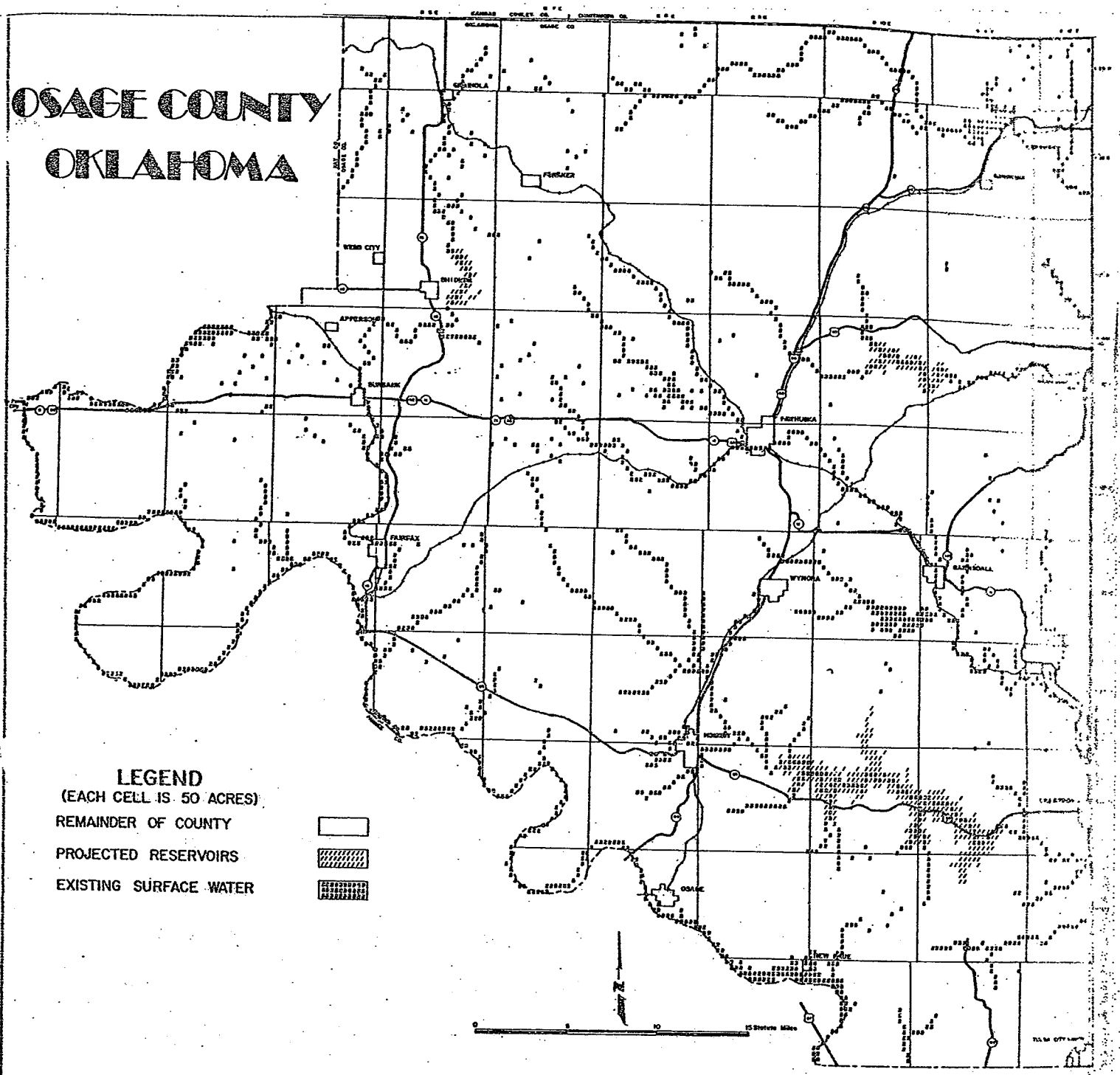


FIGURE 13. SURFACE WATER RESOURCES

assistance for over 3,000 of these small farm ponds. As of the end of 1978, only four flood retarding structures over 10 acres had been constructed. 1 are within the Caney River watershed and range in size from about 17 to 60 acres. Several more are in the planning stages. No Oklahoma Department of Wildlife Conservation lakes are found within Osage County (Oklahoma Department of Wildlife Conservation, 1973).

Surface water use in Osage County includes private drinking water supply, irrigation, recreation, pleasure craft navigation, industrial, municipal, well injection, and wildlife and livestock (mostly cattle) water supply. According to the Oklahoma Water Resources Board (personal communication, Mr. Ed Parker, November, 1978), all surface lake water supplies in Osage County are fully allocated at present with respect to municipal, industrial and other uses. None of the surface waters in the county are presently being used as cooling water sources for major electrical generating stations.

IRB personnel indicated that about 1 to 2 acre-feet of water was required for development of an average oil or gas well in Osage County. However, Osage Agency personnel noted that about 1 to 2 barrels of water per foot of well depth is required. Table 5 depicts reported water use in Osage County for 1975 and 1976. It should be noted that reported surface water use greatly exceeds groundwater use, except for the categories of irrigation and secondary oil recovery use. Secondary oil recovery comprised 20.6 percent of total use in 1975 and 10.8 percent in 1976. New well production use comprised 1.5 percent of total use in 1975 and 0.8 percent in 1976. It is also evident that municipal use is increasing and that values for 1977 and 1978 (not yet published) are anticipated to exceed the 1977 figures.

b. Surface Water Quality

Water quality in Osage County, as in most areas of northeastern Oklahoma which are not heavily urbanized, is moderately good. However, relatively high chloride concentrations exist in some surface waters, including Keystone Reservoir, because of natural or man-induced brine inflows. The Oklahoma Water Resources Board published Oklahoma's Water Quality Standards in 1976; these are summarized in Table 6. During preparation of the comprehensive Areawide Water Quality Management Plan (or 208 Plan) by INCOG (1978), water quality in Osage County was monitored at 23 stations in 1976 and 1977. Data from 13 of these stations in various parts of Osage County are given in Table 7.

The INCOG 208 planners, using data gathered specifically for that study in comparison with the Oklahoma water quality standards, indicated that there were several major water quality problem areas within the Plan's 5-county study area. Most of the problem areas were downstream of Tulsa or in the near vicinity of Tulsa. However, three problem areas were described within Osage County. In the Salt Creek sub-basin, it was noted that fecal coliform bacterial counts often exceeded State limits of 200/100 ml; this situation was ascribed partially to inadequate disinfection of municipal wastewater discharges in the watershed. In the Bird Creek sub-basin, it was noted that ph values less than 6.5 occurred at the mouth of Hominy Creek (just outside Osage County),

Table 5 . Reported surface and groundwater use in Osage County, Oklahoma for 1975 and 1976 (all values in acre-feet).

Use category	1975 From surface water	1975 From groundwater	1976 From surface water	1976 From groundwater
Crop irrigation	636	489	606	680
Municipal	7,500	58	20,555	59
Industrial	506	0	475	0
Recreation and Wildlife	0	0	228	0
Secondary oil recovery	76	2,388[a]	75	2,714[a]
Other municipal and industrial	0	0	0	0
New well development[b]	182	-	204	-
Sub-Totals	8,900	2,935	22,143	3,453
Annual Totals	11,835		25,596	

Groundwater use for secondary oil recovery includes a minor amount of alluvial and Vamoosa aquifer fresh water; however, the vast majority of the reported use consists of saline water from below the zone of potable water and reinjected to pressurize fields.

[b] Calculated values; assumes 1.5 barrels of water per foor of new well drilled, average depth of 2,200 feet; with 432 wells completed in 1975 and 483 wells completed in 1976. Although some groundwater is used, almost all use of water for new well development came from surface streams and small impoundments (personal communication, Mr. Dave Baldwin, Superintendent, Osage County, January, 1979). Other data from Oklahoma Water Resources Board.

Source: Reported Water Use, 1975 and 1976 - Oklahoma Water Resources Board.

Table - - Summary of Selected Oklahoma Water Quality Standards

Parameter*	Limits
Mineral Content	. annual mean concentration of chloride, sulfate, and total dissolved solids (TDS) cannot exceed historical yearly mean standard of each station (US Public Health Service Standard is 250 mg/l)
Bacteria	. total coliform count (monthly arithmetic mean) shall not exceed 10,000/100 ml for drinking water streams
	. fecal coliform count shall not exceed 2000/100 ml for water supply streams; 200/100 ml (monthly geometric mean) for primary body contact recreation
Oil and Grease	. all State waters shall be maintained free of oil and grease to prevent a visible film
Turbidity	. warm-water streams--50 JTU (Jackson Turbidity Units) . warm-water lakes--25 JTU
Temperature	. limit of 90° F in streams and lakes other than trout or smallmouth bass streams; temperature increases limited to 5° F in streams and 3° in lakes
	. exceptions--Arkansas River from Kaw Reservoir to headwaters of Keystone Reservoir--94° F; Salt Fork--93° F
Taste and odor	. substances other than from natural origin are limited to concentrations that will not interfere with potable water supplies
Dissolved oxygen	. minimum DO shall be 5.0 mg/l for all warm waters and 6.0 mg/l for trout and smallmouth bass waters
Nutrients	. the nitrogen/phosphorus ratio shall not be increased so as to cause undesirable eutrophication
	. nitrate-nitrogen shall be less than 10.0 mg/l for water supplies
Toxic substances	. State waters shall be maintained so that they will not be toxic to humans and fish and wildlife (0.05 to the 96-hour TLM for persistent toxic substances on the most sensitive indigenous species)
Pesticides	. shall not be present in such concentrations to cause toxicity to humans, animals, plants, or aquatic life
pH	. pH values shall be between 6.5 and 8.5

* The majority of the Oklahoma standards have been approved by the EPA with the exception of thermal and PCB criteria (PCB criteria to be set on a case-by-case basis).

Osage County, Oklahoma. (All data are averages for from 5 to 14 samples taken during 1976 and 1977).

Parameter	Units	Station												
		Arkansas River, St. Hwy. 20 at Ralston	Arkansas River, County Bridge N. of Blackburn	Bird Creek, County Road S. of Avant	Bird Creek, St. Hwy. 11 at Barnsdall	Bird Creek, St. Hwy. 11 W. of Pawhuska	Caney River, County Road 1 mi. W. Wash. Co.	Hominy Creek, at crossing of St. Hwy. 20	Penn Creek, County Road N.E. of Hominy	Sand Creek, at crossing of St. Hwy. 123	Salt Creek, at St. Hwy. 18 S. of Fairfax	Salt Creek, County Road N.E. of Burbank	Salt Creek, at St. Hwy. 18 S. of Shidler	Salt Creek, County Road W. of Foraker
dissolved oxygen	mg/l	9.2	9.7	8.3	7.8	6.8	7.6	7.5	5.2	7.3	8.4	7.9	7.9	7.6
specific conductance	µmhos	918.2	863.6	399.5	347.0	470.0	409.3	697.5	661.1	508.3	835.0	635.0	503.3	423.3
pH	st. units	7.5	7.4	7.4	7.8	7.4	6.8	6.9	7.2	6.5	7.6	7.2	7.2	7.3
hardness	mg/l	320	269	173	-	251	181	228	202	247	353	410	290	263
total phosphorus	mg/l	1.93	2.17	1.54	1.71	1.86	3.97	2.24	2.34	3.53	1.43	1.40	1.30	1.30
ammonia nitrogen	mg/l	0.27	0.21	0.19	0.17	0.17	0.36	0.22	3.23	0.23	0.31	0.17	0.12	0.15
nitrate nitrogen	mg/l	0.25	0.24	0.04	0.02	0.30	0.11	0.09	0.29	0.08	0.05	0.04	0.07	0.04
chloride	mg/l	94.3	177.4	49.7	37.2	37.5	26.5	173.5	93.8	72.0	162.0	99.1	46.2	18.2
sulfate	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-
iron	mg/l	-	-	0.53	-	0.34	-	0.43	0.39	-	-	-	-	-
dissolved solids	mg/l	665.6	571.4	353.3	224.0	300.2	207.1	465.3	341.6	316.2	513.6	375.2	243.2	290.4
suspended solids	mg/l	53.2	38.4	13.8	40.6	14.5	31.3	42.0	22.3	19.5	22.0	14.0	16.0	15.0
BOD (5-day)	mg/l	2.8	3.4	4.1	7.5	5.2	8.8	4.0	7.3	5.9	5.7	4.8	4.4	3.4
COD	mg/l	21.6	20.7	51.1	37.4	21.6	18.1	20.8	35.3	19.9	26.4	16.5	18.4	48.9
total coliforms	#/100 ml	11,672	9,406	2,126	4,000	6,464	3,052	6,148	5,678	2,335	7,825	5,000	5,000	14,020
No. of Samples	#	14	14	11	5	11	7	10	9	6	6	6	6	6

Source: INCOG 208 Areawide Water Quality Management Plan, Working Paper T-1, Water Quality Problem Areas; and computer printout of two year's data.

to runoff from adjacent oil fields. Also in the Bird Creek sub-basin, excessive chloride concentrations with a mean of 335 mg/l were measured below Pawhuska; this also was ascribed to oil well fields in the area. In addition to describing existing problems areas, the INCOG 208 Plan described in detail potential water quality problem areas. These areas were delinated during the study by comparing INCOG's monitored data with a set of future water quality goals established by INCOG. These detailed descriptions will not be repeated herein, but they generally deal with the subject of describing probable future impacts and mitigation measures for nutrients, heavy metals and bacteria within eight major sub-basins; oil field drainage problems were not mentioned specifically.

lysis of the data on Table 7 shows that water quality within Osage County is extremely variable with respect to many parameters, but that certain historic and ongoing trends are evident. For example, phosphorus, chloride and dissolved solids concentrations are generally high. BOD and COD levels are low to moderate, but coliform bacteria levels are high. It should also be noted that no existing data could be located through various Oklahoma agencies or other sources regarding oil and grease concentrations in Osage County surface waters. INCOG did not perform those analyses. The Oklahoma Health Department is capable of doing oil and grease analyses, but they are not done on a routine basis, only special request, and no special tests have been done in Osage County.

As an example of the quality of effluents entering surface streams from sewage treatment plants in Osage County, Table 8 depicts average values from six selected wastewater treatment plants.

8. Groundwater

a. Formations and Yield

Groundwater production in Osage County can be described as scant to moderate with water being of poor to fair quality. Supplies are not adequate for largescale industrial, municipal or agricultural use, and such users must depend mostly on surface supplies. Although wells in the county yield from 25 to 400 gpm (gallons per minute), most produce at rates less than 100 gpm. The best groundwater supplies, with regard to both quantity and quality, are found in the comparatively shallow alluvial deposits of the Arkansas River. In these areas, good quality water can be found at depths of 25 feet or less.

Underlying the central part of the county, in a band from north to south, is the Vamoosa aquifer, consisting of the Vamoosa formation and some adjacent strata (Figure 14). This aquifer is comprised of sandstones and interbedded marine shales of Upper Pennsylvanian age. The northern portion of the Vamoosa aquifer is a surface-exposed formation which in some places contains up to 400 feet thickness of potable water (defined as having less than 1,500 milligrams per liter of total dissolved solids). Only the potable water zone thickness is shown on Figure 14. It is underlain with saline water. The best water yields from the Vamoosa aquifer occur south of Osage County. In the extreme southern part of the county, wells into the Vamoosa can supply up to 100 gpm of water containing chiefly dissolved carbonates and bicarbonates. Over most of the remainder of

Table 8. Water quality data for six selected sewage treatment facilities in Osage County, Oklahoma. (All data are averages for from 2 to 8 samples taken during 1976 and 1977).

Parameter	Units	Station					
		City of Burbank	City of Shidler	City of Hominy	City of Pawhuska	City of Wynona	City of Avant
dissolved oxygen	mg/l	3.8	4.7	-	0.3	4.6	0.5
specific conductance	µmhos	-	-	771.0	613.3	1350.0	-
pH	st. units	-	-	6.9	6.8	-	-
total phosphorus	mg/l	9.50	41.20	11.34	16.43	56.05	70.5
ammonia nitrogen	mg/l	16.69	14.46	-	9.17	23.52	46.00
nitrite nitrogen	mg/l	0.06	0.03	-	0.03	0.07	0.03
nitrate nitrogen	mg/l	0.44	-	-	-	0.06	0.04
dissolved solids	mg/l	1281.5	625.0	-	456.0	865.0	607.0
suspended solids	mg/l	33.0	122.5	-	82.0	89.5	219.0
BOD (5-day)	mg/l	59.15	52.65	144.50	121.00	161.50	442.00
COD	mg/l	207.5	430.4	259.4	238.1	213.3	586.0
total coliforms	#/100 ml	7.5×10^6	2.4×10^7	-	2.7×10^7	2.5×10^7	6.4×10^7
fecal coliforms	#/100 ml	1.4×10^6	-	-	-	8.6×10^6	1.4×10^7

Source: INCOG 208 Areawide Water Quality Management Plan, Working Paper T-1, and computer printout of data.

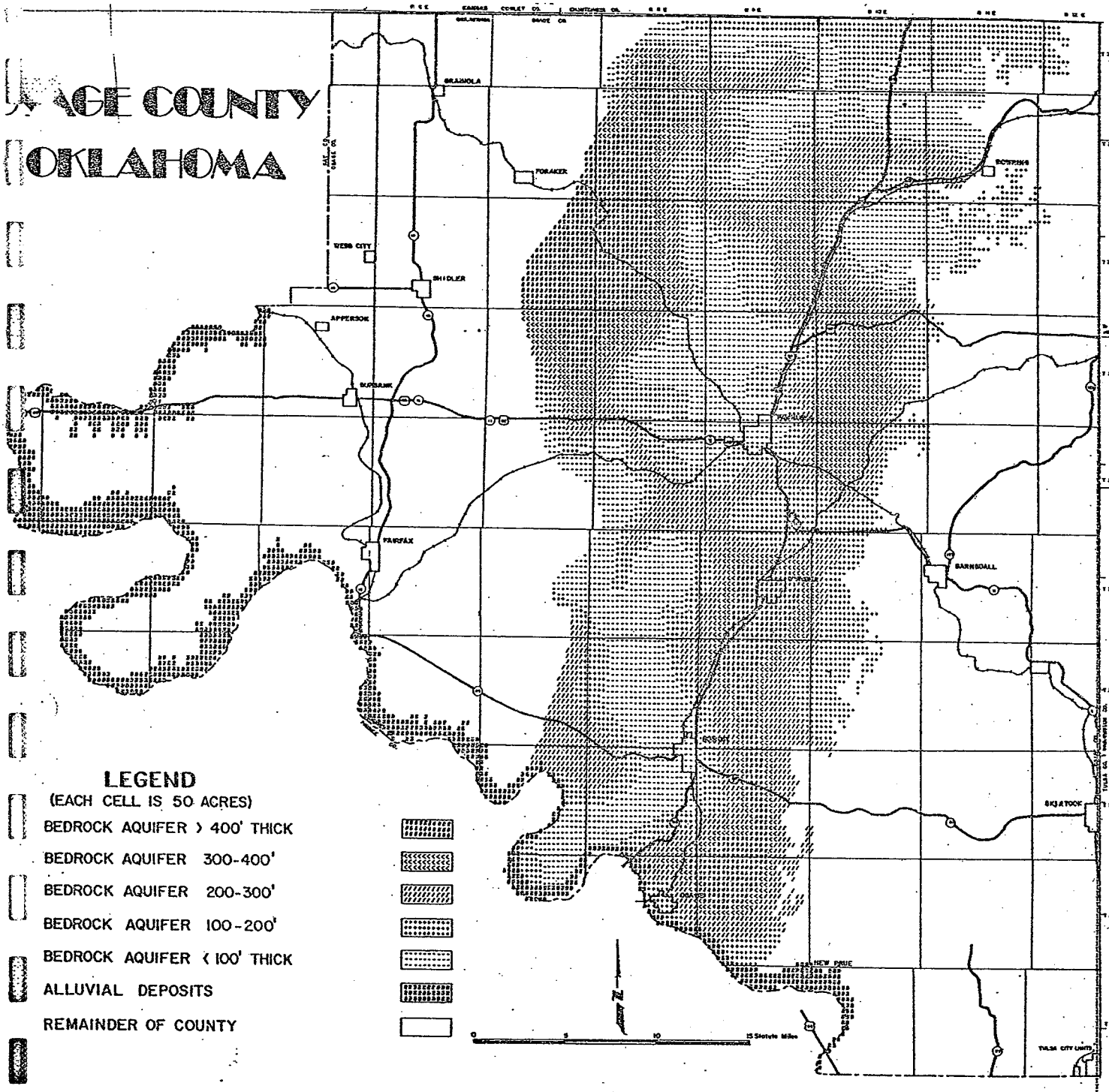


FIGURE 14. GROUNDWATER RESOURCES

the Vamoosa in Osage County, yields are less than 50 gpm, and the dissolved materials contain a high proportion of chloride/bromide in the groundwater suggesting that they may have migrated into the potable water zone from elsewhere rather than being dissolved locally.

As shown in Figure 14, outside of the areas containing alluvial deposits and the Vamoosa aquifer, the county can best be described as having localized groundwater of limited extent. Generally, such supplies are adequate for individual domestic supply, but are sensitive to any disturbance to the local hydrologic regime.

b. Groundwater Quality

Analyses indicate that water from alluvial deposits in Osage County generally contain less than 1000 mg/l (milligrams per liter) dissolved solids. Locally, alluvium along the Salt Fork of the Arkansas River and along a few other minor streams contains water with dissolved solids concentrations of more than 1000 mg/l. Groundwater from terrace deposits usually contains less than 500 mg/l dissolved solids, although concentrations locally may exceed 1000 mg/l.

Groundwater from bedrock aquifers (specifically, the Vamoosa aquifer in Osage County) also contain variable amounts of dissolved solids. Tests have shown that concentrations vary from about 60 to 4,600 mg/l; however, concentrations

of 500 to 2,000 mg/l are most common. Water containing 2,000 to 4,600 mg/l generally is limited to small local areas. Numerous shallow wells yield concentrations between 60 and 500 mg/l. The following table shows the minimum and maximum concentrations for sulfate, chloride, nitrate and total hardness for 23 samples from the Vamoosa formation (Oklahoma Geological Survey, Enid Quadrangle Report, in press):

Parameter	Minimum concentration (in mg/l)	Maximum concentration (in mg/l)
sulfate	7.0	250
chloride	5.0	360
nitrate	0.0	83
hardness	15.0	560

C. SOCIO-ECONOMIC AND CULTURAL CHARACTERISTICS

Osage County is generally characterized by rural communities set amid rolling hills and lush pasture lands. In common with most of the other counties in this region, it experienced a population decline during the 1950-1970 period, attributed to a lack of economic opportunity, few amenities, and the lure of urban life in nearby Tulsa. As a result of this economic and population decline, an effort promoting the region as a scenic and historic area has been initiated. This comprehensive approach to revitalization includes utility improvements, tourist facility development, transportation system improvements, soil conservation and flood control measures, and recreational facilities development. The northeast Oklahoma region now has almost 40 large man-made lakes, 28 parks and recreational areas and hundreds of scenic, historical or unique attractions. Furthermore, the trend toward population decline has reversed in much of the region and economic conditions are improved. Even so, the area still remains below the statewide averages for several socio-economic indicators.

1. Demography

As shown in Table 9 , population in Osage County declined by 10.1 percent during the 1950-1970 decades. The 1970 Census reported 13.5 percent of the population was 65 years and older, a 3.1 percent increase in the elderly group since the 1960 Census. Likewise, between 1960 and 1970 there was a reported increase in numbers of American Indians as well as an increase in Indians as a percentage of the total Osage County population. The Indian portion of the Osage population was reported as 8.6 percent in 1970; however, some of this increase may be the

Table 9. Demographic comparisons between Osage County and the State of Oklahoma as a whole.

	Osage County	Oklahoma
Population (x1000)		
1950	33.1	22,333.5
1960	32.4	23,282.8
1970	29.75	25,592.5
Percent change in population (1950-1970):	-10.1	+14.6
Birth rate per 1000 population (1970)	14.2	17.6
Death rate per 1000 population (1970)	12.0	10.5
Percent of population 65 years or older (1970)	13.5	11.7
Percent Indian population (1970)	8.6	3.8

Source: US Census of Population; Statistical Abstract of Oklahoma, 1972.

result of under-reporting in 1960. The birth rate in Osage County was lower than the statewide average in 1970, while the death rate was higher than the 10.5 per 1000 for Oklahoma. These data indicate a continuing trend toward an older population in the county, resulting primarily from the out-migration of young persons and from the declining birth rate. Mirroring a nationwide trend, household size in the county also has declined during the past decade or so.

Population density distribution in Osage County is depicted in Figure 15. The most populous urbanized areas in the county are Pawhuska, Hominy, Fairfax, Barnsdall, and those portions of Skiatook and Tulsa lying within the county. Of these, Hominy and Skiatook (Osage County portion) experienced appreciable growth between 1970 and 1976, probably a reflection of the economic activity related to the development of Skiatook Reservoir. Demonstrating the rural character of the county, only Pawhuska and Tulsa (Osage County portion) were urban places with more than 2,500 population. Thus, of the estimated 32,319 persons residing in the county in 1976, only about 22 percent lived in urban areas.

In 1970, a total of 11,713 dwelling units housed the county's 29,750 residents. (Since data are not readily available as to occupancy rates, these data should not be utilized to determine household size.) Recent population estimates by the Indian Nations Council of Governments (INCOG) suggest a county population in 1978 of 35,644 with about 7,700 households.

Projections for the future call for strong growth in the county by the year 2000. The Economic Development Planning Group, Series I projections, prepared in 1978,

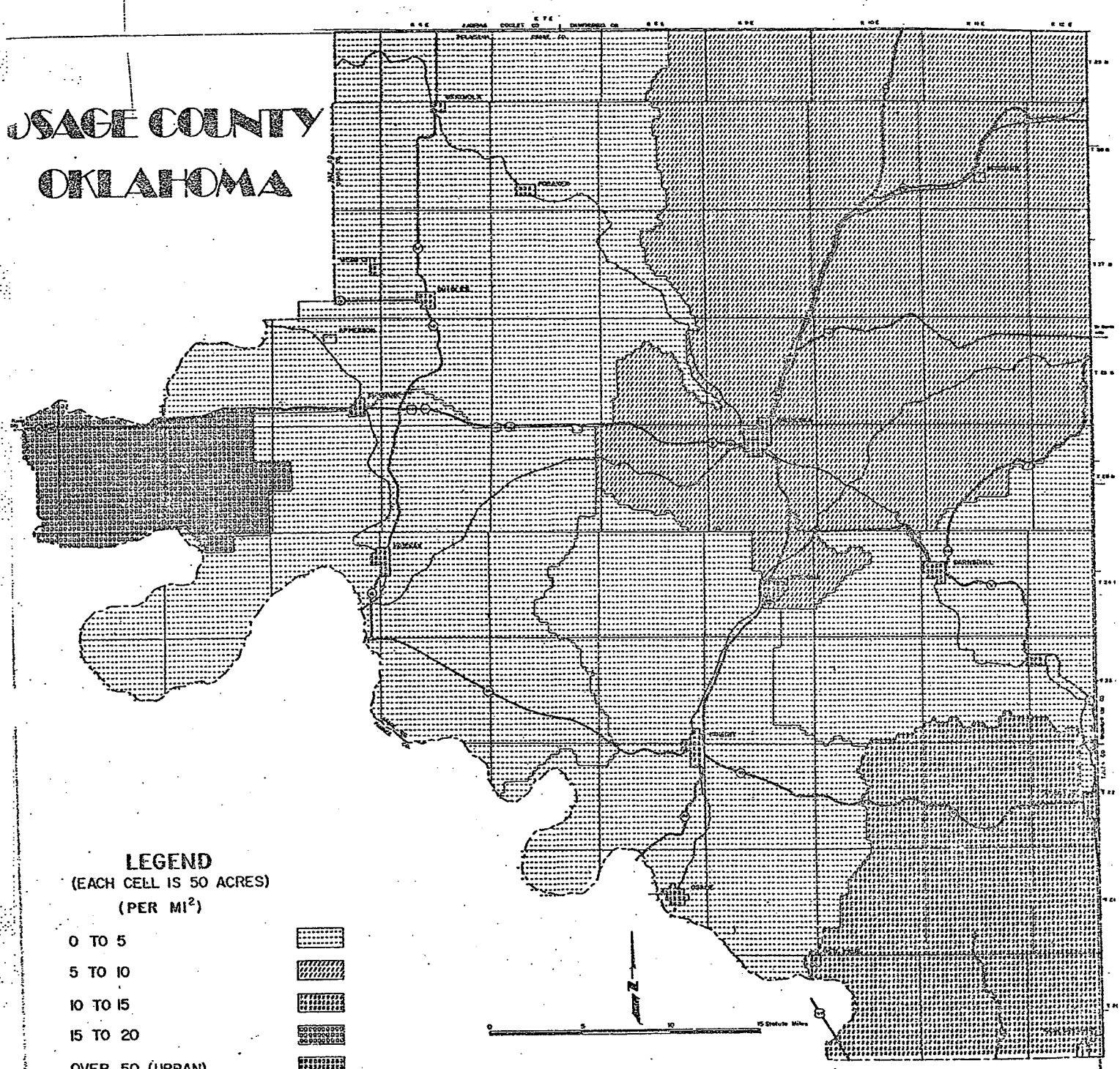


FIGURE 15. POPULATION DENSITY BY POLITICAL SUBDIVISION

suggest a 24.5 percent increase in population between 1976 and the year 2000 (Table 10). The Tulsa Metropolitan Area Transportation Study (TMATS) Level II update predicts a much greater increase, almost 100 percent. In the report Arkansas River Bed Project (Bruce B. Cornish and Associates, 1977) an increase in Osage County population is predicted to be about 7,000 persons or an increase of 22 percent. While specific projections differ in magnitude, there appears to be consensus that the area will experience significant growth over the next 20 years, primarily due to proximity of Tulsa's outward expanding metropolitan growth, increased industrial promotion, increase in new reservoir-related tourism, and development of a new prison at Hominy.

2. Individual and Family Income

The State of Oklahoma ranked 35th among the 50 states in income in 1969, reporting a median family income of $7,725, contrasting with the national median of $9,586. The northeastern region of the state ranks even below that with a median family income of $6,499 in the 23 northeastern counties. Residents of Osage County fared better than the regional median, reporting $7,640, still somewhat below the state median. In addition, there was a smaller proportion of the county population with incomes below the poverty level (12.8 percent) than for the entire state (15 percent). However, per capita income was only $4,055 in 1974-75, as compared with a State per capita income of $4,996 and a national average of $5,265.

Table 10. Population, employment, and personal income, recent and projected, for Osage County, Oklahoma.

Category	Year			
	1976	1980	1990	2000
Population [a]	32.6	34.3	35.4	40.5
Employment (total)[b]	5.5	5.5	5.2	6.1
Mining	0.7	0.7	0.6	0.7
Construction	0.1	0.2	0.2	0.2
Manufacturing	0.7	0.6	0.7	0.9
Transportation, communications and public utilities	0.1	0.1	0.1	0.1
Wholesale trade	0.2	0.2	0.2	0.3
Retail trade	0.7	0.6	0.6	0.7
Finance, insurance and real estate	0.1	0.1	0.1	0.3
Services	0.6	0.6	0.6	0.8
Government	0.8	0.8	0.9	0.8
Agriculture	1.0	0.7	0.4	0.3
Other	0.5	0.9	0.8	1.0
Personal income	$5,111[c]	$7,686	$16,079	$28,470
Per capita	($3,165)	($3,600)	($4,718)	($5,726)

[a] all data in 1000's
[b] all employment data in 1000's
[c] 1975 data
Data in ( ) are expressed in 1967 dollars

Source: Economic Development Planning Group, Tulsa Metropolitan Area Planning Commission; Population, Employment and Personal Income Projections; January, 1978.

3. Business, Industry and Agriculture

Although Osage County is primarily rural in character, its economy is based on mining (oil and gas extraction), agricultural production, apparel and textiles manufacturing and support services. In 1975, the market value of oil and gas produced in the county was in excess of $100 million. The importance of the petroleum industry to the local economy is shown in Table 11. The 1975 oil- and gas-related payrolls, (excluding refining), amounted to over $42,000,000, or 23 percent of total payrolls from all business sources in that year.

The market value of all agricultural products sold in 1974 was $23,514,000. The most valuable agricultural commodities were livestock and livestock products (Table 12). Wheat is an important crop in Osage County, with production in 1973 reaching 1,053,000 bushels. With 1,204,354 acres in farm land use in 1974 in Osage County, agriculture is an important economic activity. Echoing a national trend, farm acreage and number of farms in Osage County are decreasing, while average farm size is increasing. Likewise, the average value of land and buildings has increased, with the county average per farm much greater than for the whole state (Table 13).

In addition to agriculture and the oil and gas industries dispersed throughout the county, apparel and textiles manufacturing industries located in Pawhuska, Fairfax, and Hominy are important employers. There are two lumber companies and a small packing company in Fairfax. The State of Oklahoma and other southwestern states lag somewhat behind the rest of the nation in income derived from manufacturing, although there has been a 111.0 percent increase in earnings from manufacturing during the period 1959-75; during the same period farm earnings declined by 31.7

Table 11. 1975 oil and gas-related business activity for Osage County, Oklahoma.

Business Activity	Number of employees	Annual payroll (x $1000)	Number of establishments
Mining	1723	24,673	121
oil and gas extraction	1583	23,068	112
Crude petroleum and natural gas	878	13,751	61
oil and gas field services	500-999	NA	47
Drilling of oil and gas wells	340	5,083	16
oil and gas field services	298	3,273	24
Refining	500-999	D	D

D - Figure withheld to avoid disclosure

Source: County Business Patterns, 1976: US Census, CBP#76-38.

Table 12. Market value of agricultural products sold (1974) for Osage County, Oklahoma.

Commodity	Number of farms	Value (x $1000)
Crops and hay	336	3,720
Nursery and greenhouse products	9	175
Forest products	16	3
Livestock and livestock products	899	19,606
Poultry and poultry products	22	10
Total agricultural products sold	996 [a]	23,514
Average value/farm		23,609

[a] Since some farms sell more than one product, the total number of farms is less than the sum of those marketing listed agricultunal products.

Source: Census of Agriculture, 1974; Bureau of the Census.

Table 13. Number, acreage, and value of farms (1969 and 1974) for Osage County, Oklahoma.

	Farms and land in farms				Value of land and buildings	
Year	Number of farms	Acres in farms	Average size (acres)	Percent of land area	Average/farm	Average/acre
1969	1,184	1,225,380	1,035	84.3	$131,187	$127
1974	996	1,204,354	1,209	82.8	$268,612	$222
Oklahoma (Total) 1974	69,719	33,082,848	475	75.2	$143,320	$302

Source: Census of Agriculture, 1969, 1974; Bureau of the Census.

percent. In the mining sector, which includes oil and gas extraction, there has been an increase of 17.8 percent in annual earnings.

Since 1970, five industries with about 250 total employees were added to the Osage economic sector; in addition, three existing industries expanded adding 145 new employees. Although community facilities are somewhat inadequate and the transportation system has some limitations (highway access and curtailed rail service), the county is expected to achieve significant growth during the next 20 years. Increased industrial promotion, recreational attraction of several reservoirs, the new state prison at Hominy, and the proximity to the expansion expected in the City of Tulsa all will act as stimuli for further economic development.

4. Tax Base

In 1974, total net assessed valuation (including real property and improvements and taxable personal property, less allowed homestead exemptions) was $38,271,185 for Osage County. Added to this amount was $17,930,265 for public service assessments, bringing a total of $56,201,405 in net assessed valuation. The county had a total bonded indebtedness of $2,350,000 in 1971. The county realized $437,307.85 from the 2 percent state sales tax in 1971-72. Gross production taxes in Osage County produced $240,899.99 for roads and $241,547.96 for schools in 1971-72. Osage County budgeted a total of $932,000 in 1976. Chief sources of the revenue were the ad valorem tax and various fees. Expenditures were chiefly in the areas of roads and bridges, public safety and administration.

5. Employment

Osage County had a total employment of about 5,500 workers with an additional 820 unemployed workers in 1976. This county has a relatively high non-worker-to-worker ratio (measurement of those outside the work force), with a 1.71:1 non-worker-to-worker ratio, compared with a 1.52:1 ratio in the state as a whole.

As shown in Table 10, employment in manufacturing, services, finance, insurance and real estate industries, construction and wholesale trade categories is expected to increase by the year 2000. Mining employment (including oil and gas extraction) is expected to remain constant, while agriculture will continue to decline in proportion of those employed.

6. Housing and Education

During the fiscal year 1973-74, students in Osage County were served by schools in 15 public school districts, 8 of which were dependent districts (without 12 full grades). These districts had a combined average daily attendance of 4,516 pupils. Total revenue for these districts amounted to approximately $4,230,300. Primary sources of this revenue are the ad valorem tax and dedicated state revenues from user fees and the gross production tax.

In 1970 there were 11,713 dwelling units in Osage County, 9 percent of them categorized as dilapidated (requiring major rehabilitation work). About three-fifths of this residential property was valued below $10,000 per unit, representing a greater portion of low-value units than in the region as a whole. In 1970, 5 percent of all dwelling units were vacant.

7. Municipal Facilities and Services

The several municipalities in Osage County are responsible for operation and maintenance of municipal wastewater collection and treatment facilities. The majority of the population in the county is served by surface water supplies, with several communities purchasing water from the City of Tulsa. Residents in rural areas rely on wells for supply and on septic tanks for disposal. The county operates no health department, but there are important programs in the areas of juvenile delinquency, mental health/mental retardation, and alcoholism in the county.

Many social services are provided by the Osage Agency, where the Agency Social Worker is responsible for planning, organizing and directing the Bureau of Indian Affairs welfare program at the Agency. This program includes the fields of family service, child welfare, and community organization. The Agency also utilizes the services of a US Public Health Service Nurse, who is responsible for administering the Public Health Service program to the Indian people living on the Osage Reservation.

8. Transportation and Transmission

Although Osage County is predominantly rural, it is adjacent to the Tulsa metropolitan area. The proximity and its highly developed oil and gas production, have afforded Osage County a well-developed surface transportation system. It is crossed east-west in the northern part by US Highway 60. US Highway 64 cuts across a small part of the southern end of the county. State Highway 20

extends east-west from Skiatook to near Ralston. About eleven miles of this road are currently being relocated to avoid inundation when Skiatook Reservoir is completed by the US Army Corps of Engineers. Other State Highways which run primarily north-south are SH 10, 11, 18, 35, 97, 99, and 123. In all, about 2,050 miles of paved state and county roads are maintained by the Oklahoma State Department of Transportation, Division of Highways. In addition, about 3,000 miles of mostly gravel roads are maintained by oil companies and lessees for daily operations. According to the Osage Agency records, approximately 150 miles of unpaved roads are being added yearly to carry out new oil and gas activities.

Although no waterways or canals are found in the county, Keystone Reservoir and other large reservoirs provide pleasure craft transportation resources. It is even conceivable that Keystone and Kaw Reservoirs could one day become part of the Arkansas River barge canal system which now operates as a commercial transportation route as far north as the Port of Catoosa.

Several railroads serve Osage County. The Midland-Valley line runs from Skiatook northwest to Pawhuska and Foraker, and into Kansas. The Atchison, Topeka and Santa Fe Railroad runs from near Hulah Reservoir, in the northeast part of the county, to Ponca City and into Kansas. The Missouri-Kansas-Texas Railroad maintains freight routes from Bartlesville and southwest to Wynona, Hominy and Cleveland (at the upper end of Keystone Reservoir).

A large number of crude oil, gas and product pipelines either cross or originate in Osage County. These range in size up to 24" ID (inside diameter) for an ARCO crude oil line, and 16" ID for a Cities Service natural gas pipeline. Although no comprehensive records of pipelines currently in use are kept,

the Osage Agency estimates that there are about 8,000 miles of delivery pipelines in Osage County. They also estimate that about 200 miles of new pipelines are being installed annually at the present state of exploration and development.

9. Aesthetic Resources

The dominant scenery of Osage County is large expanses of tallgrass prairie covering its gently rolling hills. These native grasslands, found mostly in the central and northern parts of the county, are a unique element of our natural heritage, and they provide a vista suggesting the seemingly infinite extent of the nation's original prairies. A variety of other vistas exist throughout the county, including beautiful river valleys, dense woodlands and lakes of many sizes. Abundant wildlife enhance the serene rural character of all these settings.

Several tracts of land throughout the county have been protected, thus ensuring preservation of certain aesthetic resources. Hulah Lake and game management area contains over 14,000 acres of Caney River bottomlands and blackjack ridges with the wetland areas managed primarily for waterfowl and migratory birds. Other areas of bottomland timber and prime tallgrass prairies exist in the Keystone Lake area and Osage hunting areas. These provide excellent areas for recreation and future development. In addition, Osage County presently has three beautiful State Parks: Osage Hills, Wah-Sha-She, and Walnut Creek. Several others are in the development stage. Bluestem Lake is another favorite spot for recreation-minded people and provides peaceful scenery.

10. Recreation

Because of its proximity to Tulsa and its developing surface reservoir system,

Osage County is a major attraction for recreationists. In addition to the county's varied natural scenery for attracting sightseers, hikers and campers, it contains several public hunting areas (state and Federal), many good fishing lakes, and several state parks (Figure 16). Two fairly new state parks are within the Keystone and Hulah Reservoir public use areas, in addition to an older park--Osage Hills State Park, west of Bartlesville.

Of slightly over 465,000 acres of Federally-owned recreation areas in Oklahoma, about 82,000 acres (17.6 percent) are in Osage County. Of the many state recreation areas (568,000 acres in Oklahoma), about 16,600 acres are in Osage County. Even with these large outdoor areas for recreation, much of the Tulsa metropolitan area showed a deficiency in 1977 for such facilities as swimming pools, tennis courts, hiking trails, picnic areas and bicycling paths (Oklahoma Tourism and Recreation Department, 1977). The Indian Nations Council of Governments (INCOG), whose studies have embraced not only Osage County, but Tulsa and surrounding areas, has recommended future regional recreational development plans for the types of facilities mentioned above. These were designed to concentrate on the optimal use of existing park and recreation areas and the identification and acquisition of open-space tracts for long-range needs.

With respect to present and projected recreation demand (in user days), INCOG figures for the Tulsa, Osage and Creek County area provide an indication of expected outdoor recreation demand. Table 14 shows total annual demand for daily activities (in user days) for selected activities in 1975 and projected for 1980 and 1990.

For Osage County specifically, the Oklahoma Department of Tourism and Recreation and INCOG indicate that the recreation facilities which show the highest potential

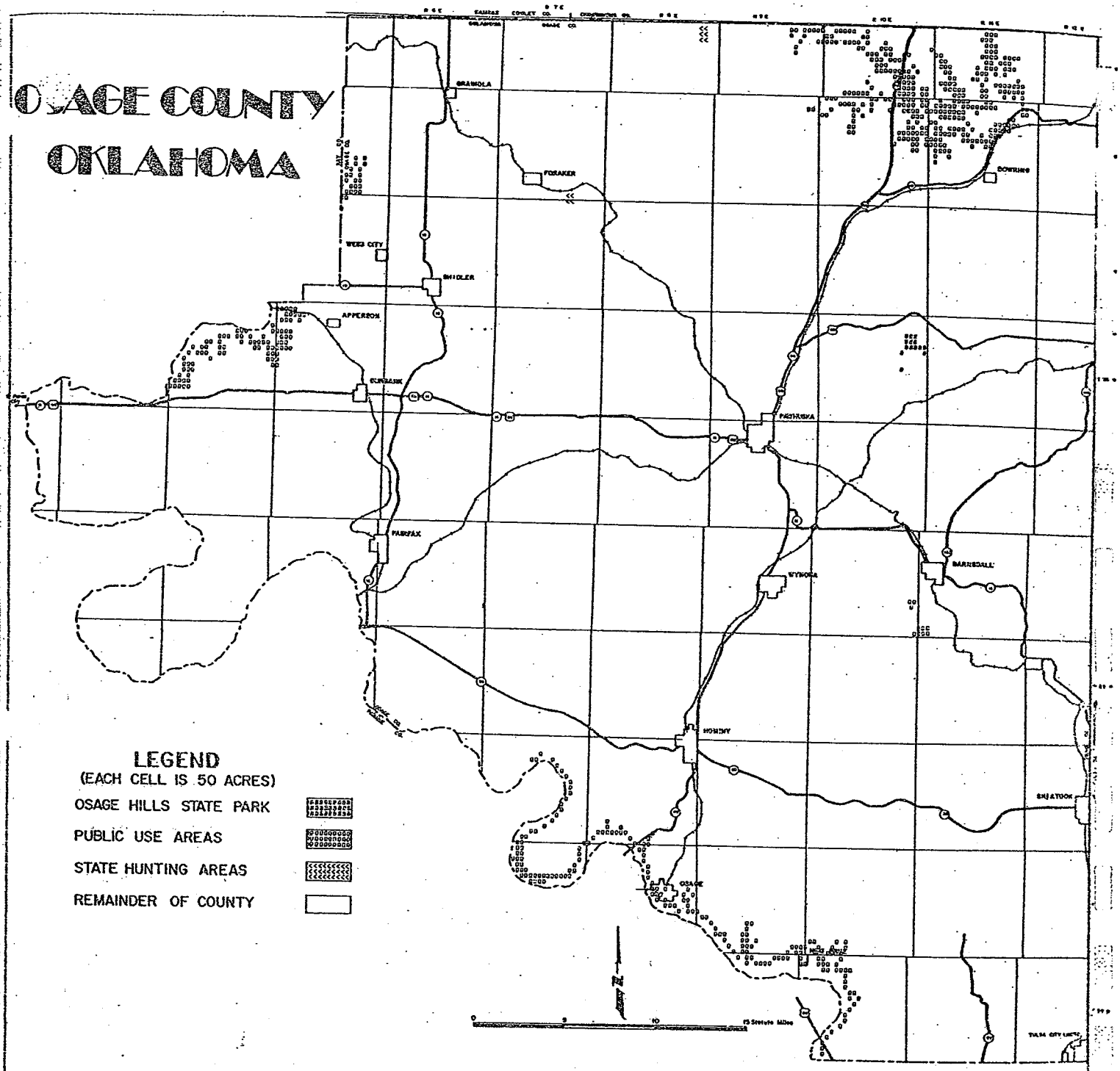


FIGURE 16. PUBLIC RECREATION AREAS

Table 14. Present and projected future recreation demand for the Tulsa and Osage County area.

Daily Activity	Year 1975	1980	1990
Fishing	6,093,072	6,342,768	6,858,072
Swimming	13,236,502	13,778,938	14,898,377
Picnicking	4,868,484	5,067,996	5,479,734
Hiking	4,360,728	4,539,432	4,908,228
Golf	2,095,738	2,181,622	2,358,863
Motor boating	2,080,804	2,166,076	2,342,054
Hunting	1,777,146	1,849,974	2,000,271
?iling	896,040	932,760	1,008,540
Water skiing	915,952	953,488	1,030,952

Source: INCOG 208 Areawide Water Quality Management Plan and Working Papers, and Oklahoma Department of Tourism and Recreation (1978).

for future development are campgrounds, picnic and field sports areas, fishing areas, golf courses, hunting areas, (small game, big game and waterfowl), historic areas, riding stables, shooting preserves, and other water sports. The Oklahoma Department of Wildlife Conservation has allocated funds for the development of 218 acres (in area not designated) for outdoor recreation in Osage County. Furthermore, long-range development is planned for 900 acres at the Hulah Game Management Area and Refuge and for 16,254 acres at the Kaw Public Hunting Area and Refuge. Osage Hills State Park also has been allotted funds for the development of about 1,200 acres. Several of the proposed or recently constructed Army Corps of Engineers reservoirs also will have public recreation areas (1,715 acres at Skiatook; 420 acres at Candy; 495 acres at Birch). Over 260 acres at Wah-Sha-She State Park near Hulah Reservoir and 1,429 acres at Walnut Creek State Park near Keystone Reservoir are expected to be developed for outdoor recreation during the next few years.

11. Historical and Cultural Resources

In Late Prehistoric times the Osage County area was mostly used by the Wichita Tribe, but by the early 1800's the Osage had become the dominant population although the area was considered Cherokee Territory until 1867. In 1828 the Cherokee had been granted the land claimed by the Osage Tribe in return for the lands the Cherokee held in Arkansas. In 1839 a treaty negotiated with the Osages at Fort Gibson gave lands to the Osage to relocate in Kansas. For the next 31 years the Osages suffered hunger and disease in their new home in Kansas with the result that they lost nearly their total population. Fighting on the side of the Confederacy during the Civil War, the Osages lost their land in Kansas to white settlers. In a series of treaties between 1863 and 1867 the Osage officially surrendered their lands in Kansas and were forced to return to the lands they formerly held

on the Cherokee Outlet in what is now Osage County. Here they have remained since that time with the exception that a western portion of these lands were given by a Congressional Commission in 1871 to the Kaw tribe who moved from Kansas in 1873 to the 100,000 acres set aside as the Kaw reservation. In 1906, Congress mandated that the area occupied by the Osage Tribe be designated a county of Oklahoma.

Two historic sites, the Osage Indian Agency and Osage Council House (City Hall), at Pawhuska have been listed on the National Register of Historic Places. In addition to these two sites, the Oklahoma Historical Society has marked the following sites as significant in the county's history: 1. Civil War battlefield in Chustenahlah; 2. Grave of Osage Chief James Bigheart; 3. Grave of Osage Chief Fred Lockout; 4. Million Dollar Elm, site of auction for sale of mineral rights to famous oil discovery; and 5. The Osage County Museum. Consideration is currently being given to add approximately fifteen more Oklahoma State Historical sites to the list given above.

12. Archaeological Resources

The records of the Oklahoma Archeological Survey at the University of Oklahoma indicate that the majority of recorded historic and prehistoric cultural resource sites in Osage County have been located during surveys connected with the construction (or proposed construction) of lakes or reservoirs by the US Army Corps of Engineers or the Soil Conservation Service. Major reservoir project areas from which sites have been reported and investigations conducted include Keystone, Kaw, Birch, Skiatook, Shidler and Hulah. Within the direct and immediate indirect impact areas of these projects, steps have been taken, or are planned, for the conservation or mitigation of significant cultural resources by the agencies involved. Outside these specific project areas the number and

distribution of cultural resource sites, especially those of prehistoric times in Osage County, are poorly documented.

Of the 188 sites recorded in the Oklahoma Archeological Survey, most have been concentrated along first and second terraces and ridge spurs along major streams and those portions of their tributaries which would be flooded by construction of the various reservoir and lake projects. Since considerably less than 15 percent of the county has been subjected to study, it is expected that several hundred additional sites are present not only in the situations noted above along the major streams, but also near small tributary streams and in the uplands.

Based on information compiled by the Oklahoma Archeological Survey, Tables 15 and 16 present a breakdown of the 188 recorded sites by cultural period, locational situation and drainage. Although cultural remains extending over a period of 10,000 years have been reported for Osage County, the best represented cultural periods are the late Archaic, Formative, and Lake Prehistoric. Only one Paleo-Indian site located on a first terrace of a small tributary stream has been reported. Along the major streams, Paleo-Indian and early Archaic period sites may be buried by silt in the floodplains because of frequent floods. Under such conditions their discovery would usually come only through accidental disturbances or erosion. The distributional data available from previous surveys on the Formative and Late Prehistoric Period cultures probably respresent a reliable sample of the number and location of major habitational sites, since the large sites of these periods tend to be situated on terraces adjacent to the larger streams. However, the lack of data for the upland areas of Osage County precludes accurate prediction of the number and kinds of seasonal activity camps and stations that may be associated with these cultures.

Table 15. Total Number of documented archaeological sites in Osage County, Oklahoma (188).

Arkansas River Drainage:
- Historic - 3 on 2nd terrace.
- Proto-historic - 1 on 2nd terrace.
- Late Prehistoric - 1 on knoll; 1 on 2nd terrace.
- Formative - 4 on knoll, 2 on 1st terrace, 4 on 2nd terrace.
- Archaic - 1 on ridge toe; 1 on knoll.
- Paleo-Indian - None reported.
- Unknown Cultural Affiliation - 1 on ridge toe; 1 on hill slope; 1 on knoll; 2 on 2nd terrace.

Caney River Drainage:
- Historic - None reported.
- Proto-historic - None reported.
- Late Prehistoric - 1 on 2nd terrace.
- Formative - 1 on 1st terrace; 4 on 2nd terrace. 1 on bluff top.
- Archaic - 1 on hill slope and top; 2 on 2nd terrace; 1 unknown.
- Paleo-Indian - None reported.
- Unknown Cultural Affiliation - 1 bluff top.

Beaver Creek Drainage:
- Historic - None reported.
- Proto-historic - 1 on 1st terrace.
- Late Prehistoric - 1 on 1st terrace.
- Formative - 1 on ridge toe; 1 on 2nd terrace.
- Archaic - 1 on ridge toe; 2 on 1st terrace; 1 on 2nd terrace; 3 unknown topography.
- Paleo-Indian - None reported.
- Unknown Cultural Affiliation - None reported.

Salt Creek Drainage:
- Historic - None reported.
- Proto-historic - None reported.
- Late Prehistoric - 3 on 2nd terrace.
- Formative - 1 on 1st terrace.
- Archaic - 1 on 1st terrace; 2 on 2nd terrace; 1 unknown physiographic situation.
- Paleo-Indian - None reported.
- Unknown Cultural Affiliation - 4 on ridge toes and tops; 2 on 2nd terrace.

Hominy Creek Drainage:
- Historic - 1 bluff shelter.
- Proto-historic - None reported.
- Late Prehistoric - 2 bluff shelters.
- Formative - 1 ridge toe; 2 on 1st terrace; 2 on 2nd terrace.
- Archaic - 1 ridge toe & top; 1 on 1st terrace; 2 on 2nd terrace.
- Paleo-Indian - None reported.
- Unknown Cultural Affiliation - 2 on ridge toes; 8 on 1st terrace; 4 on 2nd terrace; 1 on bluff top; 6 in bluff shelters.

Table 15. (Continued)

Birch Creek Drainage:
- Historic - None reported.
- Proto-historic - None reported.
- Late Prehistoric - 1 on 2nd terrace.
- Formative - None reported.
- Archaic - None reported.
- Paleo-Indian - None reported.
- Unknown Cultural Affiliation - 1 on 1st terrace; 1 on 2nd terrace; 10 bluff shelters.

Bird Creek Drainage:
- Historic - 1 on knoll; 1 on 1st terrace.
- Proto-historic - None reported.
- Late Prehistoric - None reported.
- Formative - 1 on ridge toe; 1 on hill slope; 1 on a knoll; 3 on 1st terrace; 8 on 2nd terrace; 2 in bluff shelter.
- Archaic - 4 on 1st terrace; 1 on unknown physigraphic location.
- Paleo-Indian - None reported.
- Unknown Cultural Affiliation - 2 on ridge toes; 3 on 1st terrace.

Small Tributary:
- Historic - 1 on ridge toe; 1 on hill slope; 2 on knolls; 1 on 2nd terrace; 2 in unknown topographical situation.
- Proto-historic - None reported.
- Late Prehistoric - 1 on ridge toe; 2 in bluff shelters.
- Formative - 1 on ridge toes; 1 knoll; 2 on 1st terrace; 3 on 2nd terrace 2 in bluff shelter.
- Archaic - 1 on ridge toe; 1 on hilltop or slope; 4 on 1st terrace; 3 on 2nd terrace; 1 on bluff top; 2 in unknown topographic positions or drainages.
- Paleo-Indian - 1 on a 1st terrace.
- Unknown Cultural Affiliation - 2 ridge toes; 1 on hill slopes; 3 on knolls; 5 on 1st terrace; 5 on 2nd terrace; 2 bluff shelters.

Source: Oklahoma Archeological Survey, Norman, Oklahoma.

Figure 1. Areas of distribution of 188 known archaeological sites in Osage County, Oklahoma.

	Ridge Top Slope or Toe	Hill Top or Slope	Knoll	1st Terrace	2nd Terrace	Bluff Top	Bluff Shelter	Unknown
Historic	Os-9(7)	Os-66(7)	Os-19(7) Os-25(7) Os-17(9)	Os-168(9)	Os-55(1) Os-101(1) Os-148(7) Os-18(1)	-0-	Os-104(4)	Os-150(7) Os-152(7)
Proto-Historic	-0-	-0-	-0-	Os-46(2)	Os-6(1)(2)	-0-	-0-	-0-
Late Prehistoric/ Plains Village	Os-16(7)	-0-	Os-26(1)	Os-49(2)	Os-75(5) Os-190(3) Os-189(3) Os-186(3) Os-4(6) Os-50(1)	-0-	Os-91(4) Os-85(4) Os-64(7) Os-79(7)	-0-
Formative	Os-102(4) Os-67(2) Os-166(9) Os-160(7)	Os-43(9)	Os-60(1) Os-7(7) Os-12(1) Os-82(1) Os-21(1) Os-42(9)	Os-112(4) Os-103(4) Os-185(9) Os-54 Os-13(1) Os-28(9) Os-41(7) Os-45(9) Os-42(6) Os-96(1) Os-103(7) Os-136(3)	Os-115(4) Os-107(4) Os-179(1) Os-59(1) Os-38(9) Os-37(9) Os-36(9) Os-17(1) Os-18(7) Os-31(9) Os-32(9) Os-33(9) Os-34(9) Os-35(7) Os-44(9) Os-48(2) Os-58(1) Os-81(7)	Os-99(6)	Os-80(7) Os-27(9) Os-30(9) Os-98(7) Os-98(7)	-0-
Archaic	Os-20(1) Os-68(2) Os-69(7) Os-105(4)	Os-14(7) Os-159(6)	Os-15(1)	Os-40(7) Os-49(2) Os-70(2) Os-72(9) Os-78(3) Os-86(7)	Os-2(6) Os-23(7) Os-24(7) Os-29(6) Os-47(2) Os-153(7)	Os-65(7)	-0-	Os-5 Os-61(9) Os-62(2) Os-63(3) Os-71(7) Os-73(7)

Table 16. (Continued)

	Ridge Top Slope or Toe	Hill Top or Slope	Knoll	1st Terrace	2nd Terrace	Bluff Top	Bluff Shelter	Unknown
Archaic (Continued)				Os-164(9) Os-167(9) Os-170(9) Os-174(7) Os-180(7) Os-110(4)	Os-140(3) Os-143(3) Os-122(4) Os-125(4)			Os-74(6) Os-77(2) Os-87(2) Os-88
Paleo-Indian	-0-	-0-	-0-	Os-51(7)	-0-	-0-	-0-	-0-
Unknown	Os-144(3) Os-142(3) Os-147(3) Os-137(3) Os-183(1) Os-83(7) Os-92(4) Os-93(4) Os-157(7) Os-165 Os-169(9)	Os-8(1) Os-184 Os-178(7)	Os-11(7) Os-22(7) Os-100(1) Os-154(7)	Os-121(4) Os-119(4) Os-118(4) Os-113(4) Os-108(4) Os-109(4) Os-128(5) Os-182(7) Os-176(7) Os-175(7) Os-89(4) Os-94(7) Os-147(7) Os-161(9) Os-162(9) Os-163(9) Os-141(4)	Os-123(4) Os-117(4) Os-116(4) Os-111(4) Os-139(3) Os-138(3) Os-173 Os-172 Os-158 Os-155(7) Os-1(7) Os-10(7) Os-53(7) Os-56(1) Os-57(1) Os-76(5) Os-151(7)	Os-140(4) Os-3(4)	Os-139(4) Os-106(4) Os-136(5) Os-135(5) Os-134(5) Os-133(5) Os-132(5) Os-131(5) Os-130(5) Os-129(5) Os-127(5) Os-126(5) Os-90(4) Os-95(7) Os-97(7) Os-114(4) Os-137(4) Os-138(4)	Os-149 Os-156

Arkansas River (1)
Beaver Creek (2)
Salt Creek (3)
Hominy Creek (4)
Birch Creek (5)
Caney River (6)
Tributary (7)
Bird Creek (9)

Source: Oklahoma Archeological Survey, Norman, Oklahoma.

In the eastern portion of Osage County a number of bluff shelters, or rock shelters, have been reported. Several of these shelters have been recently investigated in the Skiatook Reservoir project area. This work and additional data from nearby areas (in the files of the Oklahoma Archaeological Survey) suggests a high probability of finding archaeological remains of one or more cultural periods in or near the rock shelters. As of this time, only a fraction of the total number of rock shelters probably present in Osage County has been recorded or studied.

Current cultural resources data on the number and distribution of prehistoric sites in the uplands of Osage County are totally inadequate for predictive purposes. Although most large sites are to be found along the major streams, probably many small sites are associated with the utilization of seasonal resources in the uplands. Knowledge of these sites would be especially important since the county lies in two rather distinct physiographic zones (dissected plain and rocky hill country) with variable natural resources that would have been attractive to prehistoric man. The small camps and processing stations usually associated with upland resources have often been subjected to disturbance or destruction by the natural force of erosion and in more recent times by land altering activities associated with agricultural practices, deforestation, and mineral and oil extraction.

The Oklahoma State Office of Historic Preservation is undertaking an ongoing county-by-county survey of archaeological resources. That survey for Osage County has not been performed even though it was originally scheduled for 1978. Conversations with officials at the Oklahoma Historic Preservation Office indicate that the Osage County survey will probably take place between 1980 and 1982.

D. ECOLOGICAL CHARACTERISTICS

1. Natural Vegetation Communities

According to information from the US Soil Conservation Service (1974), about 78 percent of Osage County is covered by natural vegetation communities (Table 17). The dominant natural habitat is native rangeland which covers about 63 percent of the county. The three basic types of wooded land are upland, bottomland, and wetland, totalling about 15 percent of all acreage.

The rangeland or tallgrass prairie, when not overgrazed by cattle, is dominated by five tallgrass species: big bluestem, little bluestem, Indian grass, switchgrass, and purple top. If the rangeland is overgrazed, the original cover species cannot maintain themselves and other species become established. Among most common indicator species of overgrazing are plains larkspur, Missouri goldenrod, daisy fleabane, western yarrow, lanceleaf ragweed, annual broomweed, sidecats grama, stink grass, silver bluestem, chess, blue sage, woolly verbena, lace grass, tall dropseed, hairy grama, green milkweed, and wild petunia. When persistent severe overgrazing is permitted, weedy plants and undesirable annuals become abundant. The most common of these are threeawn and Japanese chess.

In the early 1970's, national concern developed over the status of tallgrass prairie throughout the midwest. Because of this concern, an area of about 90,000 acres of ranchland in the northern part of Osage County was considered and proposed as a National Grasslands. At this time, that proposal has been tabled, primarily because of local opposition.

Table 17. Acreage and percent cover for vegetation community types and other land use categories for Osage County, Oklahoma.

Land use category	Area in acres	Percent cover
Natural communities		
Wooded land		
Upland (postoak and blackjack oak)	209,102	14.16
Bottomland	10,898	0.74
Wetland	1,281	0.09
Non-wooded land		
Rangeland	926,617	62.76
Wetland	2,574	0.17
Other communities and categories		
Agricultural		
Cropland		
Non-irrigated	79,561	5.39
Irrigated	1,928	0.13
Horticultural, orchards and groves	511	0.03
Pastureland		
Non-irrigated	184,427	12.49
Irrigated	393	0.03
Confined feedlot operations	160	0.01
Urban and industrial		
Urban and built up	16,130	1.09
Mines, quarries, gravel pits	670	0.05
Oil waste land	2,000	0.14
Water	26,910	1.82
Highways and county roads(paved)	13,318	0.90
TOTALS	1,476,480	100.00

Source: Modified from land use map and data of the US Soil Conservation Service (1974)

Bottomland and wetland vegetation lies along stream floodplains and comprises less than 1 percent of Osage County. Eight major overstory tree species are found in these habitats: American elm, slippery elm, sycamore, cottonwood, bitternut hickory, shagbark hickory, pawpaw, and bur oak. Among the characteristic understory species in the bottomlands are blue phlox, four o'clock, smooth yellow violet, sedges, wild petunia, spiderwort, nettles, rye, milkweed, lady's thumb, bellflower, broadleaf spikegrass, purple meadow rue and yellow ironweed. Plants growing in these lowland habitats need varying amounts of moisture to survive, but few can withstand much drought.

Upland habitat is often a mixture of both wooded and grassland ecosystems. Four major species of overstory trees are found in the uplands: postoak, blackjack oak, eastern red cedar, and black hickory. In addition, the understory primarily is composed of eight plant species: big bluestem, little bluestem, coral berry, winged sumac, smooth sumac, blackberry, black rasberry, and dewberry. Because these areas are well above the water table, the plants growing in the upland woods are well adapted to withstand various degrees of drought.

Beginning in the mid-1950's, many of the ranchers in Osage County began spraying upland woods with 2, 4, 5-T herbicide to defoliate the trees and thereby permit improved growth of pasture grasses for cattle grazing. Although the actual acreage of areas subjected to spraying is not precisely known, the local Soil Conservation Service in Pawhuska estimates that 200,000 to 300,000 acres have been sprayed at one time or another. The SCS also indicated that re-spraying is necessary every 8 to 10 years to prevent tree growth. The SCS believes that the results of the spraying provides net benefit to the farmers in two ways; it keeps out undesirable plants and provides more grazing, and it reduces erosion

by allowing ground cover to hold the soil better (personal communication, Mr. Dick Bogard, District Conservationist, Soil Conservation Service, Pawhuska, Oklahoma, October 19, 1978).

2. Agricultural Lands

Although much of Osage County was used for growing small grains and cotton prior to the Dust Bowl days of the 1930's, it is now primarily rangeland or in native tall grasses and tame fescue and bermuda grass pasture. Figure 9 shows 1,928 acres of irrigated cropland and 79,561 acres of non-irrigated cropland. The principal crops are winter wheat and other small grains, alfalfa, grain sorghums and soybeans. Some corn also is grown. The corn and grain sorghums mainly are cut for silage. About 500 acres in Osage County are planted in orchards, horticultural crops or nursery crops. Much of the native and tame pasture grass is cut for hay. The majority of hay, corn and sorghum is used locally by ranchers for beef or dairy cattle operations. Other crops are shipped to both local and distant markets and sold for cash. Native timber is cut by commercial operators as a cash crop along the major streams. Most of the cutting is for oak, walnut and pecan.

In general, more and more land in Osage County is gradually being removed from crop production because of increased urban development, inundation by reservoirs, and road construction. Also, soil erosion is taking some land from production, although soil conservation measures have largely prevented this type of damage. Contour farming, strip cropping, addition of terraces or diversions, and minimization of tilling have been used extensively on Osage County croplands to reduce erosion and maintain surface soil fertility. However, for economical production of crops, all soils in the county require fertilizer for added yields (US Soil

servation Service, in press). The average yields per acre that can be expected from principal crops on various soil types are shown on Table 18 (US Soil Conservation Service, in press).

3. Aquatic Biology

a. Introduction

Osage County has approximately 1.82 percent of its area covered with water, including both streams and impoundments. Two rivers are within the county boundaries; the Arkansas River forms much of the southern and western borders of the county and the Caney River is in the northeastern portion of the county. With the notable exception of these two rivers, many streams in the county are intermittent. Throughout the county the streams vary in character from those with steep gradients, rocky bottoms, shallow, and fast flowing to those with shallow gradients, mud bottoms, deep and slow flowing. Gradients in the county range from about 3 ft/mile to more than 100 ft/mile. Although some streams exhibit shoreline cover which is essentially all grassland or all woodland, most streams have a mixture of both cover types. Thus, a wide variety of stream habitats are represented. Four reservoirs (Hulah, Birch, Kaw and Keystone) lie partly or wholly within the county, and the county has 47 lakes of between 10 and 800 acres in size. Virtually all of the lakes and reservoirs have been constructed since 1940.

The intermittent nature of many of the streams and the recent construction of the reservoirs have had a significant effect on the area's aquatic biology. Streams with highly variable flows and those subject to periodic drought tend to have a less rich and less diverse biota than permanent streams. Historically,

Table 18 Crop yields per acre for representative soil types in Osage County, Oklahoma.

Soil Association	Soil Name	Alfalfa (tons)	Grain sorghum (bushels)	Wheat (bushels)	Corn (bushels)	Soybeans (bushels)
Verdigris-Mason-Wynona	Barnsdall	4.5	65	40	65	30
	Osage	4.0	60	30	60	30
	Verdigris	4.5	70	40	70	35
	Wynona	5.0	70	40	65	35
Kiomatia-Mason-Roebuck	Choska	4.5	70	40	60	30
	Kiomatia	3.0	40	30	40	25
	Mason	5.0	75	40	60	30
	Pursely variant	4.0	65	30	55	25
	Roebuck	4.5	60	30	60	30
Dennis-Parsons-Bates	Bates	3.0	55	30	-	25
	Dennis	4.0	70	40	60	30
	Okemah	4.0	70	40	60	35
	Parsons	-	50	35	50	30
Steedman-Coweta-Bates	Prue	-	55	30	50	20
	Steedman	-	35	30	-	-
Apperson-Wolco-Dwight	Apperson	3.5	65	35	60	30
	Lula	3.0	65	40	60	30
	Wolco	3.0	50	30	-	25
Shidler-Summit-Foraker	Summit	-	60	35	55	30

Table 18. (Continued)

Soil Association	Soil Name	Alfalfa (tons)	Grain sorghum (bushels)	Wheat (bushels)	Corn (bushels)	Soybeans (bushels)
Corbin-Pawhuska	Corbin	3.0	65	35	60	30
Norge-Vanoss	Norge	3.0	60	35	60	30
	Teller	-	55	30	50	25
	Vanoss	3.5	70	40	65	35
Niotaze-Darnell	Cleora	4.2	65	35	55	25
Dougherty-Eufaula	Dougherty	-	30	20	-	-
	Eufaula	-	25	15	-	-
	Konawa	-	30	25	-	-
Darnell-Stephenville	Gasil	-	50	25	-	-
	Stephenville	-	30	25	-	-

Source: Soil Survey of Osage County, Oklahoma, Soil Conservation Service (in press).

The aquatic fauna of Osage County has been comprised of species adapted to inhabiting streams and rivers. The recent construction of reservoirs has presented special problems to many of the species. Some can readily adapt to the habitat change (stream to reservoir), and may do almost as well, or better, than before the change. However, other species cannot adapt, and the reservoir not only removes a given amount of stream habitat which is available to the species, but also may act as a barrier which limits the distribution of the species. To date, no study has been done to determine the extent to which reservoir construction has affected the aquatic fauna.

b. Fisheries

Osage County is probably among the best in the State for fishing. More than 70 species are found in the many creeks, streams, rivers and lakes of the county even though most species are not important for fishing. Some, such as the striped bass and walleye, are presently stocked or have been in the past. The most important sport species are striped bass, white bass, walleye, channel catfish and crappie. Other important species include bluegill, green sunfish, largemouth bass, blue catfish, and flathead catfish (personal communication, Don Hicks, State Fishery Biologist, December 21, 1978).

The quality of fishing in Osage County varies greatly from place to place. Some lakes or rivers support a diverse and productive fishery. An example is the Arkansas River in the area of Kaw Reservoir, where over 70 species have been recorded. Other streams or lakes have a much lower quality of fishery. Birch Creek, with only 20 species collected after intensive sampling, is an example of a limited fishery. In 1977, the Oklahoma Department of Wildlife Conservation conducted a statewide evaluation of permanently flowing streams and rivers. Seventy-

ve (75) streams in Osage County were evaluated on the basis of factors such as stream length and gradient, shoreline cover, sport fishing species present, endangered or threatened species present, quality of fishing, restoration or mitigation potential, etc. The present quality of fishing in various streams was judged to range from poor to good. In virtually every case the restoration or mitigation potential of the stream was evaluated as very low; however, data to accurately evaluate this factor were not available. Table 19 gives the ratings for sport fishing and some other evaluation factors for selected major streams in the county.

c. Aquatic Invertebrates

Aquatic invertebrates serve both as an important source of food for fishes, and act as good pollution indicators because of their relative immobility. The diversity of aquatic invertebrates varies widely throughout Osage County depending upon streamflow regime, bottom type and pollution. In general, one might expect to find aquatic annelids, mayflies, dragonflies, stoneflies, alderflies, caddisflies, riffle beetles, blackflies, midges, chironomids, fingernail clams, and freshwater mussels under favorable conditions. Stream sections with limited habitat diversity or significant pollution would show reduced species diversity with an increase in pollution-tolerant groups.

4. Game Animals

Oklahoma hunting regulations control the hunting of 49 species of game animals found in Osage County. These can be divided into resident upland game, migratory game birds, migratory waterfowl, furbearers, and big game. Game species, their

Table 19. Evaluation of fishery statistics and potential for twelve major Osage County streams.

Stream	Tributary of	Length in Osage County (km)	Shoreline cover (%woodland/ %grassland)	Reservoir present	Sport fishes (number of species)	Endangered & threatened species (number)	Quality of fishing	Recorded fish kills[1]	Overall habitat evaluation[2]
Arkansas River	note 3	135.2	51/49	Keystone Kaw	5	6	good	yes (1976)	Critical-extremely important
Salt Creek	Arkansas River	85.2	66/34	none	6	5	good	yes	Critical-extremely important
Bird Creek	note 3	97.2	67/33	none	6	0	good	yes	Critical-extremely important
Birch Creek	Bird Creek	30.7	77/23	none	4	0	good	yes	Critical-extremely important
Candy Creek	Bird Creek	25.4	68/32	none	2	0	fair	no	High priority-important
Caney River	note 3	45.1	61/39	Hulah	7	0	good	no	Critical-extremely important
Coon Creek	Caney River	14.2	97/3	none	1	0	poor	no	Substantial
Pond Creek	Caney River	37.6	31/69	Hulah	3	0	good	no	High priority-important
Hominy Creek	note 3	112.2	91/9	none	4	0	good	yes	Critical-extremely important
Wildhorse Creek	Hominy Creek	12.0	66/34	none	4	0	poor	yes	Substantial
Sand Creek	note 3	90.4	62/38	none	5	0	good	yes	Critical-extremely important
Mud Creek	Sand Creek	8.0	85/15	none	2	0	fair	no	Substantial

[1] Date of fish kill and cause not available in most cases.

[2] Based upon several factors including endangered or threatened species, importance as a sport fishery, and potential for restoration.

[3] Does not become the tributary of a longer river or creek within Osage County.

ferred habitat, and their abundance estimates for Osage County are shown on Table 20. Although little is known about detailed population estimates for each species, most game animals are common or abundant in the county. Deer kills on private lands for Osage County in 1977 totalled 471 (404 bucks, 67 does), which was 5 percent of all deer killed in the state. In addition, 73 deer (70 bucks, 3 does) were killed in the Hulah Public Hunting Area located within the county.

The distribution of these game animals within the county depends upon the habitat preference of each individual species. Of the 49 game species, 29 prefer wetland, 11 woodland, 5 openland, and 4 rangeland. The distribution of these habitats is presented in Figure 17 (openland includes rangeland on this figure).

addition to private lands available for hunting, there are six public hunting areas in or adjacent to the county. They are:

Hulah Public Hunting Area, 14,112 acres for waterfowl, quail, rabbit, dove, deer, and squirrel.

Osage Public Hunting Area Nos. 1 and 2, each 160 acres for Greater Prairie Chicken, dove, quail, and rabbit.

Kaw Public Hunting Area, 16,254 acres which border Osage County for deer, turkey, quail, waterfowl, squirrel, and rabbit.

Keystone Public Hunting Area, 15,500 acres which border Osage County for waterfowl, quail, dove, squirrel, and rabbit.

Hudson Lake, 335 acres for waterfowl.

The herbicide spraying of wooded areas within the county has reduced the amount of forest wildlife habitat and increased the amount of openland wildlife habitat. This is not all detrimental as openland habitat is preferred by many wildlife species in the county (see discussion under Non-game Wildlife). Woodland areas, however,

Table 20. List of 49 game species, their preferred habitats and abundance in Osage County, Oklahoma.

Species	Preferred habitat	Abundance
Resident Upland Game		
Bobwhite	openland	abundant
Greater Prairie Chicken	rangeland	common
Turkey	woodland	uncommon
Eastern Fox Squirrel	woodland	common
Eastern Gray Squirrel	openland	common
Blacktail Jackrabbit	rangeland	common
Migratory Game Birds		
Mourning Dove	openland	abundant
Rail spp.	wetland	uncommon
Common Galinule	wetland	uncommon
Common (Wilson's) Snipe	wetland	uncommon
American Woodcock	woodland	uncommon
Common Crow	openland	common
Migratory Waterfowl		
Mallard	wetland	abundant
Pintail	wetland	common
Blue-winged Teal	wetland	common
Green-winged Teal	wetland	common
Wood Duck	wetland	uncommon
Redhead	wetland	uncommon
Ring-necked Duck	wetland	uncommon
Canvasback	wetland	uncommon
Black Duck	wetland	uncommon
Hooded Merganser	wetland	uncommon
Gadwall	wetland	common
American Widgeon	wetland	common
Shoveler	wetland	common
Snow Goose	wetland	uncommon
Blue Goose	wetland	uncommon
Canada Goose	wetland	uncommon
White-fronted Goose	wetland	common
Ross' Goose	wetland	uncommon
Greater Scaup	wetland	uncommon
Lesser Scaup	wetland	uncommon
American Coot	wetland	common
Sandhill Crane	wetland	uncommon

Table 20. (Continued)

Species	Preferred habitat	Abundance
Furbearers		
Badger	openland	uncommon
Beaver	wetland	uncommon
Bobcat	woodland	rare
Red Fox	woodland	uncommon
Gray Fox	woodland	uncommon
Swift Fox	rangeland	rare
Mink	wetland	uncommon
Muskrat	wetland	uncommon
Opossum	woodland	common
Raccoon	woodland	common
Spotted Skunk	woodland	common
Striped Skunk	woodland	common
Longtail Weasel	wetland	uncommon
Eastern Cottontail	rangeland	common
Big Game		
Whitetail Deer	woodland	abundant

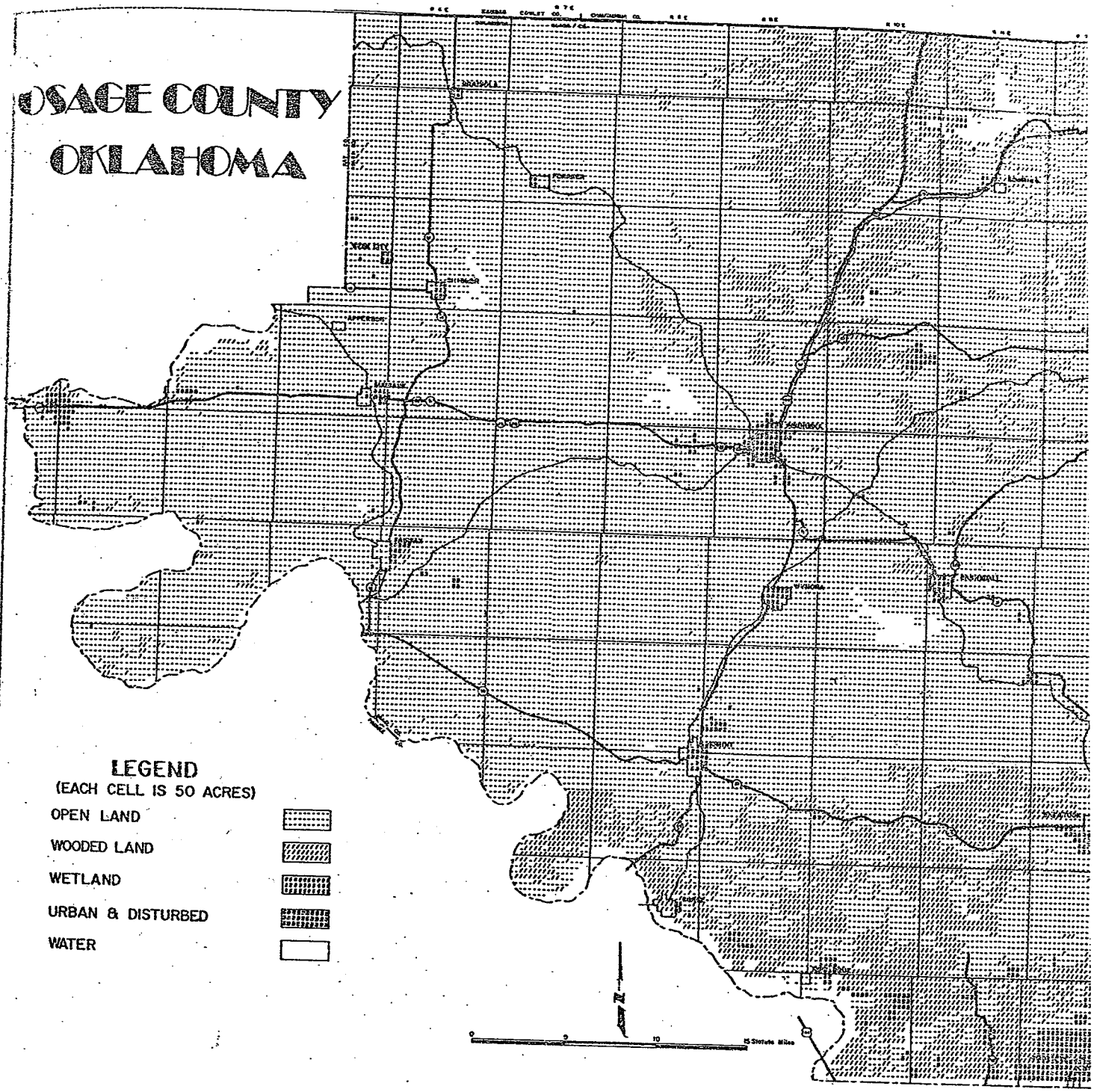


FIGURE 17. POTENTIAL WILDLIFE HABITATS

have been established throughout the county in the form of trees planted along fence rows and windbreaks.

5. Non-game Wildlife

Over 70 species of amphibians and reptiles, at least 200 non-game birds, and about 50 non-game mammals have been listed by various authors (Conant 1958, Burt and Grossenheider 1964, and Robbins, et al. 1966) as being indigenous to Osage County. The distribution of these 320 species within the county is controlled by their vegetation habitat perference. Figure 17 shows the distribution of available habitats throughout the county and Table 21 lists the habitat preferences of common and/or representative non-game wildlife. The kinds of non-game wildlife most commonly using grassy habitats (croplands, pastures, meadows, and overgrown grassy areas) include hawks, roadrunners, box turtles, cottontail rabbits, deer mice and pocket gophers. Those species using woodland habitat include many types of birds and several species of squirrels and bats. Rangeland habitat species include Eastern Meadowlark and coyote. Wetland habitat species include non-game waterfowl, several snakes, herons, and shore birds.

6. Threatened or Endangered Species

Of the 370 species of game and non-game amphibians, reptiles, birds and mammals known to be potentially found in Osage County, four bird species are officially listed by the US Department of the Interior as endangered. They are the Bald Eagle, American Peregrine Falcon, Whooping Crane, and Eskimo Curlew. The Bald Eagle is known to winter around large reservoirs such as Keystone and Kaw. The

Table 21. Selected non-game wildlife species (and preferred habitat types) which are commonly found in Osage County, Oklahoma.

Species	Preferred habitat(s)
Reptiles and amphibians	
Common Snapping Turtle	water
Three-toed Box Turtle	woodland
Ornate Box Turtle	openland, rangeland
American Toad	woodland, urban
Leopard Frog	wetland
Eastern Collared Lizard	woodland
Five-lined Skink	woodland
Hog-nosed Snake	woodland
Eastern Coachwhip	woodland
Western Cottonmouth	wetland
Birds	
Great Blue Heron	wetland, water
Cattle Egret	rangeland
Black Vulture	woodland, rangeland
Cooper's Hawk	woodland, rangeland
Red-tailed Hawk	woodland, rangeland
Killdeer	wetland
Rock Dove (pigeon)	urban
Roadrunner	rangeland
Barn Owl	woodland, rangeland
Chuck-will's Widow	woodland
Common Nighthawk	woodland, rangeland
Woodpeckers (several)	woodland
Scissor-tailed Flycatcher	rangeland
Eastern Meadowlark	rangeland
Blue Jay	woodland
Mockingbird	woodland, urban
American Robin	rangeland, urban
English Sparrow	urban
Cardinal	woodland
Mammals	
Least Shrew	rangeland
Eastern Mole	woodland
Bats (several)	woodland
Coyote	woodland, rangeland
Thirteen-lined Ground Squirrel	rangeland
Gray Squirrel	woodland
Southern Flying Squirrel	woodland
Plain's Pocket Gopher	woodland, rangeland
House Mouse	urban
Deer Mouse	rangeland
Eastern Wood Rat	woodland
Muskrat	wetland
Norway Rat	urban

American Peregrine Falcon and Whooping Crane are transients, and the Eskimo Curlew is a spring migrant. Several other species are found in Oklahoma, but are not known from Osage County.

With regard to aquatic species, Oklahoma supports about 165 species of fish. Approximately 70 of those species can be found in Osage County streams or ponds or in the Arkansas River. In 1976, an Oklahoma Endangered Species Committee reported that six species of fish were accorded threatened or endangered status for Oklahoma. Those fish are the shovelnose sturgeon, pallid shiner, bigeye chub, least darter, river shiner, and shorthead (pealip) redhorse. The shovelnose sturgeon is considered endangered while the rest are threatened. The sturgeon was listed as occurring only in the mainstream Arkansas River, but the other five species were listed not only for the mainstream, but also in seven direct major tributaries to the Arkansas River which flow through Osage County.

E. ENVIRONMENTAL DEGRADATION

Some environmental degradation in Osage County directly related to the oil and gas leasing program has occurred due to oil and/or brine spills and the resulting contamination of soil, streams and groundwater. Although previous sections of this chapter have documented the land use and water quality conditions affected by historical oil and gas activity, the rate of degradation currently extant is a function of the amount of annual petroleum production and the successful enforcment of environmental controls.

The Clean Water Act of October 1972, Public Law 92-500 Section 311 (as Amended, 1977), requires that all spills involving petroleum or hazardous materials which could potentially flow into the waters of the US be reported to the EPA under the Oil Spill Pollution Prevention Regulations (40 CFR, parts 110 and 112). These data are available for the State of Oklahoma at the EPA Region VI office in Dallas, Texas for the period from January, 1972 through November, 1978. A search of these data files provided the Statewide and Osage County information on number and size of oil spills listed in Table 22. A single crude oil spill of 6,578 barrels, which occurred in 1976 due to a break in an interstate pipeline, was omitted from consideration because it has no direct bearing on oil and gas production activities, nor is it related in any way to Osage Agency authority.

Inspection of Table 22 shows that during the period of record, Osage County has accounted for 6.36 percent of petroleum production in Oklahoma. During the same period it has experienced 7.75 percent of the reported number of spills. It is interesting to note, however, that while the county percentage of state crude oil production has increased fairly consistently between 1972 and 1978, it percentage of spills has decreased.

Table 22. Crude oil production and accident data for Oklahoma and Osage County (1972-1978); as reported to EPA Region Dallas, Texas.

Year	Total production (thousands of barrels)			Number of spills and accidents			Volume of crude oil spilled (barrels)		
	Oklahoma	Osage Co.	%for Osage Co.	Oklahoma	Osage Co.	%for Osage Co.	Oklahoma	Osage Co.	%for Osage Co.
1972	206,955	12,048	5.82	93	8	8.60	15,250	845	5.54
1973	191,260	10,988	5.75	151	15	9.93	23,093	830	3.59
1974	177,778	10,113	5.69	151	14	9.27	18,538	200	1.08
1975	163,117	10,268	6.29	146	9	6.16	10,785	1,590	14.74
1976	161,426	10,819	6.70	112	6	5.36	25,741	189	0.73
1977	156,382	11,151	7.13	152	12	7.89	8,282	303	3.66
1978	143,203	10,997	7.68	124	8	6.45	7,271	281	3.86
Totals and mean %	1,200,121	76,384	6.36	929	72	7.75	108,960	4,238	3.89

Source: Records of th US Environmental Protection Agency, Region VI, Dallas, Texas.

Although 108,960 barrels of crude were spilled during the seven years considered, only 4,238 barrels (or 3.9 percent) were spilled in Osage County. The average size of individual spills in Osage County was 58 barrels, just half the statewide average of 117 barrels. Obviously, oil production in Osage County causes much less environmental degradation per barrel of production than production elsewhere in Oklahoma. This excellent record is attributable to the strict pollution control program of the Osage Agency, and possibly to the fact that average annual well production during the past five years was 2,200 barrels for Oklahoma and only 1,288 in Osage County.

III. ENVIRONMENTAL IMPACTS

A. ENERGY PRODUCTION

The primary direct impact of the Osage Tribal oil and gas leasing program is the production, and consequent irretrievable commitment, of energy resources underlying the county. The benefit of Osage production at this point in time is nationally significant. Field thought to be rapidly decreasing in production or essentially depleted in 1970 have continued to produce by application of secondary and tertiary recovery techniques, and new fields have been discovered. Thus, in a period (1980-2000) when economically harmful foreign oil imports are anticipated to be at levels from 44 percent to 54 percent of national demand and consumption, Osage oil and gas will help mitigate our energy shortage until alternate sources are perfected.

No estimate of total Osage petroleum reserves (proven and probable) is available, although 300 to 400 million barrels is a reasonable consensus among local professionals. Based on considerations of national demands, known reserves, daily production rates, recent exploration success and improved recovery techniques, a most probable projection of total oil production from Osage County for 1979 until the year 2000 is 210.5 million barrels (see Figure 2). This amount would represent about 16 percent of all county oil production, historical and projected, for the twentieth century. A more optimistic projection of 290 million barrels between 1979 and 2000 (not used in the following impact assessment) assumes the discovery of other fields similar to the finds in the western and north-central areas of the county.

In recent decades, natural gas has been considered an important energy resource. Prior to that, much of the gas produced, especially in conjunction with oil production, was burned in the well fields as a waste product. Because of this fact, Osage County total gas production is not accurately known. However, since metering has begun, current annual production rates are estimated at 8.6 billion cubic feet. As of September 30, 1978, a total of 489 gas wells existed in Osage County, and a large number of oil wells also produce additional gas. Osage Tribal officials estimate that gas well drilling is increasing now by about 20 percent per year, and that annual gas production by the year 2000 will be at least 9,125 billion cubic feet per year. They also estimate total county recoverable reserves to be 400 to 600 billion cubic feet of gas.

B. REGIONAL LAND USE

Since 1900, when oil production first began in the county, a relatively minor impact on land use has occurred due to the exploration, drilling, production, and abandonment of wells. Even though about 34,000 wells have been drilled in the county through 1978, only about 14,000 wells of various types are still active. The sites of the 20,000 inactive wells have essentially been returned to pre-activity conditions; that is, the wells are plugged, and the ground surface has been recontoured. Within a short period the areas are revegetated by characteristic cover for the area. For the 14,000 active wells, because an average of 1/2 acre is required for the pump, storage tanks, parking, etc., about 7,000 acres (0.47 percent) of Osage County land are impacted due to energy production. Similarly, assuming small access roads for operational activities have a width of 20 feet, then the 3,000 miles of unpaved oil and gas company roads in the county impact another 7,273 acres (0.49 percent). Finally, some 30 acres (0.14 percent) of temporarily altered waste land caused by oil and brine spills exist throughout the county. Thus, land currently affected by the

Additional waste land will be created throughout the county as accidental oil and brine spills occur during the next 21 years. As detailed in Section F, an average of 164 spills per year (assuming the number of spills per year in the period 1970-1978 remains constant), will produce an additional 544 acres of wasteland by the year 2000. Added to the land use impacts of well sites and road construction, the total portion of Osage County affected by the oil and gas leasing program from 1979 to the year 2000 will be 7,182 acres (0.48 percent of the county). Accounting for existing and new wells, well abandonment, new access roads and roads taken out of use, and an approximately constant spill rate (each spill causing 0.158 acres of wasteland), then total Osage County acreage committed to the oil and gas leasing program by the year 2000 will be 23,455 acres (or 1.59 percent of the land) which contrasts to the current 16,273 acres (1.10 percent of the land).

?

?

C. PHYSICAL IMPACTS

1. Physiography and Geology

The cumulative effects of the oil and gas activities on the topography of Osage County since 1900, and likely to the year 2000, are virtually negligible. No landform or drainage pattern alterations are necessitated by the program. Likewise, no geologic disturbances in the county have been linked with the extraction of oil and gas or the injection of brine. No surface collapse, landslide or earthquake has ever been associated with program activities.

2. Soils

Soils may be impacted by contamination from oil or brine spills and erosion that is facilitated by clearing for well field service roads or well sites. Contaminated soil is classified as waste land by the Soil Conservation Service since its agricultural productivity is essentially depleted and natural recovery is an extremely slow process (often 20 or more years). About 2,000 acres of wasteland now exist, and another 544 acres are projected to result from spills between 1979 and the year 2000.

The amount of erosion from cleared areas depends upon soil type, slope, and meteorological factors. A statistical comparison of Figure 18 (slope) and Figure 3 (lease locations) revealed that 35 percent of Osage leases are found on slopes less than 5 percent, 53 percent are on slopes between 5 and 15 percent, and 12 percent are on slopes greater than 15 percent. A study (Roadside Erosion Inventory) performed by the Osage County Conservation District (1976) provides

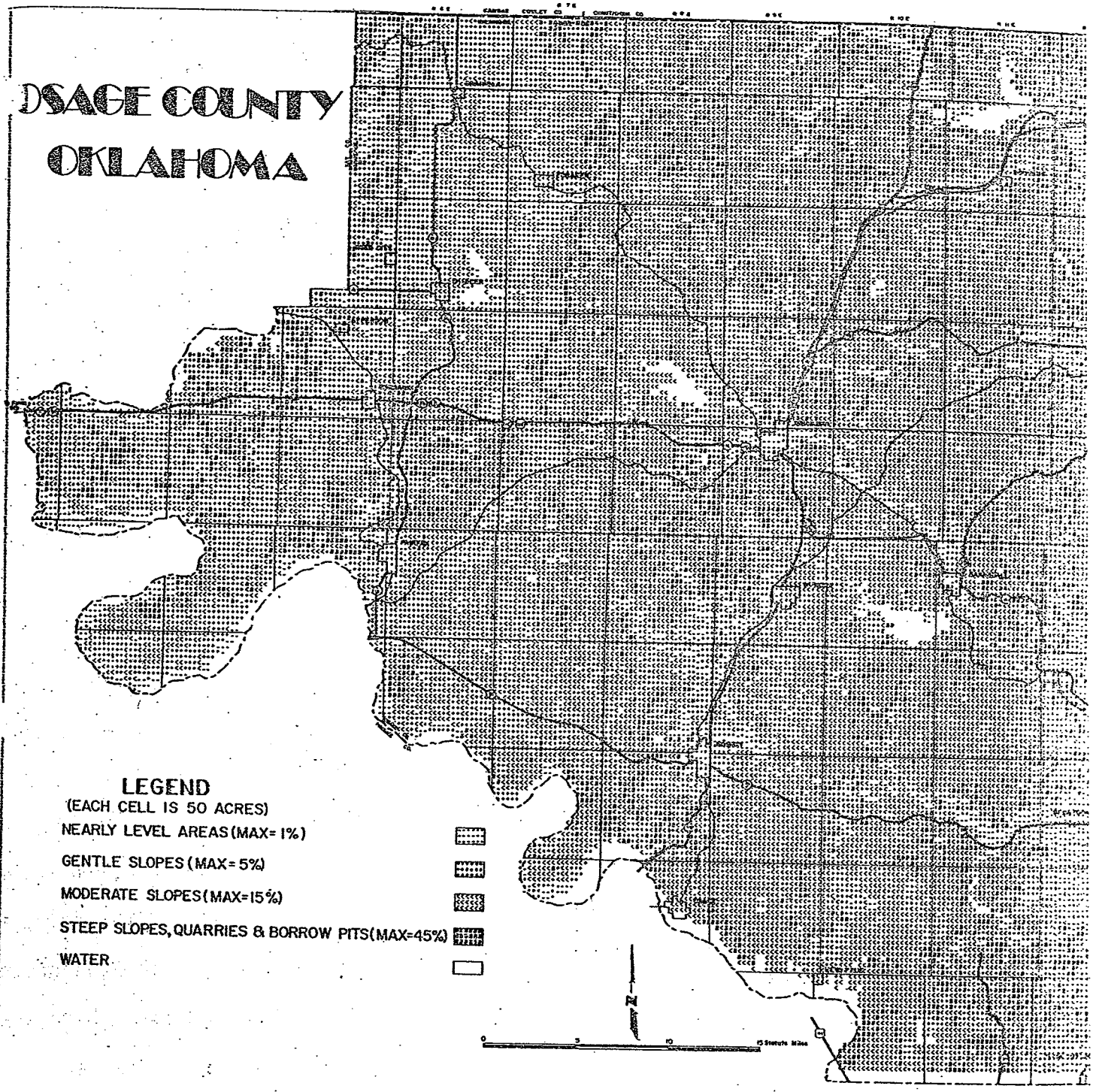


FIGURE 18. SOIL SLOPE CLASS DISTRIBUTION

an approximation of generalized erosion rates. Based on that report, "slight" erosion produced 9.9 tons/year, "moderate" erosion 65.3 tons/year, and "severe" erosion 130.7 tons/year of sediment for each exposed acre. As averages, these figures take into account variations in slope and soil type. Erosion caused by oil and gas operations may be estimated assuming: (1) well sites and roads located on slopes less than 5 percent will experience slight erosion; (2) all spills on slopes less than 5 percent will result in moderate erosion; (3) well sites and roads on slopes between 5 and 15 percent will produce moderate erosion; (4) well sites and roads on slopes greater than 15 percent will experience severe erosion; and (5) all spills on slopes greater than 5 percent will experience severe erosion. Table 23 relates the total acreage of oil and gas related soil disturbances projected by the year 2000 to the appropriate erosion rate.

Based upon the distribution of new development by slope category and the erosion rate assumptions given above, erosion from wells, roads, and spills will produce 1.4 million tons of sediment in the year 2000. The Universal Soil Loss Equation was used to approximate the amount of sediment produced by erosion over the entire county in the year 2000. The total acreage in the county was partitioned according to slope to account for the significant slope effect on erosion. These calculations indicate that the total county erosion will produce about 48.4 million tons of sediment in the year 2000. Thus, the oil and gas leasing program, which involves less than 2 percent of the county acreage, will produce 2.9 percent of the erosion expected in the year 2000. It should be noted that both program and county erosion projections reflect worst case conditions and no allowance has been made for soil conservation controls proposed by the Osage County Conservation District.

Table 23. Number of acres of well sites, roads, and spills producing different erosion rates in the year 2000.

Slope/Land use	Number of acres		
	Slight erosion	Moderate erosion	Severe erosion
Slope less than 5%			
Well sites	3,277.00		
Roads	4,042.00		
Spills		891.00	
Slope from 5 to 15%			
Well sites		4,962.00	
Roads		6,121.00	
Spills			1,348.00
Slope greater than 15%			
Well sites			1,123.00
Roads			1,386.00
Spills			305.00
Totals	7,319.00	11,974.00	4,162.00

Source: ECI calculations.

3. Air Quality

The impact of oil and gas production, storage, and transmission activities on air quality in Osage County is relatively minor, but will continue to be a long-term adverse impact. The primary pollutant which results from oil and gas operations is ozone. Ozone is formed as a photochemical oxidant when sunlight reacts with airborne hydrocarbons escaping from leaks, evaporating from open storage tanks, or released as exhaust emissions. Although a large number of wells and associated storage tanks, and daily transfer operations exist in Osgae County, the climatological characteristics of the region preclude the likelihood of stagnant air episodes. It is probable, however, that the ozone formed from the hydrocarbon emissions in Osage County can, under certain meteorological conditions, contribute to and aggravate the current ozone problem in Tulsa County and the metropolitan area. However, the impact of these emissions is estimated to be negligible in comparison to that resulting from highway vehicle and industrial emissions in and around Tulsa.

With regard to local conditions in well fields in Osage County, minor air pollution results from gas engines associated with pumping operations and drilling machinery. Additionally, fugitive dust is a seasonal nuisance during various field activities involving clearing of well sites, drilling or other activities. The local air pollution and fugitive dust are not considered significant impacts of environmental degradation.

4. Noise Levels

The oil and gas leasing program adversely affects localized noise levels in many parts of Osage County due to the unavoidable use of heavy machinery, pumps and

other equipment at well sites. Because wells are sufficiently dispersed (noise dissipates to background levels at a distance of around 1,000 feet), no significant regional impact will result from future exploration, drilling and production. However, noise levels at some sites do exceed 100 dBA.

For oil and gas operations, general industry noise standards formulated by the Occupational Safety and Health Administration state that, if exposure is for an 8-hour continuous period each day, noise from any source should not exceed 90 dBA if exposure is continuous for only 2 hours the noise level should not exceed 100 dBA. Only those individuals working for extended periods of time in close proximity to the equipment would experience excessive noise in Osage County. Section 1910.95 of the general industry standards also states that "when employees are subjected to sound exceeding those listed, - - - feasible administrative or engineering controls should be utilized." Such controls are in evidence in Osage County, and there have been no complaints or investigations regarding noise problems in the county (personal communications, Mr. James P. Johnson, Area Director, OSHA, Tulsa, Oklahoma, November 1978). Although noise can be somewhat excessive at well sites, it is mitigated by proper control through personnel work schedules and proper use of protective gear.

5. Surface Waters

Although the oil and gas leasing program will have negligible effect on the volume of surface water use, it has, and will continue to have, both direct (spills) and indirect (erosion) adverse impacts on regional water quality. As noted on Table 5, use of surface water supplies for secondary oil recovery and new well development is considerably less than from groundwater, and is only a small fraction of that used for municipal drinking water and other uses in Osage County. Although Osage

County surface water supplies are currently allocated for various uses (including oil and gas activities, as noted by personnel of the Oklahoma Water Resources Board), the ongoing development of new reservoirs and the continuing use of present supplies should be adequate to accomodate future water needs by the oil and gas industry to the year 2000. Thus, the impact of the oil and gas leasing program and operational activities in Osage County does not now, nor will it in the foreseeable future, affect surface water supply. Furthermore, groundwater from alluvial supplies and saline water from oil production provide most of the water used for secondary oil recovery in the county.

With regard to surface water quality, according to INCOG 208 planning studies and sampling, one major stream in Osage County receives pollutants (primarily high chloride concentrations) which exceed State standards and which INCOG has attributed to oil field operations. That stream is Bird Creek at two locations: one area near the mouth of Hominy Creek (just outside Osage County), and another area immediately downstream of Pawhuska. The impacts noted were that ph exceeded the State standard and that excessive chloride (above that of the Federal drinking water standard) was present, respectively. Both of the immediate watershed areas where water quality sampling was done contained a relatively large number of producing and abandoned wells and dry holes. It is obvious from the INCOG 208 study that other problem areas related to oil and gas production were evident in surrounding counties also because the report states that:

> "....conductivity readings on the streams at various locations have confirmed saltwater problems in a number of watersheds. These problems result from a variety of sources including both leaking storage tanks and transmission lines, and accidental spills as well as intentional releases of salt brine. Control of pollution from oil field production, refining, and other oil production related activities is regulated by the Oklahoma Corporation Commission. Because of the magnitude of the problem

> and the limited staff and budget for the pollution control activities, the ability of the Corporation Commission staff to control salt brine pollution has not been adequate in the past. In many cases, saltwater pollution problems are not reported to regulatory agencies by the general public. More stringent control is definitely needed" (INCOG, 1978).

Because of the regulatory authority and immediate actions taken by the Osage Agency, and because of strict reporting procedures for brine spills in Osage County, it is possible that oil operation contributions to stream chloride concentrations in Osage County is much improved over that of the surrounding counties under Oklahoma Corporation Commission regulation. Further studies may even be able to show that the chronic high chloride concentration in Bird Creek at Pawhuska is only related to natural brine seeps or from county oil activities that took place many decades in the past.

Few specific complaints have been recorded in Osage County regarding contamination of surface water lakes; however, the relatively high chloride concentration in Keystone Reservoir and perhaps in some smaller impoundments probably is influenced very minimally by brine inflows, seeps, or oil fields both in and outside of Osgae County. Both the Cimarron River and the Arkansas River have historically contained high chloride concentrations far upstream of Osage County before they flow together and are impounded by Keystone Dam west of Tulsa. The watersheds of these two rivers, and of the watershed of the Salt Creek tributary of the Arkansas River in Osage County, contain natural salt flats and also receive seepage from natural underground salt deposits. Therefore, it is not really known how much of the brine entering Keystone Reservoir can be attributed to oil and gas operations, but it is most likely that the proportion is only a small fraction of that from natural sources.

The Osage County Conservation District (1973) reported that the "number one water pollutant" in Osage County was sediment derived from a number of small isolated areas throughout the county. Their report listed four sources for which better soil conservation controls were recommended; these were: (1) agricultural and non-agricultural land, (2) unsurfaced roads and roadside erosion, (3) gully erosion, mostly on private lands, and (4) oil waste land. The report encouraged proper disposal of salt water.

Although a large number of both old and new wells are found in the county, and most of the unitized lease areas are under waterflood, surface water contamination due to oil and gas activities (as documented by INCOG, the Oklahoma State Department of Health, and the Osage County Conservation District), has been quite minimal. Total long-term adverse impacts to surface waters in general appear to be slight to moderate even though occasional brine pollution in very localized areas may be termed severe, but of short duration. In instances of severity there have been occasional fishkills or deaths of livestock reportedly due to a brine spill. In comparison with the State as a whole, as documented by EPA oil spill reports, spills in Osage County have been of lower number and volume when related to production. It appears that the Osage County Conservation District considers direct oil or brine spills to be subordinate to secondary impacts of soil erosion from oil waste land areas scattered throughout the county.

6. Groundwater

Two primary potable groundwater sources are found in Osage County. The Vamoosa aquifer underlies 573,100 acres of the central part of the county and can yield only 25 to 50 gallons per minute. It is recharged by the infiltration of rainfall

over the narrow area of its north/south outcrop. The alluvial aquifer of the Arkansas River Valley and adjacent tributaries covers 66,350 acres and can yield from 150 to 600 gallons per minute. It is recharged by rainfall and lateral infiltration from the river. Over the remainder of the county, meager supplies of groundwater are obtained from relatively shallow, localized bedrock aquifers and small alluvial deposits.

Some fresh water from the alluvial aquifer is used for well drilling and secondary oil recovery, while the Vamoosa's low yields essentially preclude such usage. As reported in Table 5, the great majority of groundwater used for injection and pressurization during waterflooding is saline. Most of this brine is reinjected formation water recovered from oil production. These groundwater use trends are expected to continue as long as secondary oil recovery using waterflooding is economically justifiable.

While only 3 percent of Osage leased acreage covers the Arkansas River alluvial aquifer, 43 percent of all county oil and gas leases overlie the Vamoosa aquifer. About 70 percent of the Vamoosa is covered by leases, with about half of these being prior to 1970 (191,150 acres) and half subsequent to 1970 (200,550 acres). With regard to brine disposal and waterflood wells, only 1 percent of these injection wells are located in the alluvial aquifer and only 30 percent are located over the Vamoosa aquifer.

Inspection of well logs and discussions with personnel familiar with the Osage oil and gas industry have indicated that old producing wells which may not have been cased to below the bottom of the freshwater zone, old wells with faulty casing now being used for injection of brine, and oil wells

which were improperly plugged represent the possible sources of potable groundwater contamination. The previous comparison reveals that the alluvial aquifer is not jeopardized by these conditions and only about one-third of the Vamoosa in Osage County (191,150 acres) has a significant probability of such contamination.

Since even before NEPA (1970), the Osage Agency has implemented and rigorously enforced regulations to protect groundwater during drilling, production reworking and plugging operations (see permits Figures 4, 7, and 8). Consequently, it is unlikely that the oil and gas leasing program has resulted in any adverse impact to the potable groundwater resources of the county since the promulgation of NEPA. Furthermore, as old wells are abandoned and plugged while new wells are drilled and cased, both under current stringent permit procedures, the annual rate of contamination will decrease each year between now and the year 2000.

D. SOCIO-ECONOMIC AND CULTURAL IMPACTS

1. Demographic Factors

Based on the relatively stable oil production projections through the year 2000 (see Figure 2), the oil and gas leasing program will have a minimal effect on the demographic and economic characteristics of Osage County during this period. Over all population in Osage County is projected to increase by 7,900 persons by the year 2000, or 24 percent since 1976. Employment is

expected to show an increase of 11 percent in that period. However, total employment as a percent of the total population is projected to drop from 16.9 percent to 15.1 percent by the year 2000. Of the total work force (an estimated 6,300 in 1980 and 7,000 in the year 2000), the number engaged in oil- and gas- related industries is expected to remain constant. Thus, with the increase in numbers of employed by year 2000, the proportion of workers in that industry will have declined slightly. Figure 19 shows recent areas of population change in Osage County.

Factors which are likely to determine the composition of the future population, the income of the work force, expansion or decrease of the tax base, and the level and quality of municipal services and facilities are several:

(i) effectiveness of continuing promotional efforts aimed at increasing recreation-related activities in the county;

(ii) effectiveness of efforts to attract industry to the area;

(iii) the types of industrial sectors operating in the area (manufacturing, services, etc.);

(iv) the level of investment of public funds in the county (such as the new prison at Hominy or the completion of the proposed Gilcrease Expressway); and

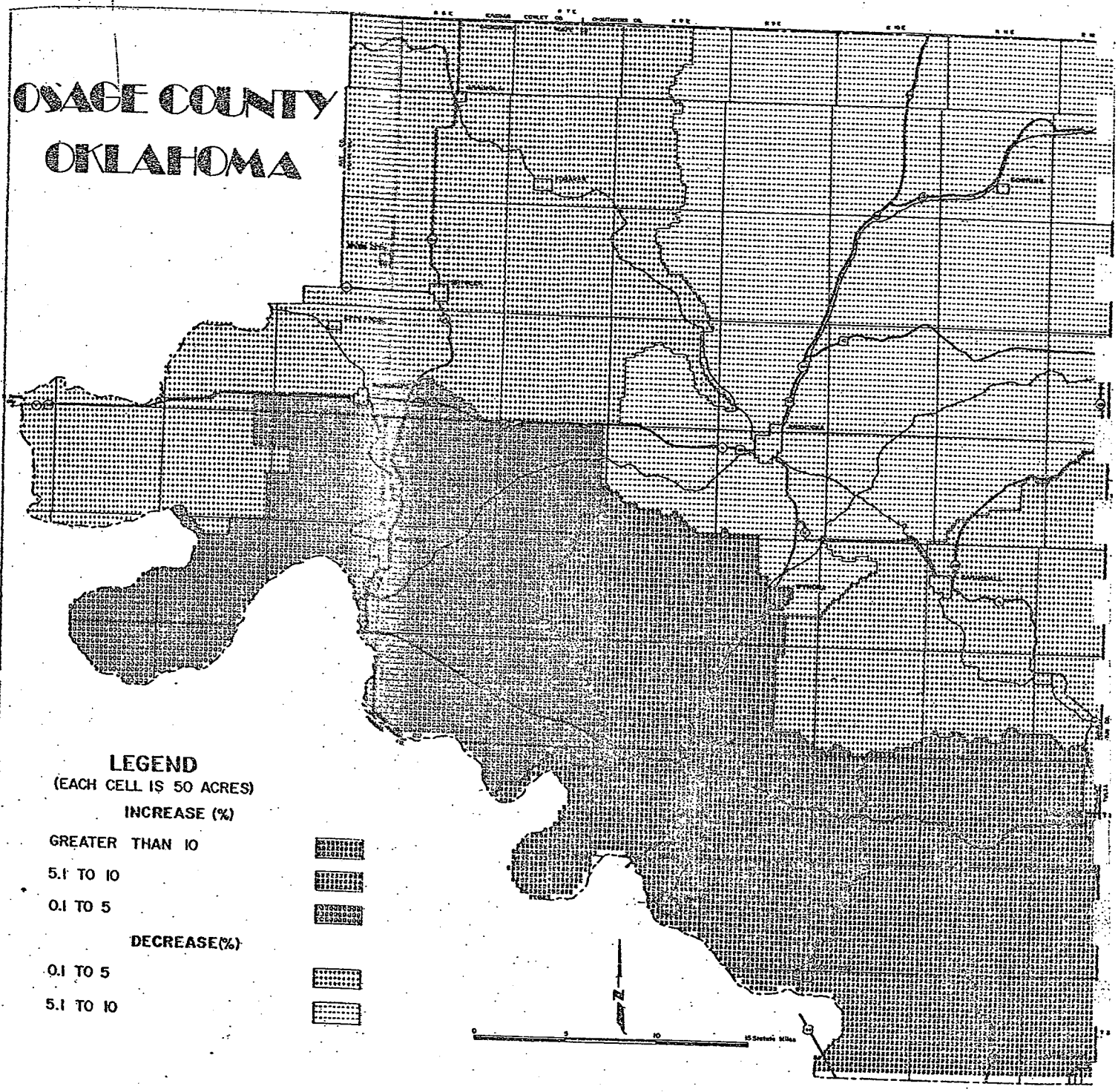


FIGURE 19. POPULATION CHANGE (1970-1976)

(v) various factors of the national economy.

Obviously, the oil and gas industry is not anticipated to be a major element in the general socio-economic future of Osage County

2. County Tax Base

Unless the gross production tax rate is changed (currently 5 percent for Osage Tribal royalties and 7 percent for operators in Osage County) or unless other taxes on oil and gas production or oil- and gas-related activities are levied, the Osage Tribal leasing program will have no different impact on the tax base from now to the year 2000 (and thus on the level and quality of county facilities and services) than it has at the present time. At the current rate of royalty payments (about $25.4 million realized for the Osage Tribe in 1978 for approximately 11 million barrels of oil), the oil and gas leasing program would bring in an additional $486.2 million in royalty payments through the year 2000. Gross production tax receipts on the total projected production would be $194.5 million, if the tax rates and market value of production is the same as in 1978. Of the 5 percent gross production tax paid to the State of Oklahoma from Osage Tribal royalties, one-fifth of that comes back to the county: half for construction and maintenance of roads and bridges and half for education. The county gets no share of the 7 percent gross production tax paid to the State by operators except as normal allocations from State funds to all counties of Oklahoma as provided by acts of the State legislature.

3. Personal Income

Personal income in Osage County is expected to increase in the next two decades, increasing by 50 percent when expressed in 1967 dollars (see Table 10). This

increase can be attributed to the larger share of total employment held by higher-paying employment categories and a small reduction in employment in lower-paying categories. Because employment in the oil- and gas-related industry is projected to remain relatively constant during the next 20 years, no change in total personal income can be attributed to the oil- and gas-related industry and, specifically, to the Osage Tribal Leasing program.

The royalty income from oil and gas leasing in Osage County provides personal income to members of the Osage Tribe. Royalty money is distributed to heirs or others who have been willed portions of the original 2,229 allotments. Although most income goes to individual Indians outside the county, a significant amount (perhaps 25 percent) is paid to tribal members living in Osage County.

Housing

Given a projected population in the year 2000 of 40,500, and assuming a slight decrease from the calculated 1978 household size (in accord with national trends). there would be approximately 15,000 housing units needed to shelter this total future population. This would represent an increase of about 3,280 units during the period 1970-2000. Because it is assumed that the projected population growth will occur in Osage County regardless of the oil- and gas-related business activities (but because of several other factors), the increase in number of housing units is not likely to be dependent on the oil and gas leasing program. Much of this increase can be expected in the northwest portion of the City of Tulsa, in Skiatook, east of Ponca City, north of Sand Springs, and in presently unincorporated areas of the eastern portion of the county.

5. Transportation

Highways and Roads

Currently, 2,054 miles of maintained State, city and county roads occupy 14,472 acres of Osage County. Another 3,000 miles of dirt and gravel access roads maintained by oil and gas lessees and operators account for an additional 7,273 acres.

Future road construction is expected to be as follows between 1979 and 2000: (1) about 10 miles per year of dirt and gravel roads will be paved in the county with only a small amount of new right-of-way; (2) about 30 miles of new paved highway will be built in the county; and (3) 150 miles of new dirt and gravel access roads will be built each year for oil field operations. New paved highway mileage will encompass 363 acres by the year 2000, while additional access roads (assuming 150 miles built per year and 66 miles abandoned) will require 4,275 more acres of land. Thus, this net conversion of land use for new access roads will be the most significant impact of the oil and gas program on transportation to the year 2000. In the year 2000, a total of 11,548 acres (0.8 percent) of Osage County will be devoted to dirt and gravel access roads.

With regard to new paved highway construction by the State or county, every attempt is made to design the alignment of the road to miss existing wells. When this cannot be done, lessees are compensated for remaining production and the well is properly plugged. With respect to drilling new wells near existing paved roads, 25 CFR 183.33 states that lessees shall not locate any well or tank within 200 feet of a public highway. Although this is generally enforced, in areas of high production this requirement can be waived by approval of the Superintendent of the Osage Agency to permit drilling closer to existing roads.

In the past (during development from the 1920's and into the 1950's) operators often did not minimize access road impacts by following the fencelines and shortest distances between wells and existing roads. Currently, every effort is made by the Osage Agency to ensure proper access road usage and maintenance. In some instances, operators still have problems maintaining access to well and tank sites, especially during wet weather. Under those situations, additional paths through rangeland or across native grassland are occasionally created by the operators to avert oil or brine spillage. This is a problem between the lessees and surface landowners which still arises. It affects efficient ranch operations both by taking additional areas out of grazing land for cattle production, and sometimes makes daily ranching operations difficult because the wet access roads (also used by the ranchers) are unpassable by the horse trailers, pickup trucks and other equipment with fairly low ground clearance and which are in popular use in the 1970's in Osage County. However, other possibly more deleterious circumstances are prevented in many instances.

No additional land for railroad use is likely to be required during the period 1979 to 2000. It may be that some additional miles of railroad track will be abandoned due to rail line consolidation or decrease in rail usage, but the magnitude of such possible abandonment has not been estimated for this study. There should be no impacts from railroads for the continued oil and gas leasing program.

b. Pipelines

Pipelines are the major mode of movement of gas, oil and their products. Approximately 8,000 miles of pipelines presently exist in Osage County. The recent ate of pipeline installment has been an average of 175 miles annually, and

this rate is not expected to change. Therefore an additional 3.675 miles of pipeline will have been added to the county by the year 2000. It is likely that little, if any, new mileage of large intra- or interstate pipelines will be placed in Osage County between now and the year 2000. However, if large lines are installed, corridors of about 15-20 feet in width will be kept cleared of large trees and brush along those lines for access. This is a relatively insignificant impact because the land can still be used for cattle grazing or growing of crops once grass is replanted or naturally recovers. Natural recovery may take from one to several growing seasons depending upon the nature of the soil. The great majority of pipelines which would be added are smaller pipelines placed on the surface by lessees. These lines would not affect cattle grazing but would interrupt crop planting and harvesting. It is up to surface landowners and lessees to work out details of pipeline installation.

Most older surface pipelines are metal and are relatively unaffected by range fires. During the present decade, some operators use plastic surface gathering lines. If a grass or brush fire occurs at the site of a plastic line, the line may melt or rupture and cause additional problems. Usually, an agreement is reached between the surface landowner and the lessee before plastic pipe is used. If additional damage is caused by a surface plastic pipe during a fire, a claim may be placed against the operator by the surface landowner if the operator is shown to have caused the fire initially. When a fire is caused by natural means (such as lightning), there would be no justification for additional damage claims if the surface owner had originally agreed to allow the installation of plastic pipe on his property. Currently, most wells, tank batteries and other installations for oil and gas production are protected by lightning rods to prevent fires or explosions.

6. Visual and Aesthetic Resources

The oil and gas leasing program has had, and will continue to have, a noticeable effect on the natural scenic resources of Osage County. The presence of 14,000 well sites with their pumps and storage tanks (increasing to over 18,000 by the year 2000) intrudes on the character of otherwise expansive rolling prairies. Noise from exploration, drilling or pumping can be an occasional aesthetic nuisance. This impact is reversible, however, and as individual wells or entire leases are abandoned, the areas are returned to their original aesthetic condition.

7. Recreation

Most of the land used for recreation, and the recreational activities themselves, will not be affected by the continuing oil and gas leasing program. Although wells can be drilled on Federal lands and State parks in Osage County, the Corps of Engineers has the ultimate authority to issue permits for drilling wells on Federal lands around reservoirs. The Corps can refuse to give permission where the land has been designated as a high public use recreation area. The State of Oklahoma has no authority to prevent drilling of wells on the several State parks or public hunting lands in Osage County.

The magnitude of future impacts on public lands is anticipated to be quite minimal. Most of the public recreation areas contained wells prior to the establishment of the areas as State parks or Federal land. New wells are not expected to significantly limit the parks and recreation areas for their intended use. Perhaps the greatest potential interference of the leasing program with recreation is the continued risk of oil and brine spills. Such spills could cause fishkills and temporarily limit fishing in a given area.

Historical, Cultural and Archaeological Resources

The continuing oil and gas leasing program will have no effect on the presently listed National Register sites of Osage County. Two historic sites are listed on the National Register of Historic Places, and five additional sites have been designated by the Oklahoma Historical Society as being significant to the history of the county (more are proposed). These sites are protected by State and Federal regulations.

The nature of prehistoric archaeological sites is such that, once disturbed, the integrity and total value of any one site is greatly diminished. Since the oil and gas leasing program and operations have been active in Osage County, no specific effort has been made to survey well sites or access road locations for the possibility that they may contain archaeological remains. Of the 188 archaeological sites recorded for Osage County thus far during surveys in reservoir basins, most have been concentrated along stream terraces and ridge spurs, but it is expected that hundreds of additional sites can be located throughout the remainder of the county, both along streams and in the uplands. It is believed that approximately 10 percent of the county has been subject to archaeological survey, resulting in discovery of 188 sites. If this sampling is representative of the entire county, then about 1,880 sites could be present. Also, if the 34,000 existing wells each disturbed 1½ acres during drilling, then 51,000 acres of the county have been disturbed by wells, and an additional 7,273 acres have been disturbed by access roads. Relating the percent of the county surface which has been disturbed to the number of possible sites, it is possible that about 75 archaeological sites in the county have been impacted by activities prior to 1978.

There is a high probability that significant historical and prehistoric resources could be affected by the continuing oil and gas leasing program since much of Osage County has been inadequately studied. However, the Office of State Historic Preservation has initiated a survey of northeast Oklahoma which will include Osage County. Once this information is available, the Osage Agency in cooperation with the State Historic Preservation Officer will take proper steps to ensure the preservation or mitigation of identified sites.

E. ECOLOGICAL IMPACTS

1. Vegetation Cover

Four principal types of vegetation cover Osage County: native rangeland, wooded land, pasture land and cropland. Together they constitute almost 96 percent of the county's land cover. Acreages of these vegetation types impacted by oil- and gas-related activities (present and projected to the year 2000) are given in Table 24. Expected decreases in vegetation related to oil- and gas-related activities generally can be attributed to new well sites, new miles of access roads, and oil or brine spills.

A total of about 926,600 acres of rangeland presently exist in Osage County. Projections indicate that there will be about 912,700 acres of rangeland in the year 2000. Approximately 7,770 acres of native rangeland will be used for oil- and gas-related activities by the year 2000. This accounts for only 0.8 percent of the present area of native rangeland in Osage County. Other activities not related to oil and gas production will significantly affect 6,103 acres of native rangeland; these include the creation of open rangeland by spraying of forest areas with 2, 4, 5-T herbicide and the conversion of rangeland to pasture land by planting burmuda and other "tame" grasses. Approximately 3,213 acres will be reclaimed to native rangeland by the year 2000 from abandoned wells and access roads.

There are presently 220,000 acres of wooded land in Osage County, which is expected to decline to 205,000 acres by the year 2000. Approximately 1,850 acres of wooded land will be removed by the year 2000 by activities directly related

to the oil and gas industry. The remaining projected loss of 13,150 acres of wooded land by the year 2000 will be caused by urbanization, defoliation of existing wooded areas by 2, 4, 5-T herbicide, and other activities beyond the realm of influence of the oil and gas industry. The impact of the oil and gas leasing program on wooded land in Osage County will be slight since less than one percent of the available wooded land will be removed from production due to oil- and gas-related activities. Oil and gas operations also account for only 10 percent of the total amount of the wooded land that will be removed from production by the year 2000. In addition, it should be stressed that only about 30 percent of the wooded land in Osage County has any commercial value, the remaining acres being characterized by low growth oaks, cedars and hickory. By the year 2000, approximately 722 acres of wooded land will be allowed to revegetate due to the abandonment of some wells and access roads.

Presently, 184,820 acres of tame fescue and bermuda grass pasture land exist in Osage County. This area is projected to increase to 222,400 acres in the county by the year 2000. The area of pasture land lost by the year 2000 to oil- and gas-related activities (1,533 acres) and urbanization will be more than offset by the amount of native rangeland and cropland which will be converted to pasture land by planting with fescue and bermuda grass. In addition, reclaimed acreage from abandoned wells and roads amounts to 783 acres.

At present there are approximately 82,000 acres of cropland in Osage County. The portion of land on Osage County devoted to cropland has been steadily declining since the 1930's. This decline is attributable to declining profits, urbanization, inundation by reservoirs, soil erosion and a minor amount due to oil- and gas-related activities. Estimates of land use in the year 2000 indicate that area used for cropland will have declined to about 60,000 acres.

Table 24. Acres disturbed by oil-and gas-related activities in four major land use categories, present and projected to the year 2000.

Land use category[a]	Acreage disturbed by new wells		Acreage disturbed by new access roads		Acreage disturbed by oil or brine spills		Total acres disturbed (1979-2000)
	Annual	Total	Annual	Total	Annual	Total	
Rangeland	126	2,646	228	4,788	16	336	7,770
Wooded land	30	630	54	1,134	4	84	1,848
Pasture land	25	525	45	945	3	63	1,533
Cropland	11	231	20	420	1.4	29	680
Totals (1979-2000)	192	4,032	347	7,287	24.4	512	11,881

Acreage disturbed at end of 1978:

active well sites = 7,000 acres
access roads = 7,273 acres
oil waste land = 2,000 acres

Total =16,273 acres

Acreage reclaimed from abandoned wells (1979-2000) = 1,838 acres
Acreage reclaimed from abandoned access roads (1979-2000) = 3,360 acres
(Assume no acreage reclaimed from oil waste land)

Total acres disturbed in the year 2000 = existing disturbed acreage + new disturbed acreage - reclaimed acreage, or:

16,273 + 11,831 - 5,198 = 22,906 acres (1.55 percent of Osage County)

[a]Accounts for about 96 percent of land use areas and areas of oil and gas activities.

Source: ECI calculations.

Approximatley 680 acres of cropland will be removed from production by oil- and gas-related activities by the year 2000. This indicates that an additional 21,320 acres of cropland will be removed from production by other factors. Is is apparent that the impact of oil- and gas-related activities on cropland in Osage County is very slight, accounting for less than 3.1 percent of the total amount of cropland removed from production by the year 2000.

2. Aquatic Biology

Several of the operational activities associated with the oil and gas leasing program in Osage County can potentially contribute to degradation of aquatic biological communities. The release of drilling fluids and mud, sludge, brine, or oil into natural watercourses causes direct adverse impacts to plants and animals living in the lakes and streams. The severity, extent and duration of impacts varies with the amount of any given spill and the area it covers, as well as upon streamflow, season, types of species present, and so forth. Adverse impacts also can result because of heavy sediment inflows to streams from barren areas where terrestrial vegetation has been eliminated by brine or land clearing. Under certain circumstances in streams or ponds, sediment inputs may be relatively high, but the fact that the water may contain highly concentrated salts can cause sediment particles to precipitate and thus leave the water free of turbidity. This situation permits enough light penetration for aquatic plant growth, but the settled colloidal sediment can cover and smother bottom-dwelling organisms which serve as food for fish. Sedimentation may also smother and kill fish eggs.

Several types of impacts affect the aquatic food chain, and ultimately result in a reduced potential for a good fishery. Brine, sediment, oil and sludge are

capable of either killing outright or reducing light penetration (and thus killing) the tiny aquatic plants (algae, phytoplankton, periphyton) which act as the primary producers and provide food to the next level of the food chain--the zooplankton and benthic organisms. This loss of food and the toxicity of the foreign substances in turn reduce the zooplankton and benthos populations which primarily serve as fish food organisms. Fish also can be killed outright by saltwater, sludge and other substances.

In Osage County, fishkills occasionally have been reported in several past years. However, within the past 3 years there have been no salt-related fishkills in Osage County according to the local State Fisheries Biologist (personal communication, Mr. Don Hicks, Fisheries Biologist, December 21, 1978). On the other hand, both the local fisheries biologist and game biologist have indicated that they are aware of at least two stream locations in Osage County which still experience chronic saltwater inflows from oil operations. One of these areas is near Kaw Reservoir (community of Lyman) and the other is on Turkey Creek, a tributary of Hulah Reservoir.

A survey of seventy-five streams in Osage County, which was conducted by the Oklahoma Department of Wildlife Conservation in 1977, showed that 23 of the streams surveyed had experienced fish kills (Table 25). Few dates and no other information was provided for the fishkills, and the actual occurrences were mostly recorded from interviews with local residents who at one time or another recalled seeing dead fish in their streams. The stream survey data did not reveal the types of fish or the numbers killed, nor the extent of each stream affected by the kill. Only one stream, Rock Creek--a tributary of Hominy Creek--was noted in the survey as having experienced numerous fishkills. Although it is likely that some of the fishkills were due to accidental spills from tanks

Table 25. Alphabetical list of 23 streams in Osage County, Oklahoma for which fishkills have been reported prior to 1978.

Stream	Tributary of	Other data
Arkansas River	-	1976
Birch Creek	Bird Creek	-
Bird Creek	-	-
Buck Creek	Wildhorse Creek	-
Bull Creek	Hominy Creek	-
Butler Creek	-	-
Choteau Creek	Bird Creek	-
Clear Creek	Bird Creek	-
Delaware Creek	-	-
Doga Creek	Arkansas River	-
Flat Rock Creek	-	-
Hominy Creek	-	-
Little Chief Creek	Salt Creek	-
Little Hominy Creek	Hominy Creek	-
Middle Bird Creek	Bird Creek	-
Mission Creek	Caney River	-
Nicicola Creek	Hominy Creek	1976
Rainbow Creek	Hominy Creek	-
Rock Creek	Hominy Creek	numerous
Salt Creek	Arkansas River	-
Sand Creek	-	-
Sycamore Creek	Arkansas River	-
Wildhorse Creek	Hominy Creek	-

Source: Stream survey and computer printout from Oklahoma Department of Wildlife Conservation, 1977 data.

carrying toxic chemicals, ammonia fertilizer or other substances, it is also possible that a few of the fishkills were due to toxic materials washed in from the oil and gas activities. The list of 23 fishkill sites reveals that they are scattered uniformly across the county and that no one particular area of the county is more prone to contaminating a stream than any other area.

In sampling Osage Agency lease files for documentation of accident statistics, several files were found which indicated that fishkills had occurred. Other files noted that brine spills had run as far as 1/2 mile into a stream or into nearby ponds. One brine spill recorded in February 1976 had caused stream salinity to increase to between 30,000 and 60,000 parts per million.

The least salt-tolerant freshwater fish can withstand chloride concentrations of up to 400 parts per million (ppm), such as young trout and pike and fry of other species. However, those coldwater species are not found in Osage County. Other more tolerant species, including the catfish, rough fish (carp), and sunfish found in the study area can exist in concentrations of several parts per thousand. Several species of bass exist in streams and lakes throughout Osage County. Tested salinity tolerances indicate that bass in general can survive 14,000 ppm of sodium chloride for approximately two weeks. However, tolerance of salt concentrations may vary to some degree in the wild.

Obviously, because of the common occurrence of moderate salinity levels in the streams, ponds, and lakes of Osage County, the fish species found there are somewhat acclimated to and tolerant of sodium chloride concentrations higher than those which trout or other coldwater species could tolerate. However, it is also obvious from reports of fishkills, that even those species naturally

found in Osage County are occasionally subjected to intolerant stream salinity concentrations. This situation is not expected to change significantly to the year 2000 without a continuing effective effort to prevent saltwater from entering permanent bodies of water containing fish.

In recent years, it appears that a much improved situation has evolved as a result of more conscientious efforts on the part of the lessees and operators to control potential spill situations and tend more carefully to older equipment. However, because an undeterminable number of spills and ground seepage are expected to continue to occur due to accidents, natural phenomena and some extremely old equipment and pipelines, a moderate number of fishkills and aquatic habitat contamination will occur in the foreseeable future.

3. Game and Non-game Animals

The game and non-game animals in Osage County will be impacted by the continuation of the oil and gas leasing program in two ways. Alteration of available habitat by oil and gas activities such as well sites, access road rights-of-way and oil wasteland will restrict the amount of preferred habitat available to some species. In addition, expansion of oil-and gas-related activities into rather isolated parts of the county will be detrimental to those species which are negatively affected by human activities.

A listing of the preferred habitat of the game and non-game animals found in Osage County are given in Table 20 and Table 21. Figure 17 depicts the distribution of wildlife habitat throughout the county. A comparison of these three exhibits provides a rough demonstration of the game and non-game wildlife distribution within the county. Projections given in Table 3 suggest

that the area of available wildlife habitat types will change considerably by the year 2000. A decline is expected for all habitat types with the exception of open pasture land which is expected to increase by 37,580 acres by the year 2000. Most of this increase is attributable to the conversion of wooded land and native rangeland to open pasture land in an attempt by ranchers to increase productivity.

As previous calculations have revealed, wooded land, cropland, native rangeland, and pasture land will be altered by oil-and gas-related activities by the year 2000. This accounts for only a small portion of the total acreage in Osage County which will change land use categories in that period. Attempts to improve productivity, inundation by reservoirs and increased urbanization will have a much greater impact on wildlife habitat availability than will activities relative to oil and gas production.

In a sparsely populated area such as Osage County, most wildlife species are able to migrate to adjoining areas if their habitat is adversely affected locally without causing significant competitive disadvantage on the existing residents. In most cases, unless soil erosion becomes a serious problem, areas which have been negatively impacted by oil and gas production activities such as well sites, access road right-of-way , and oil waste land are able to recover and become viable native rangeland within a few years after abandonment.

4. Threatened or Endangered Species

With regard to the four species of Osage County wildlife listed by the US Department of Interior as endangered, the oil and gas leasing program has had

and should not have any impact. Three of the species are transient or migrant birds (American Peregrine Falcon, Whooping Crane, and Eskimo Curlew) whose ranges only incidentally cross the county. The fourth species (Bald Eagle) spends much of its time around large reservoirs, but it is likely to be in Osage County a greater proportion of the year than would the other three species. The oil and gas-related activities in Osage County have done little to limit the Bald Eagle's habitat since oil production began in 1900. In fact, suitable habitat along the Arkansas River has probably increased since the mid-1960's with construction of Keystone and Kaw Reservoirs.

Although no Federal list has included threatened or endangered fish which are potential inhabitants of Osage County, the Oklahoma list and the stream survey conducted by the Oklahoma Department of Wildlife Conservation indicate that six species may be present which are designated as locally threatened or endangered in Osage County; they are the shovelnose sturgeon, pallid shiner, bigeye chub, least darter, river shiner and shorthead (pealip) redhorse. With the exceptions of the sturgeon and redhorse, the other four species are small, inconspicuous fish with somewhat limited habitat tolerances. The sturgeon is found only in the mainstream of the Arkansas River above Keystone Reservoir, but the other five species are found in the river and in seven major direct tributaries to the Arkansas River: Beaver Creek, Big Drum Creek, Bug Creek, Doga Creek, Gray Horse Creek, Salt Creek, and Sycamore Creek. Of the streams included in the 1977 survey of Osage County, four which contain locally threatened or endangered fish have experienced fish kills in the past; they are Doga Creek, Salt Creek, Sycamore Creek, and the Arkansas River. Even though the past fishkills in those streams have not been linked to oil and gas operations in the county, that possibility exists. Because of the size and magnitude of flow

of the Arkansas River, it is very unlikely that an oil or brine spill from local field operations could cause a significant fishkill in the river which would devastate populations of threatened or endangered fish. However, such a spill into Salt Creek, Sycamore Creek, Doga Creek, or any of the other four streams containing threatened or endangered fish could temporarily eliminate one or more of the species (depending on dilution, past acclimitization of the species to the toxic substances involved, and so forth). In all probability, the affected species would return to the tributary receiving the spill through natural redistribution from the Arkansas River.

To summarize the impact on threatened or endangered species, six fish species could experience temporary reduction of population members in streams which are direct tributaries to the Arkansas River. However, the impacts would be of relatively short duration. Taking into account the excellent fishery status of the entire county, it is fair to say that the oil and gas leasing program and operations may have had only minor adverse impact on threatened or endangered species, and that this trend would be expected to continue, probably in an even reduced manner in the future.

F. ACCIDENTS, DISASTERS AND SPILLS

1. Accidents

As in all heavy industry, workers in oil- and gas-related activities in Osage County will experience a certain number of accidents per year. Table 26 reflects the National Safety Council's recordable occupational injuries and illness incidence rates averaged for the entire country, and applied to employment data for Osage County. The figures shown in Table 26 are based on the assumption that employees work 250 days per year and 8 hours per day, thus totaling a 2,000 man-hour year. To arrive at Osage County's statistics for accidents, 1 percent of the employees in each business activity is multiplied by the nation's recorded rates (per 100 full-time workers) averaged for the years 1975-1977. Although the total work force for Osage County is expected to increase to 6,300 in 980 and 7,000 in 2000, the oil- and gas-related employment total is expected to remain constant.

The continued oil and gas leasing programs should have little or no impact on the rate of future injuries and illnesses. Table 26 shows the anticipated number of employee cases involving accidents between 1979 and 2000. Assuming that better safety conditions and precautions are introduced and enforced, these statistics could be lowered substantially. Total work days lost in the oil and gas industry to the year 2000 is expected to be only about 0.5 percent of all work days.

2. Disasters

Vandalism or deliberate destruction of property is known to occur in all businesses and industries. However, with the sparse data available, it is difficult to

quantify impacts of vandalism and its effects regarding oil and gas leasing in Osage County. Examination of a representive number of lease files showed only three reported cases of vandalism. These resulted in cut pipelines allowing 70 to 80 barrels of oil to escape. All three incidents happened within 2 months of each other in 1967. There is no accurate way to predict how often vandalism could occur in the future. Even though there will be a slight increase in the Osage County population between 1978 and 2000, the work force in oil- and gas-related activities will remain relatively constant, thus vandalism could increase slightly due to population increase, but the impacts probably will be negligible.

Natural or unintentional disasters which can occur during oil- and gas-related operations are infrequent; therefore, it is difficult to determine the probability of their occurrence. Types of natural or unintentional disasters which have occurred in Osage County vary greatly. Lightning struck a tank battery in 1965 allowing oil to escape. In the same year a log floating down a creek ruptured a pipeline which released oil into the creek. In 1976 and 1977, slush pits overflowed because of heavy rainfall, thereby releasing saltwater that damaged cropland.

Unintentional disasters include such things as overflowing trucks, corroded valves and pipelines, or lines damaged by bulldozers and other heavy equipment. Unintentional spills are occasionally caused by cattle knocking valves or pump switches loose. The types of occurrences mentioned above are virtually uncontrollable, and are expected to continue at about the same level or at only a slightly higher level into the foreseeable future. In summary, they constitute a relatively minor adverse impact, each of short duration.

Table 26. Accidents related to oil and gas activities in Osage County.

Business Activity	No. of employees	Incidence rates for workers by task category[a] Total recordable cases[b]	Total lost workday cases	Cases involving days away from work & deaths	Nonfatal cases without lost workdays	Total lost workdays
Mining (total)	1,723					
. Sand, gravel, limestone	140	25.20	5.81	5.78	19.33	196
. oil & gas extraction	1,583	98.30	24.22	23.11	73.77	696.52
.. Crude petroleum & natural gas	878	43.81	10.36	9.66	33.28	280.96
.. Oil & gas field services						
.. Drilling of oil & gas wells	340	102.99	29.21	29.34	73.58	1,043.80
. Oil & gas field services	298	49.56	13.80	13.89	35.67	458.92
Petroleum refining	500-999[c]	44.78	16.13	9.23	28.58	337.50
Annual total	2,473[d]	364.64	99.53	91.01	264.21	3,013.70
Total incidents expected between 1978-2000		8,022.08	2,189.66	2,002.22	5,812.62	66,301.40

[a] Based on OSHA definitions, 200,000 employee hours are used as the equivalent of 100 full-time employees. Annual average incidence data for the years 1975-1977 have been used.

[b] Total Recordable cases is the sum of deaths, plus total lost workday cases, plus nonfatal cases without lost workdays.

[c] Without precise data for this category an average number of 750 employees was used to calculate the incidence rates.

[d] To determine the total number of workers for oil and gas related activities between 1975-1977, an average of 750 employees for petroleum refining was used for calculations.

Source: Work Injury and Illness Rates, 1978 Edition. National Safety Council.

quantify impacts of vandalism and its effects regarding oil and gas leasing in Osage County. Examination of a representive number of lease files showed only three reported cases of vandalism. These resulted in cut pipelines allowing 70 to 80 barrels of oil to escape. All three incidents happened within 2 months of each other in 1967. There is no accurate way to predict how often vandalism could occur in the future. Even though there will be a slight increase in the Osage County population between 1978 and 2000, the work force in oil-and gas-related activities will remain relatively constant, thus vandalism could increase slightly due to population increase, but the impacts probably will be negligible.

Natural or unintentional disasters which can occur during oil- and gas-related operations are infrequent; therefore, it is difficult to determine the probability of their occurrence. Types of natural or unintentional disasters which have occurred in Osage County vary greatly. Lightning struck a tank battery in 1965 allowing oil to escape. In the same year a log floating down a creek ruptured a pipeline which released oil into the creek. In 1976 and 1977, slush pits overflowed because of heavy rainfall, thereby releasing saltwater that damaged cropland. One field lost 20 acres of potential wheat planting to a brine leak.

Unintentional disasters include such things as overflowing trucks, corroded valves and pipelines, or lines damaged by bulldozers and other heavy equipment. Unintentional spills are occasionally caused by cattle knocking valves or pump switches loose. The types of occurrences mentioned above are virtually uncontrollable, and are expected to continue at about the same level or at only a slightly higher level into the foreseeable future. In summary, they constitute a relatively minor adverse impact, each of short duration.

Analysis of literature concerning the possibility of fire or explosion during oil and gas drilling and production shows that almost all major fires and explosions occur in conjunction with high field pressure and blowout situations. High field press ge County, and therefore the possibility of a . The more probable situation is that a minor iance or by overheated equipment or leaks. operations as well, but apparently, the n s been low in recent years as evidenced by Osage ds of the US Geological Survey.

Oil spills in Osage County have caused environmental degradation ... than spills ... rest of Oklahoma.

3. Oil and Brine Sp

Historically, oil spills in Osage County have caused less environmental degradation per unit of production than spills throughout the rest of Oklahoma. Although the data in Table 22 include only oil spills reaching surface water as required by Federal law, they are indicative of the relative effectiveness of the environmental controls enforced by the Osage Agency.

To obtain a more complete description and quantification of the annual impact of both oil and brine spills in Osage County, a review of spill reports in lease files was conducted. There are approximately 5,000 files at the Osage Agency in Pawhuska representing all currently active wells. A random sampling of these files, designed to provide a statistically valid estimate of spill frequency within the county, was undertaken. A technical discussion of sampling techniques and the statistical analysis are included in Appendix A.

Briefly summarized, Appendix A reveals that within the 90 percent confidence interval the annual number of oil or brine spills within Osage is between 127

and 201. At the 95 percent confidence level, the number is between 120 and 208. For purposes of impact assessment the figure 164 is utilized as the mean number of accidents per year. Due to the sample size available, it is unadvisable to attempt to statistically project the number of accidents attributable independentl to either oil spills or brine spills. However, of the 38 spills reported in the sampled files, 66 percent were brine spills, 26 percent were oil spills and 8 percent involved spills of both substances. The sample size also is insufficient to develop a statistically valid estimator of the area killed per spill, but the arithmetic mean (6,880 square feet) serves as the best estimate for purposes of this report.

Based on the above findings, it is estimated that the yearly rate of vegetation destruction is the average number of accidents (164) multiplied by the average area destroyed per spill (6,880 square feet). This accounts for about 25.9 acres of oil waste land created each year for a cumulative total of 544 acres by the year 2000. Based on projected land use (Table 3), 84 acres of wooded land, 336 acres of rangeland, 63 acres of pastureland and 29 acres of cropland will be impacted by spills by the year 2000. This is less than 0.04 percent of the county

It is reasonable to expect that without additional spills some oil waste land is able to recover to normal vegetation within 20 years. Most of the spills, about three-fourths each year in Osage County, involve brine. As brine soaks into the soil it becomes chemically bound and is rather slow to leach out. This salt cause a severe osmotic imbalance between plant roots and associated soil particles and usually results in the death of the plant due to the lack of available water. Brine spills cause more severe impacts in low-growth communities such as rangelanc pasture land and cropland, and are less severe in areas of large trees and shrubs

which have much deeper roots. In addition to decreasing availability of water to plants, brine solutions are directly toxic to plants.

Approximately one-third of the spills in Osage County involve oil and other petroleum products. Oil also is toxic to most plants, and tends to coat the roots, stems, and leaves, thereby preventing the absorption of water and air into the plants. In most cases, oil spills do not penetrate as deeply into the soil as does brine; therefore, they produce less impact on plants with deep root systems (such as forest species).

In many cases involving oil or brine spills, the spilled substance accumulates in either a pond or stream. This situation presents a serious problem if domestic livestock or wildlife come there to drink. A few reports appear in the Osage Agency files in which accounts are given of death, miscarriage or severe weight loss in domestic animals after drinking from such a water source. Among the other types of impacts involving surface contamination from spills are salt encrustations along streams, oil floating on water surfaces, and increased aquatic plant growth (eutrophication) resulting from input of increased mineral nutrients. These types of impacts may be locally severe, although they occur only at a rare to occasional frequency.

iv. For non-governmental entities: What are the applicable statutes or regulations affecting oil and gas production in Osage County which you feel are important in fully understanding the constraints and requirements of such production?

v. Does your Agency (company, organization) have any recently compiled data relating to the physical, biological, social, or economic conditions in Osage County which could be made available to us for purposes of this study?

vi. Can you suggest other agencies or private groups with which we should confer during this study?

Several Federal agencies were not contacted during this phase of the study because it is known that their jurisdictional responsibilities are in effect only on those lands under their control (e.g., the National Park Service and U. S. Forest Service), and that they control no lands in Osage County. Similarly, the Interstate Commerce Commission, U. S. Department of Transportation and U. S. Department of Health, Education and Welfare were not contacted because their nationwide sphere of regulatory authority is not affected one way or another by oil and gas leasing operations in Osage County.

All of the agencies contacted were exceedingly cooperative in answering questions and providing data pertinent to this study. The following section summarizes the findings of these consultations. A list of all contacts is presented in Table 27. In all, 40 individuals from 26 different groups were contacted.

iv. For non-governmental entities: What are the applicable statues or regulations affecting oil and gas production in Osage County which you feel are important in fully understanding the constraints and requirements of such production?

v. Does your agency (company, organization) have any recently compiled data relating to the physical, biological, social, or economic conditions in Osage County which could be made available to us for purposes of this study?

vi. Can you suggest other agencies or private groups with which we should confer during this study?

Several Federal agencies were not contacted during this phase of the study because it is known that their jurisdictional responsibilities are in effect only on those lands under their control (e.g., the National Park Service and U.S. Forest Service), and that they control no lands in Osage County. Similarly, the Interstate Commerce Commission, U.S. Department of Transportation and U.S. Department of Health, Education and Welfare were not contacted because their nationwide sphere of regulatory authority is not affected one way or another by oil and gas leasing operations in Osage County.

All of the agencies contacted were exceedingly cooperative in answering questions and providing data pertinent to this study. The following section summarizes the findings of these consultations. A list of all contacts is presented in Table 27. Copies of coordination letters are contained in Appendix B. In all, 40 individuals from 26 different groups were contacted.

Table 27. List of agencies, organizations and individuals contacted during coordination phase of environmental report of oil and gas leasing program, Osage County, Oklahoma.

AGENCY OR ORGANIZATION	INDIVIDUAL CONTACTED AND TITLE	DATE CONTACTED (1978)
FEDERAL		
Interagency Archaeological Service	Mr. Don Fiero, Contract Representative	November 14
US Department of Agriculture, Soil Conservation Service	Mr. Dick Bogard, District Conservationist	October 19
US Department of Defense, Army Corps of Engineers	Dr. John Carroll, Chief, Environmental Analysis Section	October 18
US Department of Defense, Army Corps of Engineers	Ms. Sue Purves, Archaeologist	October 18
US Department of Defense, Army Corps of Engineers	Mr. John Proffit, Chief, Management and Disposal Div.	November 21
Department of Defense, Army Corps of Engineers	Mr. Donald Warnken, Engineer	November 21
US Department of Energy, Research Division, Energy Technology Center	Mr. Bill Linville, Research	November 15
US Department of Energy, Office of Special Counsel	Mr. Hank Egleston, Branch Manager	October 18
US Department of Interior, Fish and Wildlife Service	Mr. Robert Short, Biologist	November 28
US Department of Interior, Geological Survey	Mr. Floyd Stelzer, Area Oil and Gas Supervisor	October 18
US Department of Interior, Geological Survey	Mr. James Irwin, District Chief	October 24
US Department of Interior, Geological Survey	Mr. James Schoolar, Oil and Gas Leasing	October 24
US Department of Labor, Occupational Safety and Health Administration	Mr. James Johnson, Area Director, Tulsa Area Office	December 6

Table 27. (Continued)

AGENCY OR ORGANIZATION	INDIVIDUAL CONTACTED AND TITLE	DATE CONTACTED (1978)
FEDERAL (Cont'd)		
US Environmental Protection Agency	Mr. Charles Severs, Chief Water Supply Branch	October 13
US Environmental Protection Agency	Mr. Dwight Hoenig, Geologist	October 4
OKLAHOMA		
State Historic Preservation Office	Dr. Howard Meredith, Deputy Director	November 14
Water Resources Board	Mr. Jim Long, Head, Water Quality Division	October 20
Water Resources Board	Mr. Bill Schmidt Planning Division	October 20
Water Resources Board	Mr. J. A. Wood, Chief, Ground Water Division	October 20
Water Resources Board	Mr. Ken Morris, Limnologist	October 20
Water Resources Board	Mr. Ed Parker, Engineer, Stream Water Division	October 27
Department of Wildlife Conservation	Mr. Ric Gomez, Environmental Coordinator	October 20
Department of Transportation	Mr. Darrell Henry, Planning and Research Division	October 25
Department of Transportation	Mr. Bill King, Local Governments Branch	October 25
Department of Transportation	Mr. Jon Vermillion, Asst. Chief, Right-of-Way Division	October 25
Department of Health, Div. of Public Health Statistics	Mr. Bill Bussey, Statistical Analyst	October 27

Table 27. (Continued)

AGENCY OR ORGANIZATION	INDIVIDUAL CONTACTED AND TITLE	DATE CONTACTED (1978)
OKLAHOMA (Cont'd)		
Corporation Commission, Statistical Department	Mr. E. M. Doyle, Manager	November 1
Corporation Commission	Mr. Fred Norris, Manager, Field Operations	November 1
Department of Pollution Control	Mr. David Dillon, Chief of Water Programs	October 27
Oklahoma Geological Survey	Dr. Charles Mankin, Director	November 27
Oklahoma Geological Survey	Mr. Bill Rose, Geologist	October 26
LOCAL		
Osage County Cattle Growers Association	Mr. William Ricketts, Secretary-Treasurer	November 17
Tulsa Area Economic Development Planning Group	Mr. Marshall Vest, Chief of Comprehensive Planning	November 3
Indian Nations Council of Governments	Mr. Richard Brierre, Chief of Comprehensive Planning	November 3
Chapman-Barnard Ranch	Mr. William Bell, Attorney Ranch Manager	March 8, 1979
KANSAS		
Fish and Game Commission	Mr. Leland Queal, Wildlife Administrator	November 16
Department of Agriculture, Division of Water Resources	Mr. Riley Dixon, Hydrologist	November 16
Water Resources Board	Mr. Wayne Haas, Deputy Director	November 16
Department of Health and Environment	Mr. John Travers, Chief, Water Quality Surveillance Unit	November 27
Corporation Commission	Mr. Tom Leiker, Proration Analyst	November 27

B. SUMMARY OF FINDINGS

After all coordination and consultation efforts had been completed, either by direct interview or by telephone, a review of all information was made. Several subjects were brought out frequently, while others were mentioned only once or twice. The following sections summarize the comments received with regard to three prevalent topics, and a discussion is provided on other considerations.

1. Regulatory Jurisdiction

Of those government regulatory agencies contacted, two are involved with regulation of oil and gas leasing programs or production in programs similar to those of the Osage Agency. In the case of the US Geological Survey (USGS), which regulates much of the country's onshore oil and gas leasing program on both Federally owned and Indian lands, individuals who were contacted specifically noted that the USGS has no regulatory authority in Osage County. Similarly, the Oklahoma Corporation Commission, which regulates oil and gas production on private, State and local government lands in Oklahoma, does not exercise regulatory jurisdiction within Osage County.

The US Department of Energy (DOE) has jurisdiction in Osage County in relation to the oil and gas industry, which in turn is directly related to the leasing program of the Osage Agency. In conjunction with major oil producing companies, the DOE is funding pilot research projects involving tertiary oil recovery in two field in the county. In addition, the Tulsa Crude Production Audit Branch of the DOE has regulatory powers over pricing of crude petroleum from Osage County. This jurisdiction directly affects the oil and gas companies that lease land for production in Osage County, and also directly affects

the Osage Tribe in that it influences royalty income based on the selling prices of oil and gas.

The US Fish and Wildlife Service (FWS) in Osage County, as elsewhere, is mandated to implement the Fish and Wildlife Coordination Act (1958). Under that piece of legislation, the FWS is given the authority to provide assistance and coordinate with all Federal, State, and public or private agencies or organizations "in the development, protection, rearing and stocking of all species of wildlife, resources thereof, and their habitat, in controlling losses of the same from diseases or other causes, in minimizing damages from over abundant species, in providing public shooting and fishing areas, . . ., and in carrying out other measures necessary to effectuate the purposes of said sections." In Osage County, the FWS has carried out most of its coordination activities related to this Act with the US Army Corps of Engineers in that agency's endeavors to construct, maintain and operate several dams and reservoirs in the county. The FWS also cooperates with the Oklahoma Department of Wildlife Conservation in managing two public hunting areas in Osage County. In addition, the FWS oversees the enforcement of the Endangered Species Act (1973) nationwide.

Although the US Soil Conservation Service (SCS) has no regulatory authority in Osage County (personal communication, Mr. Dick Bogard, District Conservationist, October 19, 1978), it provides a great deal of professional technical assistance to the State and Osage County Conservation Districts in regard to managing the renewable natural resources of the county. To accomplish this, close cooperation between the various landowners and those companies or individuals who are mining the non-renewable fossil-fuel resources in Osage County is required.

The US Army Corps of Engineers (COE) presently owns and has jurisdiction over the only Federally owned lands in Osage County. Those lands comprise the acreage within the boundaries of six reservoirs which are already built, likely to be built, or under construction. Four of these reservoirs will be completely within Osage County (Hulah, Candy, Birch, and Skiatook). Only a small portion of Kaw Reservoir property and about one-fourth of Keystone reservoir property is in Osage County. The total flood pool acreage of all six reservoirs, when complete, will be about 125,500 acres. Total land requirements of the COE for those reservoirs is about 188,000 acres; that portion in Osage County is about 82,000 acres. Two other reservoirs (Shidler and Sand Creek), have been approved but not funded for construction in Osage County.

The COE has jurisdictional responsibility over the lands covered by and surrounding the reservoirs. If land containing producing oil or gas wells is required, the COE provides for compensation to the Osage Tribe and producer and plugs all producing wells. The Osage Tribe of Indians retains the mineral rights for such property, but the Corps has the right to subordinate leasing operations through a Memorandum of Agreement with the Bureau of Indian Affairs. If a potential lessee nominates a parcel of land on Corps property and it is eventually leased for oil or gas drilling, the Osage Tribal Council can approve the lease, but final permission to drill rests with the Corps, provided the Osage mineral estate has been subordinated by the COE. In most instances, permission is given unless the property is within a high public use area.

The US Environmental Protection Agency (EPA) has jurisdiction nationwide over air and water pollution under authority of the Clean Air Act (as amended

several times from 1967-1977), the Federal Water Pollution Control Act Amendments (commonly referred to as the Clean Water Act--1972, amended, 1977), the Oil Spill Pollution Prevention Act (1973), and the Safe Drinking Water Act (1974, amended 1977). It also administers the Noise Control Act (1972, amended 1976). The EPA's jurisdiction extends to Osage County, and it has cooperated in the past with the Osage Agency in ensuring that public potable water supplies were protected from contamination due to oil and gas exploration or production. Inspectors from the Region VI EPA Office in Dallas occasionally check well sites for violations of the Oil Spill Pollution Prevention Act. Any violations are subsequently reported to the Osage Agency for remedial action, although responsibility for spill prevention rests with the lessee rather than with the Agency.

The Occupational Safety and Health Administration OSHA--US Department of Labor) has nationwide jurisdiction over many aspects of industrial health and safety. Under the Occupational Safety and Health Act (Williams-Steiger Act) of 1971, general industry standards are enforced. These standards apply to the oil and gas industry, but would involve lessee's operations directly rather than the leasing program of the Osage Agency. According to the Area Director of OSHA in Tulsa, few problems have been encountered with oil and gas operators except for an occasional complaint related to disposal of sludge during oil well drilling.

The Interagency Archaeological Service (IAS), is a Federal organization which deals with studies of a cultural/historical/archaeological nature on Federal lands under the auspices of the Moss-Bennett Act (1974) and Executive Order 11593. The IAS has the responsibility of coordinating and carrying out cultural resource investigations throughout the country. In Osage County specifically,

the IAS in past years has directed cultural resource investigations on lands acquired by the US Army Corps of Engineers as reservoir flood pool lands, although the agency has never been requested by the BIA to carry out such studies on oil or gas well leases or for access roads. On the Navajo Indian Reservation in Arizona and New Mexico, archaeological studies are performed on all well sites and access roads under the direction of the IAS. Funding for these studies on the Navajo Reservation comes from the oil and gas lessees at the request of the National Park Service and the Bureau of Indian Affairs (personal communication, Mr. Don Fiero, Interagency Archaeological Service, Denver, Colorado).

Agencies of the State of Oklahoma also have jurisdictional authority in Osage County. However, the authority over oil and gas operations which the Oklahoma Corporation Commission has throughout the State does not extend to Osage County. A total of eight State agencies are in some manner involved with regulating surface or groundwater resources in Oklahoma and, hence, in Osage County. Among these agencies are the Water Resources Board, the Department of Pollution Control, the Oklahoma Conservation Commission, the Health Department, the Department of Wildlife Conservation, and the Department of Agriculture. It appears that some overlap in responsibilities exists, but each agency is vested with carrying out certain supervisory and enforcement procedures. During the coordination phase of this study, it became evident that problems discovered by these State agencies were virtually all related to the actions of an individual landowner or industry. In no instance was it mentioned that any problem was universal in Osage County or resulted from the operations of the Osage Agency oil and gas leasing procedures. There appears to be such a lack of past legal precedent regarding the ongoing operations of the Osage Agency that many of the State agencies seem uncertain as to whether or not they have any jurisdictional authority in Osage County over oil and gas lease operations or problems encountered.

2. Groundwater Protection

During the consultation and coordination process, several Federal and State agencies clearly acknowledged an interest in, or jurisdictional responsibility over, the groundwater resources in Osage County. The US Geological Survey in conjunction with the Oklahoma Geological Survey, has performed studies of the aquifers in Oklahoma. In particular, those agencies have studied the Vamoosa aquifer which extends in a north-south direction across central Osage County. One objective of their study is to determine the possibility of (and probable sources of) contamination of the potable zone of the aquifer. The Vamoosa aquifer study is currently under thorough revision regarding its findings. The Vamoosa study and similar studies are a concern of the US Environmental Protection Agency (Region VI Office, Dallas, Texas), which regulates water quality of wells used as public drinking water supplies.

The Groundwater Division of the Oklahoma Water Resources Board is the permitting Agency in Oklahoma for non-domestic water wells. All persons wishing to drill a water well for industrial, irrigation, or other non-domestic use in Osage County are required to first get approval from the Water Resources Board. A total of 36 entities have approved permit applications on file with the WRB in Oklahoma City; however, it is suspected that many water wells have been drilled without proper approval (personal communication, Mr. J. A. Wood, Groundwater Division, WRB, October 20, 1978). The WRB keeps records of annual tests of quality and depth-to-fresh water for wells in each county. Osage County contains only one such well which has been monitored since about 1970. In looking through WRB files on reports of brine contamination of wells in Osage County, no evidence was found of a reported contamination.

Throughout the consultation process, the topic of potential groundwater contamination was brought up by many groups or individuals as one of concern. Along with surface water brine contamination, this topic ranked high among all concerns. The only agencies which are in the active process of studying groundwater contamination problems as related to oil and gas drilling operations (specifically in Osage County) are the EPA and the USGS.

3. Surface Water and Soil Protection

The subject of brine contamination of surface waters and soils in Osage County was mentioned as a major concern, especially by agencies such as the EPA, SCS, WRB, FWS and other specifically involved with saltwater effects on streams, ponds, reservoirs and other natural or man-made surface watercourses. Among the specific concerns mentioned by various agencies were the deterioration of water quality for public consumption, possible deleterious effects on fish and wildlife, destruction of crops or natural vegetation by brine, and effects on livestock. With perhaps one or two exceptions, little mention was made of the secondary effects of subsequent erosion or adverse aesthetic effects due to loss of vegetation cover.

Although the topic of brine contamination was mentioned repeatedly, little was said about actual or potential oil spills due to pipeline rupture, inadequate care in drilling or production, or leakage due to other causes. Apparently, the only groups other than Osage Agency which maintain any kind of permanent records on oil spills in Oklahoma are the USGS and EPA. Formal USGS reports (Form NTL-3) have been kept since 1974. Because USGS jurisdiction does not extend to Osage County, the records show no spills there, although surrounding counties have experienced occasional spills. Table 22 (Chapter II, Section E) of this report summarizes oil spills in Oklahoma, including Osage County, reported to the EPA, Staff of

the US Fish and Wildlife Service expressed concern about ruptured waste pool walls, thereby permitting discharge of contaminants to the surface water; however, no record of such incident was provided for this study.

One of the concerns apparent from the consultation phase of this study is that reports of pollution events or accidents are not systematically made to agencies with related responsibilities. There appeared to be a desire for, but lack of, communication between various agencies about such conditions. Most agencies indicated that they only would find out incidentally about spills or accidents.

4. Other Considerations

Two local organizations have a definite interest in, although no real authority over, the oil and gas leasing program. These groups are the Osage County Cattle Grower's Association, which maintains an Oil and Gas Committee; and members of the Osage County Conservation District, who occasionally report instances of pollution to either the Osage Agency or to the local Soil Conservation Service Office in Pawhuska. It should be noted here that these groups are surface owners with no mineral interest.

Among the other topics of concern by individual agencies or groups were maintenance of access roads, protection of fish and wildlife, mitigation of cultural resources, and protection of crops and livestock. Except for discussions related to compensation to the Osage Tribe or lessees for oil or gas properties to be acquired for highway rights-of-way or Army Corps of Engineers property, no agency or organization specifically expressed concern with any of the social or economic effects within the county. Effects on agricultural productivity with regard to cattle grazing and crop growth were mentioned by several of the individuals contacted.