CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

REPORT FOR
BUREAU OF MINES
DEPARTMENT OF THE INTERIOR

THE SYNTHETIC LIQUID FUEL POTENTIAL OF ARKANSAS

MAY 21, 1951

Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK PHILADELPHIA CHICAGO LOS ANGELES

U.S. Engineer Dept.

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LETTER OF TRANSMITTAL

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LOS ANGELES
39 BROADWAY
NEW YORK 6

New York, May 21, 1951

The Chief of Engineers
Department of the Army
Washington 25, D.C.

Dear Sir:

We submit herewith our report upon "The Synthetic Liquid Fuel Potential of Arkansas", in accordance with Contract No. W 49-129 eng-137 concluded between us May 3, 1949.

Our survey disclosed widespread interest in synthetic liquid fuels. Informed public opinion recognizes the need for utilizing to the utmost all possible resources for the maintenance of our national welfare and security. Both public and private agencies have been very helpful in supplying data and entering into frank discussions with us on the subject. We welcome this opportunity to thank them for their cooperation.

Supplies of crude petroleum, the source of liquid fuels, are not inexhaustible. Provision must be made for the day when such fuel reserves become dangerously low. Foresight is required of all of us in facing this problem.

Over-all requirements of our natural resources are constantly changing. Obviously, no survey can do more than describe conditions in the light of present knowledge.

We believe that this report will be of value in formulating policy with respect to the future development of synthetic liquid fuels.

Very truly yours,

(Signed) Ford, Bacon & Davis, Inc.

REPORT

REPORT

Corps of Engineers
Department of the Army

THE SYNTHETIC LIQUID FUEL POTENTIAL
OF

ARKANSAS

LOCATION OF

SUITABLE GENERAL AREA

FOR

SYNTHETIC LIQUID FUEL MANUFACTURE

Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK
CHICAGO

PHILADELPHIA
LOS ANGELES

IDENTIFICATION OF GENERAL AREA

No.	General Area
1	Sebastian-Scott

SCALE OF MILES

10 0 10 20 30 40

SF-751 1-19-51.

CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

REPORT FOR
BUREAU OF MINES
DEPARTMENT OF THE INTERIOR

THE SYNTHETIC LIQUID FUEL POTENTIAL OF ARKANSAS

MAY 21, 1951

SUMMARY

Introduction

The Department of the Interior, as part of its broad program of synthetic liquid fuels research, requested the Department of the Army in 1947 to assist in the development of the synthetic liquid fuels program. This investigation and report on Arkansas are in part fulfillment of a contract to that effect awarded by the Corps of Engineers of the Department of the Army. The contract calls for a survey of 37 states and Alaska to determine Suitable General Areas and their potential capacity for the production of synthetic liquid fuels from coal, natural gas, oil shale, and oil-impregnated strippable deposits.

The General Areas containing raw materials and water supply of proper quantity and quality required by synthetic liquid fuels plants and various economic factors further affecting the suitability of such Areas for plant location are critically examined. No core drillings, extensive sampling, or detailed field examinations were made and studies are based on information now available. A Suitable General Area, as indicated on the map on the facing page, was determined and defined but no specific plant sites are selected.

Raw Materials

The raw materials considered in this survey of Arkansas are coal, natural gas, and oil-impregnated strippable deposits. No report was authorized in relation to oil shale deposits because it was considered that any known deposits in Arkansas of such raw materials were of doubtful economic importance.

Coal. Of the raw materials considered in Arkansas, coal is the most abundant and available. It is found to be the only raw material meeting the survey requirements for synthetic liquid fuels production.

Natural Gas. The total reserves of natural gas in Arkansas as of January 1, 1949, are estimated at 1,057,715,000 Mcf with a heating value in the order of 1,000 Btu per cubic foot under standard conditions. Most of these reserves are under contract to gas pipe lines for domestic, commercial, and industrial use; the volume of gas remaining as available is estimated at 37,300,000 Mcf. Consequently, none could be considered sufficient to meet the survey requirements which call for undedicated deposits containing, within a radius of 40 miles, at least 225 trillion Btu (225,000,000 Mcf of 1,000-Btu gas) with a heating value of at least 400 Btu per cubic foot under standard conditions.

Oil-impregnated Strippable Deposits. Available information reveals that, while there are some surface or near-surface oil-impregnated deposits in Arkansas, such deposits do not meet the survey's minimum requirements of 10,000,000 tons within a 5-square-mile area, in vertically continuous beds at least 15 feet thick, yielding not less than 10 gallons per ton and overlain by not more than their own thickness of overburden.

General Features

About one-quarter of Arkansas, in its northwest portion, is mountainous. The rest of the State is largely composed of alluvial lands and bottom lands of the Mississippi River and its tributaries. The climate is mild. The 1950 population density averages 36 persons per square mile throughout the 53,102 square miles of the State. Arkansas is primarily an agricultural State with cotton the principal crop. Major manufacturing industries include lumber and timber products, food products, cottonseed products, and petroleum refining.

Coal is found in a limited area in the western part of the State adjacent to the Arkansas River which drains the area. Five railroads serve the area.

Plant Processes

Since the only raw material available in requisite quantity is coal unsuited for hydrogenation, the fixed carbon content is more than 69 percent (maf), only the coal synthine pricess is considered. In the synthine process, coal is first converted to a gaseous mixture of carbon monoxide and hydrogen, which gases, in the presence of a suitable catalyst, combine to form liquid fuels. The process requires major quantities of coal, for direct conversion to liquid fuels and to provide energy for such conversion, and of water, chiefly as a cooling medium. The unit plant size adopted in the survey as a basis for estimates for comparison is 10,000-barrel-per-day capacity.

As a synthetic liquid fuels program of any magnitude must necessarily require a considerable period of years for its realization, estimates of unit quantities of raw materials required and unit costs of plant construction and operation used generally in this survey for determining ultimate production potential and relative desirability of General Areas have been based on the assumed use of certain improvements in equipment and process which are still under development but which seam reasonably likely to be available by the time such a program could be well under way. Moreover, the estimated data and costs for the coal synthine process have been taken from preliminary studies made by the U.S. Bureau of Mines for a report which is not yet completed. The final estimates of the Bureau, when available, may differ materially from these preliminary figures. While the data used have been selected as offering a fair basis for comparison, it must be understood that if synthetic fuels plants were to be built at the present day, using only equipment and processes already commercially available, coal requirements and plant and product costs might be appreciably higher than those shown in this report.

Subject to the above comments, daily requirements of Arkansas coals, as received at the synthetic fuels plant, should average about 4,600 tons for a coal synthine unit plant.

General Area of Coal Availability

The coal-bearing formations of Arkansas occur in a relatively limited area in the west-central portion of the State where they underlie portions of eight counties. The coal beds represent an eastern continuation of the adjoining and contiguous Pennsylvanian coal deposits in eastern Oklahoma.

A number of lignite beds are present in a curving belt across the northeastern, central, and southern portion of Arkansas. Available information on them, however, was insufficient to warrant estimates of reserves. The lignite beds are lenticular in occurrence and average thicknesses are less than prescribed by the survey requirements.

Of the eight coal-bearing counties, three contain coal deposits which are in fringe positions near the outermost edge of the coal-bearing formations and three others contain only isolated reserves insufficient to support even one synthetic liquid fuels unit plant. The remaining available reserves satisfactory for synthetic liquid fuels production, contained in the lower Hartshorne bed in two counties, were grouped in a General Area of Coal Availability containing reserves for 40 years' supply of at least one 10,000-barrel-per-day synthetic liquid fuels plant and identified by the names of the counties in which it lies as the Sebastian-Scott General Area of Coal Availability.

The total tonnage of coal considered for synthetic liquid fuels manufacture in Arkansas as of January 1, 1949, based on available information and within the limits of reserves specified by this survey as described in Part II of this report under "Survey Specifications" and in Part IV under "Survey Methods and Procedure", was estimated at 831,328,000 tons in place of which 415,664,000 tons were estimated as being recoverable. These estimates are, therefore, not comparable with other coal estimates which generally include the total coal reserves in Arkansas without the limitations imposed by this survey. For example, in Circular 94 of the U.S. Geological Survey, the total recoverable reserves for Arkansas, as of January 1, 1950 (assuming 50 percent recovery) are reported to be 766,106,000 tons. The estimate of the U.S. Geological Survey is based upon one prepared by M.R. Campbell in the years prior to 1928, because later appraisals were not available.

After giving consideration to isolated areas with insufficient reserves to provide at least one synthetic liquid fuels plant, to commercial requirements over the next 50 years, and further contract limitations as to the use of primary and secondary reserves, the total tonnage of coal, recoverable and available for the manufacture of synthetic liquid fuels in the single General Area of Arkansas, was estimated to be 250,454,000 tons, recoverable by underground mining methods. No coal reserves were classified as "strippable" under the definitions described under "Survey Specifications" and "Survey Methods and Procedure".

The total available coal reserves considered are distributed by counties as follows:

Estimated Recoverable Coal Reserves
Considered for Synthetic Liquid Fuels Manufacture
in Arkansas as of January 1, 1949
(Thousands of Tons)

County	Coal-bearing Counties (A)	Sebastian-Scott General Area (B)
Franklin	20,534	-
Johnson	56,794	-
Logan	87,882	-
Scott	28,039	28,039
Sebastian	222,415	222,415
Total	415,664	250,454

Note: (A) Before elimination of tonnage in unsatisfactory areas.
(B) After elimination of tonnage in unsatisfactory areas.

The following table lists the potential synthetic liquid fuels production, in total and as a daily average for 40 years, by the coal synthine process in the Sebastian-Scott General Area in Arkansas. The available coals are rejected for hydrogenation because of a fixed carbon content (in excess of 69 percent maf) indicated by the U.S. Bureau of Mines as being unsuitable for that process.

Potential Synthetic Liquid Fuels Production
from Recoverable Available Coal Reserves
of Arkansas

General Area	Recoverable Coal Reserves in Thousands of Tons	Average Btu Value as Received	Potential Synthine Production	
			Total in Millions of Barrels	Daily Average in Thousands of Barrels
Sebastian-Scott	250,454	13,650	543	37

The foregoing reserves, contained in the Lower Hartshorne bed, are low-volatile to medium-volatile bituminous in rank, with a fixed carbon content in excess of 69 percent (maf). Ranges in selected items of representative analyses are as follows:

Ranges in Selected Items
of Typical Analyses of Mine Samples
(As-received Basis)

	Moisture	Ash	Sulfur	Btu per Pound
Maximum	2.7%	9.2%	1.0%	14,430
Minimum	2.0	5.6	0.7	13,550

Petrographic analyses of Arkansas coals in the Lower Hartshorne bed are not available. However such analyses on coals of the same bed at locations in a bordering state indicate a composition of the "bright" petrographic type.

While specific information on representative organic and non-organic sulfur contents of the coals is not available, data on separation characteristics suggest that there is a high proportion of organic sulfur, which is not considered amenable to reduction by mechanical cleaning. However, further studies of these coals are necessary to evaluate the reduction in total sulfur which might result from mechanical cleaning.

Weathering and slacking characteristics of the Arkansas coals are similar to those of other coals of the same rank; that is, they do not usually slack readily or ignite spontaneously when exposed to air, although midwestern coals are generally more susceptible to spontaneous combustion than Appalachian coals. When properly stored, however, there is no problem of spontaneous combustion.

The coal of the Sebastian-Scott General Area appears to be similar in grindability to comparable industrial coals and may be expected to respond to fine grinding. Information on friability indicates that there may be considerable degradation by handling.

The Hartshorne bed of Arkansas frequently contains one or more bedded impurities, or partings, as well as laminations of bone or bony coal. There are irregular areas scattered throughout the General Area in which a middle parting (commonly not over 6 inches thick) is present.

While the presence of partings is not generally such as to seriously interfere with mining operations, such partings do affect the type and capacity of the necessary cleaning facilities and the amount of refuse which must be handled during the cleaning process. Data indicate that the coal is generally amenable to improvement in quality by commercial type mechanical cleaning.

The cleaning of Arkansas coal as necessary to provide raw material equivalent in quality to merchantable coal for synthetic liquid fuels plants would produce per unit plant approximately 1,165 tons of mine refuse per working day, or 279,600 tons per year equivalent to about 186,400 cubic yards. No particular disposal problem would be presented.

The initial capital cost to provide coal mining facilities for supplying coal requirements of synthine unit plants is estimated, as of March 31, 1950, at $9,262,000. for 7,019 tons per day over a 240-day year. Factors influencing this cost include depth and character of the coal bed and its associated strata, and also quantity and quality of the coal. The cost estimate provides for all necessary structures and mine operating equipment, facilities for transporting the output from two or more adjacent mining operations to a joint preparation plant, as well as for mechanical cleaning to produce merchantable coal, disposal of waste from the cleaning of the raw coal, surge storage at the mine, engineering, development, and contingencies. Costs of producing coal are estimated as of March 31, 1950, to be $5.28 per ton, equivalent to a cost of 19.34 cents per million Btu or $2.44 per barrel of products. These costs are based on underground mining and exclude allowance for return on investment and selling expense.

General Area of Coal and Water Availability

Investigation of potential sources for the large quantities of water required for synthetic liquid fuels plants shows that there is available, in excess of known and proposed water uses, enough water in the Arkansas River and its tributary, Vache Grasse Creek, in and near the Sebastian-Scott General Area to supply all the plant capacity for which coal is available. Water required for full development would amount to 75 cubic feet per second (cfs) or 48.5 million gallons per day (mgd) for process and domestic purposes. Most of the process water is needed for cooling and it is assumed that cooling water would be recirculated through cooling towers.

Water supply for a unit plant could be obtained from the Vache Grasse Creek by providing storage adequate to conserve the excess runoff during periods of high flow. Additional quantities of water necessary for full development of all coal resources in the General Area could be obtained by increasing storage in the Vache Grasse Creek Reservoir, which would supply about two-thirds of the water required; the remainder could be pumped from the Arkansas River. To minimize the effect of mineralization of the Arkansas River, its water would be taken only during periods of high flow.

Since the Sebastian-Scott General Area in Arkansas has sufficient coal and water for at least one 10,000 barrel-per-day plant for 40 years, it is designated as a General Area of Coal and Water Availability.

The estimated initial capital cost to supply process water for a unit plant in Arkansas is $3,941,000, as of March 31, 1950. This cost is based upon an adequate process water supply system consisting of impounding reservoir, pumping station, power source, aqueduct, filter plant, and storage at the plant site. The estimated operating cost, as of March 31, 1950, for process water supply is approximately 5 cents per barrel of products, exclusive of return on investment. The unit capital cost of water for complete development in the General Area in Arkansas would be approximately 60 percent of the per barrel cost estimated for one unit plant; unit annual cost would be slightly greater.

Suitability of the General Area

For the coal synthine process, waste heat can supply the steam necessary to generate the required power. However, the requirements for this process indicate the desirability of a stand-by power source. Due to the probability of excess power being available from a synthetic liquid fuels plant, it may be possible to develop satisfactory mutual power agreements with the existing power facilities serving the Sebastian-Scott General Area. Sufficient power for plant construction could be expected to be available from the local utility.

Construction and operation of synthetic liquid fuels plants will in general require direct rail or water connection and a highway connection. Railroad facilities are well distributed in the State of Arkansas except in the northern section. They generally, however, follow a traffic pattern influenced by providing transportation from Kansas City, St. Louis, and Memphis to Louisiana and Texas. The estimated initial capital cost for providing access transportation facilities in the General Area is $122,500; the estimated operating cost is less than 0.5 mills per barrel of synthetic liquid fuel products.

Satisfactorily qualified labor available within the Sebastian-Scott General Area is insufficient to satisfy the new personnel requirements for a unit plant. While it might be possible to satisfy the requirements as to total number alone, by the use of unemployed within a reasonable traveling distance from the plant, there would be a deficiency in workers possessing the desired industrial skills. This deficiency would have to be met by in-migration of such workers from surrounding industrial centers.

The average straight-time hourly rate payable in a synthetic liquid fuels unit plant in the Sebastian-Scott General Area is estimated, as of March 31, 1950, at $1.48.

The average net investment required for rental housing and community development in the Sebastian-Scott General Area, exclusive of one-half the residential property (assumed as sold) and of property used for commercial enterprises (assumed as self-supporting), is estimated as of March 31, 1950 at $16,216,304 for a coal synthine unit plant. It is assumed that rental housing will pay for its operating and maintenance costs plus a required return on the investment.

Since the synthetic liquid fuels potential of the Arkansas General Area is small in relation to the predicted future demand in the State and since all but one of the neighboring states contain Suitable General Areas, the potential marketing territory for synthetic liquid fuels plants in Arkansas is defined as including the entire State. Motor fuel consumption in Arkansas in 1948, exclusive of aviation and military use, amounted to 7.7 million barrels. This is equivalent to the gasoline output of about three unit synthetic liquid fuels plants. It is estimated that by 1975 motor fuel requirements in the marketing territory will reach an annual volume of 12.8 million barrels, the equivalent of the output of about 5 unit synthetic liquid fuels plants.

While the major product of coal synthine plants is motor gasoline, minor quantities of other fuels are specified to be produced including Diesel fuel, heavy fuel oil, and liquefied petroleum gases. The proportions of these fuels in relation to gasoline are considerably different from the present demand in the marketing territory. There is, however, some leeway in the process for varying the proportions of the various products. Consequently, it would appear that any large-scale development in the future would require synthetic liquid fuels plants to be designed so as to produce the products then in demand.

Since Arkansas is an important producer of crude oil and petroleum products, the demand for liquid fuels in the marketing territory is economically supplied and synthetic liquid fuels plants
in that State would have no competitive advantage due to location. Ark
Wholesale prices as of June 1, 1950 of petroleum products fob. re- 11
finery as in Arkansas amount to $3.96 per barrel when weighted in the same proportions as the liquid fuel products specified to be
produced by coal synthine plants. The estimates of future demand 700
for liquid fuels in the marketing territory may be substantially reduced by a major increase in liquid fuel prices altering the

basic competitive positions of fuels. The prospective future supply of petroleum appears adequate to satisfy at least a major portion of future requirements for liquid fuels for a long period of years.

At such time as synthetic liquid fuels would be required in Arkansas, the output of a single unit plant or of the total potential plants would probably be transported to the widely scattered markets in the State by railroad tank cars and trucks. Plants in the Arkansas General Area would have minimum costs for distribution of synthetic liquid fuels throughout the marketing territory except possibly in the eastern part of the State along the Mississippi River.

The operation of a synthetic liquid fuels plant, and of the coal mines to supply it with raw material, involves the production of wastes, for the disposal of which provision has been made. Liquid wastes may require skimming and sedimentation and, in some cases, chemical treatment before return to the streams; solid wastes (principally ash from the plant and refuse from coal cleaning) must be transported to the disposal areas and there piled up or compacted.

It is believed that development of the Sebastian-Scott General Area could be planned to conform to all strategic considerations outlined in publications of the National Security Resources Board.

Costs in Suitable General Area

All of the foregoing economic factors are reflected in the total capital cost and operating cost for a synthetic liquid fuels plant in Arkansas. Both cost estimates utilize the Bureau of Mines method for estimating typical unit plant costs as adjusted to existing conditions in the General Area.

The initial net capital cost for a unit coal synthine plant, shown on Exhibit No. 44, is estimated, as of March 31, 1950, to be $119,482,000. This estimate provides for adequate coal and water supply, plant facilities, and access transportation, and includes a capital amount for housing. In addition, there is provision for adequate plant waste disposal.

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The operating cost from Exhibit No. 44 for a unit synthine plant (excluding return on investment) is estimated, as of March 31, 1950, to be $6.07 per barrel (14.5 cents per gallon) of total products in the Sebastian-Scott General Area. Costs as stated herein, as directed by the Contracting Officer, are based on operating costs of the process rather than on a "cost of service" or selling price basis. Such costs are based on the Bureau of Mines formula and include a basic allowance for plant maintenance of approximately 3 percent of plant investment. They also include an allowance equal to 10 percent of direct labor, plant maintenance, and operating supplies for general administrative and general office overhead (which includes the salaries and wages of a General Manager or a Plant Manager and his immediate staff reporting directly to management); 6-2/3 percent of plant investment for depreciation; and 1 percent of plant investment for insurance and local, county, and State real estate taxes - but they include no allowance for head office or top management costs, selling expenses, return on investment, or sales and corporate (including income) taxes. Costs of coal used in the process have been computed without including selling cost or return on the investment. The cost of water has been estimated on the same basis. Return on total initial capital investment, including coal and water as indicated herein, would require 32.7 cents per barrel of products for each 1 percent gross return before the deduction of income taxes.

The costs are reported as per barrel of total products. Estimates of the equivalent cost of gasoline and credits from the sale of by-products were not considered necessary for the purposes of this report.

PART I - INTRODUCTION

INTRODUCTION

Authorization

At the request of the Secretary of the Interior, the Department of the Army directed the Corps of Engineers to make a survey of the United States and Alaska to determine areas suitable for synthetic liquid fuels manufacture. In order to accomplish this survey, a contract (W 49-129 eng-137) was made between the United States of America and Ford, Bacon & Davis, Inc., (sometimes hereinafter referred to as the Contractor). This investigation and report have been made as a part of that required by the contract. By approval of the Corps of Engineers, Department of the Army, portions of the contract obligations were subcontracted to other firms engaged as experts in their particular fields of operation, as follows:

Subcontract No. 1 to Paul Weir Company, Inc., Chicago, Ill., for coal investigations.

Subcontract No. 2 to DeGolyer and MacNaughton (a corporation), Dallas, Texas, for natural gas investigations.

Subcontract No. 3 to DeGolyer and MacNaughton (a corporation), Dallas, Texas, for oil shale investigations.

Subcontract No. 4 to Malcolm Pirnie Engineers, (a partnership), New York City, for water supply investigations.

Subcontract No. 5 to Max W. Ball (an individual), Washington, D.C., for investigations of oil-impregnated strippable deposits.

Purpose

This study was undertaken to determine the potential synthetic liquid fuels production capacity of the State of Arkansas. To make such a determination, three categories of study are usually required; in order, they are:

1. Investigate the reserves of coal, natural gas, oil shale, and oil-impregnated strippable deposits available for the manufacture of synthetic liquid fuels.

2. Select General Areas of Raw Material and Water Availability.

3. Determine the suitability of each General Area so selected for the production of synthetic liquid fuels.

Scope of Survey

In the selection of General Areas suitable for the location of synthetic liquid fuels plants, where all plant requirements can be met, the survey does not select or establish specific sites for the construction of a plant. The studies are based primarily on available information and data obtained from various authoritative sources. No detailed field surveys were carried out but a brief reconnaissance was made of the General Area in Arkansas.

Each of the subcontractors has made surveys and reported on raw materials in Arkansas in accordance with his individual contract. Their descriptions of conditions and their conclusions have been incorporated in appropriate sections of this report.

The raw materials considered in this survey are:

(a) Coal
(b) Natural gas
(c) Oil-impregnated strippable deposits (limited to the determination of raw material reserves).

No report was authorized in relation to oil shale deposits in Arkansas because it was considered that Arkansas either did not have supplies of such raw material or that known deposits of such raw material were of doubtful economic importance.

Because of the large known deposits of coal in Arkansas and their economic importance, a complete detailed study of that raw material was authorized by the Corps of Engineers. This comprised, in addition to the determination of available coal, a determination of water availability and a critical examination of the suitability of other conditions affecting plant location for the manufacture of synthetic liquid fuels.

As available information indicated that deposits of natural gas and oil-impregnated strippable deposits do not exist in Arkansas in sufficient quantities to constitute reserves, as defined herein for the production of synthetic liquid fuels (although of possible economic importance), the Corps of Engineers directed that the investigation in respect of those materials be limited to a general determination of the nature and extent of such deposits and their suitability or unsuitability for the manufacture of synthetic liquid fuels. The scope of the required report, as well as the conclusions contained in this report that available information indicated insufficient deposits of these materials to constitute reserves for the manufacture of synthetic liquid fuels, obviate the necessity for making an investigation with respect to these materials as to General Areas suitable for the location of synthetic liquid fuels plants.

To facilitate the study, those coal reserves found to be of satisfactory quality and quantity were grouped into an area not larger than a county or 1,000 square miles. Since such area contained reserves adequate for 40 years' operation of at least one 10,000-barrel-per-day synthetic liquid fuels plant, the area was designated as a General Area of Coal Availability. Since it was found also to have adequate supply of water for at least one 10,000-barrel-per-day plant it was further designated as a General Area of Coal and Water Availability.

This General Area of Coal and Water Availability was then critically examined with reference to the following factors to determine its suitability for the production of synthetic liquid fuels.

1. Raw materials
2. Water supply
3. Power
4. Access transportation
5. Labor
6. Housing
7. Marketing and products transportation
8. Waste disposal
9. Plant investment
10. Processing costs
11. Strategic Considerations.

PART II - GENERAL

GENERAL

The terminology used in this report is that in general use and acceptance. Such terms, together with those idiomatic to this survey, are defined in the following paragraphs:

Definition of General Terms

General terms used in this report are defined as follows:

A General Area as used herein is not larger than a county or 1,000 square miles, depending on local conditions. General Areas are used to facilitate the detailed study of parts of a state, and are designated by name or number.

A General Area of Coal Availability is one where adequate coal reserves are available for 40 years' operation of at least one 10,000-barrel-per-day synthetic liquid fuels plant, in conformity with raw material requirements for such plants.

A General Area of Coal and Water Availability is one where both adequate coal reserves and water supply are available for 40 years' operation of at least one 10,000-barrel-per-day synthetic liquid fuels plant, in conformity with raw material and water requirements.

A Suitable General Area is one which meets all requirements for 40 years' operation of at least one 10,000-barrel-per-day synthetic liquid fuels plant using coal, in conformity with plant requirements as to raw materials, water supply, power, transportation, labor, housing, marketing and transportation of plant products, waste disposal, and strategic considerations.

A Unit Plant is the amount of production capacity adopted in the survey for purposes of comparison and for estimation of investment, operating costs, etc. It is not necessarily the most efficient size for an independent plant. The size adopted in the survey as a unit plant is 10,000-barrel-per-day capacity for the synthine process using coal.

Definitions of Coal

Anthracite Coal - A slow burning coal with 86 percent or more of fixed carbon (mineral-matter-free basis).

Bituminous Coal - Coal having less than 86 percent fixed carbon (dry, mineral-matter-free basis) and, if fixed carbon is less than 69 percent, having a heating value of 11,000 or more Btu (moist, mineral-matter-free basis) and either agglomerating or nonweathering.

Lignite - A dull, brown compact fossil wood having a heating value of less than 8,300 Btu (moist, mineral-matter-free basis).

Types of Coal Mining and Related Terms

Strip Mining - The method of first removing the overburden so as to expose the coal seam, usually by power shovels or drag lines and then "loading" the coal.

Underground Mining - The method of coal extraction through underground operations, usually by driving a tunnel or drift, or by sinking a slope or shaft.

Overburden - In strip operations, comprises the soil or surface material, or the geological formation overlying the coal seam.

Stripping Ratio - The ratio between the thickness of the overburden and the thickness of the underlying coal seam.

Overburden Ratio - The ratio between the cubic yards of overburden and the tons of recoverable coal.

Geological Terms

Geological terms in common use include the following:

Horizon (Geological) - Strata formed at the same geological time at different locations.

Stratigraphic Section - A vertical cross section showing the relative position and thickness of geological formations in a particular area.

Coal Bed or Seam - A well-marked or homogeneous division of a stratified series, characterized by a more or less well-defined divisional plane from its neighbors above and below.

Dip - The angle which the plane of a bed makes with the horizontal plane.

Outcrop - The occurrence of any geologic stratum at or immediately below the surface of the ground.

Parting - Extraneous material in a coal bed, in a relatively thin layer, separating parts of the bed. When parallel to the plane of the coal, partings usually consist of sedimentary material such as clay, shale, slate and sandstone. Partings which cross the coal beds commonly may contain calcite, kaolinite, or pyrite.

Bench - A stratum of coal forming part of the seam.

Bone (or Bony Coal) - Slaty coal or carbonaceous shale found in coal seams.

Terms Relating to Classification and Analysis of Coal

Among the terms in general use relating to analysis, classification, and mining of coal are the following:

Raw Coal - Coal as it comes out of the mine, not having been subjected to cleaning or any other preparation.

Merchantable Coal - Processed or cleaned coal of a quality acceptable for commercial use, and generally equivalent (or in some cases, superior) in analysis to that of a channel sample; i.e., secured from coal in place, (see definition of mine sample, face sample, etc.).

Recoverable Coal - That portion of the total estimated coal in place that can be delivered as merchantable coal, after being mined and (where necessary) washed or otherwise cleaned, primarily to remove ash.

Proximate Analysis - An analysis made of coal for the determination of moisture, volatile matter, fixed carbon, and ash.

Ultimate Analysis - An analysis made of coal for the determination of constituent elements, as sulfur, hydrogen, carbon, nitrogen, oxygen (by difference), and ash.

The As-received condition representing the sample as received at the laboratory, and, for mine samples it approximates closely the condition of the coal in the mine.

Moisture-free - A condition, actual or assumed, permitting the determination or calculation of the analysis of a coal sample excluding its moisture content.

Moisture and ash-free (Maf) - An assumed condition permitting calculation of the analysis of a coal sample excluding its moisture content and its ash content.

Rank - The stage of coalification. A series showing coal rank, in order of decreasing completeness, follows:

Rank of Coal

Class	Group	Abbreviation
Anthracite	Meta-anthracite	Ma
	Anthracite	An
	Semi-anthracite	Sa
	Low-volatile bituminous	Lvb
	Medium-volatile bituminous	Mvb
Bituminous	High-volatile A bituminous	Hvab
	High-volatile B bituminous	Hvbb
	High-volatile C bituminous	Hvcb
	Subbituminous A	Suba
Subbituminous	Subbituminous B	Subb
	Subbituminous C	Subc
Lignite	Lignite	Lig
	Brown coal	Bc

Heating Value - Heat (gross) resulting from combustion of one pound of coal, expressed as Btu per pound with specification of sample condition, as "as-received", "moist, mineral-matter-free", "moisture- and ash-free" or "dry".

Btu (British Thermal Unit) - Quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit. Btu determinations for coal may be made or reported on one or more bases, as:

(1) As-received
(2) Moisture-free (i.e. dry)
(3) Moisture- and ash-free (Maf)

Mine Samples - Face Samples or Channel Samples - A sample secured from coal in place in the ground in accordance with procedures specified by the U. S. Bureau of Mines, which requires that such sample be obtained by collecting material in a uniform channel extending from roof to floor of bed, except that partings of shale, bone, and pyrite 3/8 inch or thicker and lenses or concretions of pyrite or other impurities more than 2 inches in maximum diameter, or 1/2 inch in thickness, are excluded. Such analyses are representative of merchantable coal obtainable from a mine.

"Tipple" Samples - Samples collected, in accordance with Bureau of Mines procedure, after the coal has received final treatment at the tipple or cleaning plant, or as it is loaded into railroad cars or trucks.

Delivered Samples - Samples taken, in accordance with Bureau of Mines procedure, from coal delivered for (Government) use as unloaded from the railroad cars or trucks.

Inorganic Sulfur - That portion of the total sulfur content (in coal) which exists in the form of sulfides and sulfates, the former commonly being iron pyrites, marcasite, chalcopyrite, arsenopyrite, and stibnite, with calcium sulfate (gypsum) the more usual sulfate.

Organic Sulfur - That portion of the total sulfur content other than the mineral sulfides and sulfates, which is combined in organic compounds.

Washability of Coal - The extent to which extraneous objectionable impurities (such as mineral matter, bone, and/or inorganic sulfur) can be reduced by treatment in commercial coal cleaning plants, with due consideration to the loss of coal which accompanies such treatment and the size limits of the coal before and after treatment.

Survey Specifications as to Minimum Requirements for Coal

The minimum requirements for coal deposits considered in this survey are as follows. Definitions of strip coal are included for completeness, although no coal reserves are classified as strippable.

1. Thickness -

   A. For coal to be mined by underground methods:

      (a) Anthracite and Bituminous - At least 24 inches.

      (b) Lignite - At least 48 inches.

   B. For strip-mined coal - Minimum thickness 12 inches.

2. Depth

   A. Underground-mined Coal - Not more than 1,500 feet below drainage level.

   B. Strip-mined Coal - Not more than 200 feet of overburden.

      Stripping Ratio (for coal mined by stripping) - Not more than 40 to 1 up to 75 feet of overburden, and 8 to 1 for overburden in excess of 75 feet.

The classification of coal deposits as "strippable" shall be governed by the experience and good judgment of the coal subcontractor as to the economy of that operation.

3. Minimum Recoverable Tonnage (in an area of 3 miles radius) - 30,000,000 tons for underground mining or 5,000,000 tons for stripping.

Survey Classification of Coal Reserves

Coal reserves have been classified into three groups, and the tonnages of each have been computed, on the basis of the following definitions:

Measured Coal - Coal for which tonnage is computed from dimensions revealed in outcrops, trenches, mine workings, and drill holes, with the points of observation, in general, on the order of 1/2 mile apart.

Indicated Coal - Coal for which tonnage is computed partly from specific measurements, and partly from projection of visible data for a reasonable distance on geologic evidence; the points of observation, in general, are of the order of 1 mile apart but may be as much as 1-1/2 miles for beds of known geologic continuity.

Inferred Coal - Coal for which quantitative estimates are based largely on broad knowledge of the geologic character of the bed or region, and for which there are few, if any, measurements. The estimates are based on an assumed continuity, for which there is geologic evidence. Where there are only outcrop data on which to base estimates, such inferred coal is that lying more than 2 miles in from the outcrop and within limited areas (established as described by Paul Averitt, of the U. S. Geological Survey in a paper published in the magazine "Mining Engineering" of June 1949).

Classification of Coal Reserves in respect of Plant Requirements

Available Coal Reserves - The amount of estimated recoverable coal remaining after deduction of estimated commercial and industrial requirements. Available coal reserves include primary and secondary reserves.

The classification of anthracite and bituminous coal reserves as primary or secondary is based upon thickness of seam and class of reserve as measured, indicated, or inferred. Thus, primary reserves for underground mining include only beds 28 inches or more in thickness which are classed as either measured or indicated. Definitions of strip coal are included for completeness, although no coal reserves are classified herein as strippable. The complete classification is as follows:

1. Primary Reserves ("Measured" and "Indicated" only)

   a. Underground - At least 28 inches in thickness.

   b. Strip - Minimum thickness of 12 inches. Not more than an average depth of 75 feet of overburden; stripping ratio not to exceed 15 to 1.

2. Secondary Reserves ("Measured", "Indicated", and "Inferred" not included in Primary Reserves)

   a. Underground - At least 24 inches in thickness.

   b. Strip - Minimum thickness of 12 inches. Not more than an average depth of 200 feet of overburden; stripping ratio not to exceed 40 to 1 up to 75 feet of overburden and 8 to 1 for overburden in excess of 75 feet.

Terms Relating to Water Supply

Surface Water - Water in a natural open channel or a natural lake.

Ground Water - Water existing below the surface of the ground in a porous material. It may be either stationary or moving.

Firm Water - A quantity of water that is available for use at all times - year in and year out.

Acre-foot (Af) - A quantity of water necessary to cover an area of one acre with water one foot deep.

Collection of Data

In the course of the investigation, all available data pertaining to Arkansas were obtained from various sources, especially the U. S. Geological Survey, U. S. Bureau of Mines and various Arkansas State agencies. Certain information of value was secured from private agencies, from local Chambers of Commerce, and from individuals.

A brief reconnaissance was made of the area selected as a General Area of Coal and Water Availability.

PROCESSES AND PLANT REQUIREMENTS

Processes Considered for Arkansas

The term "synthetic liquid fuels" as used in this report is applied to liquid fuels made by the synthine process using low-volatile bituminous coal as raw material. The hydrogenation process was not considered because of the high fixed carbon content of the available coals.

Unit Plant

As a basis for estimates for purposes of comparison in this survey, a unit plant (unit of plant capacity or unit capacity) has been adopted which is not necessarily the most efficient size for an independent plant. The production capacity to be understood for the coal synthine process, when the term "unit plant" is used, is 10,000 barrels per calendar day.

Basis of Estimates

The prime purpose of the estimates of construction and manufacturing cost presented in this report is for use in determining the relative desirability of individual areas as potential locations for synthetic liquid fuels plants. Since it is probable that some years would be required to construct any significant number of plants of this magnitude, it was decided for comparative purposes to base estimates of plant requirements and plant product costs upon the assumed use of certain improvements in process (including the direct pressure gasification of coal) which are still under development here or abroad, but which appear reasonably likely to be applicable by the time any synthetic liquid fuels program could be well under way. If synthetic liquid fuels plants were constructed today, basic requirements and costs might be appreciably higher than the estimates given, due to the necessity for the use of equipment and processes now commercially available. In drawing other than relative conclusions from these estimates, this qualification must be clearly recognized.

Detailed data as to plant requirements, products, and plant wastes, for typical plants operating on the synthine process, as furnished for use in this report, are shown in Exhibit No. 1.

Synthine Process Using Coal

History. Early work in Germany by F. Fischer and H. Tropsch developed a process to combine carbon monoxide and hydrogen, producing a mixture of alcohols which was called synthol. In 1926, the same men announced a modification of their process to produce, from the same gases, a mixture of hydrocarbons. To indicate the close similarity, this product was termed synthine and has given its name to the process itself.

Intensive development after 1926 resulted in the construction of a commercial plant in 1936 by Ruhrchemie, A.G. Following this installation, the number of synthine plants in Germany increased to a total of ten by the end of World War II. Required carbon monoxide and hydrogen were produced by conventional water gas equipment.

Development of the process by others has been followed for many years by the U.S. Bureau of Mines, which since 1945 has itself carried on active work at Bruceton, Pa. Simultaneously, research on the continuous production of synthesis gas (a carefully proportioned mixture of carbon monoxide and hydrogen) has been under way at Morgantown, W.Va. A 50 to 100-barrel-per-day demonstration plant for the Bureau of Mines is nearing completion at Louisiana, Mo.

Private capital has nearly completed a 7,000-barrel-per-day synthine plant to use natural gas near Brownsville, Tex.

Nature of Process. Except for obvious necessary differences in the production of synthesis gas, and in disposal of waste products, the synthine process is the same whether coal or natural gas is used as the primary raw material.

The synthine process consists essentially of the combination, over a suitable catalyst at pressures of from 200 to 400 psi and at temperatures of from 550 deg to 650 deg F, of carbon monoxide and hydrogen to form a condensable mixture of hydrocarbon vapors. The reaction releases large amounts of heat and, since the temperature may be allowed to vary only within narrow limits, adequate provision for cooling is important. The liquid products are recovered and, for the most part, separated by methods and equipment well known in petroleum technology. Subsequent catalytic cracking or hydrogenation of the heavier oil fractions may be used according to the desired product distribution.

In the reaction, most of the oxygen of the carbon monoxide is converted to water but a part reacts to form carbon dioxide and a series of both water- and oil-soluble oxygenated organic compounds consisting of alcohols, aldehydes, ketones, and acids.

The nature and quality of products of the synthine process depend entirely upon the type of catalyst used and the operating conditions regardless of the raw material used to produce the synthesis gas. This gas can be produced from any material containing combustible carbon, the hydrogen being obtainable by reaction of steam and carbon monoxide.

The principal raw materials suitable for the synthine process are coal of all ranks and natural gas. Of these, the former is available in much larger quantities. Although the latter is commonly less expensive, it is also usually less available when existing commercial demands are satisfied.

The appended block flow diagram, Exhibit No. 2, indicates a typical arrangement for such a plant, consistent with the above description and with the specific unit plant design, for which estimated construction and operating costs are given in this report. However, the synthine process is more or less flexible in application, and variations in method of synthesis gas production, type of synthesis reactors, number of reaction stages, steps in product processing and manner of separation or reuse of oxygenated chemical by-products may be used in individual plants designed to meet different local conditions.

Plant Requirements. The synthine process uses major quantities of coal and of water, both for consumption in the process, and the latter as coolant and for miscellaneous purposes.

Other necessary materials, including chemicals for catalyst manufacture, for the treatment of intermediate liquid products, and for imparting anti-knock properties to finished gasoline, are of relatively small amount.

Coal. Coal for the synthine process may be of any rank and of almost any quality although low quality (heating value) will obviously increase the quantity required for a given plant capacity. A unit plant of 10,000 barrels daily capacity would require daily about 4,600 tons of Arkansas coal, the exact amount dependent upon the heating value. Ash content is not inherently objectionable but should preferably be as low as possible. To this end, good washability is desirable. The maximum permissible ash content is 20 percent (dry basis). High sulfur content in the coal is to be avoided because of the necessity for nearly complete sulfur removal from the synthesis gas, in order to maintain catalyst activity.

Water. Water is required in a synthine plant mainly for cooling purposes. Too high a solids content will somewhat increase the requirement for solids control in cooling towers and boilers. From one-eighth to one-fourth of the water used must be capable of treatment to provide satisfactory boiler feed. Less than 1 percent need be of potable quality or fit to be made so by chlorination and other treatment. For a unit plant, the total daily requirement is about 11,150,000 gallons per day.

Power. The basic chemical reactions of the synthine process liberate quantities of waste heat sufficient for the generation of all required electric power and no additional fuel for power would be required. Outside power is required for starting up and in the event of temporary failure of plant generating facilities. Integration where possible of plant facilities with an existing power network merits consideration.

Personnel. Operating personnel for a synthine process plant must be largely of a high class of semitechnical labor as in the petroleum refining and chemical industries. Because of the use of pressure equipment, the same is true of a substantial proportion of maintenance labor. Indirect personnel includes such classifications as material handlers, stock clerks, guards, watchmen, janitors, and laborers. Technical workers will require a certain amount of training in specialized plant operations and maintenance. The Bureau of Mines has estimated that 80 percent of the technical workers can be trained from an inexperienced labor supply.

The number of employes of a unit plant will vary slightly according to the proportions of the total output represented by the various final products, but may be stated for a typical example as follows:

Personnel Required for
a Typical Unit Coal Synthine Process Plant
in Continental United States

Classification	Number of Personnel
Operations:	
Wage Earners	338
Supervision	34
Maintenance:	
Wage Earners	420
Supervision	42
Indirect Labor (Wage Earners)	103
Indirect Salaried Personnel	198
Total	1,135

Plant Products and By-products. The synthine process can produce a series of hydrocarbon liquid products comparable to petroleum fractions and meeting similar commercial specifications. Although it is expected that normally a preponderant part of the output will be gasoline, a certain limited flexibility is possible in design and operation through variations in the catalyst used and in operating conditions.

Gasoline quality from a synthine plant varies widely with the type of catalyst used. The German practice of using cobalt produced gasoline of markedly low octane number. Use of iron catalysts and higher operating pressures as contemplated by the Bureau of Mines are expected to result in entirely satisfactory motor gasolines.

Diesel oil by the synthine process is expected to be of good quality with a cetane number of about 55. The typical fuel oil product is expected to meet specifications for a higher grade than No. 6 (Bunker C), possibly as high as No. 3.

A small amount of liquefiable petroleum gases (L.P.G.), principally propane, may be produced as final product (as assumed in the basic data for a typical coal synthine plant, see following table) or may be recycled or burned as plant fuel. The same is true with respect to a series of oxygenated organic compounds formed by part of the oxygen content of the synthesis gas. Most of these products, alcohols, aldehydes, and acids, have a definite though limited market which probably could not absorb the output of such chemicals from any large production capacity of synthetic liquid fuels by the synthine process. Recycling of any of these materials is entirely possible and would result not only in solving a disposal problem but also in somewhat increased liquid fuel output or alternatively decreased raw material consumption. This practice is assumed in the specific plant design for which cost estimates are given in this report.

Wastes. Solid wastes of a typical synthine plant processing coal will consist principally of ash from the coal processed or burned as fuel. The small amounts of spent catalyst (mainly iron oxide) included will be no more obnoxious than the ash. Disposal of this waste offers no problem, except perhaps in quantity, that is not readily met in the case of any large coal-burning industrial plant.

Gaseous wastes will be principally those removed in the purification of the synthesis gas, especially hydrogen sulfide resulting from sulfur in the coal. In order to avoid atmospheric pollution, the hydrogen sulfide may be converted to sulfuric acid or elemental sulfur, the sale of which would provide a credit against cost of sulfur removal.

Liquid wastes of the plant can be handled so as to skim those carrying oils and to segregate those containing dissolved organic compounds from the process. Such segregated water, before discharge, may be treated for recovery of these compounds, either for sale or for recycling. Alternatively, it may be fed to special boilers to produce a contaminated steam replacing part of the normal process requirement. Relatively small quantities of sanitary and storm sewage can be handled by well-known methods. Some water from cooling tower operation and boiler blowdown will be discharged with an increased content of dissolved solids.

Typical Synthine Plant (Using Coal) for Continental United States. Based on the results of extensive research and development work of its own, as well as upon available data of other investigators in the United States and in Germany, the Bureau of Mines has in the course of preparation estimates of construction and operating costs of a synthine plant of commercial scale.

Preliminary data from this study, for a plant producing 10,000 barrels of synthetic liquid fuels per day from western Kentucky bituminous coal, a specific case, have been adopted for this survey for estimating construction and operating costs of a unit plant, to be used as a basis of comparison for determining relative suitability of General Areas. In drawing other than relative conclusions from these cost estimates, however, the preliminary nature of the data so far available must be remembered. The final estimates determined by the Bureau at the completion of its work may differ appreciably from the present figures.

More generalized data may be summarized as follows for a typical unit plant:

Basic Data and Estimates
for Typical Coal Synthine Unit Plant
in Continental United States
(Based on preliminary data from U.S. Bureau of Mines)

Plant Area - Acres (minimum)	77
Estimated personnel:	
Operations and maintenance (including all indirect labor)	937
Administrative, clerical and engineering (salaried personnel only)	198
Total daily coal requirements - Billions of Btu	126
Power required at 100% load factor - Kw (produced from waste heat)	114,500
Daily water requirements - Gallons	11,150,000
Total production - Barrels per calendar day:	
Propane	470
Gasoline	7,280
Diesel oil	1,900
Fuel oil	350

The current stage of development of the synthetic liquid fuels program does not permit the statement that any specific plant represents average conditions for those which may be constructed. Variations from the mean, however, will not seriously affect the utility of such a plant as a basis for the purpose of the survey; i.e., the determination of the relative suitability of General Areas.

PART III - SUMMARY OF STATE CHARACTERISTICS

SUMMARY OF STATE CHARACTERISTICS

Surface Features

The topography of Arkansas is about one-quarter mountainous, this being in the northwest portion of the State. The rest of the State is largely composed of alluvial lands and bottom lands of the Mississippi River, which is the State's eastern boundary. Coal is found in Arkansas in a limited area in the western part of the State adjacent to the Arkansas River which drains this area and flows across the State from west to southeast. The terrain of the coal-bearing sections is relatively mountainous.

Climate

Exhibit No. 3 shows the mean monthly temperatures and precipitation at Fort Smith which was selected as indicative of the coal region. The mean temperature in Fort Smith varies from 39.5 deg F in January to 81.5 deg F in July. The annual mean temperature is 61 deg. F. The rainfall at Fort Smith has averaged 39 inches annually.

Population

A preliminary count of the 1950 U.S. census put the population of Arkansas at 1,901,631, equal to a population density of 36 persons per square mile over the entire State and a decrease of 2.4 percent since 1940. The population of Sebastian and Scott Counties, which contain important coal deposits as discussed later, was according to this 1950 census 73,966, equal to a population density of 52. Of this total, 47,864 was attributed to Fort Smith, the State's second largest city. The population of these counties has decreased 3 percent in the last 10 years although Fort Smith has increased in size 31 percent in this time.

Industry and Agriculture

Arkansas is primarily an agricultural State, with cotton the principal crop. The major manufacturing industries are lumber and timber products, food products, cottonseed products and petroleum refining. In the coal-bearing region of the State, the chief sources of income are from agriculture and livestock, lumber, glass products and furniture manufacture, the coal mines and the natural gas fields. The following table shows the size of manufacturing establishments in Arkansas as compared to the United States total. The population figures are from the 1950 census and the remaining figures from the 1947 Census of Manufactures:

Comparison of Manufacturing Establishments in Arkansas and in the United States

Employes per Establishment	Arkansas: Number of Establishments	Arkansas: Percent of Total	United States: Number of Establishments	United States: Percent of Total	Arkansas Percent of the United States
1- 19	1,337	69.5%	157,651	65.4%	
20- 99	450	23.4	58,688	24.4	
100-499	120	6.2	19,878	8.3	
Over 500	17	0.9	4,664	1.9	
Total	1,924	100.0%	240,881	100.0%	0.8%
Population	1,901,631		150,697,361		1.3%

Transportation

The following major railroads serve the coal-bearing area of Arkansas: Missouri Pacific, Chicago Rock Island and Pacific, St. Louis & San Francisco, Kansas City Southern and Midland Valley. The Mississippi River on the eastern border of the State offers water transportation, and there have been proposals to make the Arkansas River navigable.

PART IV - RAW MATERIALS

COAL

General Geology of Coal Deposits

(See Exhibit No. 4, Coal Bibliography, for references below)

Bituminous and semi-anthracitic coal-bearing formations of Pennsylvanian age occur in a relatively limited area in west-central Arkansas, where they underlie portions of eight counties. This area forms the eastern end of the southernmost portion of the coal basin extending through Iowa, Nebraska, Missouri, Kansas, and Oklahoma, which is designated as the Western Region of the Interior province by the U. S. Geological Survey.

The coal-bearing strata in west-central Arkansas represent an eastern continuation of the adjoining and contiguous coal deposits in southeastern Oklahoma. The coal beds extend into Arkansas in a general east-west direction for a distance of approximately 75 miles, with a width of approximately 35 miles from north to south, along the Oklahoma-Arkansas State line, decreasing toward the eastern end to approximately 20 miles. The coal measures of west-central Arkansas are lower Pennsylvanian in age, being largely composed of alternating beds of sandstone, shale, and coal. These sediments were deposited in an elongated area of accumulation, with a maximum total thickness of approximately 12,000 feet, and are characterized by a number of intra-formational unconformities, which are further complicated by considerable divergence and convergence of individual stratigraphic units, with associated irregularities in formational thicknesses.

After original deposition and consolidation of coal beds and associated strata, the coal field was deformed and compressed by crustal stresses directed outward from the Ouachita mountain-forming disturbance, which took place south and southeast of the coal-bearing area. The present coal field of west-central Arkansas is located in a comparatively narrow basin along the Arkansas River, between the Ouachita Mountains on the south and the Ozark (Boston) Mountains on the north. This belt is composed of numerous, long, tightly-folded anticlines and comparatively broad, shallow synclines, whose axial directions are parallel or subparallel to the faulted and folded zone of older formations at the southern edge of the coal-bearing area. The intensity of folding decreases progressively toward the north, with the structures gradually merging with the poorly defined structural irregularities of the mountainous plateau north of the coal field. The coal bed outcrops and occurrences of west-central Arkansas are directly associated with the eroded surfaces of the flexures and fault blocks in the folded belt and, in consequence, follow an extremely irregular outcrop and structure pattern.

(References: 1, 2, 3, 6, 8, 10, 12, 15)

The principal coal bed of the west-central Arkansas coal field is the Lower Hartshorne bed, occurring at the base of the McAlester shale formation which overlies the Hartshorne sandstone formation. The Upper Hartshorne bed occasionally overlies the Lower Hartshorne bed in minable thickness. The Charleston and the Paris beds occur stratigraphically above the Hartshorne beds and have variously been classified as either in the McAlester formation or in the Savanna sandstone which overlies the McAlester formation. The Atoka formation, which carries a few thin beds of coal, underlies the Hartshorne sandstone.

The remaining areas of Arkansas other than the principal coal field of west-central Arkansas and the lignite-bearing belt (described immediately hereinafter) form substantial portions of the Ozark Mountains, the Ouachita Mountains, the Mississippi River embayment, and the Coastal Plains of southwestern United States. These areas are not known to contain coal deposits and were not considered further in this report.

Lignite-bearing Strata (See Exhibit No. 4 for references below) In addition to the bituminous and semi-anthracitic coal-bearing fields described above, lignite-bearing strata of Lower Tertiary age curve across the northeastern, central and southern portions of the State, in a general northeast-southwest direction. Lignite occurrences are found in areas of relatively limited extent within this belt. Individual beds are generally confined to lenticular pockets of limited extent and thickness. The following paragraphs give a brief description of the Arkansas lignite-bearing areas:

The lignite beds of Arkansas are largely contained in the Wilcox formation of Lower Tertiary age, which forms a relatively narrow band along the outer rim of sediments in the Mississippi River embayment and the southern Coastal Plain. The strata dip at low rates toward the southeast and south, under a mantle of later Tertiary and recent deposits. Although widespread, lignite occurrences have been especially exploited or noted only in Clay, Greene, Poinsett, Saline, Dallas, Calhoun, and Ouachita Counties.

Arkansas lignites are high in distillation products, yielding both oil and gas in quantities and qualities comparable with products obtained from distillation of cannel coal. Lignite has also been used locally, in relatively small amounts, as industrial and domestic fuel and in the manufacture of briquets. Products from a few areas have been processed for pitch, dyes, and montan wax.

The largest area of occurrence, as revealed by the available information, is in Ouachita County where maximum thicknesses of 8 ft 0 in. have been recorded. The average thickness of beds

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(References: 1, 2, 7, 8, 15)

in this area, however, is from 2 ft 0 in. to 3 ft 6 in., this being less than the minimum thickness which is considered as suitable for synthetic liquid fuels plant supply, according to the definitions established for this survey.

Information on lignite deposits in other portions of the State is insufficient to establish estimates of reserves and suggests that the lignite beds are lenticular in occurrence and limited in individual extent, as well as generally averaging less than 4 ft 0 in. in thickness.

In view of the limited information, the lenticular nature, and the apparent thinness of the beds, the lignite beds of Arkansas do not appear to be suitable for potential production of synthetic liquid fuels and are consequently eliminated from further consideration.

Description of Coal Trade Districts

The coal production of Arkansas is frequently subdivided into as many as 11 coal-producing districts in industrial practice, but the use of districts as definitive areas is commonly restricted to areas of producing mines. Consequently, coal reserves removed from such productive areas would not commonly be recognized as portions of these districts. The consideration of available data on Arkansas coal deposits, accordingly, was conducted by counties rather than by districts.

Although the entire coal-producing area of Arkansas was included within District 14 (Haskell, Le Flore, and Sequoyah Counties, Oklahoma, and all counties in Arkansas) under the Bituminous Coal Act of 1937, common trade practice segregates Arkansas production by individual coal-producing districts. These districts are generally separate areas in which the geographic position and/or the physical characteristics of the coal beds and the accompanying strata have been such as to encourage concentrated development. These commercial producing districts are briefly described in Appendix A.

Sources of Information

The earliest investigations of the coal-bearing regions in
Ark Arkansas were published by the Arkansas Geological Survey in 1888
38b and by the U. S. Geological Survey in 1907. Since these dates the
39a geology of the Arkansas coal fields has been comprehensively de-
3 scribed in subsequent publications by both the State and Federal
70021 Geological Surveys. The Bureau of Mines presented the results of
many analyses of mine samples in 1928. The State Mine Inspector
publishes annual reports on mine production statistics, these pub-
lications affording material information on the location, source,

and extent of production. While the references described above generally contain the major amount of available information on the coal resources of Arkansas, other publications and reports were examined throughout the survey.

Survey Methods and Procedure

In estimating the coal reserves of Arkansas, all pertinent information available from the literature and other sources was posted on previously prepared base maps, with sources of information being appropriately indicated. Each such base map covered an area consisting of one degree of longitude (east-west) and one-half degree of latitude (north-south) on a scale of 1:62,500. Such an area comprises eight 15-minute topographic quadrangle maps as ordinarily prepared by the U. S. Geological Survey. A separate print of each base map was prepared for each coal bed within the area, provided sufficient information was available to permit an evaluation of reserves.

All available information on outcrop, depth and thickness of each bed including the extent of underground and/or strip mine depletion, was posted on each base map area. The areas underlain by coal in each township were carefully analyzed and evaluated prior to delineation of classified areas of reserves. Individual depleted areas were then demarcated and eliminated from further measurement by enclosure within a limiting line located sufficiently far outside the outermost extents of the mined-out area to represent the limit of the probable barrier pillars which would be left between the mined-out area and subsequent mining operations. Where individual depleted areas approached other depleted areas to such an extent that subsequent mining operations in the intervening areas would not be practical, as by groups of mines located relatively close together in many areas of major depletion, the entire area was demarcated and eliminated from further measurement by a similar limiting line. Since the property lines toward which mining operations in active mines may be expected to proceed, were not determined in this survey, it is probable that some portions of such intervening areas thus eliminated may be undergoing current depletion. The amounts of such reserves, which are considered relatively minor in extent, would thus not be included in the total amount of estimated reserves.

Having demarcated and eliminated from further measurement all depleted areas as described above, the remaining areas of reserves adjacent to such depleted areas and to outcrops, including any portions of the bed disclosed by drill hole or isolated shaft records, were classified by lines defining the various areas of measured, indicated, and inferred underground reserves as warranted by the available information and according to the definitions established in Part II of this report. Distinctions between primary and secondary underground reserves were based on average thicknesses of bed within each township.

Each classified area of reserves within each township, as thus delineated, was measured by planimeter to determine acreage, this figure then being multiplied by average thickness of the bed as developed from the data and by a constant of 1,800 tons per acre-foot, following U. S. Geological Survey procedure, to estimate the number of tons in place. The data on thickness of coal and cover and on acreage and quantity of reserves were then tabulated by townships, on basic Coal Data Sheets attached hereto as Exhibit No. 5, with the information and estimated quantities of reserves in each township being grouped by individual beds in each county.

For reasons previously mentioned (in the discussion of coal trade districts) the analysis and study of available data on Arkansas coal deposits were conducted by counties rather than by said districts. Preliminary analysis of such available data indicated that the Charleston and Paris beds were persistently too thin to permit their inclusion in this investigation according to the definitions employed in this survey. The Denning and Spadra coals of the eastern portion of the Arkansas coal field are correlated with the Lower Hartshorne bed of the western portion of the field. This latter bed, then, represents the only coal selected for continuing consideration.

Strip mining was first reported in Arkansas in 1918. Except for a brief period of activity from 1923 to 1928, inclusive, strip mining represented less than 5 percent of total State production until 1941, when it increased rapidly until, in 1944, it represented nearly 33 percent of the total State production, this figure having remained approximately constant since that time. Information on the 1948 production indicated that approximately 82 percent of the strip mining output in that year was obtained from 14 operations in Johnson and Sebastian Counties, with the remainder being obtained from 4 operations in Franklin and Scott Counties. Except in a relatively few favorable locations, the general relationships of coal occurrence and continuity to the topography are such that large areas of strippable reserves are not present in Arkansas and large-scale operations cannot be readily conducted. This is exemplified by the fact that the average annual production in each of the 18 stripping operations in 1948 was only approximately 30,000 tons. The available information in Arkansas is insufficient to permit the delineation of strippable areas, and, accordingly, no estimates of strippable reserves have been made. It is probable that strippable reserves on a State-wide basis, if present, would represent but a slight proportion of the total reserves.

Under the definitions employed in this survey for delineating areas of measured, indicated and inferred coal reserves, estimates of measured and indicated classes of reserves are largely based upon positive points of observation at maximum intervals, as provided by the respective definitions. Estimates of inferred reserves, however, are based largely upon assumption of extent, continuity and thickness for which there is reasonable geologic evidence. While available evidence of continuity and persistence of individual coal beds has thus been taken into account in projecting areas of inferred reserves beyond areas of measured and indicated reserves, the resultant estimates are regarded only as provisional until further evidence from new or hitherto undisclosed exploration becomes available.

The information used in this survey was generally based on data from major sources such as Federal and State publications, annual production statistics, etc. Neither time nor funds were available to this project for complete collection of all potential information in the hands of private interests. Since information from these sources would probably increase the useable information on extent of demonstrated coal reserves above that available from most publications, the estimated primary reserves in this survey would probably tend to increase rather than decrease as and when such additional information may become available in the future.

The diagram following, has been prepared to indicate graphically the results of the previously described Survey Methods and Procedure as those may appear on the individual base maps on which the various coal data are shown in detail.

Elimination of Counties Not Meeting Requirements of Survey

It has been indicated that a number of lignite beds are present in a curving belt across the northeastern, central, and southern portions of Arkansas. Preliminary examination indicated that the available information was insufficient to establish estimates of reserves for the lignite deposits. It was found that the lignite beds were lenticular in occurrence and that average thicknesses were less than the minimum thicknesses for lignite established by definition for consideration in this survey. For these reasons, the counties containing lignite deposits were eliminated from further consideration in this report.

As indicated in the table following, there are eight counties in Arkansas which are entirely or in part underlain by bituminous or semi-anthracitic coal-bearing strata. Preliminary examination revealed that three of these counties (second column of the table) were either largely underlain by strata younger in age than the coal-bearing formations, which effectively concealed

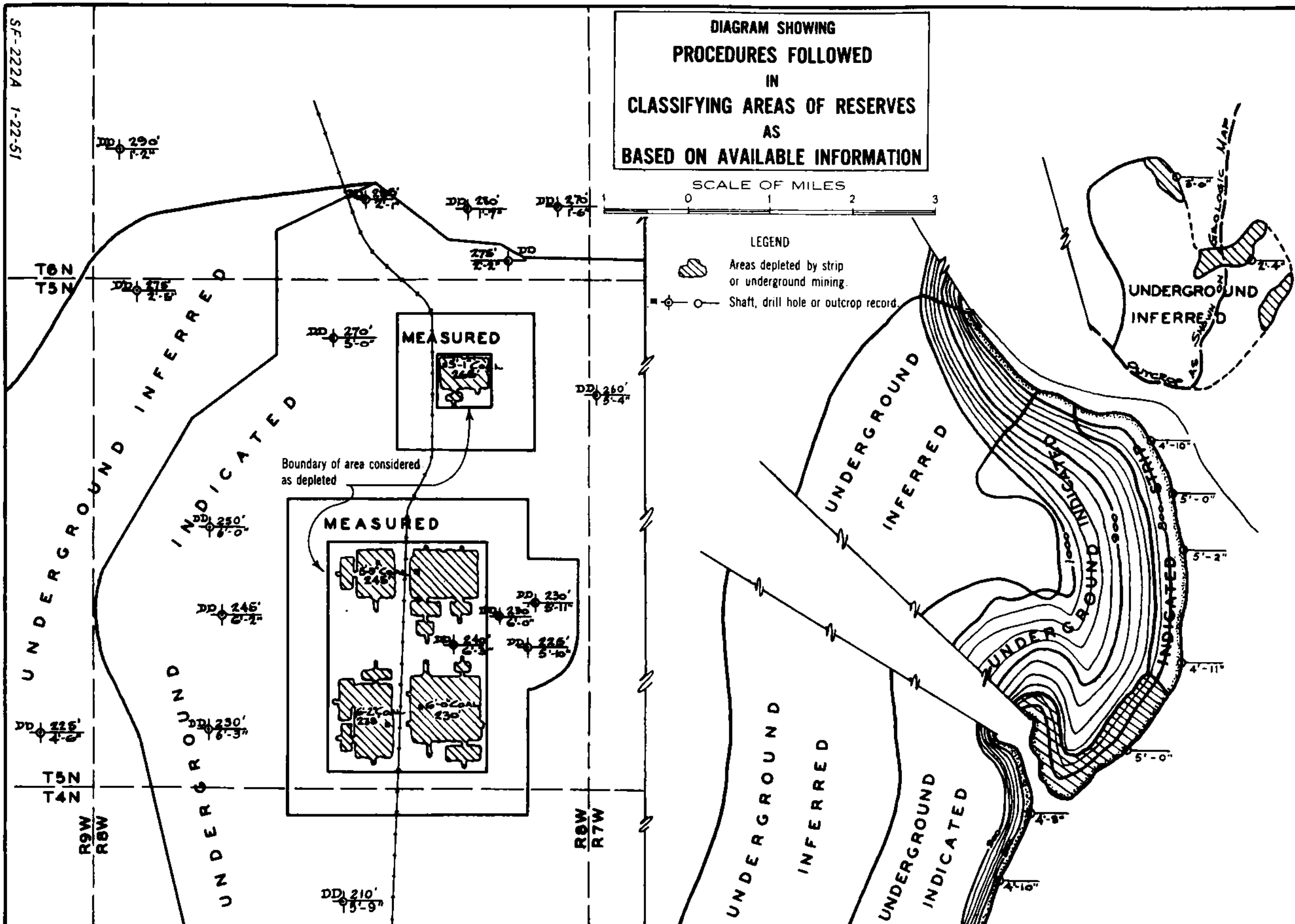
DIAGRAM SHOWING
PROCEDURES FOLLOWED
IN
CLASSIFYING AREAS OF RESERVES
AS
BASED ON AVAILABLE INFORMATION
SCALE OF MILES
1 0 1 2 3
LEGEND
Areas depleted by strip or underground mining.
Shaft, drill hole or outcrop record.
SF-222A 1-22-51
T6N
T5N
T5N
T4N
R9W
R8W
R8W
R7W
UNDERGROUND INFERRED
INDICATED
UNDERGROUND
MEASURED
MEASURED
Boundary of area considered as depleted
UNDERGROUND INFERRED
UNDERGROUND INDICATED
UNDERGROUND INDICATED
INDICATED
STRIP
UNDERGROUND INFERRED
Outcrop as shown on geologic map
DD 290' 1'-2"
DD 275' 2'-8"
DD 270' 5'-0"
DD 250' 6'-0"
DD 245' 6'-2"
DD 225' 4'-6"
DD 230' 6'-3"
DD 210' 5'-9"
DD 260' 5'-4"
DD 230' 5'-11"
DD 226' 5'-10"
DD 270' 1'-6"
4'-10"
5'-0"
5'-2"
4'-11"
5'-0"
4'-8"
4'-10"
2'-4"
1000
900
800

any surface indications of coal reserves, or were too close to the outermost edge of the coal-bearing formation to contain minable areas of even the lowermost coal beds. These three counties were accordingly eliminated from further consideration in this report. The available information on each of the remaining five counties was then compiled by coal beds and examined in detail.

The elimination of the three counties as described above, left five of the original eight counties in which the coal reserves appear to qualify as suitable for synthetic liquid fuels production. These counties are enumerated in the last column of the table, and a summary of their recoverable coal reserves is shown in Exhibit No. 6. The following section of the report describes the nature and extent of the coal beds in these counties and presents some data relating to present commercial production.

Selection of Counties in Arkansas Containing Coal Reserves Suitable for Production of Synthetic Liquid Fuels

All Counties Containing Coal-bearing Strata	Counties Eliminated Because of Fringe Position near Outermost Limit	Counties Selected for Consideration
Crawford	Crawford	
Franklin		Franklin
Johnson		Johnson
Logan		Logan
Pope	Pope	
Scott		Scott
Sebastian		Sebastian
Yell	Yell	

Descriptions of Coal Reserves in Selected Counties

Scott County. (See Exhibit No. 4 for references below) Scott County is the southernmost of the two counties, located along
Ark the Oklahoma State line, which contain coal measures in the west-
44a central Arkansas coal field. The coal-bearing portion of Scott
3 County is located along the southern flank of Poteau Mountain, at
70021 the northwestern corner of the county. Although the syncline occupied by Poteau Mountain extends northeast and eastward across the

(References: 3, 6, 10, 12, 21, 22)

entire north line of Scott County, the Upper Hartshorne bed occurs only as a horizon marker east of the southeast corner of Sebastian County.

The Bureau of Mines report, M.M.S. No. 1807, "Bituminous Coal and Lignite Production in 1948" indicates that approximately 85,000 tons were produced in Scott County in that year, of which approximately 72,000 tons were produced from one stripping operation. The available information indicates that sufficient reserves of the Lower Hartshorne bed are present in northwestern Scott County to warrant further consideration as synthetic liquid fuels plant supply.

The Lower Hartshorne bed dips northwestward under Poteau Mountain from its outcrop, which extends in an approximately northeast-southwest direction along the southern base of the mountain. The rate of dip ranges from 10 to as much as 20 degrees, from the outcrop. The bed is unusually thick at the Oklahoma-Arkansas State line, where it reaches a total thickness of 7 ft 6 in., with a thin shale parting separating the bed into two benches. The thicknesses of this and additional partings increase toward the northeast, so that the bed becomes split into from two to four benches, separated by shale partings, which increase from less than 1 inch to many feet in thickness. Where separated by thick shale partings, the individual benches are generally less than 2 ft 0 in. in thickness.

Sebastian County. (See Exhibit No. 4 for references below.) Sebastian County is the westernmost county in the principal portion of the west-central Arkansas coal field, and contains a number of areas in which mining operations have been extensively conducted. The county is crossed in a generally northeast-southwest direction by a number of sub-parallel anticlinal and synclinal axes, which generally dip toward the southwest. The principal coal of the county occurs in the Lower Hartshorne bed.

Bureau of Mines data on bituminous coal production in 1948 indicate that approximately 712,000 tons were produced from Sebastian County in that year, of which approximately 234,000 tons were produced from 9 stripping operations. The available information indicates that there are relatively substantial reserves of the Lower Hartshorne bed which are sufficient in extent to warrant further consideration as synthetic liquid fuels plant supply.

The Charleston bed outcrops around a shallow syn-
cline in the north-central portion of the county, and along the Ark
flanks of a narrow syncline in the east-central portion of the 44b
county. This bed ranges only from 1 ft 0 in. to 1 ft 6 in. in 45a
thickness, but has been opened by numerous small operations for 3
local fuel supply. 7002

(References: 3, 6, 10, 12, 21, 22)

The <u>Lower Hartshorne bed</u> has been widely mined along both the northern and southern flanks of a combined thrust fault and anticline, which form an east-west strip of barren formations across the northern portion of the county. The bed dips toward the north along the northern limb of the area at rates of from 10 to 17 degrees and toward the south, from the southern portion of the area, at rates of from 5 to 14 degrees.

The outcrop of the Lower Hartshorne bed extends in a generally southern direction across the southern portion of Sebastian County, south of the barren belt, with variations in direction of both outcrop and dip, in conformance with the synclinal and anticlinal axes. As in the northern portion of the county, this bed has been widely mined along large portions of its outcrop by both underground and stripping operations. In this area the dips of the coal bed range from 5 to as much as 25 degrees toward the northwest, west, and southwest. The thickness of the Lower Hartshorne bed in Sebastian County ranges from less than 2 ft 0 in. to approximately 5 ft 0 in.

The <u>Upper Hartshorne bed</u> exists largely as a horizon marker in Sebastian County, at intervals of from only a few feet to as much as 50 feet above the Lower Hartshorne bed. Although occasionally thickening to a maximum of 5 ft 0 in., this bed is inferior in quality and contains numerous partings of shale or bone. The areas of thickening appear to be limited in extent.

The available information indicates that there are substantial reserves of the Lower Hartshorne bed in Sebastian County which are suitable for further consideration as synthetic liquid fuels plant supply. A limiting factor in the estimating of reserves of this bed, in relatively small areas within the large areas of occurrence, is the 1,500-foot depth limitation below major drainage, as provided by the definitions employed in this survey.

<u>Franklin County</u>. (See Exhibit No. 4 for references below) The two coal-bearing areas of Franklin County are located separately in the southern portion of the county, south of the Arkansas River, and in the southeastern corner of the county, north of the Arkansas River. Bureau of Mines data on bituminous coal production in 1948 indicate that approximately 141,000 tons were produced from Franklin
Ark County in that year, of which 25,000 tons were obtained from three
45b stripping operations.
46a
3
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The <u>Paris bed</u> outcrops only in the extreme southern portion of the county and is mostly too thin to support even local mining operations.

(References: 3, 4, 10, 12, 21, 22)

The Charleston bed forms the principal coal of the Charleston district of southern Franklin County. Although averaging less than 2 ft 0 in. in thickness, the bed slopes but gently toward the axes of the relatively small synclines in which it occurs and has been extensively mined by both underground and stripping operations.

The Denning (Lower Hartshorne) bed occurs in the Denning-Coal Hill and Philpott districts of east-central Franklin County, north of the Arkansas River. In the Denning-Coal Hill district, the bed ranges up to 4 ft 0 in. in thickness and has been widely mined along the central portion of the predominant syncline in which the coal is located. The western end of the Philpott syncline in Franklin County has also been extensively mined, although the bed in this district averages less than 2 ft 0 in. in thickness.

Johnson County. (See Exhibit No. 4 for references A below.) Johnson County contains all of the Spadra district in the southern portion of the county and portions of the Denning-Coal Hill and Philpott districts, along its southwestern boundary line. The Spadra (Denning) bed in these three districts is correlated with the Lower Hartshorne bed of Scott and Sebastian Counties. Portions of all three districts have been widely mined. Information indicates that the bed ranges from less than 2 ft 0 in. to a maximum of 4 ft 0 in. in the three separate areas of occurrence. Bureau of Mines data on bituminous coal production in 1948 indicate that approximately 407,000 tons were produced from Johnson County in that year, of which 208,000 tons were produced from 5 stripping operations.

Logan County. (See Exhibit No. 4 for references B below) Logan County contains portions of the Paris district which is located in the north-central part of the county and the Scranton district which represents a southern extension across the Arkansas River from the Spadra district of southern Johnson County. Bureau of Mines data on bituminous coal production for 1948 indicate that approximately 260,000 tons were produced from Logan County in that year, all of which was obtained from underground operations. The available information indicates that a large proportion of this production was obtained from the Paris district.

The Paris bed occurs in the east-west Paris basin near the Franklin-Logan County line in north-central Logan County. Although averaging less than 2 ft 0 in. in thickness, the dips of the bed toward the axis of the shallow syncline are gentle and the bed has been widely depleted. The available information is insufficient to permit estimates of reserves.

(References A: 3, 4, 10, 21, 22)
(References B: 3, 4, 10, 21, 22)

The Spadra (Denning, Lower Hartshorne) bed in the Scranton district of northeastern Logan County is projected from but limited information on continuity and thickness. Such information indicates that the bed ranges from 3 ft 0 in. to 4 ft 0 in. in thickness.

Estimated Percentage of Recovery of Coal in Place

Broad over-all records of percentage of recovery from coal reserves in place in existing underground and strip mine operations in Arkansas are not available. In 1923 the Bureau of Mines prepared a summary report on "Amount and Nature of Losses in Mining Bituminous Coal in Eastern United States", which was published in 1925 as a portion of the Report of the United States Coal Commission, established in accordance with Public Act. No. 347 by Congress on September 22, 1922. This report, which covered only the underground mining which prevailed at that time, found that in 1921 the average amount of coal lost in mining operations in 10 eastern states was 34.7 percent, indicating a recovery of 65.3 percent. The maximum average recovery was 80.0 percent in Virginia, and the minimum average recovery was 51.0 percent in Illinois. No investigations were conducted in Arkansas.

In estimating percentage of recovery from reserves in place across broad areas such as those established in this report, the amount of over-all bed losses entailed in future mining operations would normally be considered as exceeding the average percentage of losses involved in present individual operations, assuming that methods of mining were not essentially changed. The causes of such decreases in over-all recovery in broad areas include coal left in barrier pillars between mines, coal left in mined-over areas when individual active operations are abandoned, coal unmined because of undetected local decreases in thickness, quality, or continuity, coal left in place under towns, cemeteries, railroads, schools, or other reservations, coal left in pillars around oil and gas wells, etc. In this report the recovery from coal reserves in place by underground mining, based upon available data and on providing for possible contingencies cited above, is estimated as 50 percent.

Summary Description of Estimated Coal Reserves

The total tonnage of coal considered for synthetic liquid
Ark fuels manufacture in Arkansas as of January 1, 1949, based on available information and within the limits of reserves specified for
46c this survey as described in Part II of this report under "Defini-
47a tions" and in Part IV under "Survey Methods and Procedure", was
3 estimated at 831,328,000 tons in place or 415,664 tons recoverable.
70021 Because of the limitations imposed by this survey, the estimates

presented herein of reserves considered available for the manufacture of synthetic liquid fuels, are not comparable with other coal estimates which generally include the total coal reserves in Arkansas. For example, in Circular 94 of the U. S. Geological Survey, the total recoverable reserves for Arkansas as of January 1, 1950, (assuming 50 percent recovery) are reported as 766,106,000 tons. The estimate by the U. S. Geological Survey used an estimate prepared by M. R. Campbell in the years prior to 1928, because new appraisals were not available.

The detailed data are presented by township units on the basic Coal Data Sheets (Exhibit No. 5). The recoverable reserves are also indicated on the Coal Data Sheets and summarized in Exhibit No. 6. Diagrammatic outlines of the areas underlain by reserves are indicated on Exhibit No. 7. The estimated total recoverable reserves (415,664,000 tons) are recapitulated by counties in the following table:

Estimated Total Recoverable Reserves (All Underground)
in Arkansas considered for Synthetic Liquid Fuels Manufacture
by Counties, as of January 1, 1949 (A)
(Thousands of Tons)

	Lower Hartshorne Bed (Denning, Spadra)		
County	Primary	Secondary	Total
Franklin	18,864	1,670	20,534
Johnson	54,277	2,517	56,794
Logan	21,042	66,840	87,882
Scott	23,891	4,148	28,039
Sebastian	150,429	71,986	222,415
Total	268,503	147,161	415,664

Note: (A) Estimated in accordance with specifications and procedures established for this survey.

As shown in the foregoing table, five counties were found to contain suitable reserves for production of synthetic liquid fuels according to the definitions and procedures established for this survey. All of these reserves are contained in the Lower Hartshorne bed, which elsewhere is designated as the Denning or Spadra bed. The reserves in Sebastian County are the largest for any of the individual counties, forming over 50 percent of the total reserves in the State. Reserves in the remaining counties range from 20,000,000 tons in Franklin County to approximately 88,000,000 tons in Logan County.

Commercial Coal Production
(See Exhibit No. 4 for references below)

Trends in Production. The earliest indication of coal production in Arkansas by the U. S. Geological Survey was in 1840, when 220 tons were recorded. Since that time, Bureau of Mines data, as of 1948, indicate that a total of 90,414,000 tons of coal has been produced. Achieving its maximum annual production of 2,670,000 tons in 1907, the annual coal production of Arkansas has largely ranged between 1,000,000 and 2,000,000 tons, with a total of 1,662,000 tons in 1948, the last year of record.

Beginning on a small scale in 1918, the percentage of coal produced by stripping did not exceed 5 percent of total State production (except for a brief period of increased activity during 1923 through 1928) until 1941. Strip mine production increased rapidly thereafter, until in 1944 it represented 32.2 percent of total State production, this ratio having remained essentially constant to the present.

Although mechanical loading of underground coal, commonly used as an index of underground coal mechanization, began as early as 1925 in Arkansas coal operations, it had attained only 37.1 percent of total underground production by 1937. Beginning in 1938, however, mechanical loading increased rapidly, until in 1947 and 1948 it represented 80 percent of total underground production. Nearly all of such mechanically loaded production is handled by conveyors.

In common with most other coal-producing states, the average size of mines has increased in Arkansas during recent years. In consequence, the number of active mines has decreased from a high of 146 in 1923, when total production was 1,297,000 tons, to 65 in 1948 of which 47 were underground operations and 18 were strip mines, with a total production of 1,662,000 tons. The average number of employes has also decreased from approximately 4,035 in 1922 to 2,502 in 1948.

Despite increases in mechanization of underground operations and in strip mining, the average productivity in tons per man per day in the Arkansas coal field has increased only from 2.75
Ark in 1918 to 3.69 in 1948. Bureau of Mines data on bituminous coal
48b production in 1948 indicated that, in that year, the average produc-
49a tion per man per day was 2.89 in underground mining and 8.81 in
3 strip mining. These relatively low average outputs per man result
70021 from the thin beds and adverse physical characteristics of the average mining operations in Arkansas.

(References: 4, 8, 21, 22)

Coal Beds Mined. The largest production in Arkansas is obtained from the Lower Hartshorne bed of Sebastian and Scott Counties, with which is correlated the Denning and Spadra beds of Franklin and Johnson Counties. Next in relative importance are the Paris bed of Logan County and the Charleston bed of Franklin County.

Thickness of Coal Beds. The thicknesses of coal beds being mined by commercial operations in Arkansas vary from less than 2 feet to between 7 and 8 feet, the weighted average thickness being approximately 3.1 feet. A special study by the Bureau of Mines in 1945, on underground and strip mining in the United States, indicated the following percentage of production in Arkansas by thicknesses of bed:

Arkansas Coal Production by Thickness of Bed

	Percent of Total Production	
Bed Thickness	Underground	Strip
Less than 2 feet	28.0%	23.2%
2 to 3 feet	35.0	21.1
3 to 4 feet	32.0	6.3
4 to 5 feet	(A)	20.3
5 to 6 feet	-	4.0
6 to 7 feet	(A)	22.3
7 to 8 feet	-	2.8
Weighted average thickness	2.7 feet	3.9 feet

Note: (A) Undistributed between 4 to 5 feet and 6 to 7 feet, 5.0 percent.

Quality of Coal. (See Exhibit No. 4 for references below.) The coal beds of west-central Arkansas range from low-volatile bituminous (lvb) to semi-anthracite (sa) in rank, with the rank generally increasing from west to east. In general, Arkansas coals are superior in quality to coals of Iowa, Missouri, Kansas, and northeastern Oklahoma, largely being of high-grade domestic and industrial qualities. While the Arkansas semi-anthracite does not coke, the low-volatile bituminous coals are strongly coking in character.

(References: 4, 8, 15)

Specific representative analyses of the coal beds determined to contain reserves for potential synthetic liquid fuels plant supply are presented in the summary and detailed tabulations accompanying this report. In large part, the available analyses of coal beds in Arkansas have been obtained from operating mines which are primarily located in the higher-quality beds. The analyses herein presented may not be fully representative of the entire reserves in any specific county, for this reason. But few analyses are available from beds of inferior quality, inasmuch as these have not been developed and operated for commercial industrial competition. The following ranges in selected items of analysis (for coals mined throughout the State) summarize the general quality of the individual beds considered during this survey and for which information was available (as-received basis), with the beds being listed in descending order:

Summary of General Quality of Arkansas Coal Beds
(Mostly Mine Sample, As-received Basis)

Coal Bed	Item of Analysis	Representative	
		Low	High
Paris	Moisture, percent	2.5	
	Ash "	10.0	
	Sulfur "	3.2	
	Btu per pound	13,500	
Denning (Lower Hartshorne)	Moisture, percent	1.4	4.3
	Ash, "	6.4	10.7
	Sulfur, "	1.5	3.0
	Btu per pound	13,250	14,330
Spadra (Lower Hartshorne)	Moisture, percent	1.7	3.1
	Ash, "	8.3	8.6
	Sulfur "	1.8	2.8
	Btu per pound	13,690	13,870
Lower Hartshorne	Moisture, percent	0.8	4.8
	Ash, "	6.7	11.2
	Sulfur, "	0.8	2.5
	Btu per pound	13,270	14,390

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Distribution and Use. Over 98 percent of present commercial production is loaded directly at the mines into railroad cars or trucked to railroads for shipment to destination. Except for coal used at the mines, the remaining production is loaded into trucks. Principal coal-carrying railroads in Arkansas, in the approximate order of tonnage loaded for shipment, as reported by mine operators, are as follows:

Missouri Pacific
St. Louis & San Francisco
Midland Valley
Kansas City Southern
Dardanelle and Russellville Ry. Co.
Chicago, Rock Island & Pacific

The available information on distribution of coal does not permit an analysis of the distribution of Arkansas coal by destination and use, inasmuch as production was included with that of District 14 (Haskell, Le Flore, and Sequoyah Counties, Oklahoma) in compiling such information during the years when these data were available. In general, Arkansas coals are used mainly for power generation, domestic and industrial fuel, coke-making and manufacture of briquets. While prepared at the mines in a variety of sizes, production from east-central Oklahoma and Arkansas (District 14) moves primarily as lump coal and double screened coal with top sizes over 2 inches, as modified mine-run coal with top sizes over 2 inches, and as resultant or dedusted screenings with top sizes over 3/4 inches but not exceeding 2 inches.

Future Coal Requirements. The demand for Arkansas coal has varied only between 1,000,000 and 2,000,000 tons for the past 30 years. Although the low-volatile bituminous coal of the western portion of the Arkansas coal field is adaptable for coke-making purposes, the percentage so used is relatively small. No coke is manufactured in Arkansas. According to Information Circular 7559, published by the U. S. Bureau of Mines in March 1950, 123,000 tons of low-volatile coal and 57,000 tons of medium-volatile coal from Arkansas sources were received at slot-type ovens in the United States for coke production in 1947. With a grand total of over 97,000,000 tons being received from various states for coke production at slot-type ovens, the total Arkansas coal received for such use represented but 0.2 percent of the total for the country.

It is possible that gradual depletion of high-grade coking coals in other states more favorably situated with respect to the principal coke-making centers than Arkansas, would increase the demand for coking coal from those beds in Arkansas which are best adapted to this method of utilization. It is not possible, however, to forecast the amount or extent of such possible rate of increase on the basis of available information. It appears that the future demand for Arkansas coal may approximate the rate of demand which has prevailed in recent years. At the 1948 production rate of approximately 1,662,000 tons, the total demand for Arkansas coal in the next 50 years would be 83,100,000 tons. This figure is used solely as an estimate of future requirements other than for the development of a synthetic liquid fuels industry.

Selection of General Areas of Coal Availability

Elimination of Unsatisfactory Areas. Upon completion of basic mapping and tabulation, each area of reserves was then examined as to location, extent, amount of recoverable reserves, and relationship to other adjacent or nearby reserve areas. Isolated areas with insufficient reserves to provide at least one synthetic liquid fuels plant for a 40-year life were eliminated from consideration. The locations and amounts of estimated recoverable reserves of such eliminated areas are shown in the following table.

Eliminated Areas of Unsatisfactory Reserves

County	Location in County	Estimated Recoverable Reserves in Thousands of Tons Denning and Spadra Beds (Lower Hartshorne)		
		Primary	Secondary	Total
Franklin	SE	18,864	1,670	20,534
Johnson	Southern	54,277	2,517	56,794
Logan	NE.	21,042	66,840	87,882
	Total	94,183	71,027	165,210

Deduction of Coal Reserves for Future Commercial Requirements. The total recoverable reserves in Arkansas considered for synthetic liquid fuels manufacture, as shown in a previous table, are estimated at 415,664,000 tons. It is estimated that the commercial requirements of Arkansas coal for the next 50 years, based on the 1948 production rate of 1,662,000 tons, would be approximately 83,100,000 tons. On these bases, there are 332,564,000 tons available for the production of synthetic liquid fuels.

Substantial areas of underground reserves of coals of superior quality, continuity, or thickness in Arkansas are in the hands of operating companies. While no attempt was made in this survey to confine estimates of reserves to areas not owned or controlled by operating or holding companies, some allowances for present ownership of underground coal were probably unavoidably effected by excluding from the mapping and tabulation of reserves certain relatively minor areas not yet depleted, but lying within major areas of depletion as previously described under "Survey Methods and Procedure". It is considered that such eliminated reserves, at least some of which are probably being depleted by active mines, will supply some portion of the estimated future commercial requirements for Arkansas coal. The total amount of potential supply thus provided, however, is considered as relatively minor in extent.

Demarcation of General Areas of Coal Availability. After elimination of the areas of unsatisfactory reserves, listed in the foregoing table, the remaining areas of reserves were grouped into one General Area of Coal Availability, in accordance with the definitions and procedures established for this survey. Since subsequent investigations indicated the availability of adequate water in this General Area, the area is the same as the General Area of Coal and Water Availability shown on Exhibit No. 8. The locations, boundaries and areas underlain by the included coal reserves in this General Area are diagrammatically shown by this exhibit. The detailed data pertaining to the General Area are shown in Exhibit No. 9. These data include information on thicknesses of bed, depths of cover, rank and quality of coal, area underlain by coal reserves, estimated recoverable reserves (by classes), and the daily capacity of synthetic liquid fuels plants, in thousands of barrels, which could be supported through a 40-year life, by the estimated reserves. The General Area contains adjacent portions of two counties in which the suitable available reserves are contained, within a single geologic and geographic unit.

Exhibit No. 9 indicates that the estimated reserves of 250,454,000 tons in the Sebastian-Scott General Area are sufficient to support a daily capacity over 40 years of 37,000 barrels of synthetic liquid fuels manufactured by the synthine process. It should be noted that the Arkansas coal reserves included within the General Area contain fixed carbon contents which exceed the maximum specifications of fixed carbon content (69 percent, maf) for coals indicated by the Bureau of Mines to be suitable for the hydrogenation process.

Deduction of the 250,454,000 tons to be used as reserves for production of synthetic liquid fuels in the Sebastian-Scott General Area from the total recoverable reserves of 415,664,000 tons in the entire State, leaves a balance of 165,210,000 tons, more than sufficient to satisfy the estimated future commercial requirements, for Arkansas coal (83,100,000 tons). It is possible that a portion of either synthetic liquid fuels supply or future commercial requirements will eventually be obtained from the 165,210,000 tons contained in the eliminated areas of unsatis- Ark
factory reserves. It is likewise possible that present operating 53
companies either own or control some reserves for future commercial production which were not included in the total amount of reserves 7002
estimated herein as available for synthetic liquid fuels plant supply, as previously described under "Survey Methods and Procedure". There is also the probability of additional reserves being developed in areas for which there is not now sufficient information to warrant the estimation of reserves for the purpose of this report.

Under the definitions and procedures employed in this survey and with allowances specified for future commercial production, it is concluded that sufficient coal reserves are available in the Sebastian-Scott General Area of Coal Availability in Arkansas to supply synthetic liquid fuels plants having a minimum capacity of 37,000 barrels per day for a period of 40 years, using the synthine process. It is probable that continued exploration and development of Arkansas coal reserves will result in the discovery of additional reserves for both synthetic liquid fuels plant supply and future commercial requirements in areas for which there is not now sufficient information to permit the present estimation of reserves.

NATURAL GAS

The investigation included a study of all natural gas and oil fields in Arkansas with special reference to the quantity of gas to be recovered, the gas available for synthetic liquid fuels plants, and the cost of gas in the field.

The principal oil and gas fields in Arkansas have been found in sandstones or limestones of Cretaceous or Jurassic Age. The principal gas accumulations are found in the Reynolds limestone of Jurassic age, at depths of 7,000 to 9,000 feet, with initial reservoir pressures ranging from 3,500 to 4,400 psi.

Data relating to remaining available reserves of natural gas in Arkansas, which have an average heating value of 1,022 Btu under standard conditions, are briefly summarized in the following table:

Summary of Estimated Recoverable Natural Gas Reserves in Arkansas
(in Mcf under Standard Conditions)

As of Jan. 1, 1949		
Total		1,057,715,000
Commercial Requirements:		
Contract	907,025,000	
To Be Used in Field	113,390,000	
Total Commercial Requirements		1,020,415,000
Undedicated Reserves:		
Proved Drilled	33,000,000	
Proved Undrilled	4,300,000	
Probable	0	
Total Undedicated Reserves as of Jan. 1,1949		37,300,000

Most of the gas reserves are under contract to plants or gas pipe line companies for domestic, commercial, and industrial use. The weighted average field price for gas under contract ranged from 2.3 to 5.5 cents per Mcf, depending upon the field under consideration and the life of the contract.

In the largest gas field in Arkansas, the McKamie-Patton field located in the southwestern part of the State, the remaining gas reserve is estimated to be 214,000,000 Mcf. The principal gas accumulation in this field exists in a large gas cap partially encircled by a band of oil. For purposes of maximum oil and condensate recovery a program of gas injection is in operation. The gas reserves in this field will not be available for any purpose until the program of gas injection has been completed. At that time, most of the gas will be sold to gas pipe lines under contracts now existing.

The total undedicated gas reserve amounted to only 37,300,000 Mcf, so that there were no available undedicated reserves in Arkansas as of January 1, 1949 meeting the requirements: at least 225 trillion Btu (225,000,000 Mcf of 1,000 Btu) gas producible within a radius of 40 miles and having a heating value of not less than 400 Btu per cubic foot at standard conditions. Discoveries of new fields and extensions of known fields in the interim between that date and the date of this report warrant no changes in this conclusion.

Detailed information pertaining to natural gas forming the basis for conclusions expressed are contained in the report prepared by DeGolyer & MacNaughton which accompanies this report as Appendix B.

OIL-IMPREGNATED STRIPPABLE DEPOSITS

The investigation of oil-impregnated strippable deposits was confined to a review of available data and to a general determination therefrom of the nature and extent of deposits.

Surface or near-surface oil-impregnated deposits outcrop in southwestern Arkansas in Pike and Sevier Counties and in western Arkansas in Scott County.

The available information indicates that none of these deposits is of sufficient richness, thickness, and total quantity to meet the minimum reserve requirements, which require at least 10,000,000 tons of deposits in any 5-square-mile area, in vertically continuous beds at least 15 feet thick, overlain not more than their own thickness by overburden, and yielding at least 10 gallons of oil per ton of deposit.

It is therefore concluded that there are no reserves of oil-impregnated strippable deposits in Arkansas to furnish raw materials for synthetic liquid fuels manufacture.

Detailed information pertaining to the oil-impregnated strippable deposits survey, and the basis for conclusions expressed, are contained in the report prepared by Max W. Ball, which accompanies this report as Appendix C.

WATER SUPPLY

Hydrological Features

There is one General Area of Coal Availability in Arkansas. This area is designated as the Sebastian-Scott General Area and is located in the western part of Arkansas near the Oklahoma-Arkansas State line. This Area has coal reserves adequate for the production of 37,000 barrels of synthetic liquid fuels daily.

The General Area lies entirely within the Arkansas River basin, just south of the Arkansas River. Vache Grasse Creek drains the northern part of the Area into the Arkansas River. The southern part of the Area is drained by James Fork, which flows into the Poteau River in Oklahoma. The relationship of the General Area to the streams in its vicinity is shown on Exhibit No. 10.

The coal region ranges in elevation from 400 to 700 feet, with several mountains over 2,000 feet high dominating the country in the southern part of the Area.

The average annual rainfall in western Arkansas is 47 inches. Within the General Area, it ranges from less than 40 inches in the northern part to almost 50 inches in the mountainous area to the south. During extremely dry years, the rainfall may be only 50 percent of the average.

The runoff in streams in the Area varies considerably depending upon soil conditions such as vegetation, land slopes, and distribution of rainfall. The average runoff of streams near the General Area is 1.1 cfs per square mile, or about one-third of the rainfall. Evaporation, transpiration, and seepage losses account for the remainder.

The runoff is erratic with high flood flows following storms and almost no flow at the end of long dry summers. Ample water supplies for synthetic liquid fuels plants or other purposes could be developed from the streams in the vicinity of the coal area by the construction of reservoirs to impound flood waters for later use during periods of drought. The Arkansas River, which even in dry weather has a substantial flow, is highly mineralized and not satisfactory for water supply purposes during many months of the year.

The coal area is sparsely settled and, except for Fort Smith to the north, there are no communities in and adjacent to the General Area with as much as 2,000 population.

Water Requirements for Synthetic Liquid Fuels Plants

Water is quite essential for synthetic liquid fuels production, not only for steam generated for power but for synthesis gas production in connection with the coal synthine process. Water is used for cooling purposes and for boiler and cooling tower blowdown to remove accumulation of salts left by the evaporated water.

In a coal synthine process unit plant there are approximately 54 billion Btu's that have to be dissipated daily by cooling waters.

Quantity. The following table shows the quantity of water required both for process and domestic use in connection with a synthetic liquid fuels unit project:

Water Requirements for Coal Synthine Unit Project

	Make-up		Consumed		Return	
	Mgd	Cfs	Mgd	Cfs	Mgd	Cfs
Plant Use	11.15	17.25	7.71	11.93	3.44	5.32
Domestic Supply	1.94	3.00	0.49	0.76	1.45	2.24
Total	13.09	20.25	8.20	12.69	4.89	7.56

Process. A detailed statement of the coal synthine process water requirements, given in Exhibit No. 11, shows most of the water use in the plant to be for cooling purposes. The estimates assume recirculation of cooling water over cooling towers.

One-through cooling without the towers would require about 18 times more water but the consumptive use would be much less. It would be feasible only for a unit development located on the bank of a large river or a large lake. The cost of delivering large quantities of water to a remote site would be relatively prohibitive.

In estimating water supplies for the General Area of Coal Availability in the State of Arkansas, total plant requirements have been used without allowance for water returned to the stream as possible waste or sewage. Such waste water might be returned at a considerable distance from the point of withdrawal and might contain considerably more natural salts than the original water diverted and be less desirable for some purposes. Ark

Water use data and cost estimates are based upon average annual demands. The total quantity of water required for concurrent full development in the General Area within the State would be 75 cfs or 48.47 mgd using the synthine process. 59/3

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Domestic. The amount of water to be supplied for domestic purposes, as shown in table at the beginning of this chapter, is affected not only by the total number of workers (determined by the choice of process), but also by the proportion of those workers that would come from already established communities having their own water supplies. Again, in view of the small relative cost of water as compared with the other items contributing to total product eosts, variations in conditions affecting domestic water requirements are relatively small. It is therefore, assumed for this report that domestic water would have to be supplied for all the workers in plant and mine, the service people, and the families of both. A per capita allowance of 150 gallons per day has been made uniformly for the population of the plant-city. This population is arrived at by multiplying the number of plant and mine workers by five. This amounts to 12,955 persons for the synthine process.

Quality. Process water must be relatively clear and free from turbidity and substances capable of clogging condenser tubes, cooling towers, and other equipment. The dissolved solids content is not of major importance except that a high concentration would require frequent blowdown of cooling towers and boilers and would increase the amount of make-up water. Boiler feed waters must be free of organic matter and insoluble solids and suitable for softening. Water for drinking and sanitary purposes in the mines and plants and in the communities serving the developments would have to be potable and of a quality satisfactory to the public health authorities of the State. Water softening might be required for domestic use.

Water Resources

The General Area of Coal Availability in Arkansas lies wholly within the Arkansas River drainage basin. Water for a synthetic liquid fuels plant in this Area could be obtained directly from the Arkansas River or from one or more of its tributaries. The ground water resources are limited throughout western Arkansas and particularly within the General Area. A more detailed discussion of each of these possible sources follows:

The source of information for a large part of the
Ark statistical and technical information found in the water-supply
sections of this report is shown in a Water Resources Bibli-
60 ography, Exhibit No. 12. Acknowledgements for Technical Infor-
mation on Water Supply, Exhibit No. 13, list the individuals
and agencies who rendered assistance in obtaining material for
70021 this report.

Surface Water. The most important sources of water supply for a synthetic liquid fuels development in Arkansas are the Arkansas River and Vache Grasse Creek and other tributaries of the Arkansas River.

Arkansas River. This stream, one of the major rivers of the United States, rises in the Rocky Mountains and flows eastward through some of the most arid land in the United States before reaching the relatively humid section in eastern Oklahoma and Arkansas. It is classified as a navigable stream from its mouth on the Mississippi River upstream to Muskogee, Okla., but the Corps of Engineers has reported that construction of a 9-foot channel is not economically justifiable and that the channel could not be maintained during prolonged drought periods.

The flow of the Arkansas River is highly variable, ranging from low values after long dry periods to raging floods. A hydrograph of the mean monthly flow of the Arkansas River at Van Buren, Ark., since the record was started in 1928, is shown in Exhibit No. 14. The stream flow characteristics of the Arkansas River are summarized in the following table:

Flow of the Arkansas River at Van Buren, Ark.

Drainage Area, Sq Mi	150,300
Period of Record	1928-1947
Mean Flow Cfs	32,330
Mean Flow Cfs per Sq Mi	0.215
Minimum Annual Flow, Cfs	7,523
Year of Occurrence	1940
Minimum Monthly Flow, Cfs	658
Month of Occurrence	Aug.,1934
Minimum Daily Flow, Cfs	245
Date of Occurrence	Aug.21,1934

The low flow of the Arkansas River as it passes the General Area would be barely sufficient to meet the needs of a single 10,000-barrel-per-day plant with once-through cooling and the flows would not be adequate for development of the coal resources beyond 10,000 barrels per day. In any event, the plant site probably would be so far from the Arkansas River that pumping the large quantities of water involved for once-through cooling would not be economical.

The flows of the Arkansas River, however, are adequate at all times to meet the maximum synthetic liquid fuel cooling requirements if recirculation of the cooling water through cooling towers is provided. This arrangement would be satisfactory for the General Areas except that the Arkansas River water is so highly 700
mineralized that it could be used only with difficulty because of

frequent blowdown of the cooling towers and because much more make-up water would be required.

Vache Grasse Creek and Other Tributaries of the Arkansas River. Tributary streams available for water-supply purposes near the General Area include: Vache Grasse Creek, James Fork of the Poteau River, the Poteau River itself, the headwaters of Petit Jean Creek, and other minor streams east of the Area. A tabulation of recorded and estimated stream flow data for tributaries of the Arkansas River in the vicinity of the General Area is shown in Exhibit No. 15.

The natural flow of none of the above streams is sufficient in dry weather periods to provide any substantial amount of water for synthetic liquid fuels water supply, and storage reservoirs would be required to impound the wet weather runoffs.

Water Quality and Stream Pollution. Analyses of surface waters in the vicinity of the coal area in Arkansas are summarized in Exhibit No. 16, and the average mineral content of waters in the Arkansas River during recent years is shown in the following table:

Mineral Content of Water in Arkansas River at Van Buren

	1948 Water Year		1949 Water Year	
	Average	Maximum	Average	Maximum
Dissolved Solids, Ppm	700	1,340	744	1,560
Chlorides, Ppm	292	722	301	778
Hardness as $CaCO_3$, Ppm	193	360	239	355
Mean Flow, Cfs	34,910	-	45,180	-

The shales in western Oklahoma through which the Arkansas River flows contain considerable gypsum and salt and the waters that pass through this area are readily mineralized. The salinity of the Arkansas River water is aggravated by the discharge of oil field brines upstream. By contrast, surface waters originating in the east do not pass through very soluble materials and are, therefore, of much lower mineral content. For example, the average dissolved solids, chlorides, and hardness in water from the Petit Jean Creek at Danville, Ark., during 1949 were 56, 5, and 21 ppm, respectively.

The quality of water in the Arkansas River changes with the seasons. During periods of flood, the water is turbid and relatively low in dissolved mineral matter. During periods of low flow on the other hand, the waters are very much less turbid, but they are harder and contain greater concentrations of dissolved solids. The relationship between dissolved solids and stream flow of the Arkansas River at Van Buren is shown in Exhibit No. 17.

It will be noted from Exhibit No. 17 that the Arkansas River water at Van Buren exceeded 1,000 ppm dissolved solids during three months of the year 1949. That year was comparatively wet with an average flow at Van Buren six times greater than the average flow in the dry year 1940. Chemical analyses are not available for the period of extreme low water, but it is reasonable to assume that the dissolved solids content was often 2,000 ppm, or greater. Exhibit No. 17 indicates also that generally the dissolved solids content exceeds 1,000 ppm in the waters of the Arkansas River at Van Buren when the river flow drops below 10,000 cfs. The flow at Van Buren was less than 10,000 cfs during 40 percent of the time in the 20 years of record since 1928; a flow of less than 10,000 cfs was recorded 75 percent of the time during the dry period of 1939-40.

In addition to difficulties inherent in using highly mineralized water for industrial purposes, the excessive chloride content would make the water unpalatable for long periods of time during drought periods, and other sources would have to be developed for domestic supplies. The Arkansas River is not used anywhere in Arkansas as a source of municipal water supply. Little Rock obtained its water supply from the river until 1938 when an impounded supply was developed on a tributary because of the high mineralization of the main stem of the Arkansas River. The Fort Smith water supply, previously taken from the Poteau River near its mouth, was so adversely affected by the backwater of the Arkansas River that in 1936 this source was abandoned in favor of an impounded supply on a tributary stream 25 miles from the city.

The low flows and the poor quality of Arkansas River water have been modified somewhat by the operation of recently constructed reservoirs upstream in the Arkansas River basin, and may be further modified by the construction and operation of hydroelectric power plants at several of the existing flood control reservoirs in Oklahoma. The Corps of Engineers has also proposed a series of dams on the Arkansas and Canadian Rivers in Oklahoma for flood control, with hydroelectric power facilities included at some of the sites.

If facilities for the production of firm power are installed, as authorized at the existing and proposed flood control projects, storage of flood flows and release of waters from storage through hydroelectric plants would increase substantially the low flows of the Arkansas River and would improve the water quality. In this event, the feasibility of using Arkansas River water alone for process purposes at synthetic liquid fuels plants should be considered, with development of supplies from tributary streams only for domestic consumption. However, at present, development of a water supply of good quality from Vache Grasse Creek for synthetic liquid fuels purposes is more promising.

As indicated in Exhibit No. 16, and as discussed earlier in this report, the waters in the tributary streams in western Arkansas are soft and extremely low in dissolved solids. Pollution is of minor importance in tributaries of the Arkansa River in the vicinity of the coal areas because the communities are so small and few of them have sewerage systems. Acid waste discharges from coal mines in western Arkansas have affected some of the streams, especially during low flow periods, and this condition is likely to be aggravated by coal mining activity in connection with the synthetic liquid fuels plants unless measures are taken to prevent this type of pollution.

The turbidity of the small streams is not high except during periods of heavy runoff. Where storage reservoirs are used to impound the flood runoff of streams, the reservoir would serve to remove much of the silt. Furthermore, the construction of reservoirs would improve the quality of the water, not only by providing for sedimentation of the silt and for natural purification of sewage wastes, but also by blending the runoff during wet and dry periods. The water quality in the reservoir on Vache Grasse Creek would be entirely satisfactory for cooling purposes at a synthetic liquid fuels plant, and conventional coagulation and filtration would render the water satisfactory for domestic purposes and for process uses requiring high quality water. It is expected that the boiler feed water would have to be softened, but softening of domestic water supplies would not be necessary.

<u>Ground Water.</u> Ground water resources in the vicinity of the General Area are limited except along the Arkansas River, where the relatively shallow alluvial deposits might yield large quantities of water. Away from the river, only limited quantities of water are obtained for small domestic or municipal supplies from compacted underlying sandstones and shales.

While an extensive test-drilling and pumping program might demonstrate the feasibility of ground water supply in the vicinity of the Arkansas River, the prospects are not good. Because of the uncertainty of the ground water supply and because of the distance of the alluvial deposits from the assumed plant site, it has been assumed that a surface water supply would be the most practical for a synthetic liquid fuels development in Arkansas.

Water Uses - Existing

Before making a detailed analysis of the development of the possible water resources for synthetic liquid fuels plants, the rights of existing and future downstream users are to be considered.

Municipal and Industrial Uses. Due to the extreme low flow of the streams in this area during drought periods storage is required for municipalities depending on these sources for their water needs. The principal towns, their water uses, and sources of supply are shown in the following table:

Principal Public Surface Water Supplies in the Vicinity of the Coal Area in Arkansas

City	Source	Approximate Population Served	Average Consumption (Mgd)
Fort Smith	Lake Fort Smith	60,000	5.00
Greenwood	Lake on Vache Grasse Creek	1,000	0.04
Mansfield	Impounding Reservoir on Cherokee Creek, a tributary of James Fork	900	0.07
Booneville	Lake	1,200	0.12
Charleston	Lake Charleston	900	0.17
	Total	64,000	5.40

Lake Fort Smith located on Frog Bayou has a capacity of about 12,100 AF. Its full capacity is needed for the municipal supply which serves also Camp Chaffee, a military reservation.

Control Flow. It would not be desirable, in general, to divert or store the full flow of Vache Grasse Creek. Downstream water uses are nominal, but some minimum flow might be required to satisfy domestic and farm uses. In estimating storage requirements, the minimum flow below which water would not be withdrawn for synthetic liquid fuels production is assumed as that flow which would be exceeded 90 percent of the time. This flow is defined in this report as the control flow and was estimated at 0.016 cfs per square mile. In preparing mass diagrams for the Petit Jean Creek at Danville, it was deducted from the natural stream flow.

Flood Control and Conservation. Other reservoirs in the vicinity of the coal area are the 430,000-AF Wister Reservoir on the Poteau River in Oklahoma and the 258,000-AF Blue Mountain Lake on Petit Jean Creek. All of the 400,000 AF of storage allocated for flood control in the Wister Reservoir is needed for that purpose and none of this capacity would be available for synthetic liquid fuels water supply. Wister Dam could be raised to increase the storage capacity, but only at great cost because of structural difficulties and additional relocation of railroads, highways, and other utilities. The District Office of the Corps of Engineers has suggested that part of the 30,000 AF allocated for conservation storage might be used for synthetic liquid fuels purposes. This is recognized as a possible source of water supply, but in the absence of any definite arrangements, it has not been used in the cost estimates. Blue Mountain Lake, constructed for flood control by the Corps of Engineers, is 30 miles east of the assumed plant site in the General Area, and water could not be obtained economically from it. Therefore, a separate water supply reservoir for synthetic liquid fuels production is projected in Arkansas.

Water Uses - Proposed

Potential water uses, which might affect synthetic liquid fuels development, which are under consideration by the U.S. Corps of Engineers are discussed in this section. Future water uses that might arise from the development of synthetic liquid fuels plants are discussed in a later section entitled "Water Available for Synthetic Liquid Fuels Development".

Hydroelectric Possibilities. There are no hydro power plants in the vicinity of the General Area of Coal Availability. A hydroelectric power project has been authorized for construction by the Corps of Engineers on the Arkansas River at a proposed lock and dam near Ozark.

The reservoir built for synthetic liquid fuels water supply on Vache Grasse Creek would be relatively small and would afford little head for the production of electric power. Furthermore, the head available is not sufficient to raise the water to the synthetic liquid fuels plant site. The cost of storage to provide a power pool in addition to water supply requirements would be so great as to make the production of hydroelectric power unwarranted and uneconomical.

Water Rights

The common law doctrine of water rights is applicable to the surface and ground waters in Arkansas. The common law doctrine for surface waters, also termed the riparian rights doctrine, affords to each owner of land contiguous to a stream the right to make whatever use of the water he requires for domestic purposes and the watering of livestock and to make such use of the water for irrigation or other purposes (such as manufacturing) as is reasonable with regard to like reasonable uses by all other owners of land riparian to the same stream.

The common law or old English law for ground water is based upon the principle that the owner of land is also the owner of all water underlying his realty. The land owner is, therefore, entitled to withdraw such water without hindrance and regardless of the effect such withdrawal would have on surrounding territory.

Arkansas has no regulations controlling the utilization of surface or ground waters except for the protection of fish life as promulgated by the Arkansas Game and Fish Commission. The administration of statutes by the Game and Fish Commission prevents the obstruction or blocking of any stream so that free passage of fish is not possible, and prohibits the lowering of natural water level of any body of water that would endanger the life of fish. It also requires that water works intake pipes be screened against the entry of fish. The State Board of Health supervises public water supplies and industrial water supplies used for drinking purposes. Plans for such works must be submitted to and approved by the Board.

Water Available for Synthetic Liquid Fuels Development

The possibility of taking water of better quality from the Arkansas River during periods of relatively high flow and developing Vache Grasse Creek by impounding its flood runoff for use during prolonged periods of low flow in the Arkansas River was investigated. Such a dual water supply system for a 10,000-barrel-per-day synthetic liquid fuels plant would be more costly than developing the Vache Grasse Creek alone for the water supply, because of the distance between the Arkansas River and the assumed plant site, and because the storage that would be required for such a project would be very little less than the storage required for a separate development on Vache Grasse Creek. However, Vache Grasse Creek alone would not furnish enough water for the full development of the coal resources in the General Area. In the event of such a large-scale program, pumping water from the Arkansas River during periods when the water quality is satisfactory would be feasible and more economical than developing more distant tributary streams. With this type of development, water would be taken from Vache Grasse Creek Reservoir whenever the dissolved solids content in the Arkansas River water was above 1,000 ppm.

In the absence of a gaging station on Vache Grasse Creek, the available water supply and the storage required have been estimated from U.S.G.S. stream flow records at a nearby gaging station on Petit Jean Creek at Danville. The storage required was estimated from the mass diagram and storage-yield curve prepared for the critical 1939-1942 period of low water in Petit Jean Creek, as shown on Exhibit No. 18. It is assumed that the runoff of the Vache Grasse Creek per square mile of drainage area is comparable to the unit flows in Petit Jean Creek during each month and that the total runoff at any point is proportional to the total drainage area above that point.

The 32-year period on Petit Jean Creek at Danville, the longest record of any in the vicinity of the coal area in Arkansas, indicates that the most severe extended dry spell occurred during the 1939-1942 drought. It may be assumed that in western Arkansas conditions as severe as those during this period are unlikely to recur more than three or four times in a century.

Sites for a reservoir within the area are available on James Fork as well as Vache Grasse Creek. The former would be costly to develop because it would involve railroad relocation. The Vache Grasse Creek site was therefore used in the cost estimates. The most suitable site for a reservoir is about 5 miles northeast of the assumed plant site. The boundaries of the tributary drainage area and the flow line of the reservoir were drawn on U.S.G.S. topographic maps and drainage areas and approximate capacities of reservoirs were determined by planimeter. The location of this reservoir is shown on Exhibit No. 10.

The storage estimates are based on mean monthly flow data and are slightly less than if they were estimated from daily flow data. For developments utilizing a high percentage of the total runoff and requiring maximum storage, the error introduced by using monthly flow data is not significant. In general, the allowances for storage are conservative.

The maximum yield that might be developed economically by construction of a storage reservoir on Vache Grasse Creek is about 0.6 cfs per square mile of drainage area. This yield is predicated on the assumption that the reservoir would not be drawn down during a drought period of more than three years before being refilled. With a safe yield of 0.6 cfs per square mile, a drainage area of at least 33 square miles would be required to furnish enough water for a unit 10,000-barrel-per-day synthetic liquid fuels plant.

The net storage capacity determined from the storage-yield curve in Exhibit No. 18 is increased by allowances for evaporation and siltation. For developments requiring storage over a 3-year period, the allowance for evaporation is estimated as 4 feet times the reservoir surface when two-thirds full. For the development of 20 cfs from Vache Grasse Creek, the reservoir would be drawn down over periods not exceeding 2 years, and the total evaporation is estimated at 3 feet. The loss in capacity from siltation is estimated at the rate of 0.5 AF per square mile of tributary drainage area annually over a total period of 40 years.

General Area of Coal and Water Availability

In view of the foregoing discussion with respect to water, it appears that the General Area of Coal Availability previously established and shown on the map, Exhibit No. 8, would have available water sufficient for at least one 10,000-barrel-per-day synthetic liquid fuels plant. Consequently, the Sebastian-Scott General Area may be classed as a General Area of Coal and Water Availability for the purpose of this report.

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PART V

SUITABILITY OF THE GENERAL AREA

COAL

General Discussion: General Area of Coal and Water Availability

The Sebastian-Scott General Area of Coal and Water Availability in Arkansas, which was demarcated after preliminary study as being capable of supplying raw material for synthetic liquid fuels production, was next studied in detail from an economic standpoint to ascertain its further general suitability for synthetic liquid fuels production. Available information indicates that sufficient quantities of coal are recoverable to support one or more 10,000-barrel-per-day plants for a period of 40 years, of which 20 years' supply is from primary reserves and the additional 20 years' supply from either primary or secondary reserves. The total reserves are recoverable only by underground mining, there being no strippable deposits estimated as available for synthetic liquid fuels plant supply.

Detailed estimates of coal production costs are shown in Exhibit No. 19. Basic data on coal bed characteristics, estimates of recoverable reserves, estimated capital cost requirements, and estimated cost of coal supply per barrel of synthetic liquid fuel products are shown on Exhibit No. 20.

Coal Characteristics and Properties

Rank and Chemical Analysis. (See Exhibit No. 4 for references below.) Descriptions and evaluations of the chemical and physical characteristics of the coal reserves in the General Area are generally available. These reserves, located in one principal coal bed, are low-volatile bituminous (lvb)in rank, with fixed carbon contents in excess of 69 percent (maf basis). Such coals are not considered as suitable for hydrogenation in this survey, but are suitable for the synthine process. Ranges in selected items of representative analysis for reserves in the principal bed are as follows (as-received basis):

Representative Analyses of Coal Reserves in the Sebastian-Scott General Area (Mine Samples, As-received basis)

Coal Bed	Moisture (Percent)	Ash (Percent)	Sulfur (Percent)	Btu per Pound
Lower Hartshorne:				
Maximum	2.7	9.2	1.0	14,430
Minimum	2.0	5.6	0.7	13,550

Detailed analyses and other characteristics of coal in the General

(References: 8, 12)

Area are presented in Exhibit No. 20 of this report.

Type and Petrographic Analysis. (See Exhibit No. 4 for reference A below.) Petrographic assays on the specific Arkansas coal contained in the General Area are not available, although such assays have been made on the same bed at adjacent locations in Oklahoma. In Le Flore County, Okla., the approximate petrographic composition of the Lower Hartshorne bed consists of 72 percent anthraxylon, 17 percent translucent attritus, 6 percent opaque attritus, and 5 percent fusain. Coal of this composition is of the "bright" petrographic type, wherein anthraxylon and translucent attritus predominate, with opaque attritus and fusain being present in minor amounts.

Organic and Inorganic Sulfur Content. (See Exhibit No. 4 for references B below.) Information on representative organic and inorganic sulfur contents of coal reserves in the Sebastian-Scott General Area is not available. Data on preparation characteristics of these coals suggest that there is a high proportion of organic sulfur, which is not considered amenable to reduction by mechanical cleaning.

Since representative total sulfur contents of coal reserves in Arkansas range only between 0.7 and 1.0 percent on the as-received basis, it is estimated that complete removal of pyritic (inorganic) sulfur from the raw coal, if possible, might result in decreasing the sulfur contents in the cleaned coal to minimums of from 0.5 to 0.7 percent. The actual extent of reduction, however, depends upon the amounts, sizes, and types of occurrences of the pyritic or inorganic sulfur-bearing ingredients in the raw coal. Further study of these coals is necessary, accordingly, to evaluate the reduction in total sulfur which might result from mechanical cleaning.

Storage, Weathering, and Slacking Characteristics. (See Exhibit No. 4 for reference C below.) The low-volatile bituminous rank coal reserves in the Sebastian-Scott General Area are similar to other coals of equal rank in weathering and slacking characteristics. These coals usually do not slack readily or ignite spontaneously when exposed to air. These characteristics reduce the problems of coal storage so that no difficulty is usually encountered when coal is properly stored. Surge storage at the mine would be necessary to provide daily shipments to the synthetic fuels plant because of the probable fact that the mines will operate only two shifts per day for five days each week while the synthetic fuels plant will operate continuously three shifts per day throughout the year. It is probable that substantial additional storage facilities will be necessary at the process plant to protect it from interruptions or decreases in production at the coal mines and from possible transportation stoppage between mine and plant. As only

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(Reference A: 11)
(References B: 26, 30)
(Reference C: 16)

commercially cleaned coal will be stored in volume, no especial hazards are expected, and the coal may be stored in necessary quantities for indefinite periods. Costs of surge storage at the mine, together with those of handling the coal into and out of storage, are provided for in the estimates of mine capital investment and mine production costs. Estimates of required working capital for the process plant allow for reserve storage of a 30-day coal supply. Facilities for such storage and their operation are included in process plant costs.

Grindability and Friability. (See Exhibit No. 4 for references A below.) Information on grindability of the coal in the Sebastian-Scott General Area is limited, but suggests that they are similar in grindability to comparable industrial coals and will respond without undue difficulty to fine grinding. The degree of ease with which a coal may be pulverized depends not only on its relative grindability index, but also upon the fineness of grinding desired, and on its moisture content. The standard of grindability (Hardgrove index 100) is arbitrarily selected, according to American Society for Testing Materials, as represented by low-volatile, run-of-mine bituminous coal from the Jerome Mine Upper Kittanning Bed, Somerset County, Pennsylvania. Coals of low-surface moisture content, such as those in Arkansas, accelerate pulverization by their lack of tendency toward coherence and formation in cakes.

In addition to grindability, the comparative ease of crushing varies directly with the friability of the individual coals. Information on the friability of Arkansas coals indicates that they are comparable to other low-volatile bituminous coals in this characteristic, with relatively large amounts of degradation resulting from handling.

Nature of Partings. (See Exhibit No. 4 for references B below.) The available information indicates that the Hartshorne bed of Arkansas frequently contains one or more bedded impurities, or partings, as well as laminations of bone or bony coal. There are also large areas, however, in which the bed is clean and without partings, such areas having been extensively mined along the outcrop, and for distances of from one-half to over one mile, down the dip of the bed. Irregular areas in which a middle parting is present occur at scattered locations throughout the General Area. In such locations the middle parting commonly does not exceed 6 inches in thickness, although thicknesses up to 2 ft 3 in. have been encountered in mining operations.

Mechanical Cleaning. In considering washability characteristics, the character, number, and thickness of contained partings serve as a partial guide to the relative ease or difficulty with which a specific coal may be mechanically cleaned. These factors

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(References A: 16, 20)
(References B: 8, 9, 12)

were taken into consideration in estimating mine investment and operating costs. While the presence of partings in Arkansas coals is generally not such as to interfere seriously with mining operations, they do affect the type and capacity of the necessary mechanical cleaning facilities and the amount of refuse which must be handled during the cleaning process.

Data on washability characteristics and performance of Arkansas coals are relatively limited, but indicate that these coals are generally amenable to improvement in quality by commercial-type mechanical cleaning. With installation of relatively simple facilities for removal of solid impurities and other high-ash refuse, it is estimated that the average cleaned coal products in the General Area would contain approximate ash and sulfur contents as follows:

Approximate Ash and Sulfur Contents after Cleaning
(As-received basis)

Coal Bed	Ash (Percent)	Sulfur (Percent)
Hartshorne:		
Maximum	7.5%	0.8%
Minimum	4.5	0.6

Complete information on the specific quality of the cleaned coal resulting from mechanical preparation, however, requires further washability investigations of typical samples of the available coal reserves.

The foregoing discussion of washability of Arkansas coals applies only to the preparation of raw coal from the available reserves to a merchantable quality, as would be done in ordinary commercial practice. The possibilities of further reduction of ash and sulfur, require additional study beyond the scope of this phase of the synthetic liquid fuels survey and are not herein considered.

Modern mechanical mining, because of its lack of selectivity at the working face, requires mechanical cleaning facilities to obtain economic production costs. Mechanical cleaning also insures the removal of solid impurities which might otherwise severely damage pulverizers or equipment. Provision is made in the subsequent estimates of capital and producing costs, for a mechanical cleaning plant designed simply to remove solid and high-ash impurities from the mine-run coal. There is no indication that such cleaning would present any unusual problems or require abnormal expenditures in the Sebastian-Scott General Area.

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Mine Waste Disposal. The refuse from the coal preparation plant at the mine is estimated to consist largely of shale partings and contaminating material from roof or floor, together with some bone and fusain from the coal bed. According to the Bureau of Mines report on bituminous coal for 1948, the ratio of refuse to raw coal which was cleaned was 14.2 percent in Arkansas in that year. On the basis of 14.2 percent of refuse from the total raw coal moved to a cleaning plant, the estimated percentage of refuse to clean, marketable coal would be 16.6 percent. At 16.6 percent of daily production of marketable coal, the refuse would total approximately 1,165 tons per working day, or 279,600 tons per year, equivalent to 186,400 cubic yards, based on supplying marketable coal to a synthine plant.

The disposal of this type and quantity of refuse presents no particular problems. It could be transported by tramway or by trucks from the preparation plant to nearby mine property, or to selected areas of rugged land or other land unfit for farm use, of which there are many acres in the General Area. With proper precautions, the possibilities of contamination of water supply should be negligible. The estimated capital and operating costs hereinafter established in this report, provide for waste disposal from the coal preparation plant, assuming that the waste-disposal tract is within 3 miles of the coal preparation plant.

Hydrogenation Yield. (See Exhibit No. 4 for references A below.) The degree of liquefaction of coals by hydrogenation is, roughly, inversely proportional to their moisture- and-ash-free carbon content, as determined by ultimate analysis. Coals with high-carbon content are generally low in liquefaction yield. Normal carbon contents (maf) range from approximately 55 percent in peat to 95 percent in anthracite. The coal in the Sebastian-Scott General Area of Arkansas approximates 90.4 percent in carbon content (maf). Under the specifications set forth in this survey, coals containing more than 69 percent fixed carbon (maf) are not considered as suitable for hydrogenation. Since the suitable coal reserves in Arkansas exceed 69 percent in fixed carbon content (maf), their use for hydrogenation is thereby eliminated.

Land Ownership, Coal Rights, and Surface Valuation
(See Exhibit No. 4 for reference B below.)

Private Ownership and Purchase Costs. Essentially all coal-bearing lands in Arkansas are privately owned. Purchase costs of underground coal, without surface rights, may amount to 10 cents or more per ton and, in areas of unusually favorable mining conditions or locations, may range up to 25 cents per ton. Surface land values, without coal rights, range from \$20.00 to \$150.00 or more per acre, depending on the agricultural value and geographic location of the specific property.

(References A: 11, 13, 14, 17, 18, 26)
(Reference B: 5)

Legislation Affecting Production of Coal

(See Exhibit No. 4 for reference A below.)

Taxes. Real estate and property taxes are about 1.0 percent of true value. There is a severance tax of 1.0 cent per ton on all coal mined within the State. Other taxes, such as corporate organization and qualification fee, corporation franchise tax, and sales tax, are nominal and would not apply separately to coal mining if conducted as an associated operation with all production going to a synthetic liquid fuels plant.

Restitution of Surface Damaged by Mining. There is no specific legislation in Arkansas which requires restoration of surface damaged by strip mining, or payment of damages resulting from subsidence caused by underground mining, but other existing laws would make the operator liable for damages to property of others if it could be proved that such damages were the result of underground mining. Estimated amounts for these contingent liabilities are included in the following estimated production costs.

Production Costs

(See Exhibit No. 4 for references B below.)

The data on coal bed occurrences in the Sebastian-Scott General Area are in no wise sufficient in scope or in detail to permit the preparation of actual mining layouts and of specific estimates of mining costs based thereon. Extensive drilling programs will be necessary before precise location and extent of reserves available for mining operations can be determined. Comprehensive engineering studies, based on the results of the drilling programs, will then be necessary to determine the equipment and methods of mining best adapted to the efficient and economic production of fuel for synthetic liquid fuels plant supply. The estimates of coal production costs hereinafter given are necessarily generalized in nature and are based on the assumption that thorough drilling and engineering will precede any development of mining operations in connection with coal supply for synthetic liquid fuels manufacture, thereby permitting more precise estimates of costs.

In estimating over-all mining costs for the General Area, as of March 31, 1950, the total estimated investment costs are considered to include erection of all necessary mine structures, together with purchase and installation of all necessary operating equipment. They also include investment costs of facilities for transporting the output from the necessary number of adjacent mining operations to a joint preparation plant, a mechanical cleaning plant designed largely to remove solid and high-ash impurities from the raw fuel, waste disposal from the preparation plant, sufficient coal surge storage at the mine to provide uniform daily shipments to the synthetic liquid fuels plant, engineering, development, and

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(Reference A: 5)
(References B: 19, 21, 23, 25, 27)

contingencies. While the estimated investment costs do not include purchase price of surface or coal lands, a royalty charge of $0.10 per ton of cleaned coal for underground mining, as included in producing costs, is considered to represent the cost of acquisition of coal reserves.

In estimating producing costs, separate consideration was given to each of the following principal items of cost, their total being taken as the total producing cost per ton of cleaned coal:

(1) All labor. This item includes all labor costs paid in the form of wages for mining (pieceworkers and dayworkers) and for yardage and dead work and in the form of salaries paid to supervisory, technical, and clerical employes at the mines. Weighted average wage rates were calculated from the schedules of wages established by the National Bituminous Coal Wage Agreement of 1950 for the various mining districts, with suitable adjustment for the concentration of high-wage workers in a fully mechanized underground operation. The labor cost per ton was calculated by dividing the estimated weighted average daily wage rate by the estimated productivity in tons of cleaned coal per man-shift.

(2) Vacation payments. This item represents the vacation allowance of $100 per year to each employe, where applicable, and is computed by dividing $100 by the estimated annual production per man (240 days times productivity per man-shift). In actual practice, this may be increased slightly due to injured men or others carried on the payroll but not actually engaged in production.

(3) Welfare fund. This item represents a flat payment of $0.30 per ton which is paid into the U.M.W.A. welfare fund for each ton of coal produced for use or for sale in accordance with the National Bituminous Coal Wage Agreement of 1950.

(4) All supplies. This item includes the costs of all materials and supplies used in mining and in operating the mine equipment and facilities, including the maintenance and repair of mine structures and equipment. Additional included costs consist of freight, drayage, expressage, and storage of supplies, mine office supplies, fuels other than coal, and rentals of equipment. The costs of such supplies per ton are estimated at $0.81 for underground operations.

(5) *Power.* This item includes the cost of all power requirements at the mining operations, whether purchased from outside sources or produced by a mine-operated central power station. It also includes the cost of any coal required to produce heat at the mine. While small variations in cost of power may be expected in this survey, an assumed cost of $0.15 per ton is herein employed for estimating purposes.

(6) *Payroll taxes.* This item includes the costs of social security (old-age benefits), unemployment taxes, and any other Federal or State taxes levied upon the amount of the payroll. These taxes average approximately 4 percent of the labor cost.

(7) *Other taxes, insurance, miscellaneous.* This item includes the following types of costs:

a. Real estate, personal property, and other taxes on mine property, and equipment, including reserves. These taxes may range from 1 to 6 percent of the fair cash value of the property as established by the local assessors, depending on locality.

b. Corporate, privilege, and severance taxes which average approximately $0.02 per ton.

c. Workmen's compensation and vocational disease insurance, including the sums paid to an insurance company or to a State fund for protection of the employes, which aggregate approximately 5 percent of the payroll.

d. Other insurance such as fire, tornado, and other classes of insurance applicable to the mine property which is estimated to average approximately $0.01 per ton.

e. Costs arising from unforeseeable and unpredictable conditions of all kinds which are herein estimated at a flat rate of $0.10 per ton.

(8) *Depreciation.* This item represents the cost of providing for replacement of the mining facilities and equipment at the end of their useful life. In determining producing costs the weighted average useful life of all items of mine property and equipment, exclusive of coal reserves, is estimated to be 15 years. The rate of depreciation, accordingly, is taken at 6.67 percent of the initial investment.

(9) Royalty or depletion. As discussed in a preceding paragraph, the estimated investment costs do not include the purchase costs of surface and coal properties. A royalty charge of \$0.10 per ton of cleaned coal for underground mining is herein considered to represent the cost of acquisition of coal reserves.

(10) Engineering, management, administration. This item includes the costs represented by salaries and expenses of administrative, management, and engineering personnel, together with salaries of associated assistants, bookkeepers, clerks, and stenographers. It also includes legal expenses and office expenses, or rent, including depreciation on office equipment. The cost of this item is herein estimated at \$0.10 per ton.

Although estimated total recoverable reserves in the General Area are sufficient to supply synthetic liquid fuel plants having a combined capacity of 37,000 barrels a day for 40 years, using the synthine process, the following estimates on coal production costs are based on the capacity of mine operations necessary to supply one 10,000-barrel-per-day unit synthetic liquid fuels plant. With an average Btu content of 13,650 (as-received) and at an input of 126 billion Btu per calendar day, annual synthetic liquid fuel plant requirements would be 1,684,000 tons. This amount represents a daily requirement of 4,615 tons for the plant (365 working days) and of 7,019 tons for the mine (240 working days).

Underground Mining Cost. Because of inherent limitations on transporting coal to the surface, and to minimize the possible effects of such hazards as mine fires, roof falls, floods, etc., it is assumed that the annual requirements would not be obtained through a single opening. From two to three underground mining operations would probably be opened, at appropriate intervals, for concurrent operation. Although obtained from separate underground openings, it is assumed that the raw coal would be handled through joint surface facilities, including a central preparation plant, to the transportation system by which the coal would be delivered to the synthetic liquid fuels plant. Surge storage facilities at the mine would be provided to assure continuous supply for year-round, three-shift-per-day operation of the synthetic liquid fuels plant from mines operating on a five-day-per-week, two-shift-per-day basis.

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Approximate initial capital investment required for underground production of synthetic liquid fuels plant coal supply in the quantities previously cited is estimated as of March 31, 1950, at \$9,262,000 to supply a synthine plant in the Sebastian-Scott General Area. Factors affecting mine investment costs are depth and character of the bed and its associated strata, together with quantity and quality of the coal. The quantity to be mined is governed by the Btu content, and by the specific synthetic liquid fuels process in which the coal is to be used. The quality affects the type and capacity of preparation facilities necessary to produce a merchantable coal.

The total estimated investment costs include purchase and installation of all necessary underground equipment, including investment costs of facilities for transporting the output from the separate mine openings to a central preparation plant, a mechanical cleaning plant designed largely to remove solid and high-ash impurities from the raw feed, waste disposal from the preparation plant, sufficient coal surge storage to provide uniform daily shipments to the synthetic liquid fuels plant, engineering, development, and contingencies. The estimated investment costs do not include purchase price of surface or coal lands, since a royalty charge of 10 cents per ton of cleaned coal is included in production costs which is considered to represent this cost factor.

Actual producing costs for mechanical underground mining in Arkansas have been relatively higher than average costs for the United States, having been $2.64 per ton for the United States and $5.18 per ton for the district including Arkansas in 1945, according to Economic Data, Office of Price Administration, for that year.

Estimated over-all labor productivity in new operations, measured by the average tons produced per shift by each man employed in the underground operation and in necessary surface facilities, cannot be based upon experience at present underground operations because of their relatively low degree of mechanization.

The Bureau of Mines statistics on bituminous coal production in 1948 indicated that Arkansas underground mines had an average productivity of 2.89 tons per man-shift, with that of the Sebastian-Scott County area being 3.27 tons. Assuming that the installation of modern high-capacity operations, including the purchase and use of all necessary mechanical equipment would result in an estimated productivity of 5 tons for average mining conditions, the estimated March 31, 1950 cost of production by underground operations is $5.28 per ton, equivalent to a cost of 19.34 cents per million Btu. Details of this estimated cost are shown in Exhibit No. 19. They are based on retirement of the property in 15 years and exclude selling expenses.

The above estimated cost reflects the concept of most efficient application of present-day underground mining methods and equipment. Opportunities for possible future improvements of mining methods or equipment in areas similar to Arkansas probably best await potential development of: (1) high-capacity loading equipment especially designed for longwall mining as practiced in the United Kingdom, and (2) continuous mining machines which combine cutting, drilling, blasting, and loading operations, now under scrutiny and development at a number of points in the United States.

Both of these types of equipment are being actively tested, and, if perfected, could result in changes in mining methods which would reduce the estimated producing costs in Arkansas. It is not possible at this time, however, to predict the successful application of such equipment to Arkansas coal reserves nor to estimate possible future savings in production costs which might accrue through their use.

In considering possible revolutionary techniques in utilizing areas of coal reserves, the underground gasification of coal in place offers considerable potential promise, since it would eliminate the relatively costly processes of mining the coal and gasifying the mined output in gas generators to produce synthesis gas. This method of utilization would also provide a low-cost fuel for power generation and would permit utilization of coal from beds which would otherwise be costly or uneconomic of operation. The results of experiments in underground gasifications now in progress by the Bureau of Mines and the Alabama Power Company indicate that the process has distinct possibilities and is worthy of continued experimentation. It is not possible at this time, however, to predict the successful application of this method of utilization to the coal reserves in the General Area in Arkansas.

Coal Transportation. Provision has been made, in estimating capital and operating costs, for transportation of coal from the several mine openings to a joint distribution point for handling onto the transportation system by which the coal is delivered to the synthetic liquid fuels plant. As elsewhere indicated, it has been assumed for purposes of this survey that the site of the synthetic liquid fuels plant would be located within a 3-mile radius of the mining operation. Under this assumption, no additional facilities or costs for transportation, other than that provided for in the estimates of costs already established, are contemplated.

Coal Supply from Present Operations. Bureau of Mines data on bituminous coal production in 1948 indicate that a synthetic liquid fuels plant in the General Area in Arkansas could not have been supplied with sufficient coal in that year to have produced synthetic liquid fuel products at the rate of 10,000 barrels per day. For a unit 10,000-barrel-per-day plant, a total of approximately 1,684,000 tons of coal would have been required, this amount exceeding the total State production in that year by approximately 22,000 tons.

The 1948 total production of about 1,662,000 tons was produced in 180 working days, an average of 9,230 tons per day.
Ark At such a daily rate, the additional coal which could have been pro-
80b duced during a 240-day work-year would have amounted to 553,800
81a tons, sufficient for approximately 3,300 barrels of synthetic liquid
3 fuel products per day.

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Accurate information on current costs of production at present operations in Arkansas is not available. Consideration of all known factors of increased wage rates, costs of supplies, contributions to welfare funds, etc., since the last year of available cost data (1945) indicates that coal is now being mined in Arkansas at costs ranging from approximately $0.50 to $1.50 per ton in excess of the estimated average costs ($5.28 per ton) of mine operations as herein presented. Mine-run coal could probably be purchased from current operations at such costs plus freight, plus 30 to 50 cents per ton for profit and income taxes. Selected sizes would probably run slightly higher in price, while it is possible that lower-priced sizes such as screenings could be purchased from current operations for production of synthetic liquid fuels, on a contract basis, at fob. mine prices comparable to or slightly less than the costs estimated herein. In general, such sizes would contain higher ash and sulfur contents than the cleaned mine-run products estimated as obtainable from reserves of the General Area.

An additional cost of purchasing coal from present operations would be the transportation charges, or freight rates, from existing mines to the synthetic liquid fuels plant. Unless located in the heart of a group of substantial commercial operations, such additional costs for delivered coal would probably range from $0.60 to $1.50 per ton, depending on the selection of location of a synthetic liquid fuel plant.

Total Costs. Details of the estimates of capital and operating costs and of the coal data upon which they are based are provided on Exhibits Nos. 19 and 20.

The estimated initial capital cost, based on complete facilities for underground mining, conveying of raw coal to surface, transportation to central preparation plant, mechanical cleaning, including refuse disposal, and loading for shipment or into surge storage at the mine with subsequent re-loading, is $9,262,000.

The estimated coal producing cost, including depreciation and administration, but excluding return on investment, is $5.28 per ton of merchantable coal produced. With an average Btu value of 13,650 (as-received), the unit cost of coal supply per barrel of synthetic liquid fuel final products in the Sebastian-Scott General Area of Arkansas, employing the coal synthine process only, is accordingly estimated to be $2.44.

The estimates of costs presented in this survey are based on available information and on generalized, present-day methods of mining and preparation. The installation of mining operations to provide coal supply for a specific synthetic liquid fuels plant should be preceded by detailed engineering studies, including drilling programs, before final methods of operation and firm estimates of costs can be established.

WATER SUPPLY PLAN AND ESTIMATES OF COST FOR THE GENERAL AREA

Description of Water Supply Project for General Area

Cost estimates have been prepared for a representative water supply system in the General Area. The estimates are based upon the works necessary to furnish water for a single 10,000-barrel-per-day synthetic liquid fuels plant. For purposes of this report, and for making cost estimates, a plant site or terminal point for the water works system has been selected arbitrarily as shown on Exhibit No. 10. Although this point was selected near the expected source of coal, the location is not to be considered in any way to represent a recommended plant site.

The construction cost estimates are based on unit prices as of March 1950. In estimating capital costs, 20 percent has been added to the construction costs for engineering and contingencies. Reservoir and pipe line cost estimates include allowances for the purchase of land and rights-of-way, the relocation of existing roads, utilities and structures, and the purchase of such water rights as might be necessary.

The water works system described in the following paragraphs would be large enough to furnish process and cooling water for the synthetic liquid fuels plant, and also the domestic water supply for the population serving the plant. However, the cost of the domestic water supply has been separated from the process supply and the synthetic liquid fuels plants are charged only with the cost of water used for process or cooling. It is assumed that the cost of the domestic water supply system would be paid for out of the water charges to the consumer.

Facilities Required. The water supply system used for cost estimates in the General Area in western Arkansas would include the following principal elements:

Impounding Reservoir. The reservoir would be built on Vache Grasse Creek, approximately 5 miles from the assumed plant site as shown in Exhibit No. 10. The reservoir would be located adjacent to Camp Chaffee within the maneuver area.

The drainage area at the dam site is 90 square miles. This reservoir would have an area of 2,100 acres and a total capacity of 15,300 AF, of which 7,200 AF has been allowed for evaporation and siltation. The reservoir would have a maximum depth to flow line of approximately 21 feet. The dam would be an earthfill structure with a concrete spillway section.

Pumping Station. A pumping station would be needed at the reservoir for delivering the water to the plant site. The stream gradient is relatively flat, and there is no opportunity for obtaining a gravity supply in this area. For a 10,000-barrel-per-day synthetic liquid fuels plant requiring 13 mgd, or 20 cfs, the pumping station would probably consist of three electrically driven pumps of approximately 8-mgd capacity each, with auxiliary gas or gasoline engines on two of the units. The total pumping head has been estimated at 257 feet. This includes: the difference in elevation between the intake at elevation 486 and the plant site at elevation 630 feet; a friction loss in the pipe line of 63 feet; and an allowance of 50 feet for hydraulic losses in the treatment plant and for the distribution of water at the synthetic liquid fuels plant.

Aqueduct. A 30-inch diameter pressure pipe line extending from the reservoir to the assumed plant site is used for cost estimates. The pipe line would have to go around a hill between the reservoir and plant site in order to avoid excess pumping head, and would be approximately 6 miles long.

Electric Power Transmission Line and Substation. It is assumed that power for operating the water supply works would be generated at the synthetic liquid fuels plant and would be transmitted to the pumping station by means of a transmission line extending along the pipe line right-of-way. The cost of power estimated in this manner is substantially the same as the cost of power available commercially from utility companies in the area.

Storage Basin at Assumed Plant Site. A 13-million-gallon storage basin, equal to one day's supply, is included in the estimates. This basin would provide a reserve source of storage in the event of pumping station or pipe line failure, and would also serve as a settling basin for the removal of turbidity. Settled water from the basin would be of quality suitable for plant cooling purposes and for coal preparation.

Filter Plant. The water would have to be filtered for domestic water supply, for drinking water in the plant and mines, and for boiler make-up and other minor process uses. It is estimated that 3.5 mgd, or 27 percent of the total water requirements would need to be filtered. Of this, 1.94 mgd would be needed for domestic use and 1.56 mgd for process use. A filter plant of 5-mgd capacity is included in the estimates in order to take care of peak demands, particularly during the summer months when domestic requirements would be high. The cost of filtered water storage is included in the filter plant estimates. The cost of softening boiler feed waters is considered a process expense and is not included in the water-supply cost figures.

Cost of Water Supply Project for Suitable General Area

The paragraphs following include a brief description of the water supply development for the General Area with a statement of the estimated construction cost and annual cost allocated between domestic and process water supply. A unit water cost per barrel of products is shown which includes only that water properly chargeable to process and mining. The cost trend for the complete development of all the fuel resources in the area is also shown.

Capital Costs. In apportioning the construction costs between process water and domestic water, the total cost of the supply works is allocated in the ratio of estimated consumption, that is, approximately 85.2 percent and 14.8 percent, respectively. In allocating the cost of the filter plant, the process water supply carries 44.6 percent and the domestic water supply 55.4 percent. The capital costs of the surface water supply system for process and domestic use for a single 10,000-barrel-per-day unit plant in the General Area as previously described, is estimated as follows:

Total Estimated Construction Cost for Water Supply
As of March 31, 1950

Item	Process	Domestic	Total
Storage Reservoir	$2,735,000	$475,000	$3,210,000
Pumping Station, Transmission	835,000	145,000	980,000
Storage Basin at SLF Plant	170,000	30,000	200,000
Filter Plant	201,000	249,000	450,000
Total	$3,941,000	$899,000	$4,840,000

Annual Costs. The annual operating costs and fixed charges for the water supply system in the General Area are estimated to include the following:

Power. Electric power for pumping is to come from the assumed synthetic liquid fuels plant site at 5 mills per kilowatthour, including an allowance for transmission and transformer losses. Power requirements are based upon a wire-to-water efficiency of 75 percent.

Labor and Superintendence. This has been estimated at $20,000 per year.

Miscellaneous Supplies and Repairs. This has been estimated at $5,000 per year.

Filtration. The cost of this operation has been estimated at the over-all rate of $15 per million gallons including all operating costs such as labor, chemicals, repairs, and materials. A total of 1,280 mg per annum of filtered water would be produced.

Fixed Charges. Property taxes and insurance have been estimated at 1 percent of the total depreciable capital cost. Depreciation is estimated on a straight-line basis with a 40-year life assumed for permanent structures and pipe lines, and a 20-year life for equipment items and machinery. A return on the investment, or interest, is not included in the cost. However, the additional unit water cost for each 1 percent applied to the total capital cost is noted separately.

In allocating operating costs between process water and domestic water, the first three items, which apply to the supply works, are charged in the ratio of 85.2 percent to process and 14.8 percent to domestic water. Process water supply carries 44.6 percent of filtration costs and the domestic water supply 55.4 percent. The fixed charges are allocated in the same ratio as the capital costs of the several items. The annual costs for water for the General Area and the unit costs per barrel of products are summarized in the following table exclusive of return on investment:

Estimated Annual and Unit Costs for Water
as of March 31, 1950

Item	Process	Domestic	Total
Power	$ 21,130	$ 3,670	$ 24,800
Labor and Superintendence	17,040	2,960	20,000
Miscellaneous Supplies and Repairs	4,260	740	5,000
Filtration	8,560	10,640	19,200
Taxes and Insurance	39,410	8,990	48,400
Depreciation	103,400	26,000	129,400
Annual Costs	$193,800	$ 53,000	$246,800
Process Water per Million Gallons (exclusive of return on investment)			$47.62
Process Water per Barrel of Products (exclusive of return on investment)			$ 0.053
Additional Cost per Barrel of Products for Each 1 Percent Interest on Capital Investment of $3,941,000			$ 0.011

The feasibility of the project outlined above has been checked, but no detailed surveys or subsurface investigations have been made. Other sites for reservoir development are available in western Arkansas and one site on Petit Jean Creek is shown as No. 2 on Exhibit No. 10. While the cost of more distant reservoir projects might be somewhat greater than that indicated above, the difference would not be substantial and the over-all cost of water would be approximately the same as indicated above for the project on Vache Grasse Creek. If arrangements could be made to use water from Wister Reservoir, a less costly project would be possible.

Synthetic liquid fuels plants, large enough to utilize all of the coal resources in the General Area would require a total of 75 cfs of water. If the area on Vache Grasse Creek above Reservoir No. 1 was fully developed, only 54 cfs could be obtained. The requirements of the General Area could be provided by installation of a pumping station on the Arkansas River from which water would be taken only during periods when the flow was above 10,000 cfs, at which time the mineralization of the water would not be serious. During periods when the flow was below this, water would have to be taken from a storage reservoir on Vache Grasse Creek. The total capacity of a reservoir large enough to carry over periods when water could not be pumped from the Arkansas River would be 60,000 AF. The unit capital cost of this larger development would be about 60 percent of the cost indicated for a single 10,000-barrel-per-day plant. The annual power cost would be slightly greater, because of the additional pumping from the Arkansas River.

POWER

For a 10,000-barrel-per-day plant using the coal synthine process, it is estimated that the power requirements will amount to 114,500 kw, plus 3,500 kw for the mine. However, as waste heat recovery arrangements will have sufficient output to supply the steam needed to generate this amount of electricity, outside power would be required only for construction purposes, for starting up the process plant, and as emergency stand-by.

The Sebastian-Scott General Area is served by the Southwestern Gas and Electric Company. This company is a unit in the integrated system of the Central and Southwest Corporation which extends from Arkansas through Oklahoma and Texas. As of the end of 1949, the system had a capability of 613,000 kw. It operates several steam plants with equipment designed for and using coals of high ash content. Southwestern Gas and Electric Company could supply power to a synthetic liquid fuels plant in the General Area at an average cost of about 6 mills per kilowatthour.

There is an existing low-cost hydroelectric system within 50 miles of the General Area, that of the Southwestern Power Administration and its allied system of the Grand River Dam Authority, including the Pensacola Dam in Oklahoma, the Dennison Dam in Texas, and the Norfork Dam in Arkansas. These three combined units have a present installed capacity of 142,000 kw.

Sufficient power for plant construction would be available from the local utility in the Sebastian-Scott General Area. The requirements for a coal synthine process plant indicate the need of power for starting and for stand-by purposes in the event of temporary failure of plant generating facilities. Integration of plant generating facilities with the existing power networks merits consideration.

ACCESS TRANSPORTATION

The construction and operation of a synthetic liquid fuels plant and its auxiliary coal mine facilities would, in general require a direct water or rail and a highway connection. Such services would be used during the construction period to move in the large volume of construction materials and plant equipment, and later to transport plant and community supplies and some plant products. The latter may also be handled by pipe line as described in the section of this report pertaining to "Marketing".

Railroad facilities are well distributed in the State of Arkansas, except in the northern section or foothills of the Ozarks. They generally, however, follow a traffic pattern influenced by the locations of Kansas City, St. Louis, and Memphis, providing transportation from these points to the cities of Louisiana and to those of Texas; the latter originally related to the provision of southwestern transcontinental routes.

Railroad access is very necessary but it is also important that highway access be assured for truck movement in and out of the plant and transportation of personnel to and from the Area. Highways in Arkansas are fairly well distributed but they follow much the same pattern influence as that of the railroads. Water transportation is not available to the Sebastian-Scott General Area.

The estimated cost of access facilities for the one General Area in Arkansas is given in the following table. Under the heading "Description" the first item describes the required railroad facilities and the second item the required access highway facilities from the public paved highway system.

In order to prepare cost estimates, a representative plant site, consistent with topographic and geographic features of each General Area, has been arbitrarily selected. The selection of such a point, in the final analysis, is arbitrary and is in no way intended to represent a recommended plant location.

The amounts shown for railroad facilities under construction and operating costs are based on the assumption that the plants will bear full construction and maintenance costs of the required facilities. Operating costs are to provide for maintenance at an annual rate of 5 percent of the capital costs for such facilities.

In the case of access highway facilities, costs represent one-half the construction costs with no direct maintenance charges. It has been assumed that local governments would bear one-half the construction costs and maintain the highways upon their completion. Under operating costs, the amounts charged against highway facilities are to provide for 40-year depreciation at an annual rate of 2.5 percent of the capital costs shown. Highway costs are based on a 20-foot highway of rough aggregate, bituminous-bound surface, 3 inches thick on a 15-inch base course.

Estimated Cost of Access Facilities
for the Sebastian-Scott General Area
(As of March 31, 1950)

Description	Capital Cost	Annual Operating Cost	Daily Operating Cost
Approximately 0.5 mile from Midland Valley Railroad between Excelsior and Hackett; easy grading	$ 60,000	$ 3,000	$ 8.22
Resurfaced, widened and improved, approximately 4.5 miles of Highway 10; loose surface-graded, dry weather road from its junction with Highway U.S. 71 near Greenwood	62,500	1,563	4.28
Total	$122,500	$ 4,563	$ 12.50

LABOR

General

Determination of the labor force available to a proposed new synthetic liquid fuels unit plant involves a detailed study of the number of workers existing in and around the proposed location together with their characteristics, the nature of their present employment, the extent of unemployment, and the extent to which the proposed new plant would divert existing employment from present industry to itself. Personnel requirements of the proposed plant would then be compared with results of the detailed study to determine the size of the area containing sufficient available labor to satisfy the needs of the plant. Determination of the level of wages to be paid in a unit plant involves consideration of the wage level in such an area prevailing among existing industries comparable to synthetic liquid fuels as regards the skills and experience required of workers.

In this report, such studies by particular locations were not made. Instead, data on the number and composition of the labor force in the State and in the coal counties, data on unemployment both in the State and coal counties, and data on average wages prevailing in selected industries in the State were developed. Conclusions were drawn from such data as to the availability of labor and as to the prevailing level of wages in an average location in the coal counties, which were applied to the General Area within the State.

Population and Employment Characteristics

The 1940 census showed, for the State of Arkansas, a total population of 1,949,387 of which 431,910 or 22.1 percent lived in urban areas. In the two coal counties, Scott and Sebastian, located in the western part of the State the population was 76,109, of which 36,584 or 48.1 percent lived in urban areas. The greater percentage of urban population in these coal counties is due to the location of Fort Smith, the State's second largest city, in Sebastian County. Preliminary 1950 census figures indicate that the population of the State as a whole decreased by 2.4 percent under 1940 and that of the coal counties by 2.8 percent.

91 Details of the population characteristics, labor force, and employment categories in Arkansas as a whole and for the two
Ark coal counties are shown in Exhibit No. 21 and are summarized below:

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Population, Labor Force, and Employment in Arkansas and in the Two Coal Counties

	Whole State (75 Counties)	Coal Area: 2 Coal Counties	Coal Area: Percent of State
Preliminary U.S. Census Data - 1950			
Area (Square Miles)	52,725	1,427	2.7%
Population	1,901,631	73,966	3.9
Density per square mile	36.1	51.8	
U.S. Census Data - 1940			
Population	1,949,387	76,109	3.9
Residing in Urban Areas:			
Number	431,910	36,584	8.5
Percent	22.1%	48.1%	
Labor Force	678,859	27,876	4.1
Employed Number	583,944	21,175	3.6
Percent of Labor Force	86.0%	76.0%	
Occupations of Employed Labor, Percentages of Total:			
Agriculture	51.4%	20.2%	1.4%
Mining	1.0	2.3	8.4
Construction	2.9	3.6	4.4
Manufacturing	9.9	21.5	7.9
Service	34.8	52.4	5.5

The coal counties had a 1950 population density of 51.8 per square mile. Data for the coal area as compared with State data indicates that in 1940, more than twice the percentage of people lived in urban areas, relatively fewer people were employed, relatively more people were engaged in manufacturing, mining, and service, while the percentage of those engaged in agriculture was considerably less.

Estimated Labor Force. In Arkansas the total labor force, based on the 1940 census, has previously been stated as 678,859. If the labor force has decreased proportionately to that of population, the 1950 labor force would be 662,228. The labor force of the coal counties on the same basis would be 27,091 or an average of 18,985 per 1,000 square miles.

The occupations of about one-third of the labor force in the State (workers covered by Federal Old-Age and Survivors Insurance) are indicated by the following tabulation. These workers include employes of an employer with as few as one employe.

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Workers Covered by Federal Old-Age and Survivors Insurance as of Mid-March 1948

Industry Group Mid-March 1948	Total State		2 Coal Counties	
	Total	Percent	Total	Percent
Agriculture, Forestry, and Fishing	687	0.3%	16	0.1%
Mining	6,510	3.1	1,183	7.3
Contract Construction	14,776	7.0	625	3.9
Manufacturing	73,352	34.8	6,381	39.3
Public Utilities	15,671	7.5	825	5.1
Wholesale Trade	18,092	8.6	1,565	9.6
Retail Trade	48,161	22.9	3,187	19.6
Finance, Insurance, and Real Estate	7,659	3.6	543	3.3
Service Industries	24,107	11.4	1,710	10.5
Other (A)	1,672	0.8	205	1.3
Total	210,687	100.0%	16,240	100.0%

Note: (A) Includes groups not elsewhere classified and unclassified.

The remaining two-thirds of the total labor force (disregarding any change from mid-March 1948 to April 1, 1950) were not covered and consisted of employes of government, railroads, certain non-profit organizations, agricultural, domestic and unpaid family workers, those self-employed, and those unemployed. These workers generally, except some of the unemployed, are of types that do not now have the training or skills required for operation of synthetic liquid fuels plants.

From the above tabulation it may be seen that in the State as a whole, 34.8 percent of the covered employes are engaged in manufacturing and 3.1 percent in mining, whereas in the coal counties the corresponding percentages are 39.3 in manufacturing and 7.3 in mining.

The number of workers engaged in manufacturing in the entire State of Arkansas, as shown in the above tabulation, is further broken down by industry groups as shown in Exhibit No. 22. While group totals are available for all counties in the State, individual industry figures are available only for Sebastian County, which is also shown on Exhibit No. 22. Sebastian County employes over 90 percent of manufacturing labor in the two coal counties.

Seasonal Trends in Employment. Employment of workers covered by the Arkansas Unemployment Compensation Law, is shown in the following table for a recent typical 13-month period.

Workers Covered by Arkansas Unemployment Compensation Law

Month	Number of Workers (Thousands)	Percent of Average
1948		
June	225	103.2%
July	224	102.8
August	228	104.6
September	230	105.5
October	222	101.8
November	222	101.8
December	224	102.8
1949		
January	206	94.5
February	204	93.6
March	208	95.4
April	210	96.3
May	212	97.2
June	215	98.6
Average	218	100.0%

Covered employment shows a decline of 10,000 workers from June 1948 to June 1949. This is attributed to declining employment in the manufacturing industries and in construction by the Employment Security Division of the Arkansas Department of Labor. Using the average number of employed in the 13-month period as a base employment reached a peak of 105.5 percent in September 1948, and was at its lowest in February 1949, with a percentage of 93.6. Those data indicate that there exists a seasonal variation in covered employment in Arkansas of about 6 percent above and below the average. This variation is to be expected in an area in which over one-half the labor force is employed in agriculture. Year-round employment, as would be provided by a synthetic liquid fuels plant, would be desirable in such an Area. Increased annual employment provided by such a plant could be offset by increased use of migratory labor.

Workers covered by this law exclude employes of government, railroads, certain non-profit organizations, agricultural, domestic and unpaid family workers, and the self-employed. Employes of an employer with one or more employes in a 10-day period are covered.

<u>Technical Training.</u> The Fort Smith area is one of the most important industrial districts in Arkansas. The growth in manufacturing employment during the war has probably been below the national average. Manufacturing activities include furniture, basic

lumber products, zinc smelting, flat glass, steel products, apparel, and food. Coal mining is important to the area, and the industry has been relatively stable for many years. Government work is an important activity in the area and is concentrated chiefly at Camp Chaffee, where a separation center was established at the close of the last war. This center has employed as many as 3,000 workers, many of whom have remained in the area and are qualified for many jobs in industry. Outlying sections are primarily agricultural.

The number of workers who are engaged (as of mid-March 1948) in industries employing workers of skills comparable to those required in operating and maintaining synthetic liquid fuels plants are indicated by the following table (selected from the industry groups shown on Exhibit No. 22), which table also includes workers in electric and gas utilities.

Industries Employing Workers of Skills Comparable to Those Required by Synthetic Liquid Fuels Plants

	Workers Covered by Old-Age and Survivors Insurance	
	Entire State	Sebastian County
Manufacturing:		
Chemicals and Allied Products	3,375	169
Products of Petroleum and Coal	2,427	-
Primary Metal Industries	1,009	-
Fabricated Metal Products	598	67
Machinery (except electrical)	269	-
Transportation Equipment	1,792	-
Total in Manufacturing	9,470	236
Electric and Gas Utilities	4,600	172
Total in All Selected Industries	14,070	408

Unemployment

Unemployment varies from one area to another dependent on local conditions. For a particular locality, a survey of conditions prevailing in the area would have to be made to determine its extent. In this report, however, studies by particular areas were not made. Instead, as a measure of the extent of unemployment, the percentage of unemployed workers covered by State Unemployment Insurance to average covered employment in the State were tabulated by months for the years 1947 to 1949, inclusive, and the first 2 months in 1950. These percentages were taken from Bulletins of the Bureau of Employ-

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ment Security of the U.S. Department of Labor, and plotted in the form of a graph as shown in Exhibit No. 23.

Unemployment in Arkansas follows a seasonal pattern, reaching a maximum in February and a minimum in October or November. The maximum percentage of unemployment (for month of February) has increased yearly, beginning in 1947 at 5.4, rising slightly to 5.8 in 1948 and to 8.5 in 1949 and reaching 10.9 percent in 1950. Average annual percentages of unemployment also rose during the years 1947 to 1949, from 3.6 to 5.8 and during the 12-month period ended in February 1950, to 6.3 percent.

Those seasonably unemployed may be considered as available for employment in year-round activity such as a synthetic liquid fuels plant. Eliminating the percentage of unemployment in February 1950 (10.9 percent) as being exceptional, average unemployment in February for the years 1947 to 1949, inclusive, was 6.6 percent. This percentage is closely in line with that for the 12-months ended in February 1950, and has been adopted in this report as representing a degree of unemployment normal to Arkansas and available for new employment.

<u>Estimated Total Unemployment.</u> Application of the 6.6 percent of unemployment to the total estimated labor force in 1950 of 662,228 would indicate a total number of unemployed in the entire State of Arkansas of 43,707. On the same basis the unemployed in the coal counties would be 1,788 or 1,253 per 1,000 square miles.

<u>Unemployed Skilled Labor.</u> Assuming that the 6.6 percentage of unemployment in Arkansas applies equally to the 14,070 workers in the industries employing skilled labor (as well as to the total labor force), then the unemployed skilled labor force in the entire State would be 929.

Workers in industries employing skilled labor in Sebastian County have been shown to number 408. Data from which this figure was obtained for industry classifications containing only one or two reporting units for a State or County are not shown separately although included in totals or subtotals. Thus 750 employes have not been accounted for by industry in Sebastian County. It is estimated that 375 (one-half) are employed in the primary metal industry and in fabricated metal products, as there are in Sebastian County one employer in each of the above industries who are the only reporting units in their industry classifications and who employ between 100 and 499 employes. Adding this estimated number to the number previously tabulated an indicated number of workers in industries employing skilled labor in Sebastian County would be 783. As the number of employes in manufacturing in Scott County is less than 10 percent of that in the 2 coal counties it is assumed that this number of 783 applies equally to the 2 coal counties. By application of the 6.6 percentage of unemployment, the unemployed skilled labor force in the coal counties would be 52, or 36 per 1,000 square miles.

Personnel Requirements of a Typical Synthetic Liquid Fuels Unit Plant in Arkansas

Total Personnel Requirements. The total requirements of personnel to operate and maintain a typical synthetic liquid fuels plant in Arkansas to produce all the coal necessary as a raw material for the plant, from mines owned or associated directly with the synthetic fuel plant, and to supply the service requirements of such workers and their families, are shown in the following tabulation:

Total Personnel Requirements of a Coal Synthine Unit Plant

	Number
Unit Plant Employes	1,135
Coal Mine Employes	1,621
Total Production Employes	2,756
Service Workers	1,516
Total Personnel	4,272

The numbers of unit plant employes shown above are those estimated by the U.S. Bureau of Mines for plants using the coal synthine process as shown on the Plant Requirement Sheet, Exhibit No. 1.

The number of coal mine employes shown above is that required to produce sufficient coal per annum to meet the fuel requirements of a unit plant, using the heating value and productivity per man-day shown for the General Area in Arkansas in the section of this report entitled "Coal". Development of the number of employes is shown in the following tabulation:

Total Number of Coal Mine Employes Necessary
To Produce Fuel Requirement of a
Coal Synthine Unit Plant in Arkansas

Daily fuel requirement of a unit plant in billions of Btu	126
Heating value of coal in Btu per pound	13,650
Annual fuel requirement of a unit plant in tons of coal	1,684,615
Number of working days per annum in coal mines (assumed)	240
Productivity in tons per man-shift of operational coal mine employes	5.00
Number of operational coal mine employes working daily	1,404
Number of operational coal mine employes absent due to accident, illness, etc. 10%	140
Total number of operational employes	1,544
Administrative employes, 5% of operational	77
Total coal mine employes	1,621

The numbers of service workers shown are 55 percent of the total production employes. Such workers and the relation between them and production employes are defined in a succeeding section of this report entitled "Housing and Community Development".

Skilled Plant Personnel Required. The U.S. Bureau of mines estimates that 80 percent of the technical workers in synthetic liquid fuels plants can be trained from inexperienced local labor. A maximum of 20 percent must then consist of workers already possessed of skills or experience required in such plants. The requirements of skilled personnel on this basis would be 227 in a coal synthine unit plant. It is considered that no difficulty would be encountered in obtaining the necessary skilled labor for mining operations.

Diversion of Presently Employed Labor. If a unit plant consuming large amounts of coal were to be introduced into an area already containing a large coal mining industry its requirements of coal may be presumed to have a profound effect on the economy of the industry at least within the county or General Area in which the plant is to be located. It may reasonably be presumed that existing coal mines in the area will be able and willing to divert a portion of their present capacity (at least all of their marginal business) to supplying the unit plant. Thus, a portion of the total personnel requirements of a unit plant may be satisfied by more intensive use of the productivity of existing coal mines and personnel in the area surrounding the plant, the increased productivity being diverted to the use of the plant.

New Personnel Requirements. When a new industry is introduced in a community its requirement for workers, in excess of that portion met by the diversion of existing production to the new industry, must be satisfied either directly or indirectly by recruiting of new workers; directly from workers who are not now employed, or indirectly from workers who will leave their present employment to work in the new industry and whose places must in turn be filled by recruiting from the ranks of the unemployed. An estimate of the number of new workers required by a unit plant is shown in the following tabulation:

Total Requirements of New Personnel
for a Coal Synthine Unit Plant

	Number
Unit Plant Employes	1,135
Coal Mine Employes	1,369
Total Production Employes	2,504
Service Workers	1,377
Total Personnel	3,881

The numbers of new plant employes are the same as those previously indicated under "Total Personnel Requirements". Since no such plant as the unit plant exists in the General Area the total personnel requirements, including skilled workers, are new and must be filled either directly or indirectly by unemployed workers.

The numbers of new coal mine employes are estimated to be those required to supply the fuel requirements of a unit plant on the same bases as used in developing the total personnel requirements but with the assumption that production of existing mines, as of the year 1948, will be utilized to the capacity possible by working 240 days per annum (the same as that assumed in an associated mine) with the added production diverted to the unit plant, and that the balance of production required by a unit plant will be produced in an associated mine working 240 days per annum.

The estimated number of coal miners required is developed in Exhibit No. 24.

Service workers are estimated at 55 percent (service to production worker ratio previously explained) of the new production workers required. It is logical to assume that service workers would be reduced in proportion to the reduction in production workers made possible by diversion of marginal coal production to the plant and the use of more working days per year.

Comparison of Personnel Requirements of a Unit Plant and Unemployment

The extent to which the new personnel requirements of a unit plant are met by the unemployed labor in the area surrounding the plant in an average location in the coal counties of Arkansas is indicated by the following tabulation.

Comparison of New Personnel Requirements of a Unit Plant and Unemployed per 1,000 Square Miles in Coal Counties of Arkansas and Size of Area Containing Sufficient Unemployed To Satisfy Requirements

Description and Process	New Personnel Requirement of a Unit Plant	Unemployed per 1,000 Square Miles	Size of Area Containing Sufficient Unemployed To Satisfy Requirement	
			Sq Miles	Radius Miles
Total Personnel	3,881	1,253	3,097	31.4
Skilled Personnel	227	36	6,306	44.8

The above comparison indicates that,on an average basis, in the coal counties of Arkansas it would be necessary, in order to fulfill the new personnel requirements of a unit plant, to enlist the unemployed in an area of about 30 miles radius about the plant, and all the unemployed skilled personnel in an area of about 45 miles radius. Actually, increasing the radius from which to draw upon additional unemployed would not produce proportionately greater numbers. Such an increased radius would extend into the outlying agricultural area surrounding Fort Smith and while it would produce additional numbers of unemployed, they would not possess the desired industrial skills. It becomes apparent that, while it might be possible to satisfy the requirement of a unit plant as to total numbers by use of unemployed within a reasonable traveling distance from the plant, the requirement of skilled labor could not. The deficiency in workers possessing the desired industrial skills would have to be met by inmigration of such workers from surrounding industrial centers.

Operating Labor Costs

The average straight-time hourly rate as of March 31, 1950, payable to wage earners (exclusive of supervisors) in a synthetic liquid fuels unit plant in Arkansas is estimated at $1.48. Development of this hourly rate is summarized in the following tabulation:

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Estimated Average Straight-time Hourly Rate Payable in Synthetic Liquid Fuels Unit Plant

Average straight-time hourly rate (exclusive of premium pay) prevailing in Arkansas in the industries comparable with synthetic liquid fuels plant for workers of skills and experience required	$1.38
Relocation differential - 5 percent	.07
Total straight-time hourly rate, exclusive of premium pay	$1.45
Average differential (premium) pay because of working second and third shifts	.03
Total average straight-time hourly rate payable in synthetic liquid fuels unit plant	$1.48

Introduction of a second unit plant in the General Area of Arkansas would necessitate recruiting of substantially all of the personnel requirements of such a plant from outside the Area. This might necessitate an increase in overall labor rates payable at such a plant over that estimated payable in the first.

Basis of Estimated Wage Rates. Wage rates of workers of the higher skills to be employed in synthetic liquid fuels plants are governed by the rates paid in the chemical, petroleum refining, and coal mining industries, as such workers will have to be recruited from or paid in competition with them. Wages of workers of lesser skills, however, are not dependent to the same extent on wages paid in the above industries, but are governed by wages paid in the manufacturing industries presently existing in the areas in which the proposed plants are to be located.

In estimating wage rates in the synthetic liquid fuels industry, wage rates in the chemical, petroleum refining, and coal mining industries in relation to other widespread industries has been taken at a ratio of two to one. By dividing the number of workers (exclusive of supervisors), shown by the U.S. Bureau of Mines personnel classification for a 30,000-barrel-per-day coal hydrogenation plant, into two groups as to relative skills (above or below a wage rate of $1.70 per hour) a ratio of approximately two to one is shown as follows:

Ratio of Wage Earners of Higher Skills to Those of Lower Skills

Department	Number of Wage Earners: Higher Skilled	Lower Skilled	Total
Operating	955	139	1,094
Maintenance	807	484	1,291
Indirect	22	288	310
Total	1,784	911	2,695
Ratio of wage earners of higher skills to those of lower skills	1,784 ÷	911 =	1.96

U.S. Bureau of Labor, Wage Rates by Regional Areas. Wage Survey Bulletins prepared by the Bureau of Labor Statistics of the U.S. Department of Labor, as of various dates, were used as a basis for development, by regional areas, of wages paid in industries similar to synthetic liquid fuels plants. After adjustment to a uniform date, March 31, 1950, the average straight-time hourly rate, exclusive of premium, for the southwestern States (which include Arkansas) has been developed for selected industries.

The industries selected as representative in each group of required labor skills are those for which there are available Wage Survey Bulletins covering all areas in the United States. Development of average straight-time hourly wage rates, exclusive of premium, made in the southwestern States is shown in the following tabulation.

Average Straight-time Hourly Wage Rates, Exclusive of Premium, Paid in Selected Industries in Southwestern States (As of March 31, 1950)

Industry	Hourly Wage Rate
Industries employing workers of higher skills:	
Chemical	$ 1.65
Petroleum Refining	1.83
Bituminous Coal Mining	1.63
Average straight-time hourly earnings, weighted by reported total number of workers	$ 1.77
Industries employing workers of lesser skills:	
Fabricated Structural Steel	$ 1.20
Paints and Varnishes	1.03
Ferrous Foundries	1.18
Machinery	1.45
Fertilizers	0.80
Electric and Gas Utilities	1.29
Average straight-time hourly earnings, weighted by reported total number of workers	$ 1.30
Average straight-time hourly earnings combined by means of a weighting ratio of two to one of wages paid by industries using workers of higher skills to those using workers of lesser skills	$ 1.61

<u>Wage Rates in Arkansas.</u> Straight-time average hourly wage rates, exclusive of premium, as developed for the regional area was then broken down to individual states by assuming that the ratio of the State rates to the area rates would be the same as that in-
Ark dicated by other wage studies such as: (a) that made by the Army-
103 Air Force Wage Board, in 1948; (b) the Old-Age and Survivors In-
[illegible] surance Program during the first quarters of 1948 and 1947; and
4 (c) the State Unemployment Insurance Program for the year 1946. This determination for the State of Arkansas, is shown in the follow-
70021 ing tabulation.

Straight-time Average Hourly Wage Rates,
Exclusive of Premium, Paid in Selected Industries in Arkansas
(As of March 31, 1950)

	Hourly Rates as per Source of Information		Hourly Rates Adjusted to Level of Synthetic Liquid Fuels Industry	
	Regional Area	Arkansas	Regional Area	Arkansas
Army Air Force Survey	$1.10	$1.06	$1.61	$1.55
OASI Program:				
1st Quarter 1948	1.58	1.29	1.61	1.31
1st Quarter 1947	1.43	1.17	1.61	1.32
Unemployment Insurance Program:				
Year 1946	1.32	1.08	1.61	1.32
Average Straight-time Hourly Wages - Arkansas				$1.38

Relocation Differential. In order to induce workers to relocate in the vicinity of the unit plant, it is considered that it will be necessary to offer a differential of 5 percent over the hourly rate prevailing in the State in industries comparable to synthetic liquid fuels plants. Such an increase amounts to 7 cents per hour or $145.60 per annum (of 2,080 working hours). Such an increase would probably pay relocation costs in one year and, when coupled with the prospect of steady year-round work and of new housing in a model village, should constitute inducement to sufficient workers to completely staff the plant and associated activities.

Premium Pay for Second and Third Shifts. It is the practice in manufacturing industries operating on round-the-clock basis to pay a differential, or premium to workers on the second and third shifts over hourly wages paid workers on the first shift. The differentials most prevalent in petroleum refining and bituminous coal mining are 4 cents per hour on the second shift and 6 cents per hour on the third. Assuming an equal number of workers on the three shifts in synthetic liquid fuels plants, the average amount of shift differentials would be 3 cents per hour.

HOUSING AND COMMUNITY DEVELOPMENT

Population Characteristics

The State of Arkansas has a 1950 population density of 36.1 per square mile. Of the entire State population in 1940, 22.1 percent lived in urban areas. There is only one large city in Arkansas with a 1950 metropolitan area population of over 100,000, Little Rock, with population of 207,000. (Source: Sales Management - Survey of Buying Power - further reproduction not licensed).

In two western counties of the State where a General Area for the location of a synthetic liquid fuels plant is being considered, the 1950 density of population is 51.8 per square mile. There is only one large city within these counties, Fort Smith, which had a 1950 population of 47,864. In these coal counties as of 1940, 48.1 percent of the population lived in urban areas, 26.2 percent in rural nonfarm, and 25.7 percent in rural farm areas.

Community Requirements and Population Determination

When a new manufacturing establishment is set up, unless it is located in an already established large community, it may be presumed necessary to develop an entire new community to house plant and associated workers conveniently near their place of employment to the extent that experience has shown it to be required.

Housing facilities alone, however, are not the only requisite of a new community. Residents of a new housing development require civic and commercial facilities reasonably convenient to their homes. It has been considered that such facilities must be provided as an integral part of a planned community rather than allowing them to develop without plan on the outskirts of the de-
Ark velopment.

105 An estimate follows of the population of the plant-city
10 associated with a unit plant in Arkansas, based on numbers of
70021 plant and mine employes, together with associated service workers, for whom housing would be required. This estimate is based on average conditions in the coal counties of Arkansas. It is subject to variation from one location to another based on conditions existent in each individual location.

Population of 10,000-barrel-per-day Synthetic Liquid Fuels Plant-city

	Number
Plant and Mine Employes	2,229
Service Workers	1,226
Total Workers	3,455
Number of Households or Dwelling Units	2,953
Total Population To Be Housed	11,517

Number of Plant and Mine Employes To Be Housed. The percentage of plant and mine employes for whom housing would be required in a plant-city is based on a chart, Exhibit No. 25, which shows the "Ratio of Employes Housed in a Plant-city to the Relative Personnel Demand". This chart was developed from a study of the effect of density of population in the area surrounding existing communities, in which the predominant source of employment is one plant or factory.

The number of plant and mine employes estimated to be housed in the plant-city is shown in the following tabulation:

Number of Plant and Mine Employes Estimated To Be Housed

Population Density per Square Mile in Western Arkansas Coal Counties	51.8
Population within 1,000 Square Miles (17.8 miles radius from plant)	51,800
Requirements of New Plant and Mine Personnel (from "Labor" Section)	2,504
Above Requirements in percentage of Population within 1,000 Sqare Miles	4.83%
Plant and Mine Employes To Be Housed in the Plant-city:	
Percent of Total (from Exhibit No. 25)	89%
Number	2,229

Number of Service Workers To Be Housed. In every community, there must be service workers to minister to the needs of production workers. Such workers consist of proprietors and employes of wholesale and retail trade establishments, finance, insurance, and real estate agencies, and a great variety of miscellaneous service establishments such as laundries, dry cleaners, barbers, shoe and hat cleaners and repairers, automobile repair shops, garages, motion picture houses, etc., as well as professional personnel, such as doctors, lawyers, teachers, and governmental workers. Transportation and public utility workers are also considered as service workers for the purpose of this report. In sparsely settled rural counties, only the minimum services are provided in nearby centers and the more specialized services must be secured in more distant trade centers. As mining or manufacturing expands in a community, trade and service establishments spring up within it over a period of time, and the number of workers in the service industries tends to equal the number in the production group, unless the community is a satellite of a large urban center.

In estimating the service requirements of a plant-city in Arkansas, it is considered that production workers living in the plant-city will receive the same degree of service as that prevalent in the State as a whole. The relationship between service and production workers prevailing in the coal counties is distorted by the presence there of Fort Smith, a city which supplies service facilities to an area outside the State. The percentage of service workers in terms of production workers for the State of Arkansas is developed in the following tabulation, based on data from Exhibit No. 21:

Percentage of Service Workers to Production Workers in Arkansas as of 1940

Class of Worker	Number	
Production		
Agricultural	300,071	
Mining	5,902	
Construction	17,231	
Manufacturing	57,716	
Total Production Workers		380,920
Service		
Total Service Workers		203,024
Percentage of Service Workers in terms of Production Workers		53%

Applying a rounded percentage of 55 to the plant and mine employes estimated to be housed in the plant-city, the number of service workers to be so housed would be:

Estimated Number of Service Workers To Be Housed

	Number
Plant and Mine Employes	2,229
Service Workers - 55% of Plant and Mine Workers	1,226

Population of Plant-city. The number of employed persons per household may be determined for the State of Arkansas according to the 1940 census, as shown below:

Estimated Number of Employed Persons per Household in Arkansas as per 1940 Census

Employed Persons	583,944
Households	497,820
Employed Persons per Household	1.17

The Bureau of the Census shows, for Arkansas in 1940, a population per household of 3.9.

Assuming these ratios to apply to the plant-city the total population is determined as below:

Estimated Total Population of Plant-city

	Number
Employed persons in plant-city	3,455
Households or dwelling units (employed persons divided by 1.17)	2,953
Total population (households multiplied by 3.9)	11,517

Estimates for this report have been based on the assumption of only one unit plant per 1,000 square miles. Simultaneous operation of two or more unit plants within such an area would require housing a substantially larger proportion of workers. This would entail increased investment in housing per plant with corresponding changes in operating costs.

Family Housing Requirements. In the past, common practice in construction of "company towns" has been to confine dwellings to those accommodating a single family. There is now, however, an increasing demand for multi-family or apartment dwellings. In this report, it has been assumed that 20 percent of all dwellings will be of this type, the balance being single homes. Analysis of single homes in existence in Oak Ridge in 1947 shows that about 75 percent had two bedrooms and 25 percent had three. For the purpose of estimating costs of the plant-city the distribution by types of dwelling is assumed to be as follows:

Distribution by Types of Dwellings

Type of Dwelling	Percent of Total	Number of Dwellings for Plant-city of a Unit Plant
2-Bedroom single-family	60%	1,772
3-Bedroom single-family	20	591
Multi-family Units	20	590
Total	100%	2,953

Cost of Housing and City Development for a Unit Plant

Investment in Plant-city. Based on the Contractor's experience in similar installations, a plan of a model city for employes of a synthetic liquid fuels plant was designed. This city plan provided housing, utilities, and civic and commercial facilities adequate for a population of 5,000 inhabitants. Cost estimates for such a model city were made at levels prevailing at December 1949, in the Pittsburgh, Pa., area.

From this estimate unit costs were developed for application to plant-cities of populations estimated to be required in connection with a unit plant in Arkansas. An index of building construction costs applicable to the General Area in Arkansas, as of March 31, 1950, as compared to similar costs in Pittsburgh, Pa.,
Ark as of December 1949, was developed based on data on construction costs as reported by The Dow Service, Inc. This index, for
309 Arkansas, is 94.

15 The estimated investment required to construct a plant-
70021 city in connection with a unit plant in Arkansas is shown in the following tabulation:

Cost of Housing and Community Development
Required for a Coal Synthine Unit Plant
(As of March 31, 1950)

Type of Facility	Investment
Land	
For 11,517 population at $9 per person	$ 103,653
Grading and Landscaping Site	
For 11,517 population @ $142 per person	1,635,414
Dwelling Units	
1,772 - 2-Bedroom single-family @ 806 sq ft @ $8.63 per sq ft	12,326,032
591 - 3-Bedroom single-family @ 988 sq ft @ $8.63 per sq ft	5,038,866
590 - Multi-family @ 850 sq ft @ $7.87 per sq ft	3,947,100
1,624 Garages (55% of Dwelling Units @ $761 each)	1,235,864
Total Dwellings	$22,547,862
Utilities	
Lighting, water distribution, sewage disposal, streets, roadways, sidewalks, curbs, and gutters	$ 4,213,931
Civic Facilities	
Municipal building, comfort station, schools, hospital, sanitation	3,627,855
Commercial Facilities	
Bus station, theatre, bank and professional building, shopping buildings	5,378,439
Total Investment for Complete Plant-city, exclusive of Water Supply	$37,507,154

Commercial Facilities. It is recognized that, insofar as possible, an industrial plant-city such as would be required by a synthetic liquid fuels plant should be self-supporting. Commercial establishments and services, as an integral part of a community, are profit-making entities resulting from community development. Therefore it has been considered that rental from commercial facilities would be ample to cover the charges on the investment in those facilities, including a proportionate share of the utilities and civic facilities and land. Such investment has been estimated as follows:

Allocation of Total Investment in Plant-city between Residential and Commercial Facilities, with Estimation of Appreciated Land Values

	Commercial	Residential	Total
Capital Investment	$5,378,439	$22,547,862	$27,926,301
Percent of total	19%	81%	100%
Allocation (based on percent of total) of:			
Utilities	$ 800,647	$ 3,413,284	$ 4,213,931
Civic facilities	689,292	2,938,563	3,627,855
Investment and land improvements	$6,868,378		
Appreciated value of land 1/6 of improvements	1,144,730		
Total Commercial Investment	$8,013,108		

The advantages to management in the construction, operation, and control of its own city are recognized. Among them are:

(1) A more dependable and stable labor supply
(2) More desirable living conditions
(3) Better civic administration
(4) A cleaner and more orderly community
(5) Lower plant and community taxes.

Against these advantages, management will have the responsibility and expense of construction and administration of the plant-city. It is felt however that savings to the plant in municipal taxes will be sufficient to compensate for such expense.

Employe Home Ownership. The advantages of home ownership, both to the employes as individuals and to the company, are well recognized, and it is believed that some arrangement should be encouraged whereby at least one-half the housing could be offered to employes on liberal terms, either directly by management or by reputable builders approved by management. The cost of the several types of housing including its share of land and utilities (but excluding civic facilities) and the bare cost of a garage are estimated for unit plants as follows:

Estimation of Residential Housing Costs

	Amount
Cost of land, grading, and landscaping	$1,739,067
Less allocation to commercial facilities	1,144,730
	$ 594,337
Cost of utilities allocated to residential	3,413,284
Residential share of land and utilities	$4,007,621

	No. of Units	Total Cost of Dwelling Units	Allocated Cost of Share of Land and Utilities	Residential Cost	
				Total	Per Unit
Dwelling Units -					
2-Bedroom single-family	$1,772	$12,326,032	$2,317,852	$14,643,884	$ 8,264
3-Bedroom single-family	591	5,038,866	947,535	5,986,401	10,129
Multi-family	590	3,947,100	742,234	4,689,334	7,948
	$2,953	$21,311,998	$4,007,621	$25,319,619	$ 8,574
Garages	1,624	1,235,864	-	1,235,864	
Total Residential		$22,547,862	$4,007,621	$26,555,483	

If one-half the dwellings of each type were sold at cost to its occupant then the remaining investment in dwellings and civic development would be:

Estimated Remaining Investment in Dwellings and Civic Development for Unit Plant

	Amount
Total Investment for Complete Plant-city	$37,507,154
Less:	
Commercial Facilities and Related Costs	$ 8,013,108
One-half Cost of Housing Sold to Occupants	13,277,742
Total	$21,290,850
Balance of Investment in Land, Dwelling Units, Garages, Utilities, and Civic Development	$16,216,304

This balance of investment consists of dwellings not sold to employes, together with the investment in land, grading, utilities, and civic facilities not recovered by rental of commercial facilities or sold. This investment would be operated by the plant.

Operating Costs

The annual costs of operation of investment not recovered by rental of commercial facilities or by sale are estimated below:

Annual Operating Costs

	Amount
Net Investment	$16,216,304
Operating Costs @ 6%	972,978

Annual costs of operation are estimated to comprise in terms of annual percentages on investment:

Annual Costs of Operation in Terms of Annual Percentage on Investment

	Percent
Depreciation (40-year life)	2.5%
Maintenance Costs	2.0
State and County Taxes, Insurance, and Operation of Municipal Facilities	1.5
Total Annual Percentage	6.0%

It is considered that costs of operation of housing and community development may be recovered by rents of dwelling units without the necessity of any charge to plant operations.

The average amount per month required to offset operating costs would be $54.92 as shown below:

Annual Operating Costs	$972,978
Number of Rental Units	1,476
Average per Unit:	
Annual	$ 659
Month	$54.92

Such an amount would be 18.3 percent of the average income per household of $3,602. The average annual wage of plant workers in Arkansas has been estimated at $1.48 per hour or $3,078.40 per annum (of 2,080 hours). The average income per household on this basis would be $3,602 ($3,078.40 x 1.17 wage earners).

Return on Investment

Recognizing that different investors may require different rates of return upon their capital, these estimates include no allowance for return. However, as a guide, the following tabulation indicates the amounts per month for each unit and per barrel of products which would be required for each increment of 1 percent (before income taxes) on the estimated net total investment in housing and community development associated with a unit plant in Arkansas:

Incremental Costs for Each 1 Percent Gross Return on Net Investment in Housing and Community Development

Net Investment	$16,216,304
1 Percent Return on Above:	
Per Annum	$162,163
Per Dwelling Unit:	
Per Annum	$ 110
Per Month	9.17
Per Calendar Day	444
Per Barrel of Products	$0.044

The monthly rental to be paid by the occupant would be the average monthly operating cost plus the required return on the investment.

MARKETING

Introduction

The agreement under which this report was prepared requires the General Areas suitable for the location of synthetic liquid fuels plants to be arranged in groups of relative desirability, with at least 2,000,000 barrels of daily production in the most desirable group for the total United States. This is equal to 730,000,000 barrels annually, or approximately 36.3 percent of the total demand for liquid fuels in the United States for the year 1949.

Motor Fuel - Major Plant Product. If a substantial part of the demand for liquid fuels in the United States were supplied by synthetic plants, the principal product would be motor gasoline.

Plants Using Coal or Natural Gas. For plants using coal or natural gas as raw materials, motor gasoline would be the major plant product. The amounts of motor gasoline specified to be produced from these raw materials by the various processes are as follows:

Percentage of Motor Gasoline
Specified To Be Produced by the Various Processes

Process	Percent
Hydrogenation	72.2%
Synthine Using Coal	72.8
Synthine Using Natural Gas	91.5

Plants Using Oil Shale. In the case of shale-oil plants, for the purpose of this report, motor gasoline is not specified as one of the products to be produced although such plants, if so designed, could produce motor gasoline. For a 10,000-barrel unit shale-oil plant, the principal products specified are 5,150 barrels of jet fuel and 3,350 barrels of Diesel fuel daily. The annual production of Diesel fuel of such a plant would be 1,220,000 barrels. In the year 1948 total sales of Diesel fuel in all of the Mountain States amounted to only 5,209,000 barrels. In other words, about five shale-oil plants would have been sufficient to satisfy the total demand for Diesel fuel in the Mountain States in that year. In the case of jet fuel, the annual output of a single 10,000-barrel-per-day shale-oil plant would be 1,880,000 barrels. This is approximately equal to the total sales of jet propulsion fuel in the year 1948 of 1,891,000 barrels in the total United States. Consequently, it appears that if a relatively large number of synthetic liquid fuels plants should be established, the principal product would be motor gasoline. Furthermore, since it appears that only enough natural gas will be available for relatively few synthetic liquid fuels plants, motor gasoline would amount to approximately 75 percent of the total productive capacity, based upon the plant product specifications.

From the foregoing, it is evident that of the total 2,000,000 barrels of daily productive capacity (which is equivalent to the capacity of 200 10,000-barrel synthetic liquid fuels plants) required to be included in the most desirable group of General Areas, gasoline would amount to approximately 1,500,000 barrels daily, or 547,500,000 barrels annually. This would be 62.3 percent of the total United States demand for motor gasoline in 1949, which amounted to 878,887,000 barrels. If the total demand for motor gasoline in 1949 had been supplied by synthetic liquid fuels plants, a total of 321 such plants would have been required. This is a relatively small number in contrast to the several thousands of plants potentially possible based on raw materials available.

Estimated Future Liquid Fuel Requirements. While the hazards of a long-range forecast of liquid fuel consumption are well recognized, it has been considered necessary in this present study to attempt to estimate probable liquid fuels requirements over the next 25 years because the usual short-term forecasts of a few years' duration would have little significance in appraising the economic factors that may have a bearing on the bringing into existence of a long-range program, such as the development of a synthetic liquid fuels industry. On the basis of present-day factors affecting motor gasoline consumption, the future demand has been projected by states and from this the total demand for the United States has been estimated, as shown in Exhibit No. 26, which demand in 1975 amounts to approximately 59 billion gallons, or 1.4 billion barrels annually. If this demand were met entirely with synthetic motor gasoline, the equivalent of 511 plants each of 10,000 barrels daily capacity would be required.

In recent years, the proportion of motor gasoline to the total demand for liquid fuels in the United States has averaged approximately 40 percent. At the present time, there are several factors which indicate that the motor gasoline percentage may rise in the next few years. There is a tendency for the percentage of residual fuel oils to decline as refining operations are altered. Furthermore, it is expected that the expansion of the natural gas industry may reduce relatively the consumption of fuel oil and kerosene. On the other hand, there may be some counterbalancing factors, such as the increasing use of jet propulsion fuel and Diesel fuel. However, on the basis of motor gasoline consumption of 40 percent, the total United States demand for liquid fuels in 1975 would be of the order of 3.5 billion barrels annually.

In order to provide a check upon the reasonableness of this estimate, the total annual energy supply for the United States was studied and projected to 1975. This is shown on the chart, Exhibit No. 27, which indicates estimated total energy requirements in 1975 of 50 thousand trillions of Btu. In a recent study, "Energy Uses and Supplies, 1939, 1947, 1965", by the U. S. Bureau of Mines, Information Circular 7582, energy supplies in the United States are projected at approximately 48 thousand trillions of Btu in 1965. This is in close agreement with the 47 thousand trillions of Btu for 1965 shown on the chart, Exhibit No. 27. Of the estimated total energy supply in 1975 of 50 thousand trillions of Btu, the 3.5 billion barrels of liquid fuels would constitute 42 percent as contrasted with 35 percent in 1948, as shown on the chart, Exhibit No. 28. The relative proportions of energy supplied by coal, natural gas, and petroleum, which are also shown on that chart, indicate the reasonableness of the estimate. Some studies of liquid fuel demand have estimated that consumption in 1975 may be of the order of 5 or 6 billion barrels. If these quantities are related to the estimated 1975 total energy requirements, they would amount to 60 percent and 72 percent respectively. Such high percentages would appear to assume an unreasonable limitation on the use of other fuels such as coal and natural gas.

<u>Crude Oil Reserves and Production.</u> As of December 31, 1949, the estimated proved reserves of crude oil in the United States stood at 24,649,489,000 barrels, which is an all-time record high. This amount is 13.6 times the crude oil production of 1,818,800,000 barrels in 1949. If the proved reserves of natural gas liquids are added to the crude oil reserves, the estimated proved reserves of liquid hydrocarbons as of December 31, 1949 amounted to 28,378,501,000 barrels. In the past, new discoveries and extensions of old fields have added to the known supply. The following tabulation shows the amount of crude oil added to the supply by 5-year periods from 1925 to 1949:

<u>Amounts of Crude Oil Added to the Supply</u>

Period	Billions of Barrels
1925-29	10.044
1930-34	3.325
1935-39	12.161
1940-44	9.296
1945-49	13.336
Total	48.162

The above tabulation shows that, when the incentive has been strong, substantial quantities of crude oil have been discovered. It must be anticipated that further substantial quantities of oil will be discovered in the future. Recent important oil discoveries in Scurry County, Texas, and in California have increased appreciably the optimism with respect to future oil discoveries. Furthermore, the major oil discoveries made in Alberta, Canada, in recent years indicate that vast oil resources may exist in western Canada. This has led to the belief that important oil resources also may be found in North Dakota. In fact, the oil companies have under lease in the United States more than 200 million acres of untested lands, having geological formations considered favorable to the discovery of oil.

Based upon the estimate of future requirements of liquid fuels in 1975, as previously developed, crude oil production during the next 25 years would be required in the amount of approximately 62 billion barrels. This may be compared to the 48.2 billion barrels added to the supply in the 25-year period 1925-1949. Stated in other terms, the estimated crude oil requirements during the next 25 years are at about the rate of additions to the supply developed in the 5-year period 1945-1949. Through 1949 the total amount of crude oil produced in the United States amounted to approximately 39 billion barrels. This, together with the estimated requirements to 1975, would indicate a total cumulative production by that time of approximately 100 billion barrels. In recent years it has been variously estimated that the total amount of oil ultimately recoverable from primary onshore operations amounts to approximately 110 billion barrels. In addition, it is estimated that approximately 40 billion barrels more might be obtained from offshore operations and from secondary recovery. In the petroleum industry, it is generally estimated at present that less than half of the oil originally in place is produced. Important changes in methods of production, therefore, might add considerably to the recoverable supply.

<u>Order of Desirability Influenced by Markets.</u> Since there are some 25 states having Suitable General Areas, it is not possible in these separate state reports, which are being prepared seriatim, and not simultaneously, to contemplate all of the factors to be developed in subsequent state reports, which might tend to vitiate some of the material presented herein. It might be shown subsequently, for example, that markets allocated to nearby General Areas could be supplied more economically from synthetic liquid fuels plants located in other distant states. In any case, the determination of the order of desirability of the General Areas must take into consideration the cost of transporting products to a designated market that could absorb the assumed output and not be based solely on estimated fob. plant costs. In these state reports, markets are defined and allocated to the General Areas under consideration with the full realization that information subsequently developed may show that the markets could be served more economically by other potential synthetic liquid fuels plants.

Definition of the Marketing Territory

As shown in Exhibit No. 8 there is only one Suitable General Area of Coal and Water Availability in Arkansas, located in the western part of the State. The neighboring States of Louisiana, Texas, Oklahoma, Missouri, and Tennessee also contain Suitable General Areas for the production of synthetic liquid fuels. A determination of the potential markets for the major products of synthetic liquid fuels plants in Arkansas must, therefore, give consideration to the limiting factors placed upon the market by the existence of potential plant sites in neighboring states. At the present time, no General Areas suitable for the location of synthetic liquid fuels plants are known to exist in the State of Mississippi which borders on Arkansas to the east. However, as demonstrated subsequently in this section of the report, the synthetic liquid fuels potential of the one Arkansas General Area is small in relation to the predicted future demand for liquid fuels in the State of Arkansas itself. Consequently, it appears desirable to establish limits to the marketing territory to be served from synthetic liquid fuels plants in Arkansas on the assumption that synthetic liquid fuels produced in Arkansas would be marketed entirely within the State. While such a limitation of markets is somewhat arbitrary, it is believed to be necessary in order to avoid allocating the same marketing territory to the synthetic liquid fuels plants of more than one state.

Consumption of Motor Fuel in Arkansas

The major product specified to be produced from coal by synthetic liquid fuels plants is motor gasoline. Motor gasoline constitutes approximately 75 percent of the total productive capacity. Since this product constitutes such a high percentage of the total proposed output, extensive consideration has been given to the factors bearing upon the present and predicted future demand and the present and predicted future supply of motor gasoline.

In this analysis, data on motor fuel consumption published by the Public Roads Administration have been used. In these figures, motor fuel consumption is reported for on-highway and off-highway uses excluding sales to the Federal Government for military purposes. Consequently, military requirements are eliminated from consideration in this report.

Although it is recognized there is some leeway in the process for producing some higher grade gasolines, the quality of gasoline proposed to be produced by the coal synthine plants is specified to be about 80 octane motor method rating. Since this gasoline would be of lower standard than commonly used for aviation, aviation gasoline consumption has been eliminated from the total off-highway consumption of motor fuel as published by the Public Roads Administration. Therefore, motor fuel consumption figures given in this analysis do not include aviation use or purchases by the Federal Government for military purposes.

Motor gasoline consumption for the State of Arkansas in the year 1948 amounted to 7,705,000 barrels. The annual production of motor gasoline from coal by a synthine plant of 10,000-barrel-per-day capacity, would be approximately 2,737,500 barrels. Consequently, if the entire motor gasoline consumption in the State of Arkansas in 1948 had been supplied by synthetic liquid fuels plants, approximately 3 such plants would have been sufficient to satisfy the total demand.

Since the motor fuel requirements of Arkansas are well satisfied at the present time by petroleum products and since it appears that it may be many years before large quantities of synthetic liquid fuels will be required, it is desirable to estimate the future demand for motor fuel in Arkansas. While ordinarily five or ten years might be considered the limit to which an estimate of future demand might be extended with a reasonable degree of accuracy, it was believed desirable in the present instance to attempt to estimate motor fuel consumption in the State of Arkansas to 1975. Even though the hazards of such long-range prediction are realized, the main purpose of the estimate is to indicate the probable maximum number of synthetic liquid fuels plants which would be needed were no petroleum liquid fuels available.

<u>Future Consumption of Motor Fuel in Arkansas.</u> To make an estimate of the future demand in the State of Arkansas, motor fuel consumption was divided into on-highway and off-highway uses. The estimate of future on-highway use of motor fuel was based primarily on the growth trends of population, motor vehicle registrations, and consumption per vehicle. The off-highway use was determined principally from the on-farm consumption.

<u>Population.</u> In general, the future population estimates were based on an estimate published in November 1949, by the Bureau of Agricultural Economics of the U. S. Department of Agriculture. In the report, the population of the United States was projected to 1975 by major geographic divisions and the basis for these projections was past population figures of the Bureau of the Census.

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The projections of future population by geographic 121
divisions of the United States were based upon two estimates of 121
future population by the Bureau of the Census. One of these, termed 122
the high projection, was described as high fertility, low mortality, 3
200,000 net immigration per year, and high internal migration. 7002
The other, termed the low projection, was based upon medium fertility, medium mortality, no net immigration after 1950, and low internal

migration. In this report, the high projection has been used since that forecast appears to be more reasonable, considering present population trends. On this basis, the population of the United States in 1975 is estimated by the Bureau of Agricultural Economics as 188,585,000.

Exhibit No. 29 shows the population by major geographic divisions of the United States from 1870 to 1950, with estimates to 1975. The extensions to 1975 on the chart correspond to the high projections made by the Bureau of Agricultural Economics, adjusted in the Pacific, Mountain, and South Atlantic States to reflect more recent conditions as indicated by the results of the 1950 census. It should be noted that these extensions carry out the trends in the past and may provide a fairly accurate gauge of the population growth in the years to come.

Since the State of Arkansas is in the West South Central geographic division, the population of each state in that division was studied, both in absolute numbers and as percentages of the total population of the geographic division. From the percentage figures, projections of past trends were extended to 1975. The percentages so derived were then applied to the total estimated population of the geographic division in order to determine the population estimates for the various states. The figures so derived are presented in chart form in Exhibit No. 30, which shows the population of each of the states in the West South Central geographic division from 1900 to 1950 with estimates to 1975. The total estimated population of the four states in 1975 is equal to 17,614,000 which is the estimate for the West South Central geographic division prepared by the Bureau of Agricultural Economics. The population of Arkansas as of April 1, 1950 was 1,909,511 and the estimate for 1975 is approximately 1,937,000.

Motor Vehicles. To obtain an approximation of the number of automobiles likely to be in use during the next 25 years, data of past automobile registrations published by the Public Roads Administration were studied. The number of persons per private and commercial automobile registration in each state was calculated and projected to 1975. In making these projections, attention was given to effects of present and possible future population density, income per capita, and other economic factors which would influence the number of persons per automobile.

Exhibit No. 31 shows the number of persons per private and commercial automobile plotted against income payments per capita, for each of the states of the United States in 1948. It will be noted that on this chart the number of persons per private and commercial automobile decreases as the income payments per capita increase, except in the most densely populated states. The lower limit appears to be about three persons per vehicle and this limit seems to be approached only in those states where the income payments per capita are high and where the population density is not high. These data were used as guides in projecting the future number of persons per private and commercial automobile in each of the states. Exhibit No. 32 shows the number of persons per private and commercial automobile in each state of the West South Central States for the years 1930 to 1949, with projections to 1975.

The number of persons per private and commercial automobile in the State of Arkansas in 1948 was approximately 7.55. The estimate for 1975 is approximately 4.07 persons per private and commercial automobile. Using the future population estimates mentioned previously and this number of persons per automobile, the number of private and commercial automobiles in the State of Arkansas in 1975 is estimated to be approximately 476,000, while the number in 1949 was approximately 270,000, an increase of about 76 percent. Exhibit No. 33 shows private and commercial automobile registrations in Arkansas for the years 1927 to 1949 with estimates to 1975. The number of publicly owned automobiles in 1975 was assumed to bear the same relationship to private and commercial automobiles in that year as existed in 1948. On this basis, the total number of automobiles estimated for the State of Arkansas in 1975, including both publicly owned and private and commercial vehicles, is 477,300.

The number of motor trucks likely to be in use in the State of Arkansas by the year 1975 was estimated in much the same manner as that employed in calculating the number of automobiles. Consideration having been given to the main economic factors which would influence the growth in number of motor trucks, the number of persons per private and commercial truck was projected to 1975. The present and possible future conditions with respect to population density and income per capita were considered. Special attention was given to the number of farm motor trucks now in use in the various states, since farm motor trucks comprise approximately 29 percent of the total number of private and commercial trucks in the United States. A study was made of the size and number of farms in each state, and the potential number of farm trucks which could be supported was taken into consideration. With this and the other guides mentioned, the number of persons per private and commercial motor truck in each of the states was projected to 1975. Exhibit No. 34 is a chart which shows the number of persons per private and commercial motor truck in the West South Central States for the years 1930 to 1948 and estimates to the year 1975. From the future projection on this chart for the State of Arkansas, the number of persons per private and commercial truck in 1975 is shown to be 11.0. Using the population estimates developed previously and the same proportion of publicly owned motor trucks as existed in 1948, the total number of motor trucks expected to be in use was projected to 1975. In that year the estimate is 183,000 motor trucks as compared with 1948 registrations of 129,542, as reported by the Public Roads Administration. This is an increase of about 41 percent.

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To estimate the growth in bus registrations, Public Roads Administration figures were used in conjunction with more recent figures obtained from the bus census of "Bus Transportation". From these data the number of persons per common carrier bus and per school bus were computed and projected to 1975. Using the population figures previously developed, the total number of buses for the State of Arkansas was projected to 1975 with the number in that year amounting to approximately 3,340 buses.

<u>On-Highway Consumption of Motor Fuel in Arkansas.</u> To arrive at an estimate of future on-highway use of motor fuel in Arkansas, the weighted average annual use of motor fuel per vehicle by type of vehicle was calculated from information of on-highway consumption for the State of Arkansas published by the Public Roads Administration for 1948. The estimated future on-highway use of motor fuel was then calculated from the number of motor vehicles previously estimated, multiplied by the weighted average annual consumption per vehicle. In other words, the estimates of future consumption are predicated on the average annual consumption per vehicle obtained in 1948. It is realized that motor vehicle efficiencies may increase somewhat in the future but data published by the Public Roads Administration covering vehicle travel per gallon of fuel consumed over the past 15 years would not indicate the likelihood of any striking changes in over-all efficiency. It may be that eventually motor vehicles will consume less fuel per vehicle-mile but it was believed preferable in this study to run the risk of overstating the future consumption rather than understating it by taking into consideration statements concerning future motor vehicle efficiencies that may not be achieved. If motor vehicle fuel efficiencies are increased appreciably in the future, the estimates of future on-highway consumption here developed will be proportionately too large. Based on the estimated number of vehicles and weighted average annual fuel consumption per vehicle, the on-highway motor fuel consumption in Arkansas in 1975 is estimated at 485,827,000 gallons. This is an increase of approximately 62 percent over 1948 on-highway consumption of 299,218,000 gallons.

<u>Off-Highway Use of Motor Fuel in Arkansas.</u> Since the consumption of motor fuel in agriculture constitutes the largest single item of off-highway use, special attention was given to the consumption of motor fuel by tractors on farms. To estimate the number of farm tractors that will be required in 1975, the amount of crop land harvested per tractor was studied. Exhibit No. 35 shows in chart form the average crop land harvested in acres per tractor for the United States from 1940 to 1949 with estimates to 1975.

To estimate the future number of tractors on farms for individual states, analyses were made of the number of farms by size groups, trends in the number of tractors on farms, the amount of crop land harvested in acres per tractor, per capita income payments, and the average amount of crop land harvested per farm. The chart, Exhibit No. 36, shows for each of the states in the United States for the year 1949 the average crop land harvested per tractor plotted against the average harvested crop land per farm. From the analysis of the number of farms by size groups, estimates were made of the maximum number of tractors which could be economically supported in each state. These numbers were then adjusted in view of the other factors mentioned above to arrive at an estimate of the number of tractors in each state. Using the estimated number of tractors in each state for 1975, the average crop land harvested per tractor was calculated and plotted against the average crop land harvested per farm, as shown in the chart, Exhibit No. 37.

The number of tractors on farms in the United States obtained for the year 1975 by totaling the individual state estimates developed as above amounts to 5,264,000 tractors. The reasonableness of the estimate of the number of tractors in each state in 1975 is indicated by the fact that the total for the United States (obtained in this manner) agrees quite well with the total estimated by the U. S. Department of Agriculture. In a study of food and harvested crop land required in 1975, the Department of Agriculture estimated that there would be 5,000,000 tractors on farms in the United States. That Department's estimate of the harvested crop land required, however, was based upon a lower estimate of future population than now appears reasonable. These estimates for tractors in 1975 may be compared to 3,365,000 tractors (excluding garden tractors) on United States farms as of July 1, 1949.

For the State of Arkansas the number of farm tractors in 1975 is estimated at 88,000. This is an increase of approximately 88 percent over the 46,700 tractors estimated on Arkansas farms as of July 1, 1949. The amount of motor fuel consumed per tractor in each state in 1948 was obtained from information published by the Bureau of Agricultural Economics. These amounts were then multiplied by the estimated number of tractors in each state to arrive at estimates of future consumption of motor fuel by tractors in each state. For Arkansas, motor fuel consumption by tractors in 1975 is calculated at 49,280,000 gallons.

Other off-highway uses of motor fuel in Arkansas in 1948 represent only a small percentage of the total consumption and for purposes of this estimate are assumed to bear the same relationship in the future as in the past. The total motor fuel consumption in Arkansas for the years 1927 to 1948 is shown on the chart, Exhibit No. 38, which also presents the estimate of future motor fuel consumption to 1975. It will be noted from the chart that the total motor fuel consumption (excluding aviation and military uses) for 1975 is approximately 537,033,000 gallons or about 12.8 million barrels. This represents an increase of approximately 66 percent over 1948 consumption.

Number of Synthetic Liquid Fuels Plants Equivalent to Motor Fuel Consumption in the Marketing Territory

The following tabulation shows a summary of total motor fuel consumption, less aviation and military use, in the State of Arkansas for the year 1948 and the estimate for 1975. The tabulation also presents the number of coal synthine plants, the motor fuel productive capacity of which would be equivalent to the total motor fuel consumption in the marketing territory.

Motor Fuel Consumption and Equivalent Number of Unit Synthetic Liquid Fuels Plants in Arkansas

	Annual Consumption (Millions of Barrels)	Equivalent Number of Unit Synthetic Liquid Fuels Plants
1948	7.7	3
1975 Estimate	12.8	5

While it is indicated by the above tabulation that the output of motor fuel of 5 coal synthine plants of 10,000 barrels daily capacity would be the equivalent of the estimated consumption in the marketing territory in 1975, it must be emphasized that it is not implied that this number of synthetic liquid fuels plants would be required. The calculation is made to show the maximum number of such plants that would be needed if no supplies of petroleum products were available and for purposes of comparison with the number of synthetic liquid fuels plants potentially possible, based upon the coal and water availability. As shown previously, these are sufficient to support approximately 3.7 unit synthine plants.

Consumption of Liquid Fuel Products other than Motor Fuel in Arkansas

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Although motor gasoline is specified as the major plant
126 product of synthine plants using coal as a raw material, other
liquid fuel products are also specified to be produced. These are
15 listed in the following tabulation, which shows the plant product
70021 distribution for coal synthine plants and also shows the other
products as percentages of the proposed motor gasoline production.

Unit Plant Product Distribution

	Synthine Using Coal	
	Barrels per Day	Percent of Gasoline
Gasoline	7,280	100.0%
Diesel Fuel	1,900	26.1
Fuel Oil	350	4.8
Propane	470	6.5
Total	10,000	

The actual consumption of liquid fuels in Arkansas by principal product classifications is presented in the following tabulation:

Liquid Fuel Consumption in Arkansas in the Year 1948 by Principal Product Classifications

Description	Thousands of Barrels
Motor Fuel	7,705
Kerosene	1,718
Diesel Fuel	998
Other Distillates	840
Residual Fuel	2,079
Total	13,340

In the above tabulation the figures for motor fuel consumption are exclusive of aviation and military uses. The data given for the other product classifications are sales figures as published by the Bureau of Mines. Consumption or sales figures for liquefied petroleum gases are not published by states but are available by Petroleum Administration for War Districts. The figures for District No. 3, which includes the State of Arkansas, and 5 other states, show that sales of liquefied petroleum gases in the year 1948 amounted to approximately 28.1 percent of the motor fuel consumption in that district.

The following tabulation shows, for petroleum products similar to the products specified to be produced by synthetic liquid fuels plants, consumption in Arkansas in 1948 as percentages of motor fuel consumption.

Consumption of Other Liquid Fuel Products
as a Percentage of Motor Gasoline Consumption in Arkansas

Description	Percent
Motor Gasoline	100.0%
Diesel Fuel	13.0
Residual Fuel Oil	27.0

The distribution of actual product consumption evident in the above tabulation differs in some respects from the proposed distribution of plant products specified to be produced by coal synthine plants. The actual consumption of Diesel fuel amounts to 13.0 percent of the motor fuel consumption, whereas for coal synthine plants the estimated production is 26.1 percent. The consumption of liquefied petroleum gases in 1948 in P.A.W. District No. 3 amounted to approximately 28.1 percent of the motor fuel consumed in that District. It appears probable, however, that liquefied petroleum gas consumption in Arkansas in that year amounted to a much smaller percentage of the gasoline consumption than the figure given for P.A.W. District 3. This district also includes the States of Texas and Louisiana, which accounted for approximately 94 percent of the total liquefied petroleum gas production in District No. 3 in 1948, and undoubtedly the great bulk of the liquefied petroleum gases sold in District No. 3 were consumed in Texas and Louisiana since these products are at low cost near the source of production. Consequently, it appears probable that the consumption of liquefied petroleum gases in Arkansas in 1948, when taken as a percentage of the motor fuel consumption, was of the same order as the output of propane by coal synthine plants at 6.5 percent.

It is apparent from the above analysis that the plant product distribution for coal synthine plants does not fully correspond to actual product consumption in Arkansas. According to the proposed plant product distribution, the percentage of Diesel fuel specified is too high. If the entire amount of motor fuel re-
 quirements were to be supplied by synthine plants, the plants would have to be redesigned to approach more nearly the required product
 distribution. It appears, however, that complete reliance upon synthetic liquid fuels plants as a source of supply is so far in the
 future that the product demand pattern may change considerably in

the intervening years. At such time as synthetic liquid fuels plants are economically feasible, it is probable that they would be so designed as to produce the products then in demand.

Sources of Liquid Fuel Supply for Arkansas

Sources of Crude Oil. Production of crude oil in Arkansas for the year 1949 amounted to approximately 28 million barrels, while proved reserves of crude oil, as estimated by the American Petroleum Institute, stood at 297,463,000 barrels as of December 31 of that year. Although the total production of crude oil in Arkansas is more than adequate to care for the total crude oil requirements in the State, a portion of the crude oil produced is shipped to refineries in other states, with the consequence that refineries in Arkansas obtained part of their requirements of crude oil from another producing state. Receipts of crude oil at refineries in Arkansas by states of origin are presented below for the year 1948:

Receipts of Crude Oil at Refineries in Arkansas by States of Origin in the Year 1948

	Thousands of Barrels
Receipts from	
Arkansas	16,305
Louisiana	3,182
Total Receipts of Crude Oil	19,487

Approximately 84 percent of the crude oil received at refineries originated in the State of Arkansas, while the remainder of the receipts came from Louisiana. Furthermore, over 98 percent of the crude oil received was delivered by pipe lines, with tank cars and trucks accounting for less than 2 percent of the total amount delivered. The following tabulation shows receipts of crude oil at refineries by methods of transportation for the year 1948:

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Receipts of Crude Oil at Refineries in Arkansas
by Methods of Transportation
in the Year 1948

	Thousands of Barrels
Intrastate Receipts:	
By Pipe Lines	16,073
By Tank Car and Truck	232
Total Intrastate Receipts	16,305
Interstate Receipts:	
By Pipe Lines	3,152
By Tank Car and Truck	30
Total Interstate Receipts	3,182
Total Receipts:	
By Pipe Line	19,225
By Tank Car and Truck	262
Total Receipts of Crude Oil	19,487

Crude Oil Refining Capacity. The present oil refining capacity in Arkansas amounts to approximately 21 million barrels of crude oil annually and is more than adequate to cover the State's annual consumption of liquid fuels, amounting to about 13 million barrels in 1948. In that same year crude oil runs to stills amounted to 19 million barrels.

As of January 1, 1950, there were six refineries located in the State of Arkansas. A list of the refineries with their locations, crude oil capacities, and operating companies is given below.

Oil Refineries in Arkansas
as of January 1, 1950

Location	Crude Oil Capacity (Barrels per Day)	Company
El Dorado	23,250	Pan-American Southern Corp.
El Dorado	22,000	Lion Oil Co.
Norphlet	3,300	Macmillan Petroleum Corp.
Smackover	6,000	Henry H. Cross Co.
Stephens	1,800	Berry Asphalt Co.
Waterloo	1,000	Berry Asphalt Co.
Total	57,350	

Prices of Petroleum Products in Arkansas

As shown previously, production of crude oil and products in Arkansas is greatly in excess of total liquid fuel requirements in the State. Consequently, potential synthetic liquid fuels plants in Arkansas would be situated in an important petroleum producing region. Under such circumstances synthetic liquid fuels plants would have no competitive advantage due to location.

In this study consideration has necessarily been given to the prices of petroleum products in Arkansas as being one of the important factors affecting present and future demand for liquid fuels in the marketing territory. A weighted average composite price of petroleum products has been computed based upon the same liquid fuel products and proportions as those specified to be produced by coal synthine plants. This composite price was constructed from quotations obtained on the various petroleum products in wholesale quantities fob. refineries in Arkansas, excluding taxes. While the cost calculations for synthetic liquid fuels plants and products contained in other sections of this report are based upon prices and quotations prevailing as of March 31, 1950, it was deemed preferable to use, in these calculations, quotations for petroleum products as of June 1, 1950 because refinery margins as of that date, appear to have been more nearly normal. In the tabulation on the following page, prices of the various petroleum products in Arkansas, as of June 1, 1950, are weighted according to the plant product distribution specified for coal synthine plants.

In the tabulation referred to, the price shown for gasoline is that of regular grade house brand containing tetraethyl lead with an octane rating of 82 or better. This product is evidently superior as a motor fuel to the gasoline specified to be produced by the synthine process using coal. The gasoline produced by this process is stated to have an octane rating of 80 motor method and no provision has been made in the calculations for the addition of tetraethyl lead, although it is understood that such addition could be made at nominal cost above the base cost of the required tetraethyl lead. The quotation on Diesel fuel is for a product with a rating of 55 cetane. In the tabulation, the price used for fuel oil for the synthine process is that of No. 6 (residual fuel oil). Propane is specified to be produced by the synthine process using coal and in the tabulation referred to, the price of that product has been used.

Composite Price of Petroleum Products Fob. Refineries in Arkansas as of June 1, 1950
Weighted according to the Plant Fuel Product Distribution Specified for Synthine Plants Using Coal

Product	Synthine Plant Product Distribution (Percent)	Prices of Petroleum Products: Cents Per Gallon	Dollars Per Barrel	Weighted Composite Dollars Per Barrel
Gasoline	72.80%	10.38¢	$4.360	$3.174
Diesel	19.00	8.50	3.570	.678
Fuel Oil	3.50	4.29	1.800	.063
Propane	4.70	2.50	1.050	.049
Total	100.00%			$3.964

In the tabulation above, the composite wholesale price fob. refinery of petroleum products as of June 1, 1950 weighted in the same proportions as the liquid fuel products specified to be produced by coal synthine plants is shown to be $3.96 per barrel. It should be pointed out that the estimates of future demand for petroleum products have been based on projections of present-day factors affecting consumption. It is not known how or when synthetic liquid fuel products will become competitive with petroleum products in the marketing territory. If, due to difficulties in developing supplies, costs of crude petroleum rise to such an extent in the future as to cause petroleum product prices to rise substantially relative to the general price level and to alter the competitive price positions of fuels, the projected future demand may be considerably less than the amounts estimated previously for the marketing territory.

Transportation of Plant Products

When synthetic liquid fuels plants become economically feasible, they will occur first obviously in those General Areas where the over-all conditions appear most favorable for financial success. An important advantage of synthetic liquid fuels plants in certain areas would be their proximity to markets made possible by raw material resources located in or near regions of high population density. In such cases the resultant lower costs of distributing plant products to the points of consumption within the marketing territory would give an important economic advantage to the local plants. Such competitive advantages would not accrue to synthetic liquid fuels plants in Arkansas, however, since that State is an important crude oil producer.

The estimated population of the counties of Arkansas by size groups as of January 1, 1949 is shown on the Map, Exhibit No. 39. This exhibit also shows the approximate center of the one Suitable General Area in Arkansas. During 1948, the average annual per capita consumption of motor fuel in Arkansas was about 4.0 barrels. At that rate 684,000 persons would consume the motor gasoline production of a single synthine plant. It is clear from a study of this map that there are no large concentrations of population in Arkansas and that in the western part of the State, where the General Area is located, the population is small and widely scattered. At such time as synthetic liquid fuels might be required in Arkansas, it appears that a single unit plant could dispose of its output to local markets within trucking distance of the plant and by rail tank car movement to the Little Rock market, if the products were distributed by an important marketer or if there was an exchange of products between companies.

At present there are no product pipe lines in the vicinity of the Arkansas General Area and, furthermore, there are no large concentrated markets in Arkansas that would make the construction of a pipe line from the General Area appear to be economically feasible. Consequently, in the case of complete development of the total synthetic liquid fuels potential of the Arkansas General Area the products would have to be transported by railroad tank cars and trucks to the widely scattered small markets. While this method of distribution would be costly, no General Areas in other states would appear to be so situated as to be able to serve the Arkansas market more economically except possibly in the far eastern part of the State along the Mississippi River which might be supplied by barge movement from General Areas located along the river in other states.

The cost of transportation of plant products to the marketing territory is one of the factors that must be taken into consideration in determining the relative desirability in the United States of General Areas suitable for synthetic liquid fuels plants. It has been shown previously that a single 10,000-barrel-per-day coal synthine plant located in the Arkansas General Area could probably move all of its output to bulk stations or to dealers' premises within reasonable trucking or rail distance. In this study, it is not considered feasible or necessary to measure the cost of transporting products to local distribution points.

While the cost of transportation is one of the factors that must be considered in determining the relative desirability of General Areas, in this study this requirement has been construed not to include the cost of moving products within the marketing territory. By definition, the marketing territory for plants located in the Suitable General Area in Arkansas was limited to the area in which it was assumed the local plants would have transportation cost advantages over synthetic liquid fuels plants located in states outside of the marketing territory. In other words, the transportation costs with which this study is concerned are those covering the movement of products to distant marketing territories and not those incurred in distributing products to points of consumption within the defined marketing territory. It is assumed that the cost of distribution within a given marketing territory would be about the same for plants located outside as for those within the territory but that outside plants would incur additional costs of transporting products to the market under consideration. Consequently, in determining the relative desirability of General Areas, costs of transportation need not be taken into consideration for those General Areas which lie wholly within a local marketing territory.

Summary and Conclusions

For the purpose of analyzing potential markets for synthetic liquid fuels plants in Arkansas, the marketing territory has been defined as including the entire market in that State. Motor fuel consumption in Arkansas in 1948 amounted to 7.7 million barrels and is estimated to reach an annual volume of 12.8 million barrels by 1975. These amounts of motor fuel consumption would be equivalent respectively to the gasoline output of about three and five coal synthine plants of 10,000 barrels daily capacity.

The plant product distribution specified for coal synthine plants does not correspond fully to the present actual product consumption in the marketing territory. If the entire motor fuel requirements were to be supplied by synthine plants there would be an over-production of Diesel fuel. At such time as synthetic liquid fuels plants in Arkansas are economically feasible it is probable that they would be so designed as to produce the products then in demand.

The demand for liquid fuels in the marketing territory is economically supplied at present since Arkansas produces crude oil and petroleum products greatly in excess of its requirements. Wholesale prices of petroleum products as of June 1, 1950 fob. refineries in Arkansas amount to $3.96 per barrel when weighted in the same proportion as the liquid fuel products specified to be produced by coal synthine plants. A major increase in liquid fuels prices altering basically the competitive positions of fuels would have the effect of reducing substantially the estimates of demand within the marketing territory.

Ark In the United States during the 5-year period 1945-1949,
the amount of crude oil added to the known supply was larger than
134 in any similar period; and furthermore, proved reserves as of
December 31, 1949 stood at an all-time record high of about 25
15 billion barrels. During this 5-year period proved reserves in-
70021 creased 4,864,959,000 barrels. From the analysis, the prospective

supply of petroleum appears adequate to satisfy the demand for liquid fuels for the present and at least a major portion of future requirements for a long period of years.

When synthetic liquid fuels plants, using coal as a raw material, become commercially feasible, it appears likely that they will be constructed first in those General Areas where there is a combination of unusually favorable factors. An important advantage for synthetic liquid fuels plants in certain parts of the United States would be their proximity to large centers of consumption distant from the principal source of petroleum. However, since Arkansas is an important crude oil producing State, synthetic liquid fuels plants in that State would have no competitive advantage due to location. At such time as synthetic liquid fuels would be required in Arkansas, it appears that a single unit plant could dispose of its output in local markets within trucking distance of the plant and by rail tank car movement to the Little Rock market. In the event of complete development of the synthetic liquid fuels potential, transportation to the small scattered markets in the State would no doubt be by truck and rail, since the construction of a pipe line from the General Area would not appear feasible. Within the marketing territory, plants in the Arkansas General Area would have minimum costs for the distribution of synthetic liquid fuels except possibly in the eastern part of the State along the Mississippi River. For the purpose of determining the relative desirability of General Areas in the United States, costs of transportation of plant products need not be taken into consideration for those General Areas which lie wholly within a local marketing territory.

WASTE DISPOSAL

General

The manufacture of synthetic liquid fuels from coal by the synthine process produces gaseous, liquid and solid wastes, all of them constituting potential nuisances. Any or all of these may require special treatment or disposal in degree, depending upon the location of the plant with respect to settled communities, public water supply, farming areas, etc. The principal gaseous wastes are sulfur compounds, resulting from combustion or removal of sulfur present in the coal. Liquid wastes consist of waste water from process, carrying oil and chemical oil and chemical contamination; blowdown from cooling towers and boilers, which may carry excessive concentrations of dissolved solids; and plant sanitary sewage. Solid waste consists of ash originally present in the coal, any unburned coal and spent catalysts, principally iron oxide.

Gaseous Wastes

In the coal synthine process, the steam and power required is generated from waste heat. The coal received at the plant goes direct to synthesis gas manufacture, the sulfur in the coal appearing principally as hydrogen sulfide, which is removed in concentrated form in the course of gas purification. If necessary, hydrogen sulfide may be burned in flares, producing sulfur dioxide. In the case of high-sulfur coals, however, the quantity of hydrogen sulfide produced may be too great for such disposition. In such case, hydrogen sulfide may be converted to sulfuric acid or to elemental sulfur, the choice depending upon local markets for these by-products. In any event, it appears practicable to reduce the sulfur nuisance to any reasonable extent required.

Liquid Wastes

In the synthine process, side-reactions, together with scrubbing operations, result in a water stream containing large quantities of organic compounds, principally aliphatic alcohols, acids, aldehydes, and ketones. Information from the U.S. Bureau of Mines, together with preliminary studies by other engineers in the petroleum industry who have worked on this problem, indicates that scrubbing may be limited to the point where total quantity of process and scrubbing water combined amounts to about 450,000-500,000 gallons per day in a unit plant. To the extent that a market can be found for the chemical by-products, they may be recovered and sold. However, after a few synthine plants have been established, it is anticipated that the existing market for such products in refined state would be saturated, with the result that their recovery would no longer be profitable. In such case it is assumed that a crude mixture of the more volatile alcohols and ketones will be removed by a simple distillation, and either sold at fuel value or returned to process for gasification to provide additional synthesis gas. The contaminated water remaining would be used as boiler feed to provide make-up steam for synthesis gas production.

Plant sanitary sewage from synthine plants would be of the order of 100,000 gallons per day in a unit plant. If local authorities require treatment before this effluent is run into the streams, the necessary sewage disposal plant should not involve an investment of more than $100,000 to $150,000.

Engineers of the U.S. Bureau of Mines have stated that the plant cost estimates include an allowance of approximately $1,000,000 to cover waste disposal from a unit plant. This should be sufficient to cover maximum requirements for complete treatment of contaminated liquid process wastes and plant sanitary sewage. Since over-all plant operating cost estimates are based primarily upon factors proportionate to construction cost, the inclusion of adequate construction cost provision for liquid waste disposal in the general estimates also implies inclusion of proportionate allowance for disposal system operating costs. The probable adequacy of this allowance is indicated by preliminary estimates. In respect of coal synthine, some dissenting opinion exists as to whether the scrubbing water may be limited within the amount which can be reabsorbed in process. Any excess would require treatment before disposal. Further development work is necessary before the question may be resolved. At the worst, a disposal cost of $0.10 to $0.20 per barrel of products might be required, over and above the allowance already included in general process cost estimates.

The remaining liquid plant waste to be considered is that resulting from boiler and cooling tower blowdown. Since the principal water consumption in both hydrogenation and synthine processes is by evaporation loss, the water rejected from the plant, other than the process and sanitary wastes mentioned, will consist largely of these blowdowns and will contain practically all of the daily tonnage of dissolved solids in the gross water make-up drawn by the plant. As a result, the concentration of dissolved mineral salts in the blowdown water may be several times as great as that in the original make-up. For plant locations where the make-up water is not already abnormally high in dissolved salts and where the wastes can be discharged into streams of which the minimum flow is large in proportion to the waste volume dilution of the blowdown with other plant effluents should serve to keep the whole within acceptable limits. Where large quantities of blowdown are to be discharged into small streams having a low minimum flow, the increase in solids might affect the suitability of the water for other uses. Such uses are minor, and in general, no difficulty should be encountered in the discharge of blowdown from cooling towers. In extreme cases, however, it is possible that State authorities may require a reduction in the concentration of dissolved solids before approval is granted. This may involve added costs, over and above those included in the general allowance for waste disposal. Actual determination of these added costs (if any) for any specific plant location would require detailed information, such as individual standards applying to the particular stream which would receive the wastes, complete analysis of the water available for cooling tower make-up and for possible dilution purposes, and similar data, not available in the current general survey.

Stream Pollution. In regard to possible stream pollution and the necessity for treatment of liquid wastes in Arkansas, the following condition has been developed in the course of the investigation.

Arkansas, through its Water Pollution Control Commission, which was created in 1949, is engaged in the abatement and control of stream pollution. Pollution is defined as the contamination of waters of the State so as to create a nuisance or render the waters so unclean as to be actually or potentially detrimental to public health, safety, or welfare, to domestic, commercial, industrial, agricultural or recreational use or to animal, bird, or aquatic life.

While the Commission has not yet promulgated any pollution control regulations, it is almost certain that if a synthetic liquid fuel plant was constructed within the Sebastian-Scott General Area in Arkansas, treatment of the wastes would be required. A high degree of treatment might not be necessary, especially if the wastes were discharged into the Arkansas River, because no public water supplies are taken from any streams which drain the General Area. Sewage is discharged into the Arkansas River without treatment at Fort Smith, Little Rock, and other smaller communities.

If the water supply for the synthetic liquid fuel plant in the Sebastian-Scott General Area was taken from an impounding reservoir on Vache Grasse Creek, as projected in the water supply section of the report, the water might be polluted by wastes from the plant. Complete treatment of the sewage would undoubtedly be necessary, and organic compounds in the process wastes would have to be very nearly eliminated. To avoid such complete treatment, the wastes could be discharged into a tributary of James Fork without effect on the water supply.

Ark Treatment of the sewage from the community associated
with the synthetic liquid fuel plant would be relatively inexpen-
138b sive and would represent only a small part of the over-all community
10 facilities.
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Legal Aspect. The Arkansas Water Pollution Control Commission has the power to enforce pollution control laws and regulations, investigate pollution, establish pollution standards and classify the waters of the State. The Commission is an agency within the State Board of Health. The Chief Sanitary Engineer of the State Board of Health serves as the Technical Secretary of the Commission, and as such is the administrator of all pollution control activities.

In order to abate pollution, the Commission is empowered to conduct hearings and thereafter to order discontinuance of the discharge of sewage or industrial wastes. Plans for any waste disposal system must be submitted to the Water Pollution Control Commission and a permit obtained prior to construction.

Solid Wastes

Solid wastes of the order of 540 tons per day, consisting of coal ash, unburned coal, and spent catalysts, would be produced by a 10,000-barrel-per-day coal synthine plant operating on Arkansas coal as raw material.

Cost of Solid Waste Disposal. The quantity requiring disposal is sufficient to justify fairly elaborate mechanical handling and stacking in order to minimize labor cost. Estimates prepared for this purpose indicate that approximately 220 acres of land will be required to provide space for the ash dumps resulting from 40 years of plant operation. The ash transport and disposal system considered assumes hydraulic and pneumatic conveying of ash and spent catalyst, from the various sources to separating and holding tanks located at the disposal area. Decanted water would be recycled. Moist ash accumulated in the tanks would be carried, after drainage, by belt conveyor to an unloader-stacker which would distribute it onto dump piles, with the assistance of a bulldozer to compact the piles and maintain formation. Total cost of ash disposal area equipment of the capacity required for a unit synthine plant operating on Arkansas coal, (about 540 tons of ash per day) is estimated at approximately $680,000. This does not include ash collection equipment, which is normally covered in process plant costs. Total operating cost and fixed charges are estimated at approximately $420 per day, or $0.042 per barrel of product. Each percent of the total investment accrued as gross return would amount to about $19 per day, or to $0.0019 per barrel of products.

In the coal synthine process practically all ash appears in the gasifier (synthesis gas producer) and must be completely removed from the synthesis gas before it passes to the reactors.

The estimated solid waste disposal plant investment and daily operating cost (exclusive of return on investment) for the Sebastian-Scott General Area, for coal synthine unit plants, are shown in the following tabulation.

Solid Waste Disposal

Sebastian-Scott General Area	Coal Synthine
Estimated Disposal Plant Investment (As of March 31, 1950)	$684,000
Estimated Disposal Plant Operating and Fixed Costs:	
Per Day	$ 418
Per Barrel	0.042

The operation of such a disposal installation would require a total of about 20 employes, including direct operating and maintenance wage earners and supervisors, with a proportionate allocation of indirect personnel.

Over-all Costs of Waste Disposal

The preceding discussion indicates that treatment of liquid process wastes may absorb practically all of the allowance for waste disposal included in the general cost estimates for the process plant. In such event, costs of solid waste disposal developed above are in addition to and above any general processing costs and must be added separately to the total cost of product.

At certain locations, however, the study of stream pollution indicates that considerably less than maximum waste treatment may be acceptable. In such case the saving in cost of liquid waste disposal presumably could be applied as a credit against the cost of handling solid wastes.

PROCESS COSTS

Basis for Estimate

As noted in a preceding section, under "Processes and Plant Requirements", the estimated plant construction costs and process costs developed in the following pages are intended primarily for use in comparing the relative desirability of different areas as potential plant locations. For this reason, they were based on the assumed use of certain improvements in process and equipment which are still in the development stage but which appear reasonably likely to be applicable by the time significant numbers of synthetic fuel plants could be constructed. For plants constructed as of today, using only equipment and processes now commercially available in this country, basic requirements and costs could be considerably higher than the estimates given.

Based on the results of extensive research and development work of its own, as well as upon available data of other investigators in the United States and in Germany, the Bureau of Mines has in the course of preparation estimates of construction and operating costs of a synthine plant of a commercial scale. Preliminary data from this study, for a plant producing 10,000 barrels of synthetic liquid fuels per day from western Kentucky bituminous coal, a specific case, have been adopted for this survey for estimating construction and operating costs of a unit plant, to be used as a basis of comparison for determining relative suitability of General Areas. In drawing other than relative conclusions from these cost estimates, however, the preliminary nature of these data so far available must be remembered. The final estimates determined by the Bureau at the completion of its work may differ appreciably from the present figures.

Estimates of plant capital investment and operating costs follow for the synthine process using coal as the raw material. The Bureau of Mines estimate of operating capital has been adjusted by the contractor, as explained later in the text, to reflect basic costs of labor and material prevalent in Arkansas as of the time of this report.

Process costs estimated herein, as of March 31, 1950, as directed by the Contracting Officer, have been limited to operating costs included in U.S. Bureau of Mines cost estimating procedure, rather than costs comprising "cost of service" or selling prices. The Bureau of Mines procedure includes an allowance of approximately 3 percent of plant investment for plant maintenance; 6-2/3 percent
Ark for depreciation; 1 percent for insurance and local, county, and
141a State real estate taxes; and an allowance equivalent to 10 percent of direct labor, plant maintenance and operating supplies for gen-
70021 eral administrative and general office overhead (which includes the salaries and wages of the General Manager or Plant Manager and his immediate staff reporting directly to management); but they include no allowance for head office or top management costs, selling expenses, return on investment or sales and corporate (including income) taxes. Costs of coal used in the process have been computed

on a "captive mine" basis and as such do not include selling expenses or return on the initial investment. The cost of water has been estimated on the same basis. To show the effect of return on investment, estimates are included herein to show the total investment required by its component parts, and the amount per barrel required for each 1 percent gross return (before income taxes) on capital investment.

Operating costs shown herein are reported, as directed by the Contracting Officer, in dollars per barrel of total products. Estimates of the equivalent cost of gasoline and credits for sale of by-products were not considered necessary for the purpose of this report.

It is considered that any difference in cost levels prevailing between that date and the date of the Bureau of Mines estimate, March 1, 1950, is within the range of accuracy of the original estimate. No adjustment of costs for change in location from Caseyville, Ky., to the General Areas in Arkansas has been made as such an adjustment is considered to be within the range of accuracy of the original estimate. Consequently, the Bureau of Mines estimate of plant erection cost has been considered directly applicable to such a cost in Arkansas.

Plant Capital Investment. Based on preliminary estimates of the Bureau of Mines for a typical unit plant, the required plant capital investment has been estimated for a 10,000-barrel-per-day unit plant in Arkansas using the coal synthine process. The table below shows figures as estimated by the Bureau of Mines and as adjusted for a unit coal synthine plant in Arkansas.

Estimates of Plant Capital Investment
for a Unit Plant
Using Coal Synthine Process

Item	Bureau of Mines Preliminary Estimate of Typical Unit Plant as of March 1, 1950	Adjusted Estimate of Unit Plant in Arkansas as of March 31, 1950
Plant Erection Cost	$81,805,000	$81,805,000
Interest during Construction	2,455,000	2,455,000
Depreciable Investment	$84,260,000	$84,260,000
Operating Capital	4,000,000	4,995,000
Total Investment	$88,260,000	$89,255,000

Construction costs and required total investment for a coal synthine unit plant are shown in Exhibit No. 40, as estimated by the Bureau of Mines.

Adjusted Estimate for Arkansas. For this survey, estimates of processing costs in Arkansas are as of March 31, 1950.

Interest during construction was estimated, as by the Bureau of Mines, at 3 percent of plant construction costs.

Operating capital was estimated for one plant in the General Area as shown in Exhibit No. 41. In the absence of information as to the method employed in the Bureau of Mines estimate of costs of a typical unit plant using the synthine process the method followed for the hydrogenation process was used.

This method, as described in the Bureau of Mines' R.I. 4564, is as follows:

"In determining the amount of operating capital required, it is assumed that the plant will reach designed production within its first year of operation. It is expected that limited plant operation will begin at the end of 3 years' construction, and that construction and operation will be carried on simultaneously during the fourth year. It is expected that the average production rate during this period will be approximately 50 percent of full normal production. Similarly, it is assumed that consumption of raw material will be 25 percent of normal for the first 6 months and 100 percent for the last 6 months. The raw materials include coal, catalysts, and water. Operating capital must cover the cost of the initial 30-day supply of coal, raw materials, consumed during the first 6 months of operation, labor, maintenance, and all other operating costs except fixed charges. Fixed charges are not assessed until construction is completed; interest during construction is treated as a part of total plant cost. Operating expenses during the second 6 months will be financed from the sale of products made during previous operations".

In estimation of operating capital the Contractor has included in the inventory prices of coal and water, an allowance for return on investment in coal mines and water works.

It is considered that the operating capital requirements for additional plants, or the extension of the initial plant beyond a 40-year life will be the same as for the initial plant, as operations will in either event be based on underground-mined coal.

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Operating Costs. Estimates of manufacturing costs, based
143 on estimates by the Bureau of Mines, for the typical synthine unit
plant for which estimated construction costs have been stated, are
70021 summarized in the first column of the following table:

Estimated Processing Costs Using Bureau of Mines Method
10,000-barrel-per-day Coal Synthine Plant

Manufacturing Costs	Bureau of Mines Preliminary Estimate of Typical Plant per Calendar Day	Bureau of Mines Estimate Adjusted to General Areas in Arkansas as of March 31, 1950 Per Calendar Day	Per Barrel of Products
Direct Costs			
Direct Materials:			
Coal	$14,383	$24,367	$2.44
Catalysts and Chemicals	1,200	1,200	.12
Total Direct Materials	$15,583	$25,567	$2.56
Direct Labor:			
Wage Earners	$ 3,150	$ 2,695	$0.27
Supervision	473	404	.04
Total Direct Labor	$ 3,623	$ 3,099	$0.31
Plant Maintenance:			
Wage Earners	$ 3,897	$ 3,334	$0.33
Supervision	585	500	.05
Total Maintenance Labor	$ 4,482	$ 3,834	$0.38
Materials	2,241	2,241	.23
Total Plant Maintenance	$ 6,723	$ 6,075	$0.61
Payroll Overhead	$ 1,013	$ 867	$0.08
Operating Supplies	1,345	1,215	.12
Make-up Water	1,115	531	.05
Total Direct Costs	$29,402	$37,354	$3.73
Indirect Costs			
Indirect Labor	$ 963	$ 824	$0.08
Indirect Salaried Personnel	1,953	1,953	.20
Other Indirect Costs	2,930	2,418	.24
Total Indirect Costs	$ 5,846	$ 5,195	$0.52
Total Direct and Indirect Costs	$35,248	$42,549	$4.25
Fixed Costs			
Local, County, and State Taxes and Insurance	$ 2,308	$ 2,308	$0.23
Depreciation	15,390	15,390	1.54
Total Fixed Costs	$17,698	$17,698	$1.77
Total Manufacturing Costs	$52,946	$60,247	$6.02
Less Coal and Make-up Water	$15,498	$24,898	$2.49
Other Processing Costs (A)	$37,448	$35,349	$3.53

Note: (A) Other than coal and make-up water.

The estimate, based on that of the Bureau of Mines of daily operating costs of a typical unit coal synthine plant, is developed by methods summarized in Exhibit No. 42.

Operating costs estimated to apply in the General Area of Coal and Water Availability in Arkansas as of March 31, 1950 are summarized in the second column of the table.

The bases of the adjusted estimate of daily operating costs of a unit plant in the General Area of Coal and Water Availability in Arkansas, as of March 31, 1950 are tabulated in Exhibit No. 43.

The items of plant maintenance materials, operating supplies, and other indirect costs might have been taken at the same cost in Arkansas as at Caseyville, Ky., (i.e. treated similarly to catalysts and chemicals and indirect salaried personnel) but have been computed according to methods adopted by the Bureau of Mines.

Return on Investment. Recognizing that different investors may require different rates of return upon their capital, these estimates include no allowance for return. However, as a guide, the following tabulation indicates the amounts per day and per barrel of products which would be required for each increment of 1 percent on the estimated plant capital in the case of Arkansas:

Incremental Costs for Each 1 Percent Gross Return on Initial Investment in Process Plant in Arkansas

Total Initial Capital Investment	$89,255,000
1 Percent Return on Above:	
Per Annum	$ 892,550
Per Calendar Day	2,445
Per Barrel of Products	$0.245

Effect of Coal Characteristics. In preparing estimates of coal quantity required, plant cost, and processing cost in each General Area, the calculations have been based on an (average) total daily raw material requirement of 126,000,000,000 Btu for a typical coal synthine unit plant, as specified in the plant requirements data furnished for use in this report.

Actually, for a plant of given capacity in terms of daily production of synthetic liquid fuels, the daily Btu requirements and physical size of the plant (and hence construction and operating costs) vary with certain characteristics of the coal used as raw material. The over-all Btu consumption increases with increasing moisture content of the coal, as received at the process plant, since additional Btu, over and above basic process requirements, must be consumed in evaporating surplus moisture to produce a coal of the requisite dryness for gasification. Furthermore, construction costs (dependent on physical size) of a synthine plant of given production capacity may vary through a maximum range of 20 percent, according to the rank of the coal available.

A study of the effect of these factors was made to determine the maximum range of possible variation within the limits of the coals considered in this survey. The results of this study showed that in the case of Btu requirements the maximum probable variation, over the entire range of coals included in the survey, from anthracite to the lowest grades of brown coal, is approximately plus or minus 10 percent of the mean. As stated above, there may be a variation in plant cost because of rank of coal of not more than plus or minus 10 percent from the mean. The base cost and Btu requirements for the typical plants used in the foregoing calculations differ somewhat from the actual mean. However, only the lower grades of lignites and brown coal give rise to Btu requirements and plant costs more than 10 percent greater than the base figures used. In the large majority of cases, the variation should be only a few percent.

As the maximum error is within the probable limits of accuracy of the base figures themselves, in the interest of simplicity no adjustment has been made to reflect the effect of coal characteristics on Btu requirements and physical size of plant.

STRATEGIC CONSIDERATIONS

Based on studies made by the National Security Resources Board, it is believed that areas of industrial concentration of less than 5 square miles, or urban concentrations of less than 50,000 people separated by about 10 miles of relatively open country, will be reasonably secure from atomic bomb attack under all circumstances expected to prevail.

The only urban concentration in or reasonably near the Sebastian-Scott General Area which merits consideration is the city of Fort Smith, with an estimated 1950 population of 47,864. This city is located near the northwest corner of the General Area, about 10 miles from the assumed synthetic liquid fuels plant site.

It is believed that the development of a new synthetic liquid fuels industry in Arkansas could be planned to conform to the present published policies of the National Securities Resources Board with regard to strategic considerations.

PART VI - CONCLUSIONS

CONCLUSIONS

Conclusions drawn from this investigation and the determination of a single Suitable General Area in Arkansas for the production of synthetic liquid fuels are based upon presently available information. It should also be noted that the determination of such a Suitable General Area does not at this stage:

(a) Constitute or propose a program for development;

(b) Imply any relationship to Suitable General Areas in other states; nor

(c) Reflect any allowance for new developments and additional future information which can be neither foreseen nor predicted.

Subject to such reservations, the following major conclusions are developed from this investigation and report.

1. Low-volatile and medium-volatile bituminous coals, suitable for the coal synthine process but not for hydrogenation, are the only raw materials meeting the requirements adopted for this survey. There are no available reserves of natural gas, or oil-impregnated strippable deposits in Arkansas suitable and adequate for synthetic liquid fuels production. No report was authorized in relation to oil shale deposits in Arkansas because it was considered that Arkansas either did not have supplies of oil shale, or that known deposits were of doubtful economic importance.

2. There is one Suitable General Area in Arkansas, which is designated the Sebastian-Scott General Area.

3. Coal deposits occur in 8 counties in west-central Arkansas but satisfactory deposits are confined to 5 counties containing total reserves in place of 831,328,000 tons (according to the specifications and procedures of this survey) of which the recoverable reserves are estimated to be 415,664,000 tons.

4. None of the coal reserves of Arkansas is classified as strippable under the definitions of the survey.

5. The recoverable coal reserves of Arkansas are distributed by counties as follows, in total and as contained within the single Suitable General Area:

Estimated Recoverable Coal Reserves Considered for Synthetic Liquid Fuels Manufacture, by Counties (As of January 1, 1949)

County	Total Reserves: Thousands of Tons	Total Reserves: Percent of Total	Available Reserves: Thousands of Tons	Available Reserves: Percent of Total
Franklin	20,534	4.9%	-	-
Johnson	56,794	13.7	-	-
Logan	87,882	21.1	-	-
Scott	28,039	6.8	28,039	11.2%
Sebastian	222,415	53.5	222,415	88.8
Total	415,664	100.0%	250,454	100.0%

6. The 250,454,000 tons of recoverable reserves in the Sebastian-Scott General Area are all in the Lower Hartshorne bed, require mining by underground methods, and may be converted to synthetic liquid fuels only by the coal synthine process. The coals are not suited to the hydrogenation process because of their high fixed-carbon content.

7. The available recoverable coal reserves of Arkansas, all in the Sebastian-Scott General Area, are estimated to be equivalent to about 540,200,000 barrels of synthetic liquid fuels produced by the coal synthine process.

8. It is probable that continued exploration and development of Arkansas coal resources will result in the discovery of additional reserves in areas for which there is not now sufficient information to warrant the present estimation of reserves for this survey. Information available at the time of this survey indicates that, after an allowance of 83,100,000 tons of coal for future commercial requirements (50 years' production at the 1948 rate of production of 1,662,000 tons annually), sufficient reserves are available to supply for a 40-year period synthetic liquid fuels capacity amounting, as a maximum, to 37,000 barrels per day by the coal synthine process.

9. Cleaning of Arkansas coals as necessary to provide raw material equivalent in quality to merchantable coal for synthetic liquid fuels plants would produce, per unit plant, approximately 1,165 tons of mine refuse per working day. The equivalent annual quantity of refuse would amount to about 186,400 cubic yards. No particular disposal problem would be presented.

10. Coal of the Sebastian-Scott General Area in Arkansas is low- to medium-volatile bituminous in rank with fixed carbon content exceeding 69 percent (maf) and heating value, as received, ranging from 13,550 to 14,430 Btu per pound. Moisture, ash, and sulfur contents are:

Content of Selected Components
(Mine Samples, As-received basis)

	Maximum	Minimum
Moisture	2.7%	2.0%
Ash	9.2	5.6
Sulfur	1.0	0.7

11. Estimated initial capital required for coal mining facilities to supply a single coal synthine unit plant is, as of March 31, 1950, $9,262,000.

12. Coal production costs, exclusive of selling expenses and return on investment, are estimated to be $5.28 per ton as of March 31, 1950.

13. Exclusive of return on investment, the cost of coal per barrel of products in a coal synthine unit plant is estimated to be $2.44 as of March 31, 1950.

14. Ample water resources exist for the supply of sufficient synthetic liquid fuels plant capacity to
Ark process all available coal in a period of 40 years. Water conservation works would, however, be re-
150b quired. The maximum water requirement is estimated
151a at 75 cfs.

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70021 15. The principal water sources to supply the Sebastian-Scott General Area would be the Arkansas River and its tributary, the Vache Grasse Creek.

16. Initial capital investment and annual costs, exclusive of return on investment, required for process water supply for a complete coal synthine unit plant are estimated as of March 31, 1950 to be $3,941,000 and $193,800, respectively.

17. Annual costs of domestic water supply, exclusive of return on investment, are not chargeable to plant operations since it has been assumed that these costs would be paid for by the consumers living in the plant-city. Initial capital investment and annual costs, in connection with a unit plant, are estimated as of March 31, 1950 at $899,000 and $53,000, respectively.

18. Local utilities could be expected to have adequate power available for construction purposes in the Sebastian-Scott General Area. Power for the plant and coal mine is assumed to be supplied from waste heat. For starting up and emergency use, a power tie-in and interchange agreement with the local utility merit consideration.

19. The costs of installing and operating, exclusive of return on investment, the necessary access transportation facilities for an initial synthetic liquid fuels unit plant in the Sebastian-Scott General Area, as of March 31, 1950, are estimated at $122,500 capital expenditure and $4,563 annual cost.

20. There would not be sufficient satisfactorily qualified labor available within the Sebastian-Scott General Area to meet the new personnel requirements of a unit plant. While there might be adequate labor within a reasonable traveling distance, there would be a deficiency in workers possessing desired industrial skills which would have to be met by in-migration. The average straight-time hourly rate in a unit plant in the General Area is estimated, as of March 31, 1950, at $1.48.

21. The necessary plant-city for an initial coal synthine unit plant would be expected to accommodate 11,517 persons. The corresponding required initial investment estimated as of March 31, 1950 for housing and community development, exclusive of domestic water supply works, would be $37,507,154.

22. The value of commercial facilities (assumed to be self-supporting) and of one-half of the dwelling units in the plant-city (assumed to be sold) plus a proportionate share of the cost of land and utilities, is estimated at $21,290,850 for a coal synthine unit plant. The remaining net investment in rental housing and plant-city development would therefore be $16,216,304.

23. From the standpoint of motor fuel, the average daily consumption (exclusive of aviation and military use) in Arkansas amounted to about 21,000 barrels in 1948 and is estimated to increase to approximately 35,000 barrels in 1975. Such demands would be equivalent respectively to the gasoline output of about three and five synthetic liquid fuels unit plants.

24. The proportion of various liquid fuel products specified for plants considered in this survey differs importantly from the distribution of actual product consumption in Arkansas. At such time as large-scale development would be required, synthetic liquid fuels plants undoubtedly would be designed, since the process is to a considerable extent flexible, to conform to the then existing demand pattern.

25. Liquid fuel requirements in Arkansas are economically supplied by petroleum products at a refinery price of $3.964 per barrel as of June 1, 1950 for the fuel product distribution specified for coal synthine plants.

26. When synthetic liquid fuels are required, plants in the Arkansas General Area would be well located for the distribution of their products within the defined marketing territory.

27. No unusual methods would be required in Arkansas for the inoffensive disposal of solid and gaseous wastes of synthetic liquid fuels plants.

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28. The treatment of liquid waste before disposal to meet any anticipated requirements is feasible at costs within allowances made therefor in the general estimates for the process plant.

29. Disposal of solid wastes from coal synthine plants in Arkansas is estimated as of March 31, 1950 to involve a capital investment of $684,000 and operating costs, before return on investment of $418 per day or $0.042 per barrel of products.

30. A coal synthine unit plant in the Sebastian-Scott General Area in Arkansas would involve a plant investment as follows:

Estimate of Initial Capital Investment
for a Typical Plant Using the Coal
Synthine Process
(As of March 31, 1950)

	Amount
Plant Erection Cost	$81,805,000
Interest during Construction	2,455,000
Depreciable Investment	$84,260,000
Operating Capital	4,995,000
Total Investment	$89,255,000

31. A coal synthine unit plant in Arkansas would incur daily processing costs, exclusive of return on investment, estimated as follows:

Estimated Processing Costs of a Typical
Coal Synthine Unit Plant
in the Sebastian-Scott General Area
Exclusive of Return on Investment
(As of March 31, 1950)

Processing Costs	Per Calendar Day
Direct Materials	$25,567
Water	531
Other Direct Costs	11,256
Direct Costs	$37,354
Indirect Wages and Salaries	$ 2,777
Other Indirect Costs	2,418
Indirect Costs	$ 5,195
Taxes and Insurance	$ 2,308
Depreciation	15,390
Fixed Costs	$17,698
Total Manufacturing Costs	$60,247
Less Coal and Make-up Water	24,898
Total Other Processing Costs	$35,349

32. Development of a synthetic liquid fuels industry in Arkansas could be planned to conform with presently published policies of the National Security Resources Board with respect to strategic considerations.

33. In the Suitable General Area of Arkansas, the initial net capital required for the complete installation of a synthetic liquid fuels unit project, including the manufacturing plant, process water supply, rental housing, and mine and other incidental facilities, but exclusive of commercial facilities and domestic water supply for the plant-city (assumed as self-supporting) and of one-half of the dwelling units (assumed to be sold), as shown on Exhibit No. 44, is estimated, as of March 31, 1950, at $119,482,000.

34. Operating costs, exclusive of return on investment, (see Exhibit No. 44), of a synthetic liquid fuels unit project in Arkansas is estimated at $6.07 per barrel of products, equivalent to 14.5 cents per gallon.

35. The amount required to yield 1 percent gross return, on the net initial investment is estimated, as of March 31, 1950 (also shown on Exhibit No. 44), to be 32.7 cents per barrel.

EXHIBITS

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**Synthetic Liquid Fuels Plant Requirements
Coal Synthine Process
(Approved by Corps of Engineers)
As of May 15, 1950**

Coal Synthine
Requirements for a 10,000-barrel-per-calendar-day Unit
Based on a 10,000-barrel-per-day Plant

A. DESCRIPTION OF PROCESSES

(Brief Description of Flow Sheet, Names of Equipment or Units Proposed for Use, Significant Temperatures and Pressures, Over-all Efficiency (A) for Average Rank of Coal)

Raw coal is pulverized and gasified with oxygen and steam at 450 psi pressure. The resulting synthesis gas, composed of mainly carbon monoxide and hydrogen is purified by the removal of hydrogen sulfide and organic sulfur compounds and then fed to a single stage synthesis reaction. The synthesis reaction takes place at 300 psi pressure and about 600° F. An internally cooled reactor using liquid-suspended iron catalyst has been assumed in this estimate. Alternate types of reactors are solid bed catalyst internally cooled reactor, or iron catalyst slurry process. The liquid products are separated by distillation into motor gasoline, Diesel fuel, and heavier fractions which are refined and upgraded by conventional petroleum and refinery processes to finished products. Steam and power facilities are provided within the plant. The data below are based on the following efficiency:

Over-all 41.2% (A)

B. RAW MATERIALS

Quantity

Coal Requirements in Btu x 10^9 per Calendar Day — Process 126; Total 126

Quality

Ash

Maximum Allowable Ash Content to Equipment (Dry Basis) — Process 20%

Other Characteristics (Chemical Analysis, etc.)

1. Good washability is desirable
2. Chemical analysis and physical properties should be known.

Sulfur

Cost of Desulfurization

Cost of desulfurization does not change materially with percent of sulfur in coal when credit of 1/5 of market price is taken for recovered sulfur.

Other Characteristics

High organic sulfur content in raw coal is undesirable since it is not easily removed by cleaning.

Other Characteristics (Effect of Rank, Opaque Attritus, Fusain, etc.)

Fixed Carbon	No limit
Volatile Matter	No limit
Sulfur	No limit
Moisture	No limit

Decrease in rank increases amount of plant required. (Range of plant cost 20% between extremes of rank).

Information Required for Evaluation:

1. Ultimate analysis (maf basis) Btu content
2. Proximate analysis - dry basis - include moisture as lb per lb of dry coal (face sample).

C. WATER

Quantity

Heat Capacity of Coolant Required in Btu x 10^9 per Calendar Day (includes Coolant for Power Requirements) — 54 Average for All Ranks of Coal

Water Requirements in Thousands of Gallons per Calendar Day	Make-up	Consumed	Returned
Evaporated (Cooling Towers)	6,410	6,410	
Blowdown from Cooling Towers	1,920	960	960
Boiler Make-up for Boiler Blowdown	737	147	590
Boiler Make-up for Synthesis Gas Mfg.	578	51	527
Sanitary Water for Plant	60		60
Sanitary Water for Mines	48		48
Water for Coal Preparation	300	80	220
Water for Mines	Information not available.	(Assumed to be self-sufficient)	
Water for Mine Power	81	65	16
Miscellaneous, 10%	1,016		1,016
Total	11,150	7,713	3,437

Quality

1. Boiler water suitable for treatment.
2. Sanitary water suitable for chlorination and potable.
3. Cooling water is based on soft water. Water of high solids content increases water requirements or necessitates a water treatment plant.

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Synthetic Liquid Fuels Plant Requirements
Coal Synthine Process
(Approved by Corps of Engineers)
As of May 15, 1950

	Coal Synthine Requirements for a 10,000-barrel-per-calendar-day Unit Based on a 10,000-barrel-per-day Plant
D. POWER	
Total Power Required for Mine (Kw)	3,500 (based on 2 shifts per day - 5-day week - 5 Kwhr per ton)
Total Power Required for Plant (Kw)	114,500
By-product Power (Kw)	114,500 (Produced from waste heat)
Prime Power (Kw)	0
E. PERSONNEL	
Total Operating Personnel Required for Year-Round Operation	
Plant (3 shifts), 365 days (year)	Operational 937 Administrative 198
Underground Mines (2 shifts, 240 days per year operation) (B)	
Operational	Bituminous (13,100 Btu) 1,005 Subbituminous (9,500 Btu) 1,387 Lignite (7,000 Btu) 1,882
Administrative	Bituminous (13,100 Btu) 50 Subbituminous (9,500 Btu) 69 Lignite (7,000 Btu) 94
Strip Mine (2 shifts, 240 days per year operation) (C)	
Operational	Anthracite Culm (11,500 Btu) 366 Bituminous (13,100 Btu) 403 Subbituminous (9,500 Btu) 554 Lignite (7,000 Btu) 752
Administrative	Anthracite Culm (11,500 Btu) 18 Bituminous (13,100 Btu) 20 Subbituminous (9,500 Btu) 28 Lignite (7,000 Btu) 38

F. PRODUCTS

Estimated Quantity of Products per Calendar Day (Ranges or Specific Quantities)

	Barrels Per Day	Btu per Pound	Btu x 10^9 per Day
Liquefied Petroleum Gases:			
Propane	470	21,700	1.833
Motor Gasoline	7,280	20,310	37.26
Diesel Oil	1,900	19,990	10.72
Residual Fuel Oil	350	19,775	2.151
Total	10,000		51.964

G. WASTES

Nature and Amount of Wastes

Coal Cleaning Plant and/or Mine	Solid Wastes	Liquid Wastes	Gaseous Wastes
	Reject from cleaning plant Spent Catalyst Dry Box Mass - 0.5 tons per day Ash (Total ash in coal) Unburned Coal		Hydrogen Sulfide from Girbotol 240 cu ft per 1% sulfur per ton of coal (as received). Can be converted to sulfur or burned as Sulfur Dioxide. The amount of wastes varies with sulfur in coal.

H. AREA

Area Required in Acres (Minimum) 77

Note: (A) Over-all Efficiency is defined as - $\frac{\text{Btu in products}}{\text{Btu in coal}} \times 100$

(B) Assuming 8 tons of coal per man and shift; administrative personnel 5% of operational; 10% allowance for absenteeism.

(C) Assuming 20 tons of coal (25 tons of anthracite culm) per man and shift; administrative personnel 5% of operational; 10% allowance for absenteeism.

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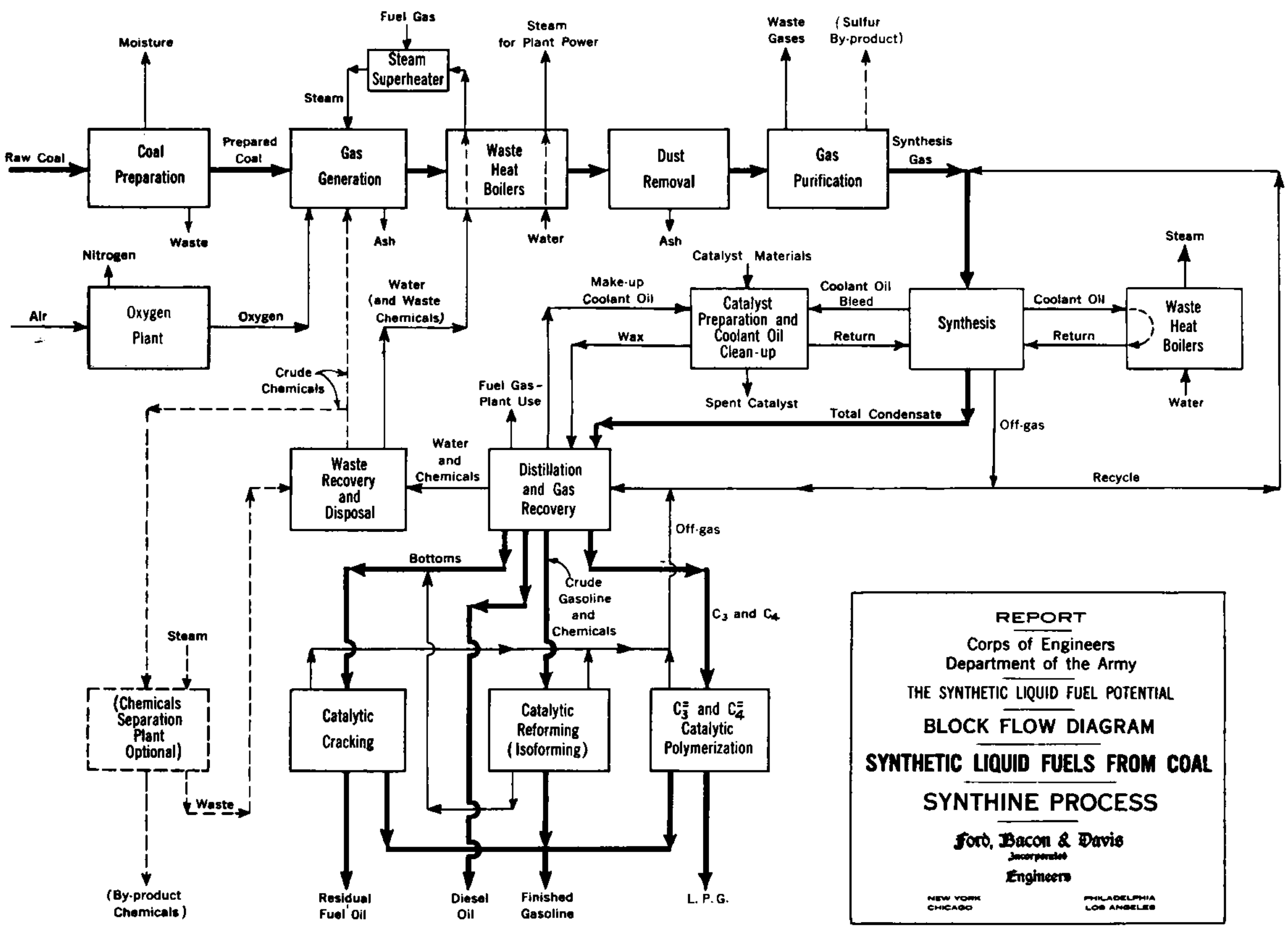


REPORT

Corps of Engineers
Department of the Army

THE SYNTHETIC LIQUID FUEL POTENTIAL

BLOCK FLOW DIAGRAM

SYNTHETIC LIQUID FUELS FROM COAL

SYNTHINE PROCESS

Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK CHICAGO PHILADELPHIA LOS ANGELES

EXHIBIT NO. 2

EXHIBIT NO. 3

REPORT

Corps of Engineers
Department of the Army

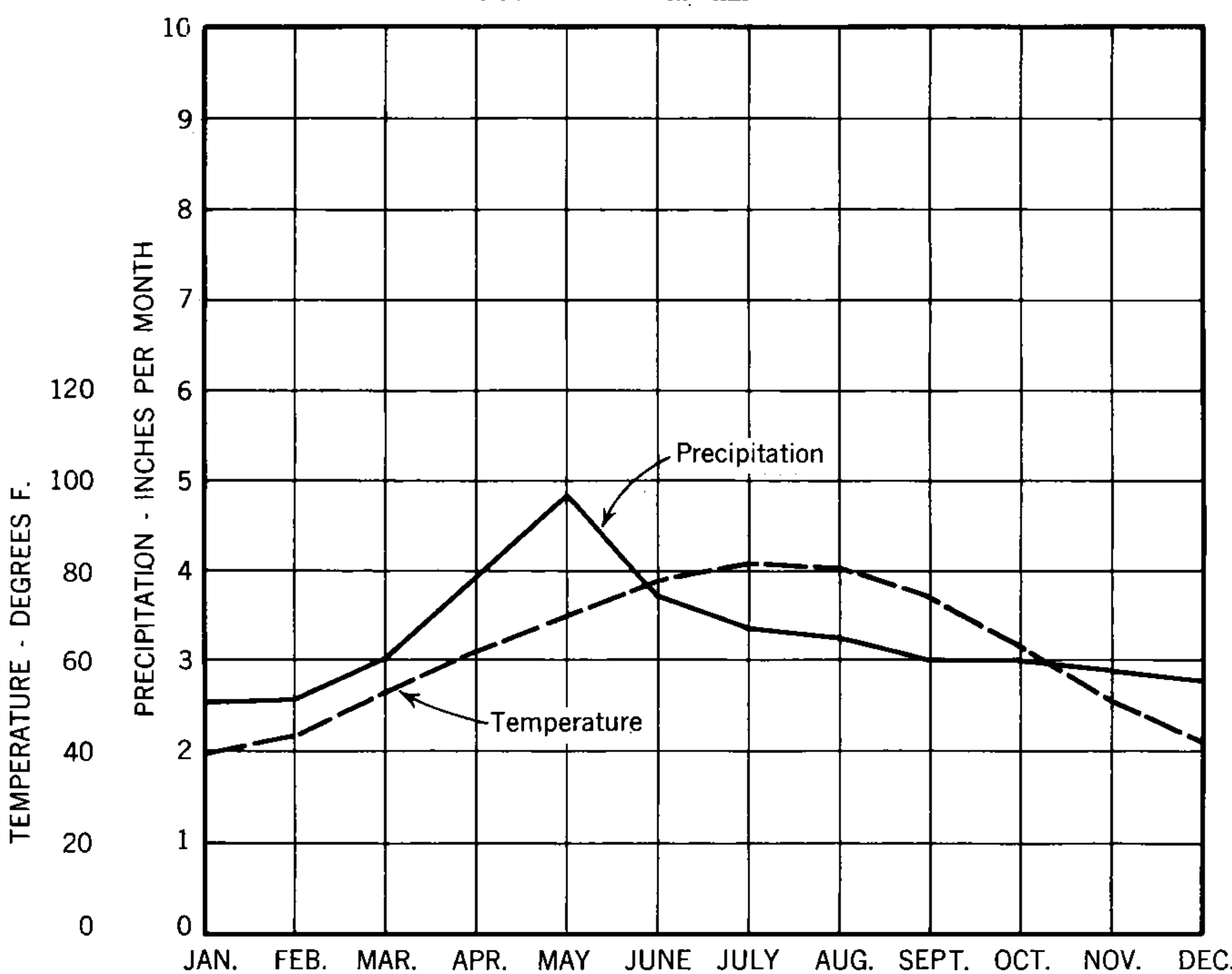
THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS

WEATHER DATA

AVERAGE PRECIPITATION AND TEMPERATURE
BY MONTHS
AT FORT SMITH, ARKANSAS

(SELECTED AS REPRESENTATIVE OF THE COAL-BEARING AREA OF ARKANSAS)

Ford, Bacon & Davis
Incorporated
Engineers
NEW YORK CHICAGO PHILADELPHIA LOS ANGELES



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SYNTHETIC LIQUID FUEL SURVEY

DETAILED COAL DATA SHEETS

SHOWING QUANTITIES OF COAL IN PLACE BY COAL BEDS

(SUBDIVIDED BY TOWNSHIPS AND COUNTIES)

AS OF JANUARY 1, 1949

LATITUDE: 35°-00′ LONGITUDE: 93°-00′

STATE: ARKANSAS

COAL FIELD:

COAL SEAM: LOWER HARTSHORNE (SPADRA, DENNING)

EXHIBIT NO. 5

	Township or Area Unit	County	Thickness of Coal (Inches) Max	Min	Ave	Dip of Bed (Degrees) Max	Min	Ave	Thickness of Cover (Feet) Underground Mining Max	Min	Ave	Strip Mining Max	Ave	Rank of Coal	● Analysis (As Received) Proximate: Moisture	Volatile Matter	Fixed Carbon	Ash	Ultimate: Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	B.T.U. As Received	Moisture and Ash Free	Area of Unmined Coal (Acres)
1	T10N R24W	JOHNSON			40	7	0				100			Sa	2.5	12.0	76.1	9.4	23					13,590	15,420	288
2	T9N R23W				35	7	0				75			Sa												3,469
3	T9N R24W				40	7	0				100			Sa												11,539
4	T9N R25W				46	3	0			25				†† Lvb	3.6	15.3	73.9	7.2	2.4	4.2	79.8	1.8	4.6	13,740	15,410	2,099
5		TOTAL				7	3																			17,395
6		Recoverable Reserves																								
7	T9N R26W	FRANKLIN			44					75				Lvb	3.6	15.3	73.9	7.2	2.4	4.2	79.8	1.8	4.6	13,740	15,410	5,184
8	T8N R26W				42					50				Lvb												1,088
9		TOTAL				8	0																			6,272
10		Recoverable Reserves																								
11	T9N R23W	LOGAN			38						100			Sa	4.2	11.6	77.3	6.9	1.4					13,700	15,410	4,339
12	T9N R24W				38					50	50			Sa												1,408
13	T8N R23W				38						100			Sa												8,160
14	T8N R24W				38					50	50			Sa												13,837
15		TOTAL				14	0																			27,744
16		Recoverable Reserves																								
17																										
18																										
19																										
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67																										
68																										
69																										

	Primary Reserves in Place (Thousands of Tons) Underground Mining Measured Acres	Tons	Indicated Acres	Tons	Strip Mining Measured Acres	Tons	Indicated Acres	Tons	Secondary Reserves in Place (Thousands of Tons) Underground Mining Measured Acres	Tons	Indicated Acres	Tons	Inferred Acres	Tons	Strip Mining Measured Acres	Tons	Indicated Acres	Tons	Inferred Acres	Tons	Remarks
1			288	1,920																	
2			3,469	20,242																	
3			10,784	71,908									755	5,034							
4	1,299	8,963	800	5,520																	
5	1,299	8,963	15,341	99,590									755	5,034							
6		(4,482)		(49,795)										(2,517)							50% Recovery
7	2,534	16,724	2,144	14,150									506	3,340							
8			1,088	6,854																	
9	2,534	16,724	3,232	21,004									506	3,340							
10		(8,362)		(10,502)										(1,670)							50% Recovery
11			3,232	20,475									1,107	7,012							
12			1,408	8,920																	
13			403	2,553									7,757	49,141							
14			1,600	10,136									12,237	77,527							
15			6,643	42,084									21,101	133,680							
16				(21,042)										(66,840)							50% Recovery

SOURCES OF INFORMATION AND OTHER FOOTNOTES: U.S.G.S.: BULL. 847-E – GEOLOGY AND MINERAL RESOURCES OF THE WESTERN PART OF THE ARKANSAS COAL FIELD – 1937

U.S. BUREAU OF MINES: TECH. PAPER 416 – ANALYSES OF ARKANSAS COALS – 1928; BULL. 446 – TYPICAL ANALYSES OF COALS OF THE UNITED STATES – 1942.

†† NO ANALYSIS AVAILABLE, ESTIMATED FROM ADJOINING COUNTY

● AVERAGE ANALYSIS OF MINE SAMPLES OBTAINED BY STANDARD U. S. BUREAU OF MINES PROCEDURE.

SF-662 12-19-50

SYNTHETIC LIQUID FUEL SURVEY

DETAILED COAL DATA SHEETS

SHOWING QUANTITIES OF COAL IN PLACE BY COAL BEDS

(SUBDIVIDED BY TOWNSHIPS AND COUNTIES)

AS OF JANUARY 1, 1949

LATITUDE: 35°-00' LONGITUDE: 94°-00'

STATE: ARKANSAS

COAL FIELD:

COAL SEAM: LOWER HARTSHORNE

EXHIBIT NO. 5

	TOWNSHIP OR AREA UNIT	COUNTY	THICKNESS OF COAL (INCHES) MAX	MIN	AVE	DIP OF BED (DEGREES) MAX	MIN	AVE	THICKNESS OF COVER (FEET) UNDERGROUND MINING MAX	MIN	AVE	STRIP MINING MAX	AVE	RANK OF COAL	● ANALYSIS (AS RECEIVED) PROXIMATE MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	ULTIMATE SULPHUR	HYDROGEN	CARBON	NITROGEN	OXYGEN	B.T.U. AS RECEIVED	MOISTURE AND ASH FREE	AREA OF UNMINED COAL (ACRES)
1	T7N R30W	SEBASTIAN			36						250															4,570
2	T7N R31W				43						400															11,437
3	T7N R32W				42						140															11,699
4	T6N R30W				40						425															4,794
5	T6N R31W				40						200															3,942
6	T6N R32W				32						325															7,756
7	T5N R31W				33						175															1,222
8	T5N R32W				36						425															10,982
9	T4N R31W				32						250															1,498
10	T4N R32W				46						625															16,013
11		TOTAL				25	0							Lvb	2.7	18.1	70.0	9.2	1.0	4.5	78.8	1.6	5.1	13,550	15,380	73,913
12		Recoverable Reserves																								

	QUANTITY OF PRIMARY RESERVES IN PLACE (THOUSANDS OF TONS) UNDERGROUND MINING MEASURED ACRES	TONS	INDICATED ACRES	TONS	STRIP MINING MEASURED ACRES	TONS	INDICATED ACRES	TONS	QUANTITY OF SECONDARY RESERVES IN PLACE (THOUSANDS OF TONS) UNDERGROUND MINING MEASURED ACRES	TONS	INDICATED ACRES	TONS	INFERRED ACRES	TONS	STRIP MINING MEASURED ACRES	TONS	INDICATED ACRES	TONS	INFERRED ACRES	TONS	REMARKS
1			608	3,283									3,962	21,395							
2	1,837	11,849	5,626	36,288									3,974	25,632							
3	1,632	10,282	4,915	30,965									5,152	32,458							
4	992	5,952	3,802	22,812																	
5	1,984	11,904	1,958	11,748																	
6	1,958	9,398	4,128	19,814									1,670	8,016							
7	1,222	6,049																			
8	1,030	5,562	4,704	25,402									5,248	28,339							
9	96	461	1,402	6,730																	
10	3,296	22,742	8,640	59,616									4,077	28,132							
11	14,047	84,199	35,783	216,658									24,083	143,972							
12		(42,100)		(108,329)										(71,986)							50% Recovery

SOURCES OF INFORMATION AND OTHER FOOTNOTES: U.S. GEOL. SURVEY: BULL. 847-E - GEOLOGY AND MINERAL RESOURCES OF THE WESTERN PART OF THE ARKANSAS COAL FIELD - 1937

U.S. BUREAU OF MINES: TECH. PAPER 416 - ANALYSES OF ARKANSAS COALS - 1928

BULL. 446 - TYPICAL ANALYSES OF COALS OF THE UNITED STATES - 1942

● AVERAGE ANALYSIS OF MINE SAMPLES OBTAINED BY STANDARD U. S. BUREAU OF MINES PROCEDURE.

SF-663 12-19-50

LATITUDE: 34°-30' LONGITUDE: 94°-00'

STATE: ARKANSAS

COAL FIELD:

COAL SEAM: LOWER HARTSHORNE

EXHIBIT NO. 5

SYNTHETIC LIQUID FUEL SURVEY

DETAILED COAL DATA SHEETS

SHOWING QUANTITIES OF COAL IN PLACE BY COAL BEDS

(SUBDIVIDED BY TOWNSHIPS AND COUNTIES)

AS OF JANUARY 1, 1949

	TOWNSHIP OR AREA UNIT	COUNTY	THICKNESS OF COAL (INCHES) MAX	MIN	AVE	DIP OF BED (DEGREES) MAX	MIN	AVE	THICKNESS OF COVER (FEET) UNDERGROUND MINING MAX	MIN	AVE	STRIP MINING MAX	AVE	RANK OF COAL	REMARKS
1	T4N R31W	SCOTT			45						1100				
2	T3N R31W				45						750				
3	T3N R32W				102						750				
4		TOTAL				20	5							Mvb	
5		Recoverable Reserves													50% Recovery
6															
7															
8															
9															
10															
11–69															

	● ANALYSIS (AS RECEIVED) PROXIMATE: MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	ULTIMATE: SULPHUR	HYDROGEN	CARBON	NITROGEN	OXYGEN	B.T.U. AS RECEIVED	B.T.U. MOISTURE AND ASH FREE	AREA OF UNMINED COAL (ACRES)
1												461
2												768
3												3,123
4	2.0	21.3	71.1	5.6	0.7					14,430	15,620	4,352
5												

	QUANTITY OF PRIMARY RESERVES IN PLACE (THOUSANDS OF TONS) UNDERGROUND MINING MEASURED ACRES	TONS	INDICATED ACRES	TONS	STRIP MINING MEASURED ACRES	TONS	INDICATED ACRES	TONS
1								
2								
3			3,123	47,782				
4			3,123	47,782				
5				(23,891)				

	QUANTITY OF SECONDARY RESERVES IN PLACE (THOUSANDS OF TONS) UNDERGROUND MINING MEASURED ACRES	TONS	INDICATED ACRES	TONS	INFERRED ACRES	TONS	STRIP MINING MEASURED ACRES	TONS	INDICATED ACRES	TONS	INFERRED ACRES	TONS
1					461	3,112						
2					768	5,184						
3												
4					1,229	8,296						
5						(4,148)						

SOURCES OF INFORMATION AND OTHER FOOTNOTES: U.S.G.S.: BULL. 847-E - GEOLOGY AND MINERAL RESOURCES OF THE WESTERN PART OF THE ARKANSAS COAL FIELD - 1937

U.S. BUREAU OF MINES: TECH. PAPER 416 - ANALYSES OF ARKANSAS COALS - 1928

BULL. 446 - TYPICAL ANALYSES OF COALS OF THE UNITED STATES - 1942

● AVERAGE ANALYSIS OF MINE SAMPLES OBTAINED BY STANDARD U. S. BUREAU OF MINES PROCEDURE.

SF-664 12-19-50

EXHIBIT NO. 6

SYNTHETIC LIQUID FUEL SURVEY

SUMMARY OF RECOVERABLE COAL RESERVES IN ARKANSAS*

CONSIDERED FOR SYNTHETIC LIQUID FUELS MANUFACTURE

BY COUNTIES AND BEDS

AS OF JANUARY 1, 1949

No.	COUNTY	BED	THICKNESS OF COAL (INCHES)			DIP OF BED (DEGREES)			THICKNESS OF COVER (FEET) UNDERGROUND MINING			THICKNESS OF COVER (FEET) STRIP MINING		RANK OF COAL
			MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	AVE	
1	JOHNSON	LOWER HARTSHORNE	40	35		7	0		100	75				Sa
2		LOWER HARTSHORNE			46	3	0			25				†† Lvb
3		TOTAL												
4														
5	FRANKLIN	LOWER HARTSHORNE	44	42		8	0		75	50				Lvb
6														
7	LOGAN	LOWER HARTSHORNE			38	14	0		100	50				Sa
8														
9	SEBASTIAN	LOWER HARTSHORNE	46	32		25	0		625	140				Lvb
10														
11	SCOTT	LOWER HARTSHORNE	102	45		20	5		1100	750				Mvb

No.	● ANALYSIS (AS RECEIVED) PROXIMATE				ULTIMATE						B.T.U.		AREA OF UNMINED COAL (ACRES)
	MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	SULPHUR	HYDROGEN	CARBON	NITROGEN	OXYGEN		AS RECEIVED	MOISTURE AND ASH FREE	
1	2.5	12.0	76.1	9.4	2.3						13,590	15,420	15,296
2	3.6	15.3	73.9	7.2	2.4	4.2	79.8	1.8	4.6		13,740	15,410	2,099
3													17,395
4													
5	3.6	15.3	78.9	7.2	2.4	4.2	79.8	1.8	4.6		13,740	15,410	6,272
6													
7	4.2	11.6	77.3	6.9	1.4						13,700	15,410	27,744
8													
9	2.7	18.1	70.0	9.2	1.0	4.3	78.8	1.6	5.1		13,550	15,380	73,913
10													
11	2.0	21.3	71.1	5.6	0.7						14,430	15,620	4,352

No.	QUANTITY OF PRIMARY RESERVES (THOUSANDS OF TONS) UNDERGROUND MINING MEASURED		UNDERGROUND MINING INDICATED		STRIP MINING MEASURED		STRIP MINING INDICATED	
	ACRES	TONS	ACRES	TONS	ACRES	TONS	ACRES	TONS
1			14,541	47,035	NONE		NONE	
2	1,299	4,482	800	2,760	"		"	
3	1,299	4,482	15,341	49,795	"		"	
4								
5	2,534	8,362	3,232	10,502	"		"	
6								
7			6,643	21,042	"		"	
8								
9	14,047	42,100	35,783	108,329	"		"	
10								
11			3,123	23,891	"		"	

No.	QUANTITY OF SECONDARY RESERVES (THOUSANDS OF TONS) UNDERGROUND MINING MEASURED		UNDERGROUND MINING INDICATED		UNDERGROUND MINING INFERRED		STRIP MINING MEASURED		STRIP MINING INDICATED		STRIP MINING INFERRED				TOWNSHIPS	
	ACRES	TONS	ACRES	TONS	ACRES	TONS	ACRES	TONS	ACRES	TONS	ACRES	TONS				
1	NONE		NONE		755	2,517	NONE		NONE		NONE				T9N-R23W; T9,10N-R24W;	1
2	"		"				"		"		"				T9N-R25W	2
3	"		"		755	2,517	"		"		"					3
4																4
5	"		"		506	1,670	"		"		"				T8,9N-R26W	5
6																6
7	"		"		21,101	66,840	"		"		"				T8,9N-R23,24W	7
8																8
9	"		"		24,083	71,986	"		"		"				T6,7N-R30-32N; T4,5N-R31,32W	9
10																10
11	"		"		1,229	4,148	"		"		"				T3,4N-R31W; T3N-R32W	11

SOURCES OF INFORMATION AND OTHER FOOTNOTES: †† NO ANALYSIS AVAILABLE, ESTIMATED FROM ADJOINING COUNTY

* BASED ON ESTIMATED RECOVERY FACTOR OF 50 PER CENT FOR UNDERGROUND RESERVES IN PLACE.

● AVERAGE ANALYSIS OF MINE SAMPLES OBTAINED BY STANDARD U. S. BUREAU OF MINES PROCEDURE.

SF-661 12-19-50

EXHIBIT NO. 7

REPORT

Corps of Engineers
Department of the Army

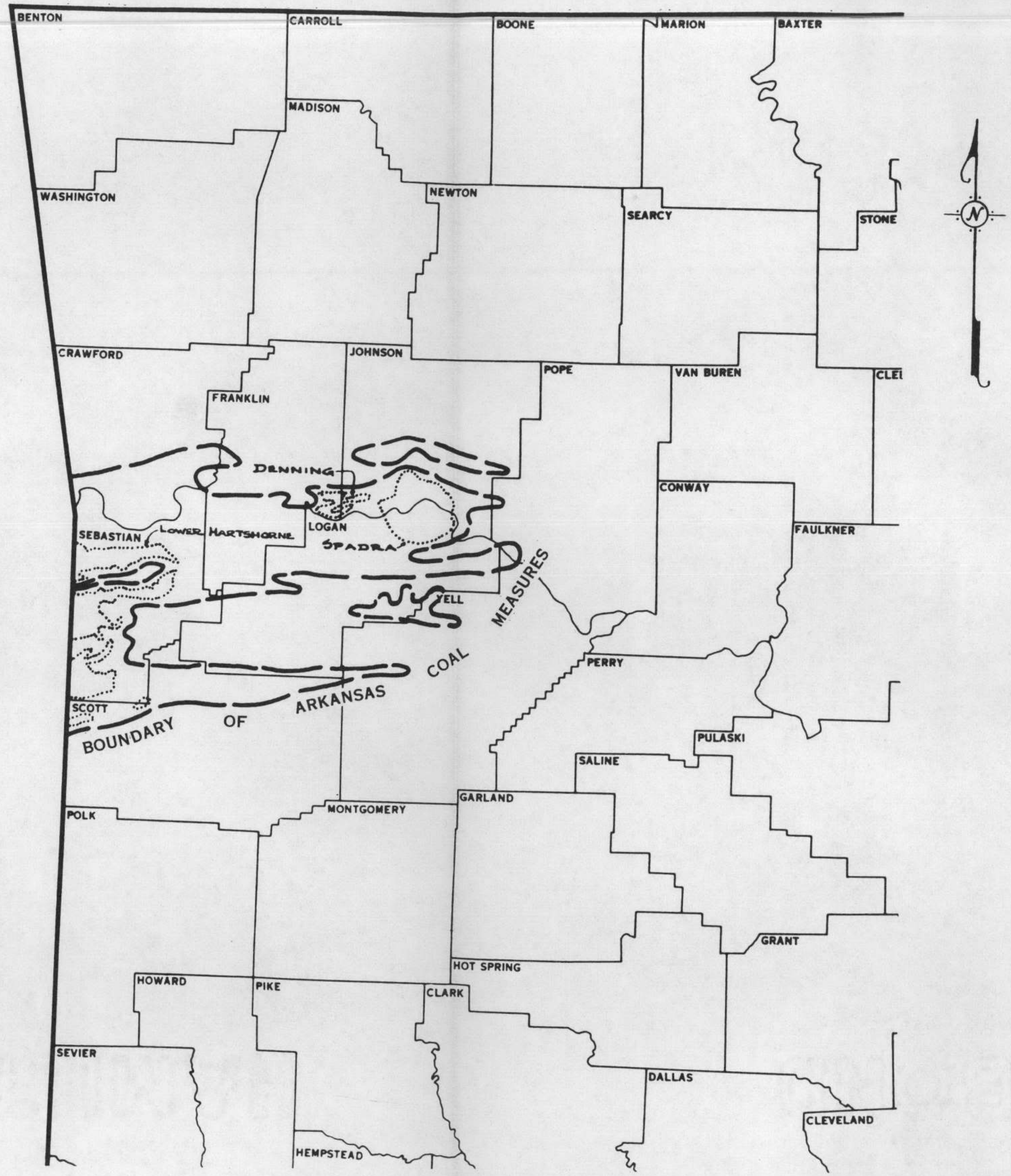
THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS

AREAS UNDERLAIN BY COAL RESERVES

SCALE OF MILES
10 0 10 20 30 40 50

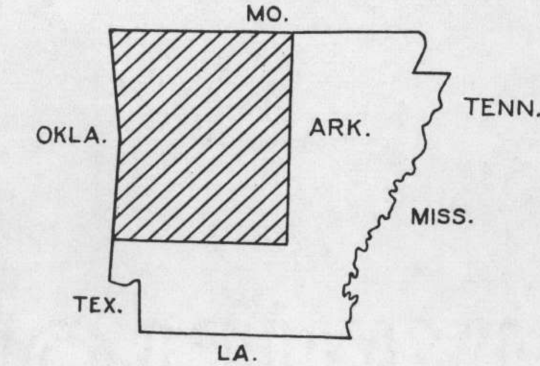
Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK CHICAGO PHILADELPHIA LOS ANGELES



LEGEND

Areas of Coal Reserves



SF-687 1-2-51

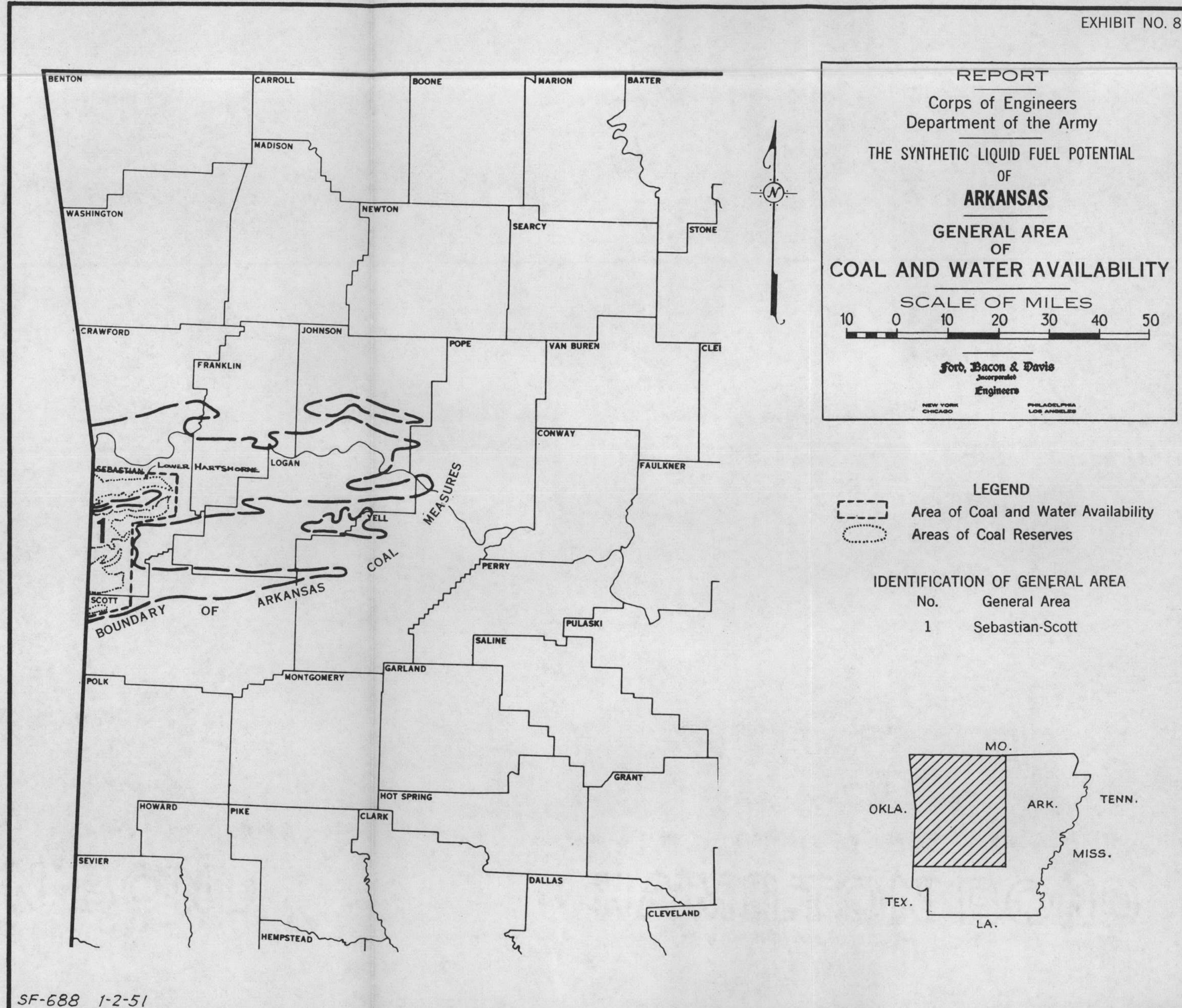


EXHIBIT NO. 8
REPORT
Corps of Engineers
Department of the Army
THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS
GENERAL AREA
OF
COAL AND WATER AVAILABILITY
SCALE OF MILES
10 0 10 20 30 40 50
Ford, Bacon & Davis
Incorporated
Engineers
NEW YORK
CHICAGO
PHILADELPHIA
LOS ANGELES
N
LEGEND
Area of Coal and Water Availability
Areas of Coal Reserves
IDENTIFICATION OF GENERAL AREA
No. General Area
1 Sebastian-Scott
BENTON
CARROLL
BOONE
MARION
BAXTER
MADISON
WASHINGTON
NEWTON
SEARCY
STONE
CRAWFORD
JOHNSON
POPE
VAN BUREN
FRANKLIN
CONWAY
FAULKNER
SEBASTIAN
LOWER HARTSHORNE
LOGAN
YELL
1
MEASURES
COAL
ARKANSAS
OF
BOUNDARY
SCOTT
PERRY
PULASKI
SALINE
GARLAND
POLK
MONTGOMERY
GRANT
HOT SPRING
HOWARD
PIKE
CLARK
SEVIER
DALLAS
CLEVELAND
HEMPSTEAD
MO.
OKLA.
ARK.
TENN.
MISS.
TEX.
LA.
SF-688 1-2-51

Sebastian-Scott
General Area of Coal Availability
(As of January 1, 1949)

	Lower Hartshorne Coal Bed		Totals and/or Weighted Averages
	Sebastian Co.	Scott Co.	
Portion of County	Western	NW.	
Thickness (inches):			
Maximum	46	102	
Minimum	32	45	
Dip of Bed (degrees):			
Maximum	25	20.	
Minimum	0	5	
Overburden Thickness (feet):			
Maximum	625	1,500	
Minimum	140	75	
Rank (A)	Lvb	Mvb	
Analysis: (B)			
Moisture	2.7%	2.0%	2.6%
Volatile Matter	18.1	21.3	18.5
Fixed Carbon	70.0	71.1	70.1
Ash	9.2	5.6	8.8
Sulfur	1.0%	0.7%	1.0%
Btu (as-received)	13,550	14,430	13,650
Btu - moisture- and ash-free	15,380	15,620	15,410
Area Underlain by Reserves (acres)	73,913	4,352	78,000
Estimated Recoverable Reserves (thousands of tons):			
Primary Underground	150,429	23,891	174,320
Primary Strip	-	-	-
Primary Total	150,429	23,891	174,320
Secondary Underground	71,986	4,148	76,134
Secondary Strip	-	-	-
Secondary Total	71,986	4,148	76,134
Total Underground	222,415	28,039	250,454
Total Strip	-	-	-
Total Underground and Strip	222,415	28,039	250,454

Sebastian-Scott
General Area of Coal Availability
(As of January 1, 1949)

Capacity of Synthetic Liquid Fuel Plant:

	Thousands of Barrels Per Day (C)		
	Underground	Strip	Total
Hydrogenation Process	-	-	-
Synthine Process	37	-	37

Note: (A) Lvb - Low-volatile bituminous; Mvb - Medium-volatile bituminous

(B) Average or representative analyses of mine samples obtained by standard U.S. Bureau of Mines procedure; as-received basis

(C) Based on total demand of 126 billion Btu per calendar day for synthine plant

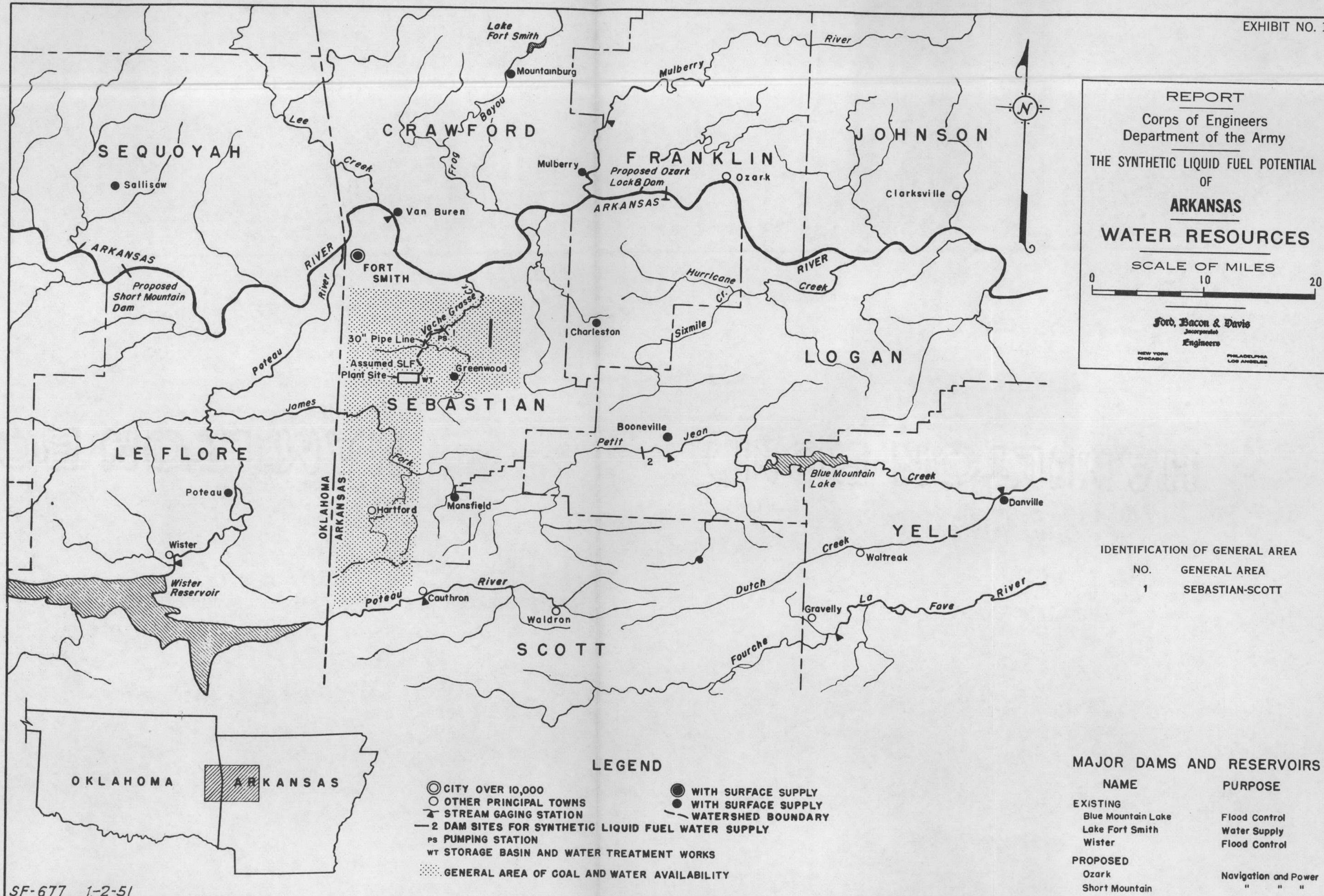


EXHIBIT NO. 10
REPORT
Corps of Engineers
Department of the Army
THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS
WATER RESOURCES
SCALE OF MILES
0
10
20
Ford, Bacon & Davis
Incorporated
Engineers
NEW YORK
CHICAGO
PHILADELPHIA
LOS ANGELES
SEQUOYAH
CRAWFORD
FRANKLIN
JOHNSON
LOGAN
SEBASTIAN
LE FLORE
YELL
SCOTT
OKLAHOMA
ARKANSAS
Lake Fort Smith
Mountainburg
Lee
Creek
Frog
Bayou
Mulberry
River
Mulberry
Proposed Ozark Lock & Dam
Ozark
Clarksville
Sallisaw
Van Buren
ARKANSAS
RIVER
Proposed Short Mountain Dam
FORT SMITH
River
Poteau
Vache Grasse Cr.
30" Pipe Line
PS
Assumed SLF Plant Site
WT
Greenwood
Charleston
Hurricane
Cr.
Sixmile
Creek
James
Fork
Booneville
Petit
Jean
2
Blue Mountain Lake
Creek
Danville
Poteau
Hartford
Mansfield
Wister
Wister Reservoir
Cauthron
Poteau
River
Waldron
Dutch
Creek
Waltreak
Gravelly
La
Fave
River
Fourche
IDENTIFICATION OF GENERAL AREA
NO. GENERAL AREA
1 SEBASTIAN-SCOTT
OKLAHOMA
ARKANSAS
LEGEND
CITY OVER 10,000
OTHER PRINCIPAL TOWNS
STREAM GAGING STATION
2 DAM SITES FOR SYNTHETIC LIQUID FUEL WATER SUPPLY
PS PUMPING STATION
WT STORAGE BASIN AND WATER TREATMENT WORKS
GENERAL AREA OF COAL AND WATER AVAILABILITY
WITH SURFACE SUPPLY
WITH SURFACE SUPPLY
WATERSHED BOUNDARY
MAJOR DAMS AND RESERVOIRS
NAME
PURPOSE
EXISTING
Blue Mountain Lake
Flood Control
Lake Fort Smith
Water Supply
Wister
Flood Control
PROPOSED
Ozark
Navigation and Power
Short Mountain
" " "
SF-677 1-2-51

Daily Process Water Requirements with Recirculation
Of Cooling Water for 10,000-barrel-per-day Plant Using Coal Synthine Process

Item	Use	Make-up (A)			Consumed (B)			Returned (C)		
		Gallons (1,000's)	AF	Cfs	Gallons (1,000's)	AF	Cfs	Gallons (1,000's)	AF	Cfs
1	Evaporated (Cooling Towers)	6,410	19.67	9.92	6,410	19.67	9.92	-	-	-
2	Blowdown for Cooling Towers	1,920	5.89	2.97	960	2.95	1.48	960	2.94	1.49
3	Boiler Make-up for H_2 Manufacturing	-	-	-	-	-	-	-	-	-
4	Boiler Make-up for Synthesis Gas	578	1.77	0.89	51	0.15	0.08	527	1.62	0.81
5	Boiler Make-up for Boiler Blowdown	737	2.26	1.14	147	0.45	0.23	590	1.81	0.91
6	High Pressure Injection H_2O (Process H_2O)	-	-	-	-	-	-	-	-	-
7	Sanitary H_2O for Plant	60	0.19	0.09	-	-	-	60	0.19	0.09
8	Sanitary H_2O for Mines	48	0.15	0.08	-	-	-	48	0.15	0.08
9	Water for Coal Preparation	300	0.92	0.46	80	0.25	0.12	220	0.67	0.34
10	Water for Mines	-	-	-	-	-	-	-	-	-
11	Water for Mine Power	81	0.25	0.13	65	0.20	0.10	16	0.05	0.03
12	Miscellaneous	1,016	3.12	1.57	-	-	-	1,016	3.12	1.57
13	Total	11,150	34.22	17.25	7,713	23.67	11.93	3,437	10.55	5.32

Note: For "once-through" cooling with 33° F rise in water temperature through the plant, approximately 197 mgd, or 304 cfs of water are required in place of Items 1 and 2 above.

(A) Make-up - The Total amount of water required to be delivered from the source to the plant.

(B) Consumed - The amount of water evaporated or used in the coal synthine process.

(C) Returned - The amount of water returned to a stream as waste and sewage.

Exhibit No. 12

Water Resources Bibliography

1. 1934, Evaporation from Water Surface, A symposium; vol. 99, Transactions of American Society of Civil Engineers, pages 671-747

2. 1939, Arkansas Water Resources, Arkansas State Planning Board

3. 1943, Survey Report on Arkansas River and Tributaries, Arkansas and Oklahoma, for Navigation, Hydro-electric Power and Other Purposes; Corps of Engineers, U.S. Army

4. 1944, A Review of the Cost of Water Works Structures; Charles B. Burdick; vol. 36, Journal of American Water Works Association, pages 821-831

5. 1945, Inventory of Water and Sewage Facilities in the United States; Federal Security Agency, Public Health Service

6. 1947, Arkansas River and Tributaries, Arkansas and Oklahoma; House Document No. 758, 79th Congress, 2nd Session

7. 1947, Public Water Supplies of Arkansas; Harrison Hale, R.C. Baker, I.W. Walling, D. M. Parrish, and G.A. Billingsley; Research Series No. 11, Bureau of Research, University of Arkansas

8. 1948, Reservoirs in the United States, G. Earl Harbeck, Jr., Circular 23, U.S.G.S.

9. 1949, Corps of Engineers Projects, Arkansas and Southern Missouri, Corps of Engineers, U.S. Army

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11. 1950, Water Treating Experiences; A.H. Ullrich; Water and Sewage Works, vol. 97, No. 1, pages 10-12

12. - Surface Water Supply of the United States; part VII, Various Publications, U.S.G.S.

Exhibit No. 13

Acknowledgments for Technical Information on Water Supply

G. A. Billingsley, District Chemist
U. S. Geological Survey
Fayetteville, Arkansas

John L. Saunders, District Engineer
U. S. Geological Survey
Fort Smith, Arkansas

F. L. McDonald, Chief Sanitary Engineer
Arkansas Water Pollution Control Commission
Little Rock, Arkansas

District Engineer
U. S. Corps of Engineers
Tulsa District
Tulsa, Oklahoma

District Engineer
U. S. Corps of Engineers
Little Rock District
Little Rock, Arkansas

EXHIBIT NO. 14

REPORT

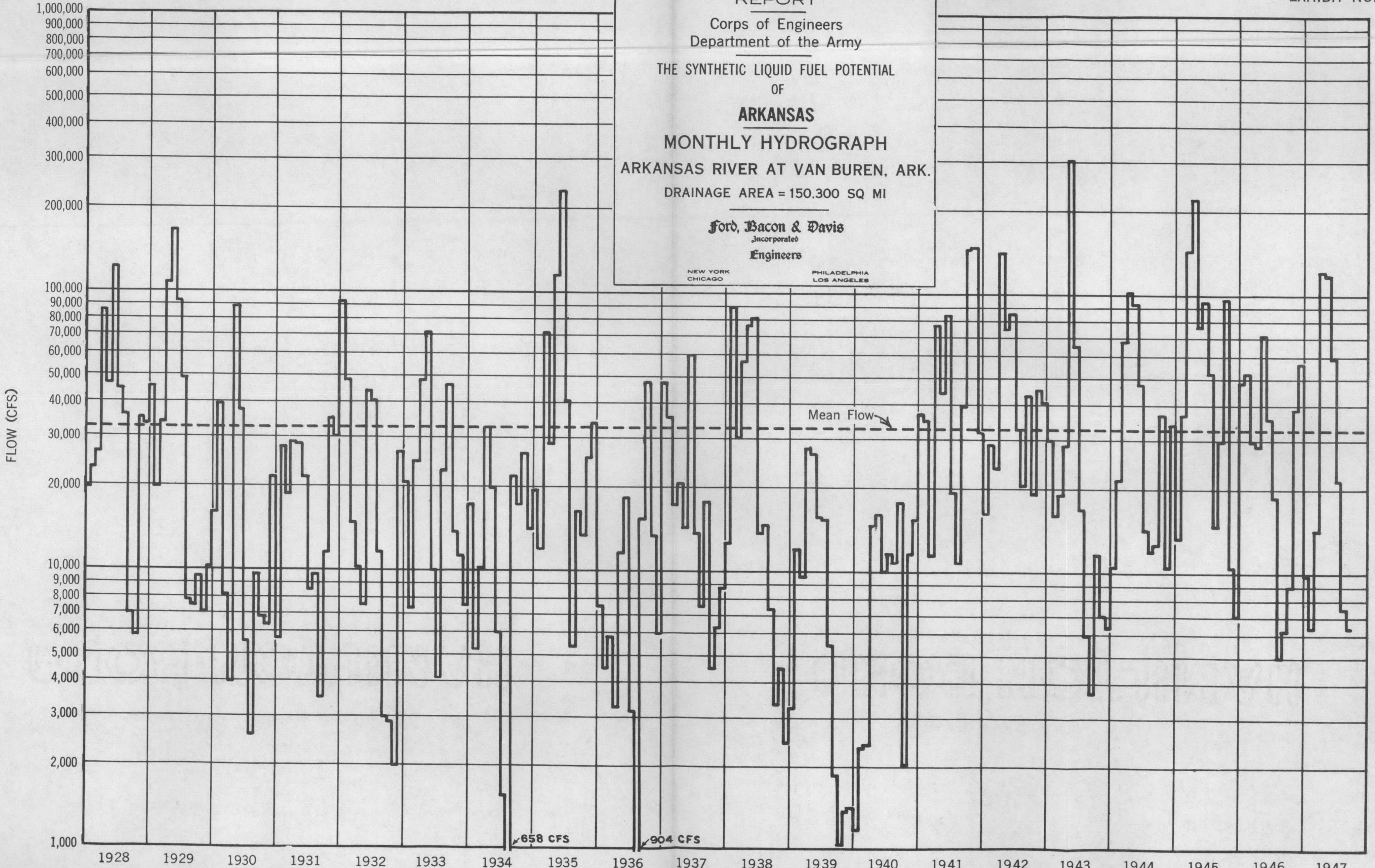
Corps of Engineers
Department of the Army

THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS

MONTHLY HYDROGRAPH
ARKANSAS RIVER AT VAN BUREN, ARK.
DRAINAGE AREA = 150.300 SQ MI

Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK
CHICAGO
PHILADELPHIA
LOS ANGELES



SF-724 1-8-51

Stream Flow Records and Estimates

Stream and Gaging Station	Drainage Area (Sq Mi)	Years of Record	Mean Annual Flow Cfs	Mean Annual Flow Cfs per Sq Mi	Minimum Flow Monthly (Cfs)	Minimum Flow Daily (Cfs)	Records Used in Preparing Estimates
Recorded Flow Data							
Arkansas River at Van Buren	150,300	1928-1947	32,330	0.215	658	245	-
Fourche La Fave River near Gravelly	413	1940-1948	573	1.39	0	0	-
Petit Jean Creek at Danville	760	1917-1948	836	1.10	0	0	-
Petit Jean Creek near Booneville	247	1940-1948	263	1.06	0	0	-
Mulberry River near Mulberry	372	1939-1948	570	1.53	0.03	0	-
Poteau River near Wister, Okla.	1,085	1939-1948	1,314	1.21	0	0	-
Poteau River at Cauthron	198	1940-1948	228	1.15	0	0	-
Estimated Flow Data							
Petit Jean Creek at Reservoir No. 2	212	-	234	1.10	(A)	(A)	Petit Jean Creek at Danville
Vache Grasse Creek at Reservoir No. 1	90	-	99	1.10	(A)	(A)	Petit Jean Creek at Danville
Poteau River at Mouth	1,895	-	2,290	1.21	(A)	(A)	Poteau River near Wister, Okla.
James Fork at Oklahoma-Arkansas State Line	146	-	168	1.15	(A)	(A)	Poteau River at Cauthron

Note: (A) Less than 1 Cfs

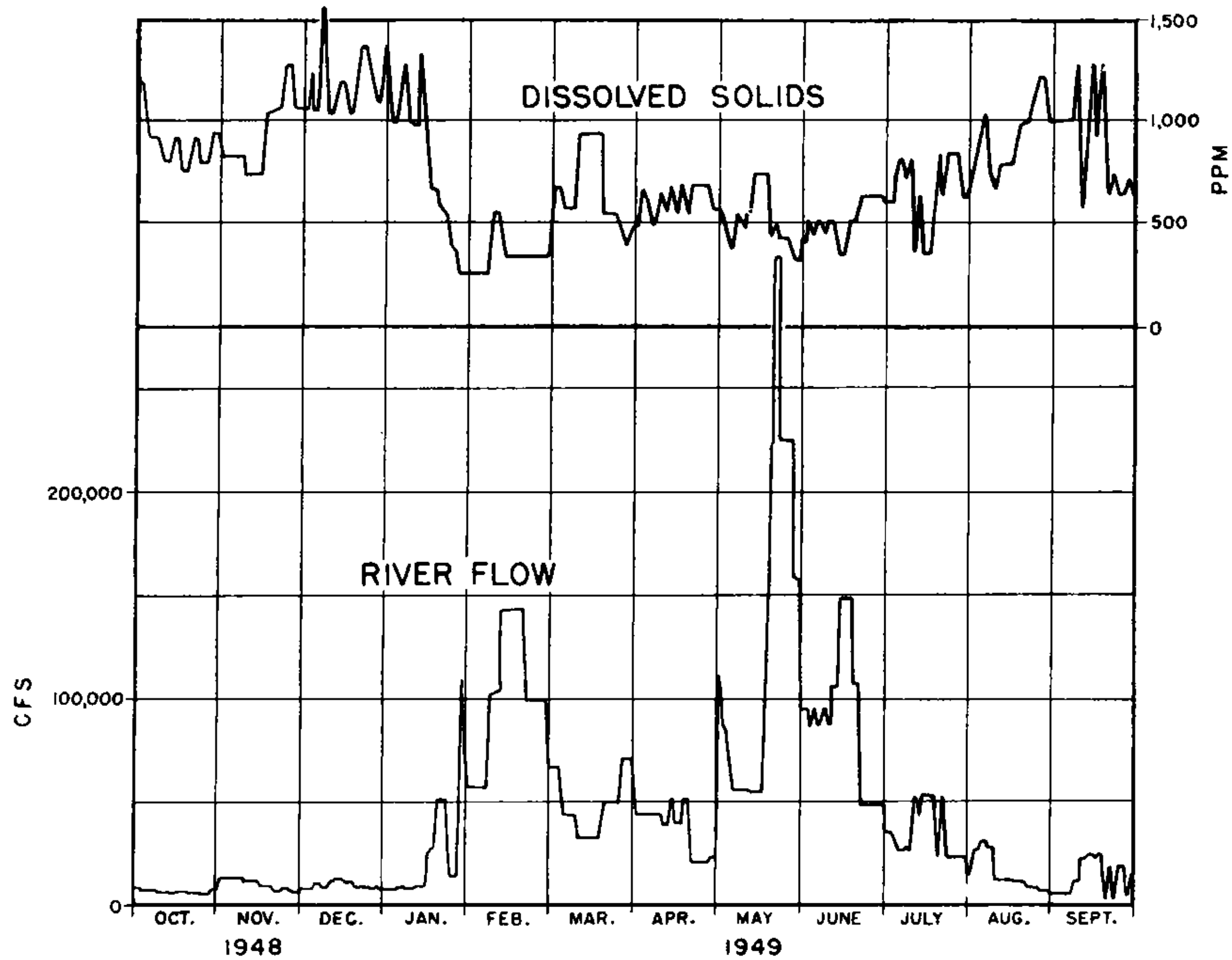
Chemical and Physical Water Analyses in Arkansas at Selected Sampling Stations

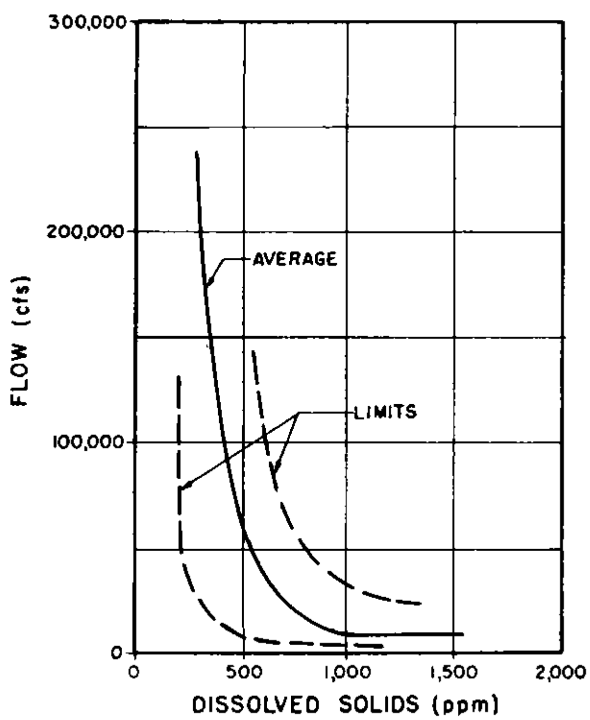
Sampling Station	Arkansas River at Van Buren			Poteau River at Cauthron		Vache Grasse Creek impounded near Greenwood	Frog Bayou near Mountainburg	Petit Jean Creek near Boonville		Petit Jean Creek at Danville			Dutch Creek at Waltreak	Fourche La Fave River near Gravelly		Hartford Well
Source of Data	(A) *	(A)	(A)	(B)	(B)	(C)	(B)	(B)	(B)	(A) *	(A)	(A)	(B)	(B)	(B)	(C)
Date of Collection	10- 1-48 to 9-30-49	9-21,23 24,29-49	5-21,22-49	7-23-45	5-27-46	5-14-46	9-24-48	4-24-46	9-24-48	10- 1-48 to 9-30-49	12-11 to 15-48	1-25,26, 28,29-49	9-24-48	8-23-45	4-25-46	5-14-46
River Discharge - Cfs	45,180	2,452	313,000	9.2	345		.0	5,640	.0	1,073	4.18	12,750	.4	359	2,190	
Temperature - ° F	63	70	72							63	49	46				
Color		10	10								45	23				
pH						7.7										7.4
Sp. Cond. (K x 10^5)	874	1,210	845	5.30	5.00	11.8	4.58	4.80	10.3	65.9	78.1	28.9	7.76	4.30	3.20	173
Silica (SiO_2) - Ppm						13										9.2
Iron (Fe) - Ppm						.53										3.4
Manganese (Mn) - Ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium (Ca) - Ppm	50	67	59	3.4		13	3.0	1.1	3.7	3.7	4.5	1.1	3.2	2.3	1.2	64
Magnesium (Mg) - Ppm	11	13	6.8	3.0		2.7	1.3	1.5	4.5	2.9	3.2	2.1	3.2	2.5	1.4	50
Sod. and Pot. (Na + K) - Ppm	116	169	107	3.7		7.4	8.3	5.2	10	5.5	7.7	2.2	7.9	1.4	4.1	268.8
Bicarbonate (HCO_3) - Ppm	112	121	154	24	15	9.0	22	12	42	22	34	10	34	17	13	253
Sulfate (SO_4) - Ppm	63	88	56	4.8	7.0	15	8.4	5.7	6.7	6.4	4.8	4.0	2.1	1.8	3.2	613
Chloride (Cl) - Ppm	184	272	157	3.0	2.2	4.2	2.5	3.0	5.0	4.7	5.2	2.2	5.0	2.0	2.5	69
Fluoride (F) - Ppm						.1										.1
Nitrate (NO_3) - Ppm	3.3	3.6	3.2	.0	1.2	.5	.2	.2	.6	1.9	1.1	1.0	.4	.5	.2	1.2
Total Hardness as $CaCO_3$ - Ppm	169	220	175	21	24	44	13	8.9	28	21	24	11	21	16	8.8	365
Non-Carbonate - Ppm	77	122	49							4	0	3				
M.O. Alkalinity as $CaCO_3$ - Ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Solids - Ppm	514	718	491	52		88	43	60	69	56	55	42	50	48	42	1,240
Turbidity - Ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Well Depth in Feet																200 to 300

Note: (A) Unpublished records of U.S.G.S.
(B) Surface Water Resources of Arkansas, Arkansas Resources and Development Commission and University of Arkansas, Institute of Science and Technology, I.S.T. Research Series No. 18, Division of Geology Bulletin No. 17, J. L. Saunders, G.A. Billingsley, and U.S.G.S. (1950)
(C) Public Water Supplies of Arkansas, University of Arkansas, Bureau of Research, Research Series No. 11, Harrison Hale, R.C. Baker, I.W. Walling, D.M. Parrish and G.A. Billingsley (1947).

* Weighted Average (Weighted by discharge)

EXHIBIT NO. 17





REPORT

Corps of Engineers
Department of the Army

THE SYNTHETIC LIQUID FUEL POTENTIAL
OF

ARKANSAS

RELATION BETWEEN
DISSOLVED SOLIDS AND FLOW
FROM UNPUBLISHED RECORDS OF U. S. G. S.

ARKANSAS RIVER AT VAN BUREN, ARK.

1949

MEAN FLOW 1949 = 45,180 CFS

MEAN FLOW 1928-1947 = 32,330 CFS

Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK
CHICAGO
PHILADELPHIA
LOS ANGELES

SF-676 1-2-51

ARK

EXHIBIT NO. 18

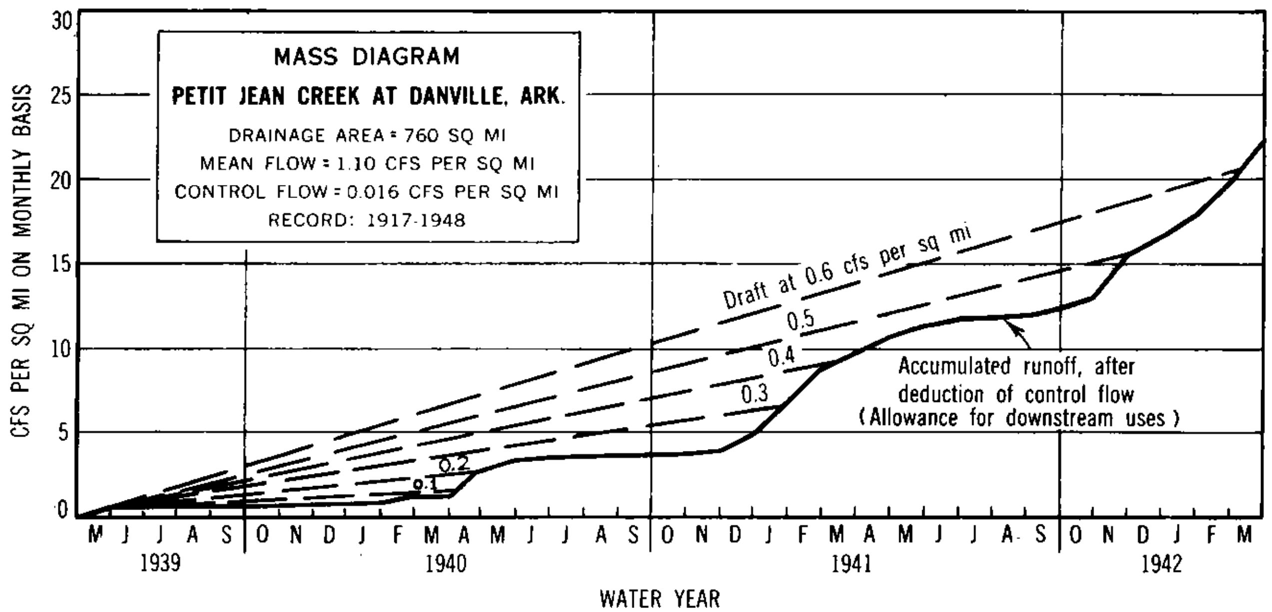
REPORT

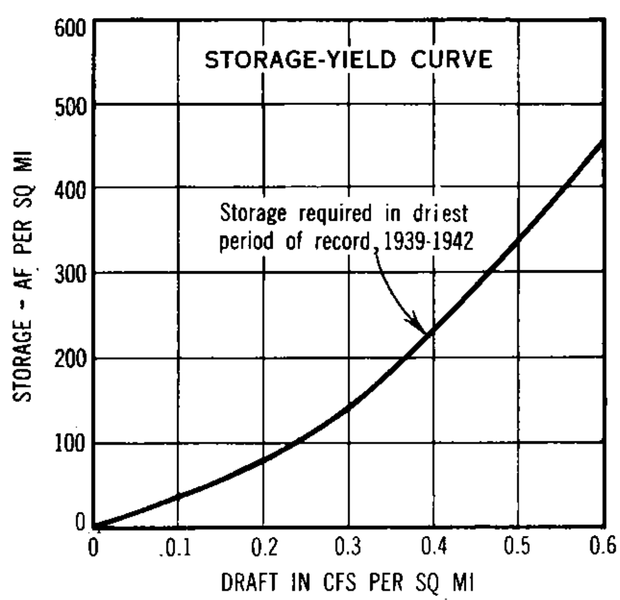
Corps of Engineers
Department of the Army

THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS

CURVES USED TO ESTIMATE
WATER STORAGE REQUIREMENTS

Ford, Bacon & Davis
Incorporated
Engineers
NEW YORK CHICAGO PHILADELPHIA LOS ANGELES





SF-723 1-30-51

ARK

Estimate of Coal Production Cost as of March 31, 1950

General Area Designation	Sebastian-Scott
Type of Mining	Underground
Productivity (tons per man-shift)	5
Hydrogenation (H) or Synthine (S) Process	S
Daily Production - tons (240 days per year)	7,019
Annual Production (thousands of tons)	1,684
Daily Plant Consumption - tons (365 days per year)	4,615
Life of Reserves (years)	149
Plant Investment (thousands of dollars)	$9,262
Items of Cost per Ton:	
All Labor	$2.80
Vacation Payments	.08
Welfare Fund	.30
Total Labor	$3.18
All Supplies	.81
Power	.15
Payroll Taxes	.11
Other Taxes, Insurance, Miscellaneous	.46
Depreciation	.37
Royalty or Depletion	.10
Engineering, Management, Administration	.10
Total	$5.28
Btu per pound of coal (as-received)	13,650
Cost per Million Btu (cents)	19.34¢

Coal Characteristics and Cost Summaries
Sebastian-Scott General Area of Coal and Water Availability
(Reserves as of January 1, 1949)
(Costs as of March 31, 1950)

General Area Designation	Sebastian-Scott
Hydrogenation (H) or Synthine (S) Process	S
Type of Mining (Underground or Strip)	U
Coal Bed Designation	Lower Hartshorne
Thickness of Bed (inches):	
Maximum	102
Minimum	32
Dip of Bed (degrees):	
Maximum	25
Minimum	0
Overburden Thickness (feet):	
Maximum	1,500
Minimum	75
Rank of Coal (A)	Lvb
Proximate Analysis: (B)	
Moisture	2.6%
Volatile Matter	18.5
Fixed Carbon	70.1
Ash	8.8
Sulfur	1.0%
Btu	13,650
Btu - moisture- and-ash-free	15,410
Estimated Recoverable Reserves (thousands of tons):	
Primary	174,320
Secondary	76,134
Total	250,454
Synthetic Liquid Fuels Plant Capacity (C) (thousands of barrels per day)	37
Estimated Mine Capital Cost (thousands of dollars)	$9,262
Estimated Cost per Ton of Coal Produced:	
Available by Stripping	None
Balance from Underground	$5.28
Combined (weighted average cost)	$5.28
Estimated Cost per Million Btu (cents)	19.34¢
Estimated Cost per Barrel of Synthetic Liquid Fuel Final Products:	
Coal, Cost to Produce	$2.44
Transportation to Process Plant	-
Total Cost per Barrel	$2.44

Note: (A) Lvb: Low volatile bituminous
(B) Representative analyses of mine samples obtained by standard Bureau of Mines Procedure; as-received basis
(C) Based on total demand of 126 billion Btu per calendar day for unit synthine plant.

ARK

70021

Exhibit No. 21

Population, Labor Force, and Employment in Arkansas in 1940 and Preliminary 1950 Census

County	Area (Square Miles)	1950 Census Preliminary Count	Population (1940) Total	Population (1940) Urban	Population (1940) Rural Nonfarm	Population (1940) Rural Farm	Labor Force (1940)	Numbers Employed (1940) Total	Agri-culture	Mining	Construc-tion	Manu-facturing	Service
Coal Counties													
Scott	898	10,045	13,300	-	5,717	7,583	4,248	3,486	1,858	16	85	702	825
Sebastian	529	63,921	62,809	36,584	14,223	12,002	23,628	17,689	2,424	478	677	3,838	10,272
Total Coal Counties	1,427	73,966	76,109	36,584	19,940	19,585	27,876	21,175	4,282	494	762	4,540	11,097
Other Counties	51,298	1,827,665	1,873,278	395,326	386,530	1,091,422	650,983	562,769	295,789	5,408	16,469	53,176	191,927
Total State	52,725	1,901,631	1,949,387	431,910	406,470	1,111,007	678,859	583,944	300,071	5,902	17,231	57,716	203,024
Percentages Showing Composition of Population and Numbers Employed in Coal Counties and in Entire State													
Coal Counties:													
Total Population			100.0%	48.1%	26.2%	25.7%							
Total Employed								100.0%	20.2%	2.3%	3.6%	21.5%	52.4%
Entire State:													
Total Population			100.0%	22.1%	20.9%	57.0%							
Total Employed								100.0%	51.4%	1.0%	2.9%	9.9%	34.8%
Percentages of Classified Population in Coal Counties in Relation to Entire State													
Coal Counties		3.9%	3.9%	8.5%	4.9%	1.8%	4.1%	3.6%	1.4%	8.4%	4.4%	7.9%	5.5%
Other Counties		96.1	96.1	91.5	95.1	98.2	95.9	96.4	98.6	91.6	95.6	92.1	94.5
Entire State		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Manufacturing Workers Covered by Old-Age and Survivors Insurance by Industry Groups

Industry Group Mid-March 1948	Entire State Number of Employes	Entire State Percent of Total	Sebastian County Number of Employes	Sebastian County Percent of Total
Food and Kindred Products	8,154	11.12%	1,116	19.18%
Tobacco Manufactures	10	.01	-	-
Textile Mill Products	1,806	2.46	-	-
Apparel, Fabric Products, etc.	3,410	4.65	127	2.18
Lumber and Wood Products	32,754	44.65	247	4.25
Furniture and Fixtures	4,195	5.72	1,907	32.77
Paper and Allied Products	3,265	4.45	-	-
Printing, Publishing, etc.	2,292	3.12	351	6.03
Chemicals and Allied Products	3,375	4.60	169	2.91
Products of Petroleum and Coal	2,427	3.31	-	-
Leather and Leather Products	2,287	3.12	-	-
Stone, Clay, and Glass Products	2,725	3.71	1,008	17.32
Primary Metal Industries:				
Iron and Steel Foundries	123	.17		
Primary Smelting and Refining, nonferrous	871	1.19		
Nonferrous Foundries	15	.02		
Total Primary Metal Industries	1,009	1.38%		
Fabricated Metal Products:				
Heaters, Plumbers' Supplies, etc.	66	.09%	-	-
Fabricated Structural Metal Products	347	.47	55	0.94%
Metal Stamping, Coating, Engraving	27	.04	12	.21
Miscellaneous Fabricated Metal Products	158	.22	-	-
Total Fabricated Metal Products	598	0.82%	67	1.15%

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70021

Manufacturing Workers Covered by Old-Age and Survivors Insurance by Industry Groups

Industry Group Mid-March 1948	Entire State		Sebastian County	
	Number of Employes	Percent of Total	Number of Employes	Percent of Total
Machinery (except electrical)	269	0.37%	-	
Transportation Equipment:				
Motor Vehicles and Equipment	1,564	2.13		
Ship and Boat Building, Repairing	97	.13		
Transportation Equipment, n.e.c.	131	.18		
Total Transportation Equipment	1,792	2.44%		
Instruments, etc.	1,810	2.47		
Miscellaneous Manufacturing Industries	931	1.27	77	1.32%
Unaccounted for and added to balance total	243	.33	750(A)	12.89
Total Manufacturing	73,352	100.00%	5,819	100.00%

Note: (A) Industries with 1 or 2 employes not classified but with 100-499 employes in Primary Smelting and Refining and Cutlery, Tools and Hardware.

Ark

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70021

EXHIBIT NO. 23

REPORT

Corps of Engineers
Department of the Army

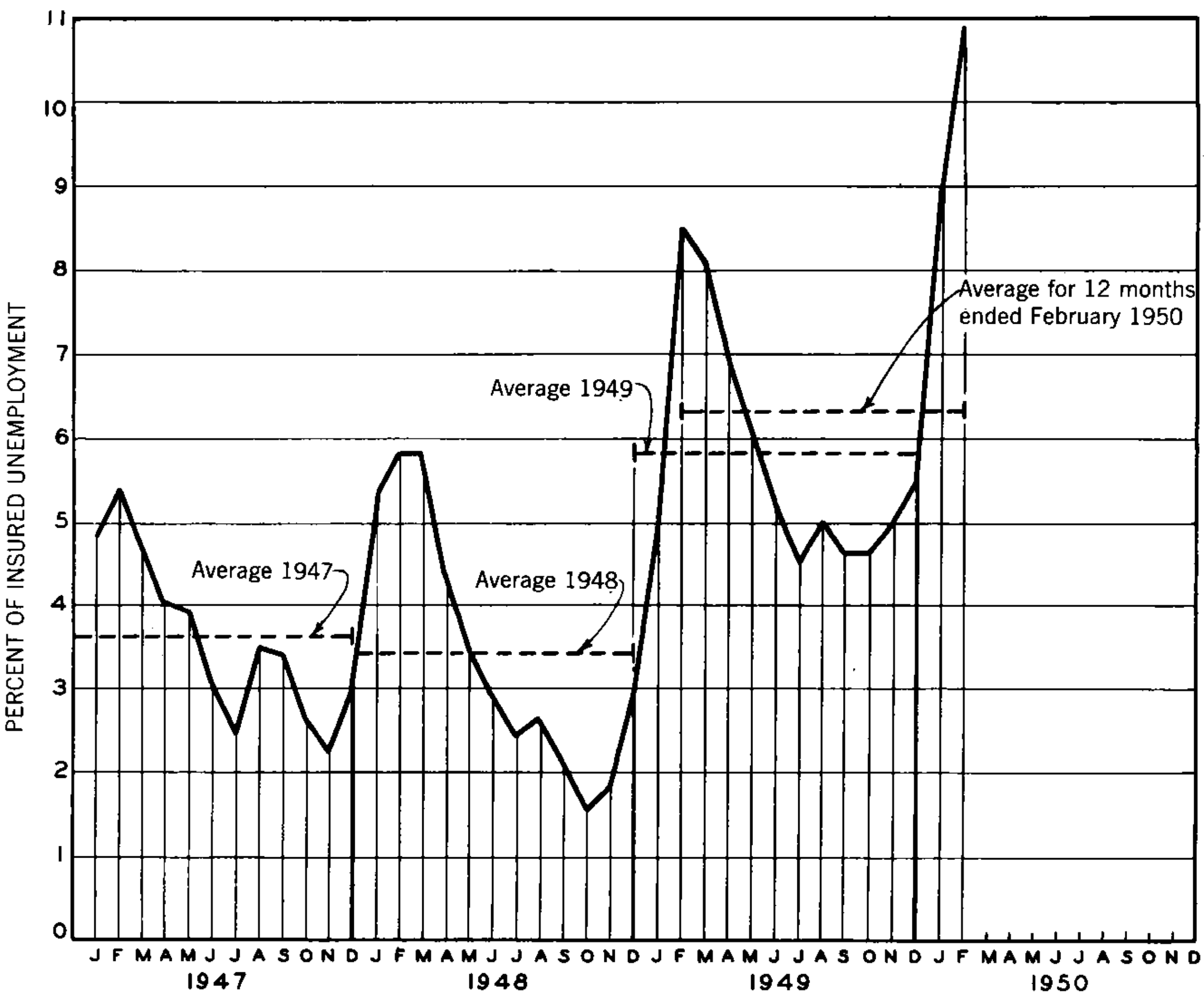
THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS

PERCENT OF
INSURED UNEMPLOYMENT
OF
AVERAGE MONTHLY COVERED EMPLOYMENT

1947-1950

Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK CHICAGO PHILADELPHIA LOS ANGELES



ARK

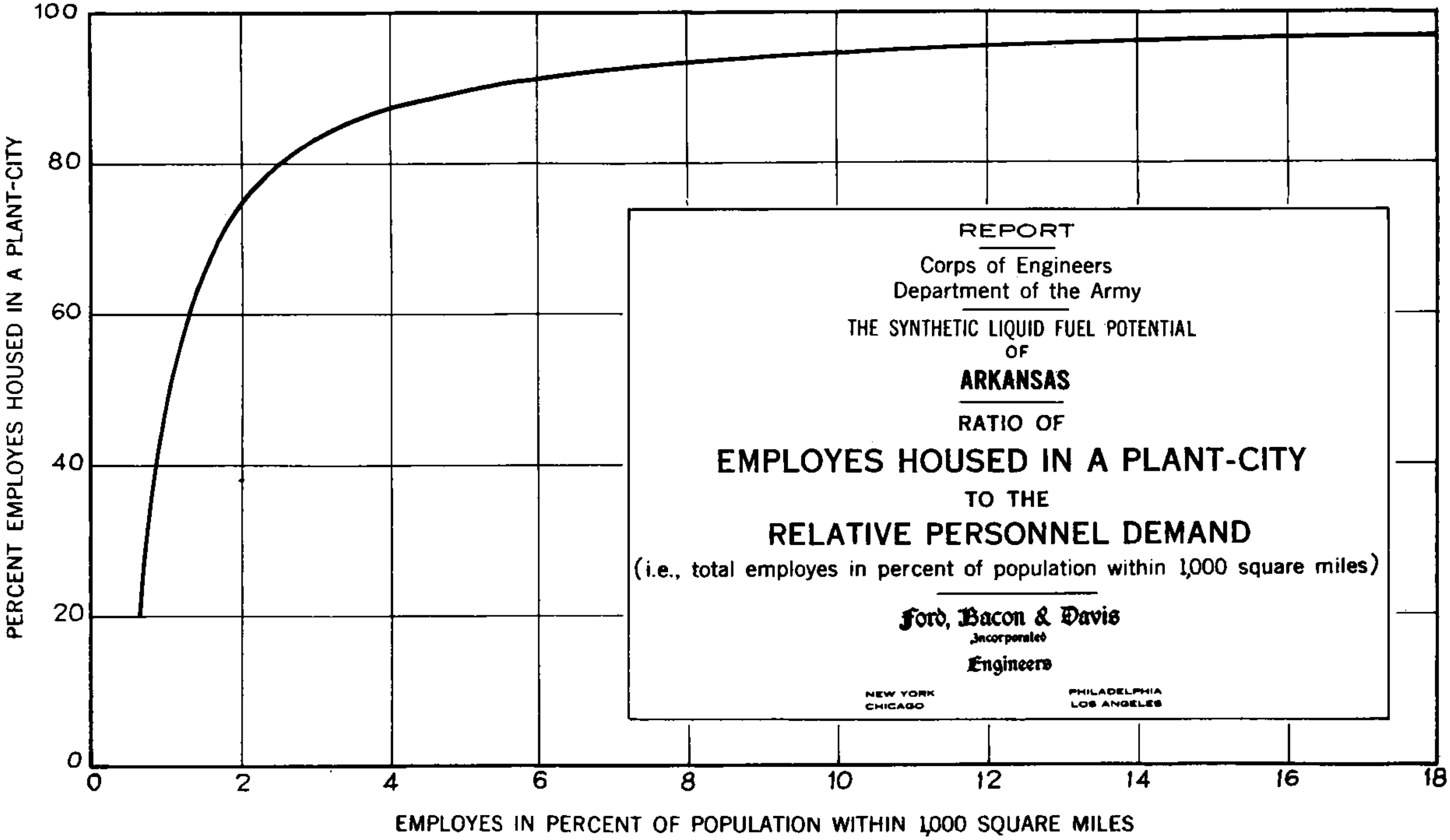
SF-737 1-16-51

Number of New Coal Mine Employes Necessary To Produce Fuel Requirement of a Typical Unit Plant after Diversion of a Portion of Present Production Capacity in the General Area to the Unit Plant

	Coal Production (Tons)	Number of Working Days	Productivity per Man-day (Tons)	Number of Men Working Daily
Before Introduction of Unit Plant (1948)				
Total 2 Counties (One General Area):				
At present conditions	796,911	180	4.23	1,044
Production capacity at 240 working days per year	1,059,869	240	4.23	1,044
Increase in capacity at 240 days over present	262,958			
After Introduction of Coal Synthine Unit Plant				
Fuel requirement of unit plant	1,684,615			
Less increase in capacity, 240-day basis	262,958			
Balance, production required of associated mine	1,421,657			
Number of new operational workers		240	5.00	1,185
Vacations, illness, etc. (10%)				119
Total operational employes				1,304
Administrative employes (5%)				65
Total new coal mine employes required				1,369

ARK.

SF-547 8-2-50



REPORT

Corps of Engineers
Department of the Army

THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS

RATIO OF
EMPLOYES HOUSED IN A PLANT-CITY
TO THE
RELATIVE PERSONNEL DEMAND
(i.e., total employes in percent of population within 1,000 square miles)

Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK
CHICAGO
PHILADELPHIA
LOS ANGELES

EXHIBIT NO. 25

ARK

SF-324 8-2-50

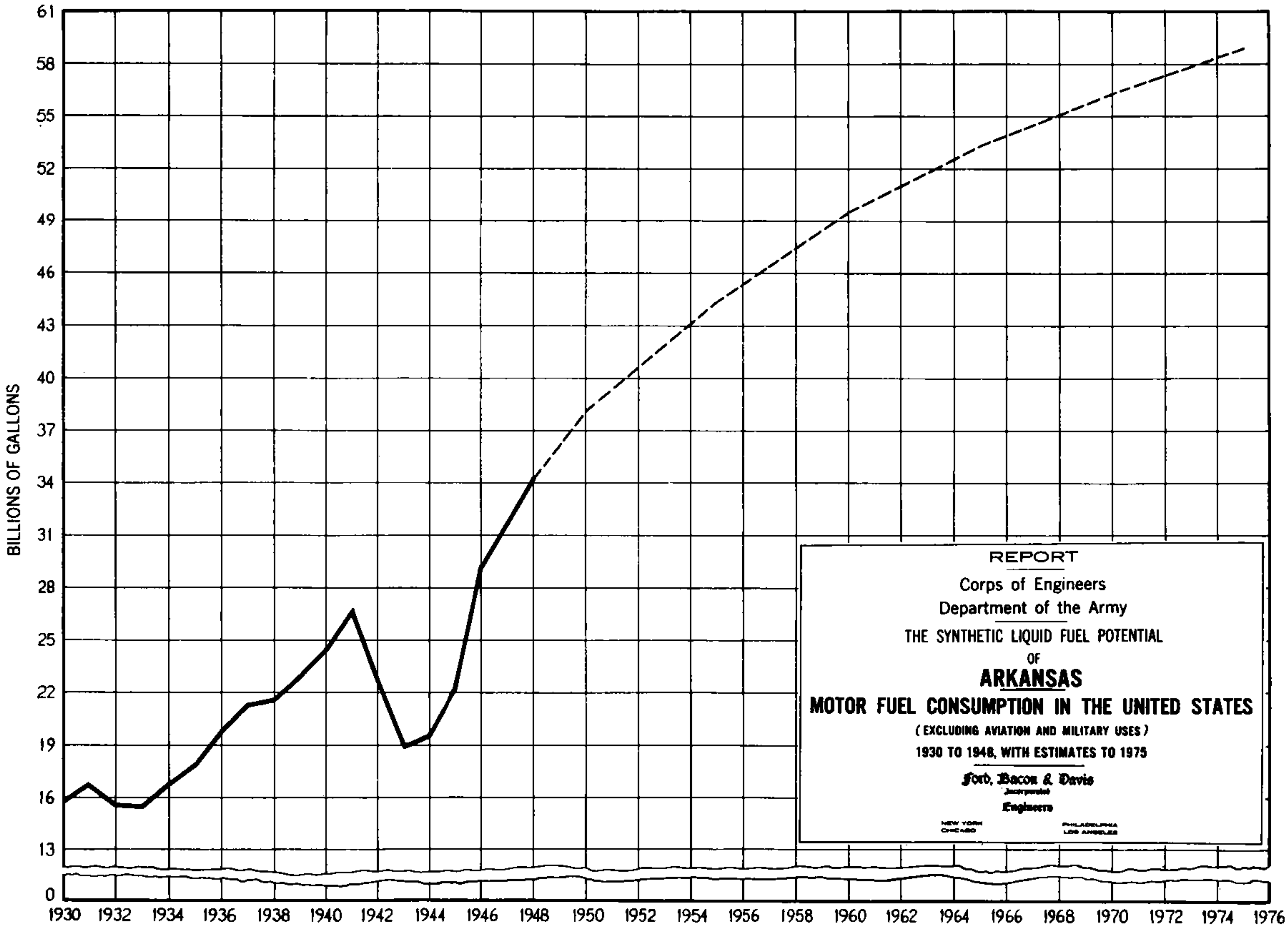
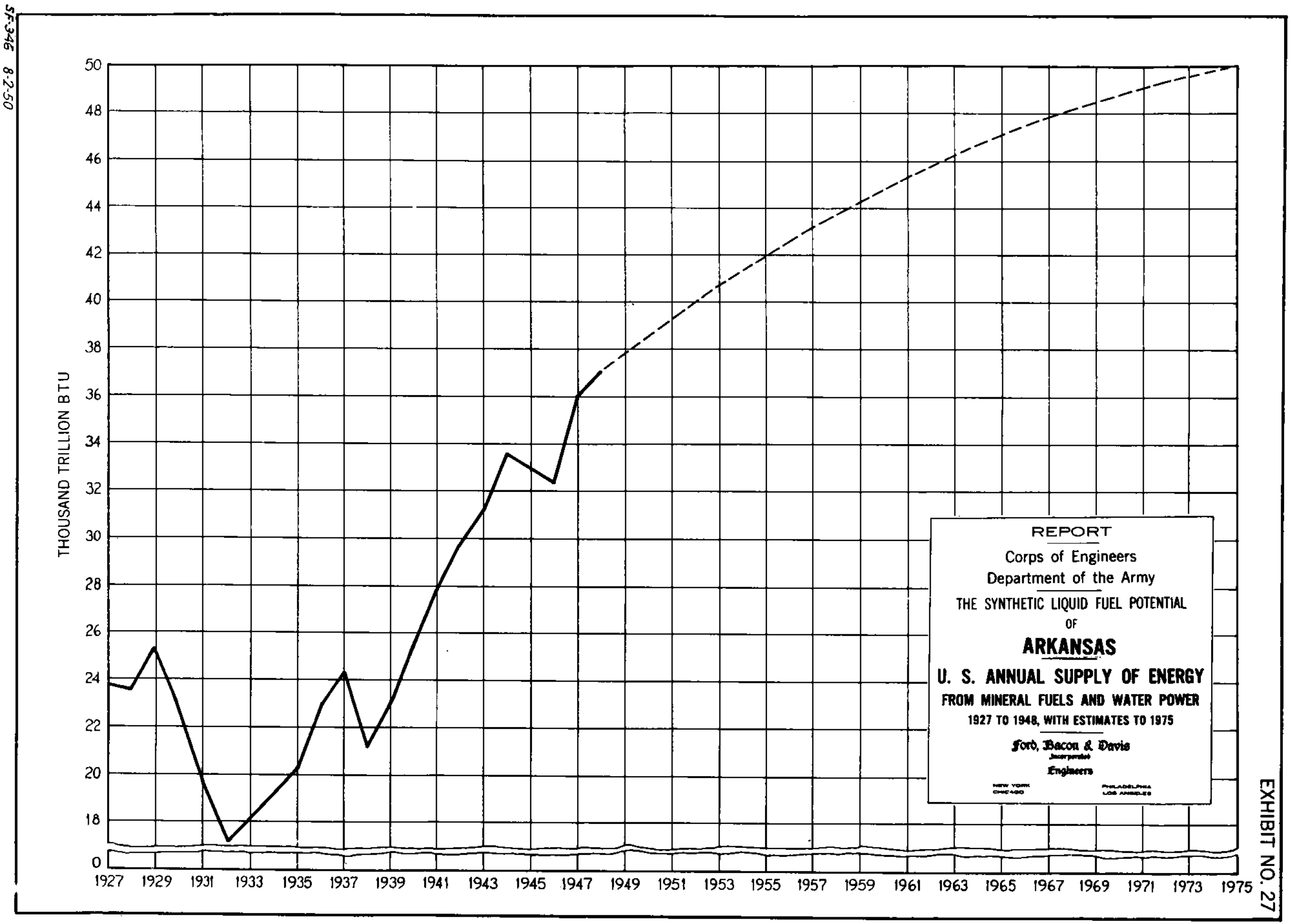


EXHIBIT NO. 26

ARK


SF-346 8-2-50
THOUSAND TRILLION BTU
50
48
46
44
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40
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36
34
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30
28
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24
22
20
18
0
1927
1929
1931
1933
1935
1937
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1975
REPORT
Corps of Engineers
Department of the Army
THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS
U. S. ANNUAL SUPPLY OF ENERGY
FROM MINERAL FUELS AND WATER POWER
1927 TO 1948, WITH ESTIMATES TO 1975
Ford, Bacon & Davis
Incorporated
Engineers
EXHIBIT NO. 27

ARK

SF-368 8-2-50

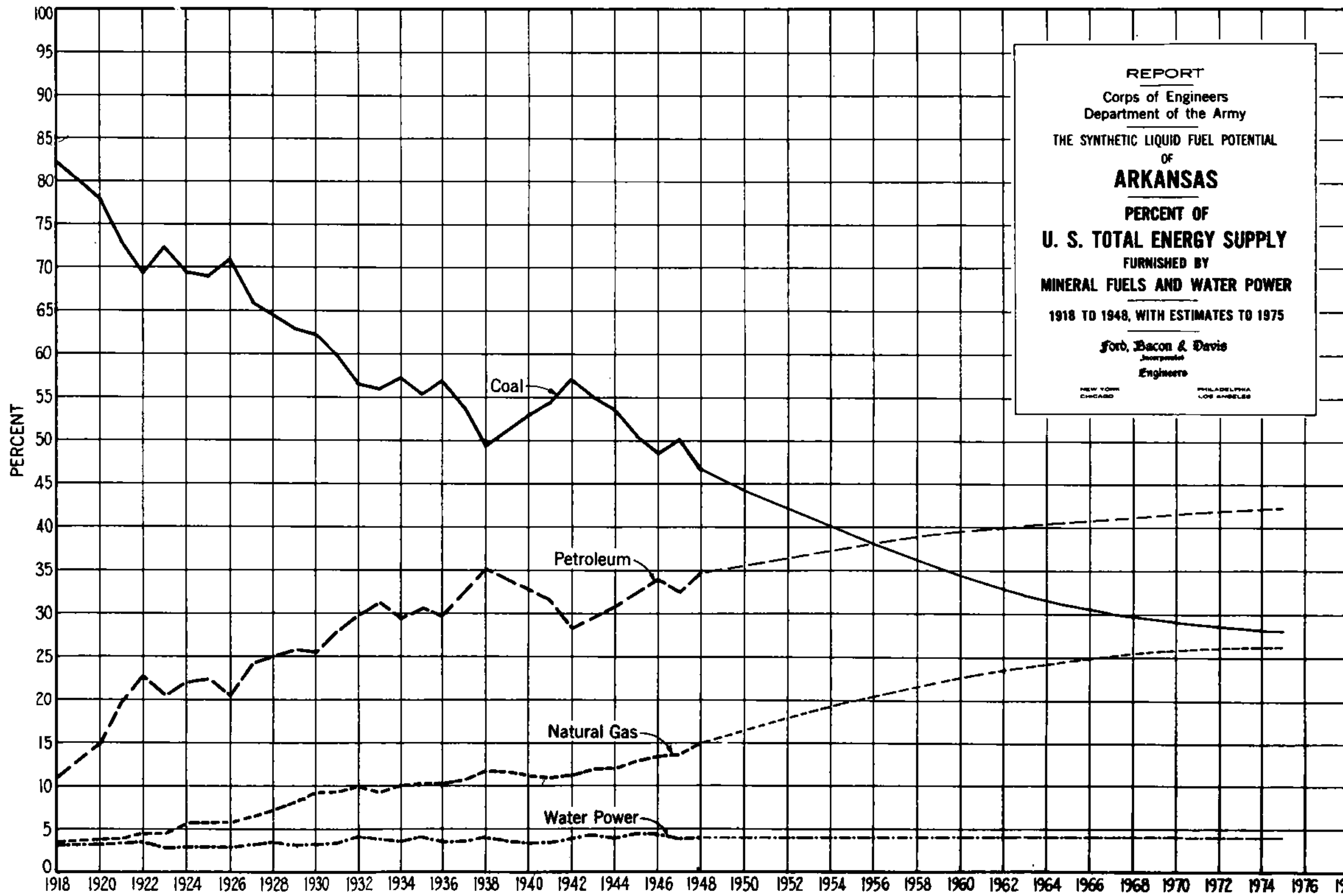

EXHIBIT NO. 28

ARK.

SF-392 11-16-50

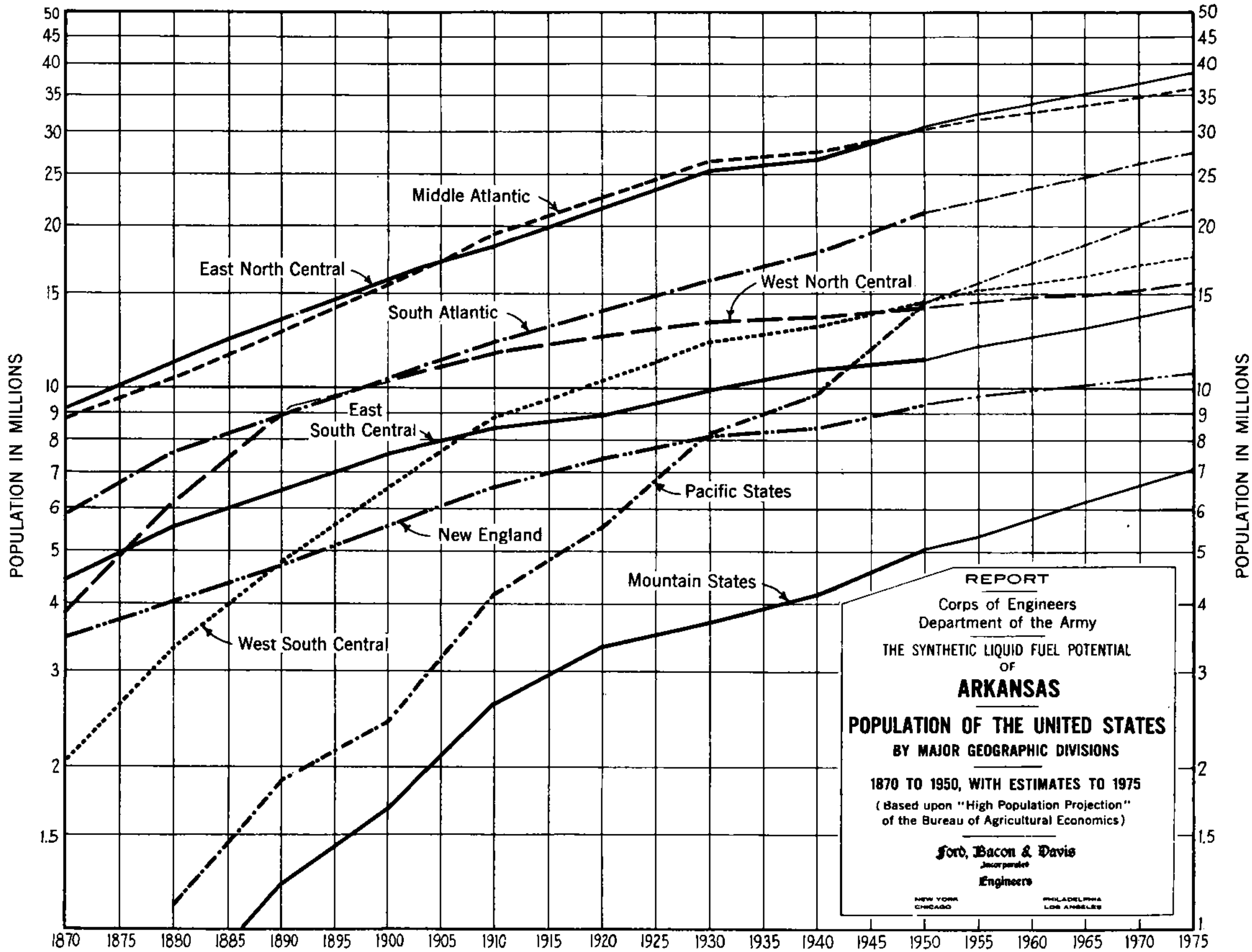

EXHIBIT NO. 29

ARK

SF-736 1-16-51

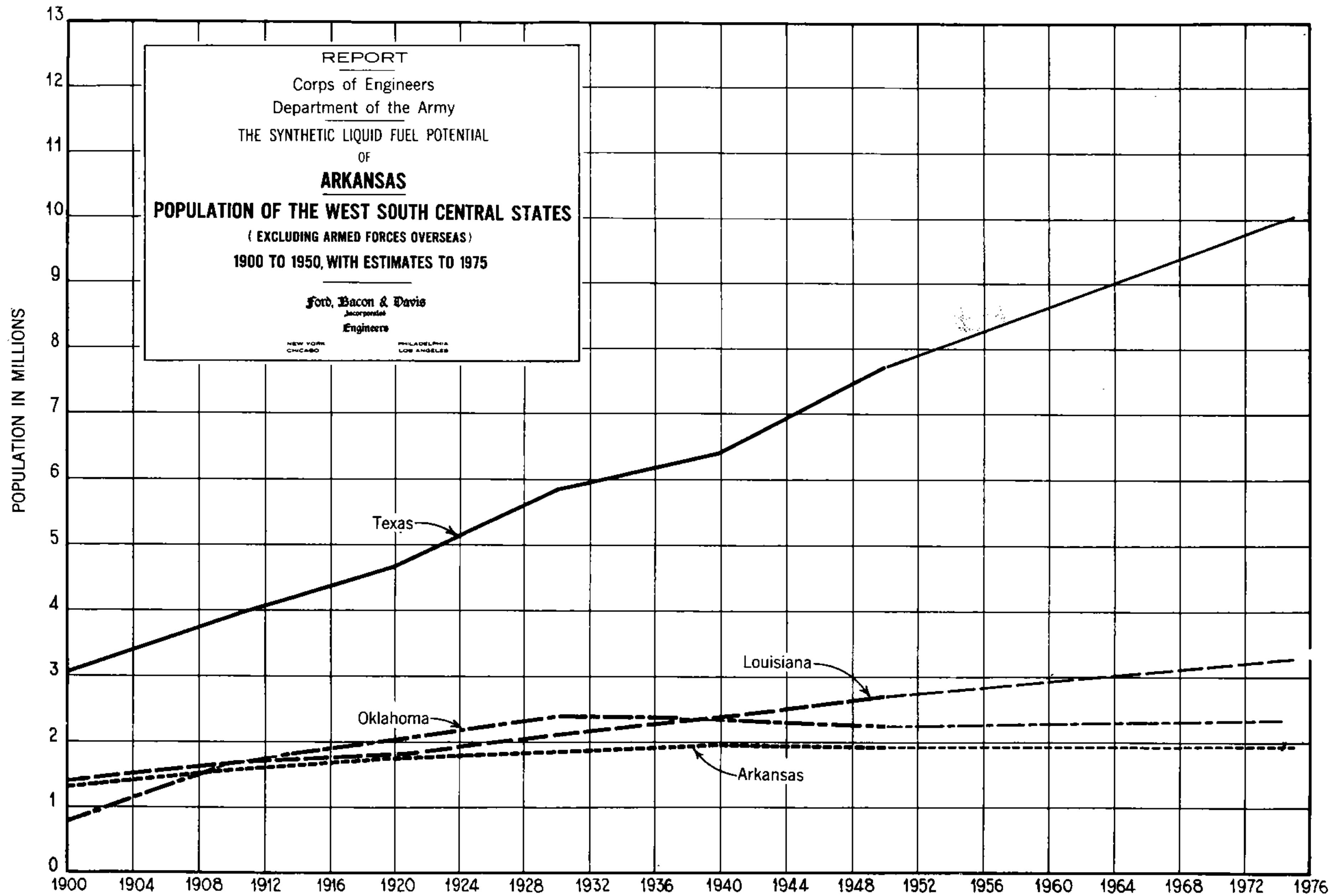

EXHIBIT NO. 30

ARK.

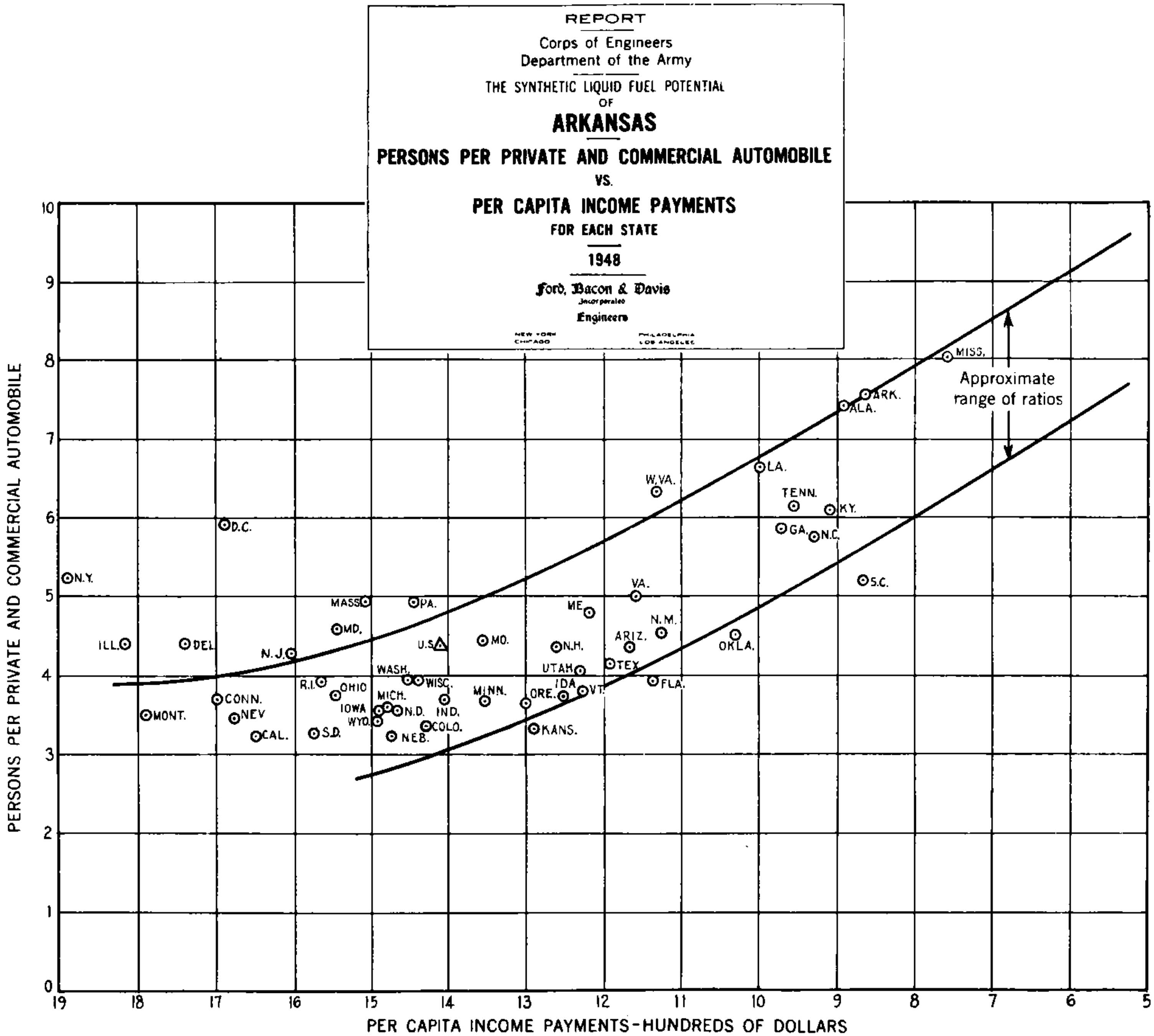

EXHIBIT NO. 31

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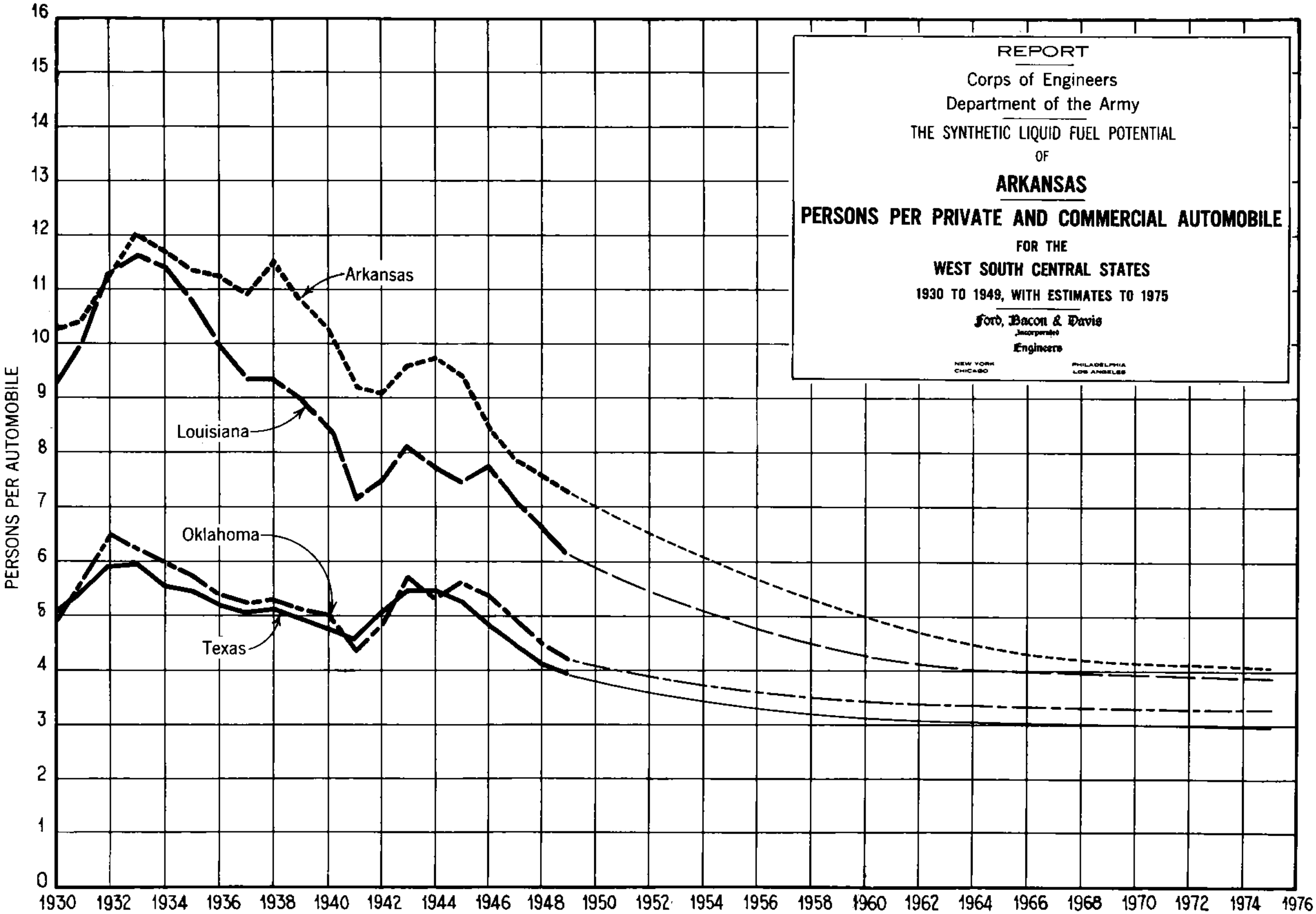


EXHIBIT NO. 32

ARK

SF-732 1-16-51

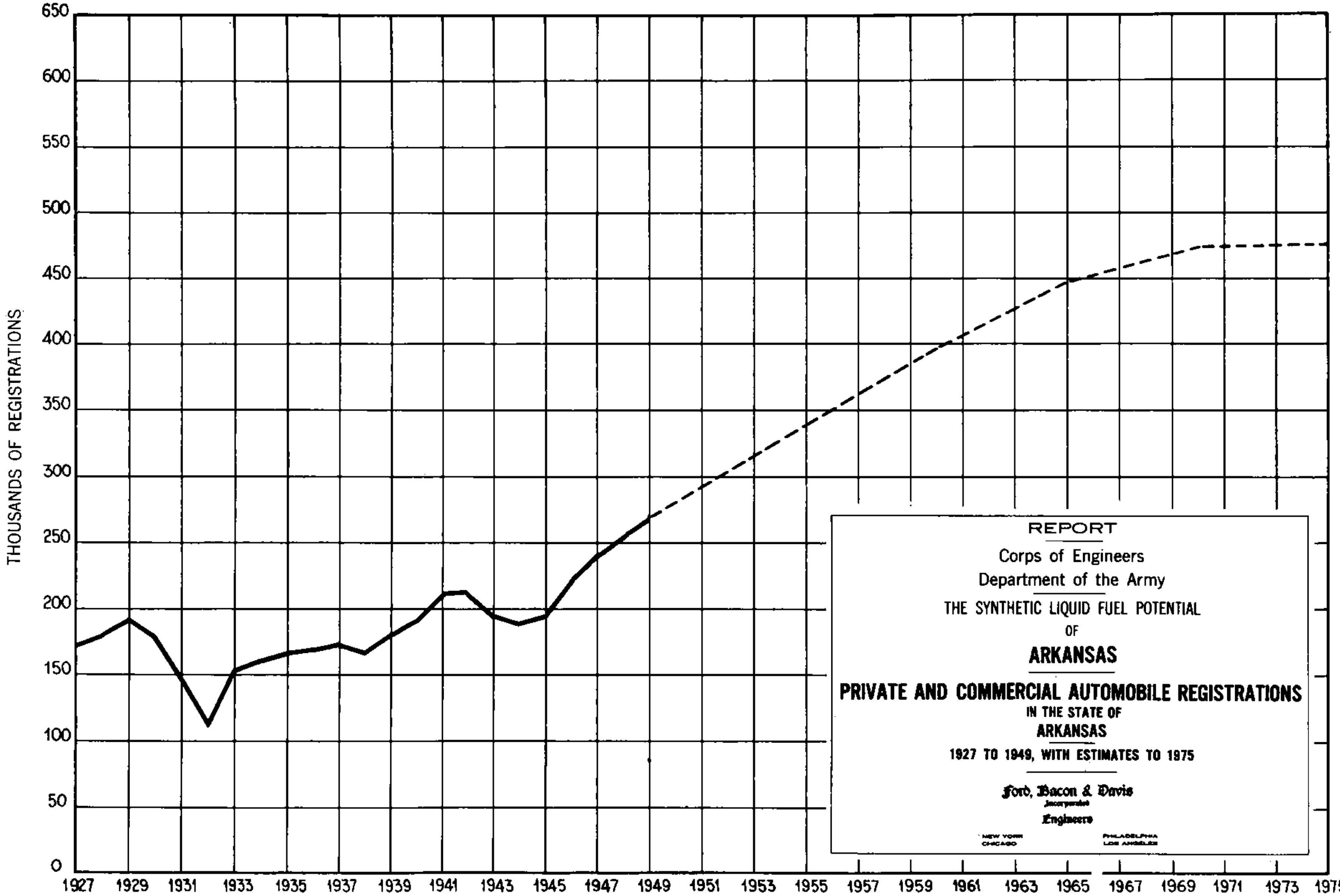


EXHIBIT NO. 33

ARK

SF-735 1-16-51

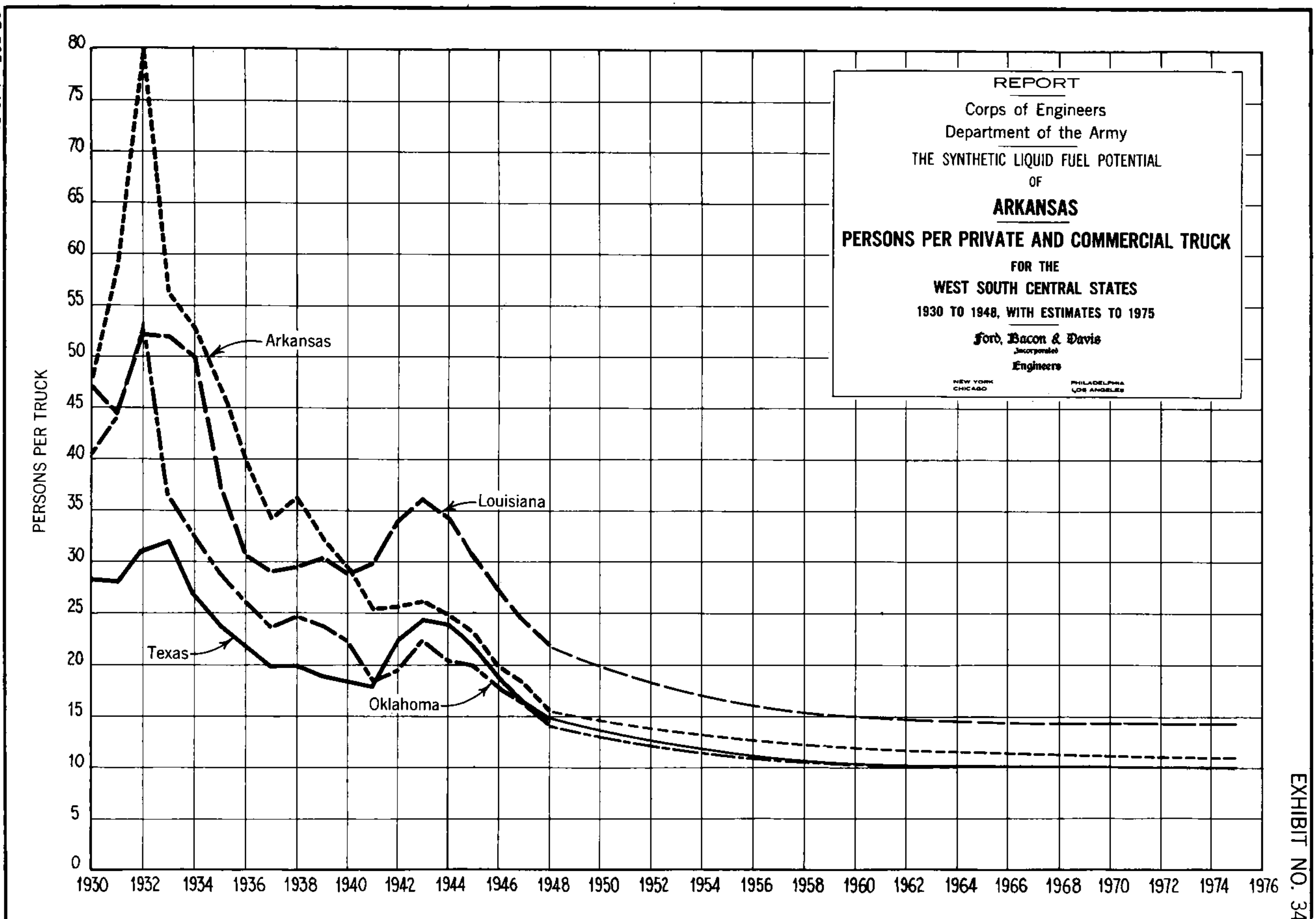


EXHIBIT NO. 34

ARK

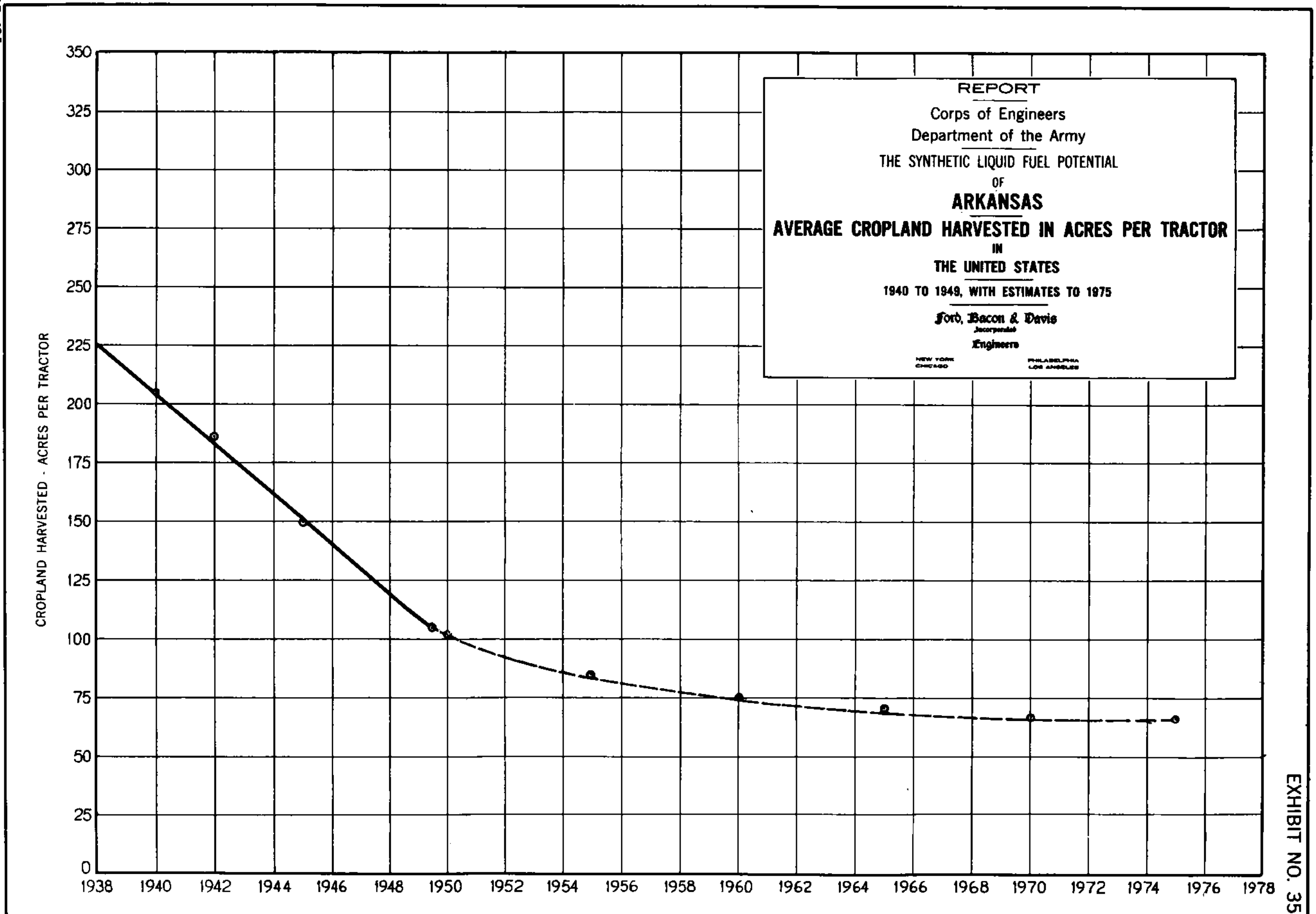
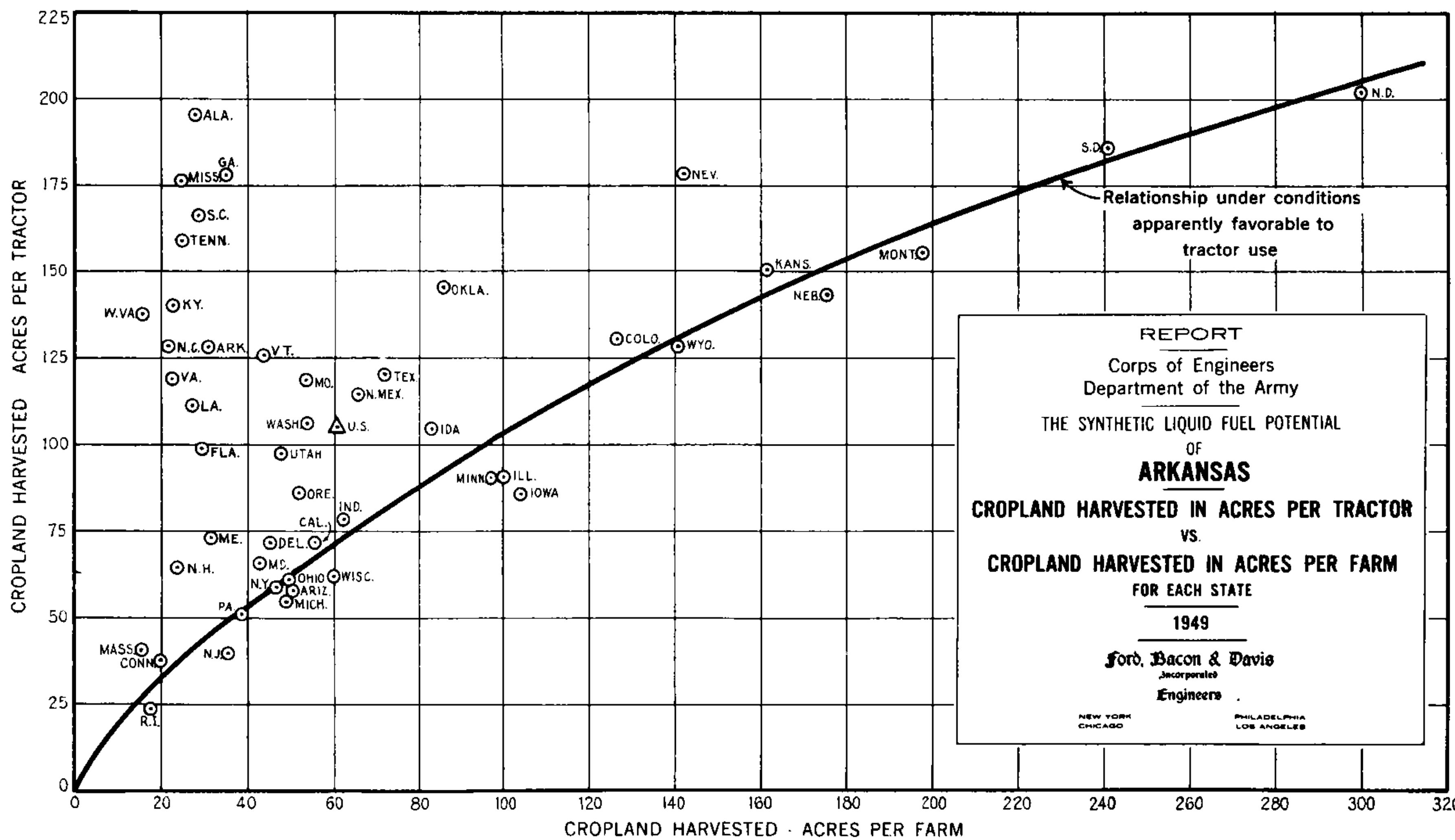


EXHIBIT NO. 35

ARK

SF-458 8-2-50



REPORT

Corps of Engineers
Department of the Army

THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS

CROPLAND HARVESTED IN ACRES PER TRACTOR
VS.
CROPLAND HARVESTED IN ACRES PER FARM
FOR EACH STATE

1949

Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK CHICAGO — PHILADELPHIA LOS ANGELES

EXHIBIT NO. 36

ARK

SF-480 8-2-50

REPORT

Corps of Engineers
Department of the Army

THE SYNTHETIC LIQUID FUEL POTENTIAL
OF

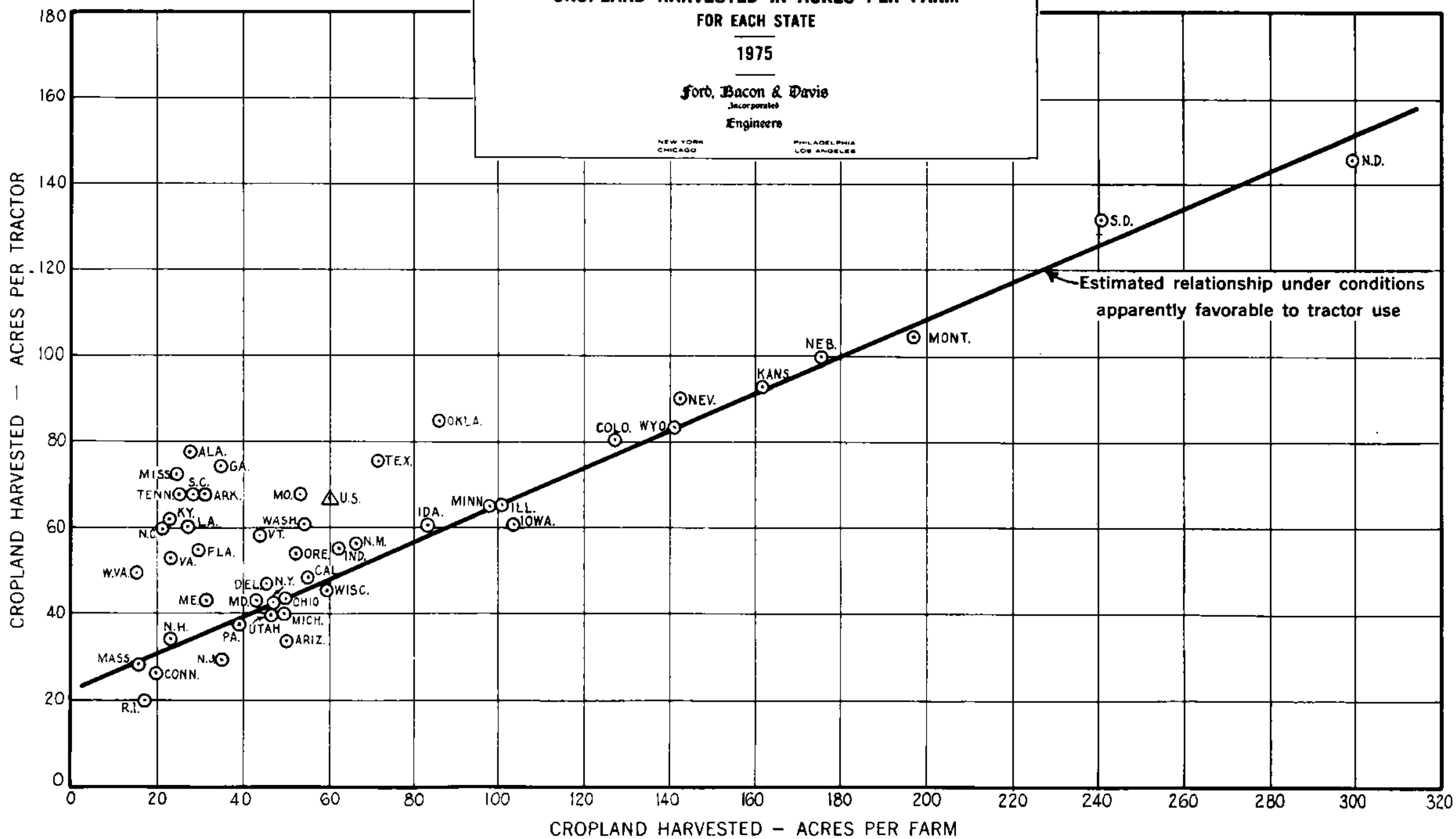
ARKANSAS

ESTIMATED CROPLAND HARVESTED IN ACRES PER TRACTOR
VS.
CROPLAND HARVESTED IN ACRES PER FARM
FOR EACH STATE

1975

Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK CHICAGO PHILADELPHIA LOS ANGELES



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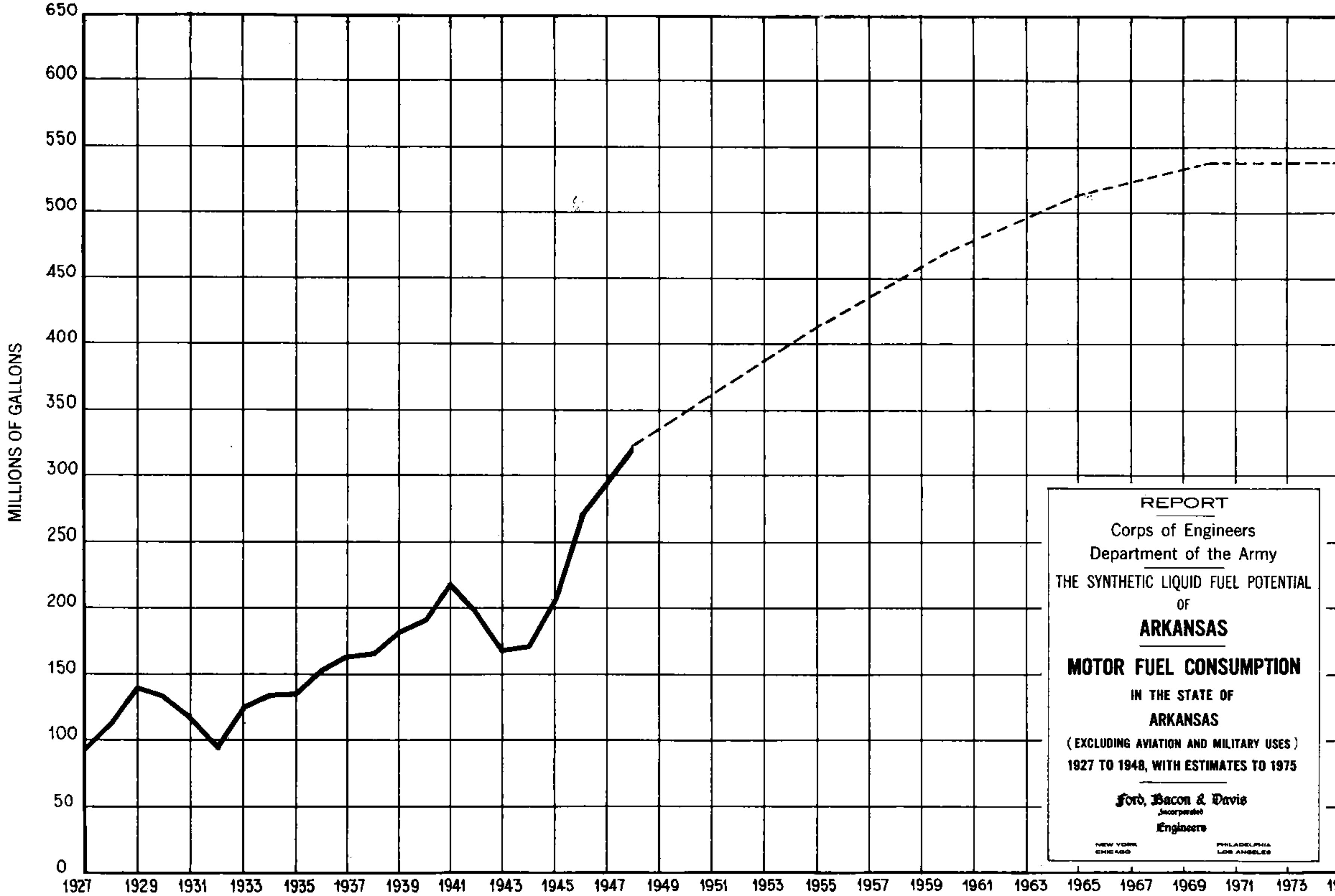

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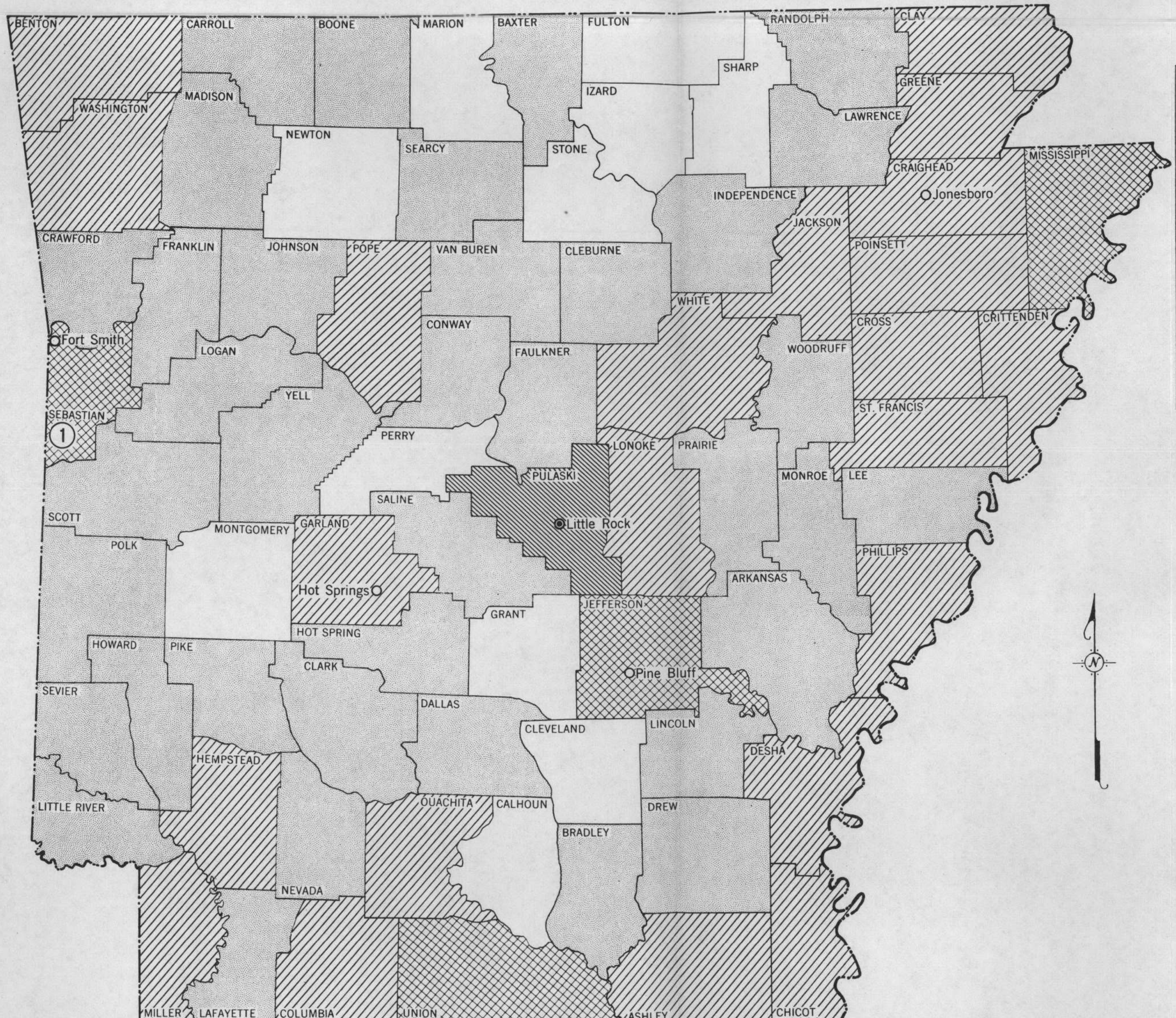
EXHIBIT NO. 39



REPORT

Corps of Engineers
Department of the Army

THE SYNTHETIC LIQUID FUEL POTENTIAL
OF
ARKANSAS

ESTIMATED POPULATION OF COUNTIES IN ARKANSAS
BY SIZE GROUPS
AS OF JANUARY 1, 1949
AND APPROXIMATE CENTER OF THE GENERAL AREA

Ford, Bacon & Davis
Incorporated
Engineers

NEW YORK CHICAGO   PHILADELPHIA LOS ANGELES

SCALE OF MILES
10 0 10 20 30 40

LEGEND

(1) etc. Center of General Area of Coal and Water Availability

IDENTIFICATION

Approx. Center	General Area
(1)	Sebastian-Scott

POPULATION

0 to 10,000
10,001 to 25,000
25,001 to 50,000
50,001 to 100,000
OVER 100,000

SF-753 1-19-51

Estimated Coal Synthine Unit Plant Construction Costs and Required Total Initial Investment Plant near Caseyville, Ky., using W. Kentucky Bituminous Coal

(Based on Preliminary Estimates of the U.S. Bureau of Mines)

Subdivisions of Total Plant	10,000-barrel-per-day Plant Using Coal (As of March 1, 1950)	
Synthesis Gas Production Section:		
Coal Preparation	$ 2,995,000	
Gas Generation	8,330,000	
Gas Purification	3,780,000	
Oxygen Production and Compression	21,700,000	
Total Synthesis Gas Production Section		$36,805,000
Synthesis and Other Processing Section:		
Synthesis	$11,100,000	
Catalyst Preparation and Coolant Oil Clean-up	250,000	
Distillation and Gas Recovery	7,350,000	
Polymerization	875,000	
Catalytic Reforming and Cracking	1,365,000	
Waste Recovery and Disposal	1,000,000	
Total Synthesis and Other Processing		$21,940,000
General and Auxiliary Plants Section:		
Tankage	$ 2,100,000	
Power Plant	3,570,000	
Plant Utilities	9,660,000	
Plant Facilities	7,730,000	
Total General and Auxiliary Plants		$23,060,000
Total Plant Construction Cost		$81,805,000
Interest during Construction		2,455,000
Depreciable Investment		$84,260,000
Operating Capital		4,000,000
Total Investment entitled to Return		$88,260,000

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Estimation of Operating Capital
Coal Synthine Unit Plant in Arkansas
(As of March 31, 1950)

	Sebastian-Scott General Area of Coal and Water Availability
Costs per Calendar Day	
Coal:	
Mine Investment (Thousands)	$ 9,262
Daily Plant Consumption (Tons)	4,615
Cost per Ton	$ 5.28
Daily Cost excluding Return	$ 24,367
Daily Return on Investment @ 4%	1,015
Daily Coal Cost including Return	$ 25,382
Water:	
Water Investment (Thousands)	$ 3,941
Annual Cost	$ 193,800
Daily Cost excluding Return	$ 531
Daily Return on Investment @ 5%	540
Daily Water Cost including Return	$ 1,071
Catalysts	$ 1,200
Total Raw Material	$ 27,653
Total Direct and Indirect Costs excluding Raw Material (A)	$ 16,451
Operating Capital	
Cost of 30 days' coal supply at rated capacity operation	$ 731,010
Cost of direct materials and water for one-half year operation at average 25 percent capacity	1,261,668
All other operating costs for one-half year (except fixed costs)	3,002,308
Total	$4,994,986

Note:
(A) From Contractor's Estimate of Processing Costs -

Total Direct and Indirect Costs	$ 42,549
Less Direct Materials (Coal and Catalysts)	25,567
Less Make-up Water	531
Balance Direct and Indirect Costs excluding Raw Material	$ 16,451

Methods Used in Preparation of
Estimates of Daily Production Costs
For a Typical Coal Synthine Unit Plant
in Continental United States
(Based on Preliminary Data from the U.S. Bureau of Mines)

Direct Labor:

Direct labor (75 men per shift), as estimated in detail by individual functions (A)

Supervisory personnel 10 percent of direct labor personnel (A)

Total labor personnel 4.5 times (average) personnel per shift (A)

Direct labor wage rate (at Caseyville, Ky., first quarter 1950) - average, all classifications, $1.75 per hour (A)

Cost of supervision 15 percent of labor cost (A)

Plant Maintenance Labor and Supervision:

Total annual cost of maintenance labor and supervision 2 percent of plant cost, erected (cost as of March 1, 1950) (A)

Maintenance labor personnel 420 men, approximately 5/4 of direct labor personnel (A)

Supervisory personnel 10 percent of maintenance labor personnel(A)

Total maintenance labor personnel 4.5 times (average) personnel per shift

Total maintenance labor cost 100/115 of total daily cost (1/365 of annual cost) of maintenance labor and supervision (as above)

Cost of supervision 15 percent of labor cost (A)

Plant Maintenance Materials:

Per year, 1 percent of plant cost erected (A)

Payroll Overhead:

12-1/2 percent of direct labor and supervision and maintenance
Ark labor and supervision (A)

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Operating Supplies:

70021 20 percent of maintenance labor, supervision, and materials (A)

Methods Used in Preparation of
Estimates of Daily Production Costs
For a Typical Coal Synthine Unit Plant
in Continental United States
(Based on Preliminary Data from the U.S. Bureau of Mines)

Total Indirect Costs (general administrative, office overhead, and indirect operating costs):
50 percent of direct labor and supervision, plant maintenance labor, supervision and materials, and operating supplies (A)

Indirect Labor:
Total indirect labor personnel (wage earners) 12 percent of total wage earners (including indirect labor) (A)

Indirect labor wage rate (at Caseyville, Ky., first quarter 1950) - average, all classifications, $1.64 per hour (A)

Total daily payments to indirect labor, 1/365 of annual cost at 2,080 hours per year, per man (B)

Cost of supervision, none (supervision provided by salaried personnel)

Indirect Salaried Personnel:
Average salary rate $3,600 per year (A)

Total indirect salaried personnel, number of employes at $3,600 per year payable from a sum equal to 50 percent of total indirect costs less payments to indirect labor (A)

Other Indirect Costs:
Balance remaining after deducting from total indirect costs (as above) the sum of payments to indirect labor and indirect salaried personnel (also as above)

Local, County and State Taxes and Insurance:
Per year 1 percent (A) of depreciable investment (plant cost
Ark erected plus interest during construction)

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Depreciation:
70021 15-year straight line; per year 6-2/3 percent (A) of depreciable investment

Methods Used in Preparation of
Estimates of Daily Production Costs
For a Typical Coal Synthine Unit Plant
in Continental United States

(Based on Preliminary Data from the U.S. Bureau of Mines)

References:

(A) Memorandum, U.S. Bureau of Mines Synthetic Oil Plant, Louisiana, Mo., March 8, 1950: "Fischer-Tropsch Commercial Liquid Synthetic Fuel Plant - 10,000 Barrels per Day Estimate".

(B) R.I. No. 4564, U.S. Bureau of Mines, August 1949: "Estimated Plant and Operating Costs for Producing Gasoline by Coal Hydrogenation".

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Methods Used in Preparation of
Estimates of Daily Operating Costs
For Coal Synthine Unit Plants
in Arkansas as of March 31, 1950

Direct Materials:
Coal, from section of report entitled "Coal"; for example, 4,615 tons at $5.28 per ton.

Catalysts and Chemicals, same cost as estimated by Bureau of Mines.

Direct Labor:
Wage earners, daily cost estimated by Bureau of Mines multiplied by ratio of $1.48 over $1.73. $1.48 represents estimated average straight-time hourly wage rate payable to wage earners (exclusive of supervisors) in synthetic liquid fuels plants in Arkansas as developed in the section of this report entitled "Labor". $1.73 represents the weighted average hourly wage rate of wage earners (exclusive of supervisors) as used in the Bureau of Mines estimate of operating costs in a typical coal synthine unit plant.

Supervisors, 15 percent of daily cost of wage earners.

Plant Maintenance Labor and Supervision:
Wage earners, daily cost estimated by Bureau of Mines multiplied by ratio of $1.48 over $1.73, as developed under direct labor.

Supervisors, 15 percent of daily cost of wage earners.

Plant Maintenance Materials:
Per Year, 1 percent of plant construction cost.

Payroll Overhead:
12-1/2 percent of direct labor and supervision and maintenance labor and supervision.

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Methods Used in Preparation of Estimates of Daily Operating Costs For Coal Synthine Unit Plants in Arkansas as of March 31, 1950

Operating Supplies:
20 percent of maintenance labor, supervision, and materials.

Total Indirect Costs (general administrative, office overhead, and indirect operating costs):
50 percent of direct labor and supervision, plant maintenance labor, supervision and materials, and operating supplies.

Indirect Labor:
Daily cost estimated by Bureau of Mines multiplied by ratio of $1.48 over $1.73 as developed under direct labor.

Indirect Salaried Personnel:
As estimated by Bureau of Mines.

Other Indirect Costs:
Balance remaining after deducting from total indirect costs (as above) the sum of payments to indirect labor and indirect salaried personnel (also as above).

Local, County, and State Taxes:
Per year, 1 percent of depreciable investment (plant construction cost plus interest during construction).

Depreciation:
15-year, straight-line; per year 6-2/3 percent of depreciable investment.

Summary of Capital Investment, Operating Costs
and Requirement for Each Percent of Gross Return on Investment
for One 10,000-barrel-per-day Coal Synthine Unit Plant in Arkansas
(As of March 31, 1950)

	Sebastian-Scott General Area
Capital Investment ($1,000's)	
Raw Material (Coal)	$ 9,262
Water, Process	3,941
Other Processing (A)	89,255
Access Transportation	124
Product Transportation	(F)
Waste Disposal (Solids)	684
Subtotal	$103,266
Housing (B)	16,216
Total	$119,482
Operating Costs, exclusive of Return on Investment, in Dollars per Barrel of Products (C)	
Raw Material (Coal)	$2.44
Water, Process	.05
Other Processing (D)	3.54
Access Transportation	(H)
Product Transportation	(F)
Waste Disposal (Solids)	.04
Subtotal	$6.07
Housing	(G)
Total (E) - per barrel	$6.07
- per gallon	$0.145
Dollars per Barrel Required for Each Percent of Gross Return on Capital Investment (C)	
Raw Material (Coal)	$0.025
Water, Process	.011
Other Processing	.245
Access Transportation	(H)
Product Transportation	(F)
Waste Disposal (Solids)	.002
Subtotal	$0.283
Housing	.044
Total - per barrel	$0.327

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(See following page for footnotes)

Summary of Capital Investment, Operating Costs
and Requirement for Each Percent of Gross Return on Investment
for One 10,000-barrel-per-day Coal Synthine Unit Plant in Arkansas
(As of March 31, 1950)

Note: (A) Includes plant erection cost, interest during construction, and operating capital.

(B) Exclusive of capital invested in commercial facilities, one-half of residential housing assumed sold to employes and domestic water supply.

(C) Individual costs sometimes adjusted in last digit to agree with total.

(D) See text of "Processing Costs" for details of items included.

(E) Exclusive of domestic water supply and housing, assumed offset by a portion of water rents and residential housing rents.

(F) Product transportation; i.e., the cost of moving products to distant markets has not been considered for those General Areas with adjacent local marketing territory capable of absorbing the output of a unit plant.

(G) Operating costs offset by a portion of rentals paid by occupants of dwelling units.

(H) Less than 0.5 mills.

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APPENDIX A

DESCRIPTION OF COAL TRADE DISTRICTS
IN ARKANSAS

APPENDIX A

DESCRIPTION OF COAL TRADE DISTRICTS IN ARKANSAS

The Bonanza-Jenny Lind district is located in northern Sebastian County along the north flank of a combined anticline and thrust fault which forms a barren strip extending in an east-west direction across the northern portion of the county. The Lower Hartshorne bed ranges from less than 3 feet to over 4 feet along its outcrop in this district and has been extensively depleted along the outcrop for distances of one mile or more down the dip of the bed. These operations were conducted by slopes, shafts, or by combinations thereof.

The Excelsior-Greenwood district is located along the southern limb of the barren area which forms an east-west strip across the northern portion of Sebastian County. The rates of dip along portions of the outcrop in this district are steep so that while the outcrop has been extensively depleted, the depth and distance of underground operations away from the outcrop are relatively small.

The Hartford-Huntington district is located in the southern portion of Sebastian County where the Lower Hartshorne bed has been extensively worked by both underground and stripping operations. The coal in this district generally ranges from 3 ft 0 in. to 5 ft 0 in. in thickness.

The Bates district occurs in northwestern Scott County where the Lower Hartshorne bed outcropping along the southern flank of Poteau Mountain has been mined to a relatively limited extent by both underground and stripping operations. The bed in this district is relatively thick near the Oklahoma-Arkansas State line, but splits into individual benches separated by thick partings toward the northeast.

The Charleston district is located largely in southern Franklin County where the Charleston bed, with thicknesses averaging less than 2 ft 0 in., outcrops around the flanks of three synclines of various sizes. Operations have been conducted by both underground and stripping methods.

The Paris district is located in north-central Logan County where the Paris bed outcrops persistently around a relatively small syncline, with its thickness averaging less than 2 ft 0 in. The bed has been extensively depleted by both stripping and underground operations.

The Scranton district is located in northeastern Logan County where the Spadra coal bed extends southward across the Arkansas River from the main Spadra district in southern Johnson County. In Logan County, the Spadra bed is relatively unmapped and unmined, with but few measurements and locations to indicate its existence.

The Denning-Coal Hill district is located on the northern side of the Arkansas River in southeastern Franklin and southwestern Johnson Counties. In this area, the Denning bed ranges from less than 2 ft 0 in. to a maximum of 3 ft 0 in., but has been widely mined by both underground and stripping operations. The Denning bed is correlated with the Lower Hartshorne bed of Sebastian and Scott Counties.

The Philpott district consists of a relatively shallow but narrow syncline, extending in an east-west direction from east-central Franklin County into western Johnson County. Although extensively mined, largely by stripping operations, the Denning (Spadra) bed in this district averages less than 2 ft 0 in. in thickness.

The Spadra district, located south of Clarksville in southern Johnson County, consists of a large area underlain by the Spadra bed, which is correlated with the Lower Hartshorne bed of Sebastian and Scott Counties. The Spadra bed ranges from less than 2 ft 0 in. to a maximum of 4 ft 0 in. and has been widely mined by both underground and stripping operations, largely in areas of thicker coal occurrence.

The Ouita and Shinn Basins represent the easternmost projections of the west-central Arkansas coal field in western Pope County. The coal bed in this county is of the same stratigraphic horizon as the Spadra and Lower Hartshorne beds in the central and western portions of the Arkansas coal field. The bed is variable in thickness, but has been extensively mined around the outcrop. Both basins are small in extent.

APPENDIX B

REPORT BY DeGOLYER and MacNAUGHTON
ON
NATURAL GAS IN ARKANSAS
AS OF JANUARY 1, 1949

APPENDIX B

REPORT BY DeGOLYER AND MacNAUGHTON ON NATURAL GAS IN ARKANSAS AS OF JANUARY 1, 1949

SUMMARY

The purpose of this report is to investigate and determine the nature and extent of natural gas deposits in Arkansas in connection with a nationwide synthetic liquid fuel survey.

The natural gas investigation included a study of all of the gas and oil fields in Arkansas with especial reference to the quantity of gas to be recovered, the gas available for a synthetic liquid fuels plant, and the cost of gas in the field. The map, Exhibit No. B-1, accompanying this report, shows the oil and gas fields and main natural gas pipe lines in Arkansas. Data relating to the oil and gas fields and the natural gas reserves in Arkansas are tabulated in Exhibit No. B-2. These data are presented and discussed in the report.

Data relating to reserves of natural gas in Arkansas, which have an average heating value of 1,022 Btu under standard conditions, are briefly summarized in the following table:

Summary of Estimated Recoverable Natural Gas Reserves in Arkansas
(In Mcf under Standard Conditions)

As of Jan. 1, 1949		
Total		1,057,715,000
Commercial Requirements:		
Contract	907,025,000	
To Be Used in Field	113,390,000	
Total Commercial Requirements		1,020,415,000
Undedicated Reserves:		
Proved Drilled	33,000,000	
Proved Undrilled	4,300,000	
Probable	0	
Total Undedicated Reserves as of Jan. 1, 1949		37,300,000

The weighted average field price for gas under contract in Arkansas ranged from 2.3 to 5.5 cents per Mcf, depending upon the field under consideration and the life of the contract, as shown on Exhibit No. B-3.

As shown by the above table, most of the gas reserves are under contract to gas pipe lines or plants for domestic, commercial, and industrial use.

None of these deposits of natural gas could be considered an available reserve for the purpose of this study. The total undedicated gas reserves in all of Arkansas of 37,300,000 Mcf are less than the minimum reserve requirements for the purpose of this study; i.e. undedicated deposits containing at least 225 trillion Btu producible within a radius of 40 miles and having a heating value of not less than 400 Btu per cubic foot at standard conditions. Considering the heating value of the gas to be in the order of 1,000 Btu per cubic foot, the magnitude of available gas reserves to meet minimum requirements for a synthetic liquid fuel plant would be 225,000,000 Mcf.

In the largest gas field in Arkansas, the McKamie-Patton field located in the southwestern part of the State, the remaining gas reserve is estimated to be 214,000,000 Mcf. The principal gas accumulation in this field exists in a large gas cap partially encircled by a band of oil. For purposes of maximum oil and condensate recovery a program of gas injection is in operation. The gas reserves in this field will not be available for any purpose until the program of gas injection has been completed. At that time, most of the gas will be sold to gas pipe lines under contracts now existing.

It is, therefore, concluded there are no undedicated reserves of natural gas in Arkansas presently available for synthetic liquid fuels plants. Discoveries of new fields and extensions of known fields in the interim between January 1, 1949 and the date of this report warrant no changes in this conclusion.

PART I - INTRODUCTION

Authorization

This investigation and report on natural gas deposits in Arkansas have been made as a part of that authorized by a contract, dated June 1, 1949, between Ford, Bacon & Davis, Inc. (called the Contractor) and DeGolyer and MacNaughton (called the Subcontractor). The contract is identified as Subcontract No. 2 of the Principal Contract No. W 49-129 eng-137, dated May 3, 1949, between the United States of America and Ford, Bacon & Davis, Inc., designated as the Contractor. The subcontract was duly approved for the Government by a Contracting Officer.

Purpose and Scope of Report

The purpose of the investigation is to present an inventory of natural gas reserves, or deposits that meet minimum standards as to quantity, quality, and occurrence as later defined herein.

The investigation and report have been confined to a general determination of the nature and extent of natural gas deposits in Arkansas, and conclusions as to their suitability or unsuitability for the manufacture of synthetic liquid fuels. Such a report is required for a state in which present information indicates that production of synthetic liquid fuels from existing raw materials is not feasible at the present or near future time (due among other possible causes to excessive raw material costs or existing commercial requirements in excess of possible production) even though such deposits may technically meet the minimum requirements.

The study included the collection of available basic data,
Ark the preparation of maps, and the determination of factors necessary
to estimate the gas reserves by horizons in each oil and gas field
B5 in Arkansas; the estimation of the reserves; and the determina-
10 tion of the suitability and availability of the reserves for syn-
thetic liquid fuels manufacture. No detailed field investigations
0021 were made.

PART II - GENERAL

Definitions Relating to Natural Gas and Gas Reserves

Natural Gas - Natural deposits of a combustible gas that occur in porous strata of the earth and consist of a mixture of hydrocarbon gases composed principally of methane, small quantities of ethane, and which very often contain small quantities of other heavier hydrocarbon gases such as propane, butane, pentane, and hexane; usually having a heating value of about 1,000 Btu per cubic foot at standard conditions, which value may vary considerably depending upon the contained percentage of nitrogen and other inert gases.

Heating (or Calorific) Value - Heat (gross) resulting from combustion of fuel, expressed for natural gas as Btu per cubic foot at standard conditions.

Standard Conditions - For natural gas, commonly 14.65 pounds per square inch absolute pressure and 60° F temperature.

Minimum Gas Reserves - Deposits of natural gas are not considered reserves for the purpose of this study unless they contain at least 225 trillion Btu in natural gas producible within a radius of 40 miles and with a heating value of not less than 400 Btu per cubic foot at standard conditions.

Estimates of Natural Gas Reserves - The quantities in each of the categories of "proved drilled", "proved undrilled", and "probable" are calculated assuming standard conditions.

(a) Proved drilled reserves - Those reserves of natural gas which will be produced from existing wells.

(b) Proved undrilled reserves - Those reserves of natural gas proved by existing wells and other data, but which will be produced from new wells as yet undrilled.

(c) Probable reserves - Those reserves of gas indicated to be present by existing wells and other data, and which are classified as probable rather than proved due to the nature or scarcity of the data, or the inability to reach definite conclusions from the available data.

Non-Associated Gas - Free gas not in contact with crude oil.

Associated Gas - Free gas in contact with crude oil.

Dissolved Gas - Gas in solution in crude oil.

Availability of Natural Gas Reserves - From the viewpoint of availability of natural gas reserves, the quantity remaining after allowance for present commercial and industrial requirements. Available reserves are considered sufficient for one or more plants when there is a recoverable amount sufficient to supply a natural gas synthine plant with a capacity of 5,000 barrels of synthetic liquid fuels per day for a period of 20 years of which 10 years' supply is from primary reserves and the additional 10 years' supply is from either primary or secondary reserves.

(a) Primary Reserves - Deposits containing at least 225 trillion Btu producible from gas wells within a radius of 20 miles, with a minimum heat value of 700 Btu per cubic foot at standard conditions.

(b) Secondary Reserves - Deposits containing at least 225 trillion Btu producible from gas wells within a radius of 40 miles, with a minimum heat value of 400 Btu per cubic foot at standard conditions.

Unit Plant or Unit Capacity - A synthetic liquid fuels plant for processing natural gas by the synthine process with a production capacity of 5,000 barrels of liquid fuel products per day. Such a plant would require 55,000,000,000 Btu daily or 55,000 Mcf of 1,000 Btu gas. It would consume 20,075,000 Mcf of 1,000-Btu gas annually and would require a reserve of such natural gas of 401,500,000 Mcf over a 20-year period. The estimated cost of a 5,000-barrel plant (taken at one-half the amount estimated by the U.S. Bureau of Mines for a 10,000-barrel plant) is $30,000,000. Such a plant size is adopted in the survey for comparative purposes and is not necessarily the most efficient size for an independent plant.

A Suitable General Area - As considered herein, an area not larger than a county or 1,000 square miles, depending on the local conditions, with natural gas reserves and water supply adequate for at least one unit gas synthine plant, and with other satisfactory qualifications as to labor supply, housing, power supply, and transportation.

Available Sources of Information

Data for this study were obtained from files of the Subcontractor, from public records of the Federal Power Commission, from oil and gas companies operating in the State and from records of the Arkansas Oil and Gas Commission.

Reference has been made to principal publications on natural gas in Arkansas with particular attention to publications of Federal and State authorities. Important publications consulted are listed in the bibliography, Exhibit No. B-4.

Personnel of natural gas companies and geologists familiar with geologic formations in Arkansas were interviewed. The cooperation and assistance of individuals listed in Exhibit No. B-5 are gratefully acknowledged.

PART III - STUDY OF SURVEY DATA

History of the Natural Gas Industry in Arkansas

In the early part of 1887, the Choctaw Oil and Gas Company drilled to a depth of 1,400 feet, the first recorded test well for gas in the town of Fort Smith in northwestern Arkansas. Although the well encountered shows of gas it was abandoned as dry. In 1902, the Choctaw Oil and Gas Company discovered the first commercial gas field in Arkansas with the completion of the Duncan No. 2 well near the town of Mansfield in northwestern Arkansas. This well was drilled to a total depth of 1,125 feet, and initial production was estimated at 960 Mcf of gas per day. This field was known as the Mansfield gas field.

The first commercial gas discovery in southern Arkansas was in April 1920, when the Constantin Refining Company completed the No. 1 Hill well in Union County, from the Nacatoch sand at about 2,250 feet. The estimated initial open flow was 60,000 Mcf per day. This field was the El Dorado field. A year later in January 1921, a well drilled in this field, the No. 1 Armstrong was completed making 35,000 Mcf of gas and 10,000 barrels of oil and water per day. This large oil producer stimulated additional exploratory drilling, and in 1922 the prolific Smackover oil field was discovered. As of January 1, 1949, this field had produced almost 420,000,000 barrels of oil.

These discoveries caused an extensive exploration and development program, and it is estimated that as of January 1, 1949, some 11,600 wells had been drilled for oil or gas, resulting in the discovery of 53 oil fields and 20 gas fields, and the production of some 755,000,000 barrels of oil and an estimated amount of gas in excess of 1,000,000,000 Mcf.

The reported annual production of gas from Arkansas had increased from less than 800,000 Mcf in 1907 to 43,566,000 Mcf in 1926 and to 73,678,400 Mcf in 1948. There were 352 wells drilled or recompleted in 1948, of which 167 were dry holes, 19 were gas wells, and 166 were oil wells.

Gas was initially utilized in Arkansas for heating and lighting purposes in the towns of northwest Arkansas as a result of the gas discovery in 1902. The development of the gas and oil fields in southern Arkansas caused an expansion in the gas transmission lines in Arkansas, and an increase in the number of domestic, commercial, and industrial consumers.

Most of the gas in southern Arkansas is processed through gasoline plants before being sold to pipe line companies. About 61,000,000 Mcf of gas was processed in 10 gasoline plants in southern Arkansas during 1948. In addition, about 10,000,000 Mcf of gas was used as raw material and fuel in an anhydrous ammonia plant.

The principal purchasers of gas in Arkansas are the Arkansas-Louisiana Gas Company, the Lion Oil Refining Company, the Arkansas Power and Light Company, the Arkansas-Oklahoma Gas Company, and the Arkansas Western Natural Gas Company.

General Geology and Natural Gas Reservoirs

Arkansas is divided into two principal geologic regions, the hilly Paleozoic region in the northwest and west, and the Gulf Coastal Plain region in the east and southwest. Beginning at the eastern limit of the exposed Paleozoic formations, the sediments of the Gulf Coastal Plain dip gently in a southeasterly and southern direction with the thickness of the sediments increasing toward the south. The Paleozoic region is characterized by deeply dissected plateaus, the Fredricksburg- Ouachita Mountain System, and the broad east-west trending Arkansas Valley.

The principal oil and gas fields in Arkansas have been found in southern Arkansas in sands or limes of Cretaceous or Jurassic age. The principal gas accumulations are found in the Reynolds lime of Jurassic age at depths of 7,000 to 9,000 feet with initial reservoir pressures ranging from 3,500 to 4,400 psi. The gas fields in the northwest produce from formations of either Pennsylvanian or Ordovician age, and are found mostly in the valley of the Arkansas River.

The formations having the best possibilities for future gas production are sands of Cretaceous age, sands of the Cotton Valley series, and limes of Jurassic age, all occurring in southern Arkansas. In northwestern Arkansas additional gas will probably be found in sands of Pennsylvanian age, and in limes of Ordovician age.

Gas Well and Production Data

During 1948, natural gas in substantial quantities was produced from 300 gas wells and from 2,629 oil wells. In addition, 33 gas wells and 25 oil wells capable of production were not produced.

All the dry gas fields in northwestern Arkansas have pipe line outlets. Likewise, the gas produced from the oil and condensate fields in south Arkansas is under contract to gas pipe line companies or plants operating within the State.

The reported daily average net amount of gas produced in Arkansas during 1948 was in the order of 176,000 Mcf. Of this amount, about 16,000 Mcf were produced from the dry gas fields in northwest Arkansas, and about 160,000 Mcf from the oil and condensate fields in south Arkansas.

Gas Purchase Contract Data

Most of the dedicated gas is under contract for a term of 10 years and from year to year thereafter. The average price per Mcf of gas over the life of the contracts varies from 2.3 to 5.5 cents, depending upon the field under consideration. Data concerning the principal gas purchase contracts in effect are shown in Exhibit No. B-3.

Estimation of Natural Gas Reserves

Gas reserves of the fields in this State have been estimated by the volumetric and pressure-cumulative production decline methods. For each reservoir of major consequence, a structural map and an isopachous map of net productive thickness were used to obtain the net effective volume. Data concerning the physical characteristics of the reservoir and the gas were used to estimate the volume of gas reserves. Where possible, reservoir pressure-cumulative production decline curves were utilized. Recovery factors or abandonment pressures were estimated for each reservoir, depending on the primary type of energy mechanism in the expulsion of gas from the reservoir, the deliverability characteristics of the wells, and the size of the gas field.

The estimates are divided into categories of "proved drilled", "proved undrilled", and "probable" reserves and are calculated assuming standard conditions to be a pressure of 14.65 psi and a temperature of 60° F.

The following table is summarized from Exhibit No. B-2:

Classification of Estimated Recoverable Gas Reserves as of January 1, 1949 in Mcf

		Total	Undedicated and Available for Synthetic Liquid Fuels Manufacture
Ark	**Reserves**		
B11	Proved Drilled	997,335,000	33,000,000
10	Proved Undrilled	32,840,000	4,300,000
70021	Probable	27,540,000	0
	Total	1,057,715,000	37,300,000
	Type of Gas		
	Non-Associated	179,025,000	25,000,000
	Associated	541,750,000	9,300,000
	Dissolved	336,940,000	3,000,000
	Total	1,057,715,000	37,300,000

The principal remaining gas reserves are found in the McKamie-Patton, the Magnolia and the Dorcheat-Macedonia fields, in which the reserve is estimated to be 214,000,000 Mcf, 202,400,000 Mcf, and 184,000,000 Mcf, respectively. Other fields having substantial reserves are Village, Schuler, and Warnock Springs.

Undedicated Natural Gas Reserves

Although the remaining recoverable gas reserve in Arkansas is estimated to be 1,057,715,000 Mcf, most of this reserve is under contract to gas pipe line companies or plants for a 10-year period, and a year to year period thereafter. In the past, such contracts have generally been renewed at the end of the primary term.

In the McKamie-Patton field the remaining gas reserve is estimated to be 214,000,000 Mcf. The gas accumulation exists in a large gas cap partially encircled by a band of oil. In order to maintain the reservoir pressure and prevent retrograde condensation of the liquids in the gas cap, a program of gas injection is in operation. The gas reserves in this field will not be available for any purpose until the program of gas injection is completed. At that time most of the gas will be sold to gas pipe lines under contracts now existing.

The undedicated reserves amounted to only 37,300,000 Mcf in all of Arkansas as of January 1, 1949. These reserves existed either in small gas fields or in oil fields having minor reserves of solution gas.

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PART IV - CONCLUSIONS

Data relating to remaining available reserves of natural gas in Arkansas, which have an average heating value of 1,022 Btu under standard conditions, are briefly summarized in the following table:

Summary of Estimated Recoverable Natural Gas Reserves in Arkansas
(In Mcf under Standard Conditions)

As of Jan. 1, 1949		
Total		1,057,715,000
Commercial Requirements:		
Contract	907,025,000	
To Be Used in Field	113,390,000	
Total Commercial Requirements		1,020,415,000
Undedicated Reserves:		
Proved Drilled	33,000,000	
Proved Undrilled	4,300,000	
Probable	0	
Total Undedicated Reserves as of Jan. 1, 1949		37,300,000

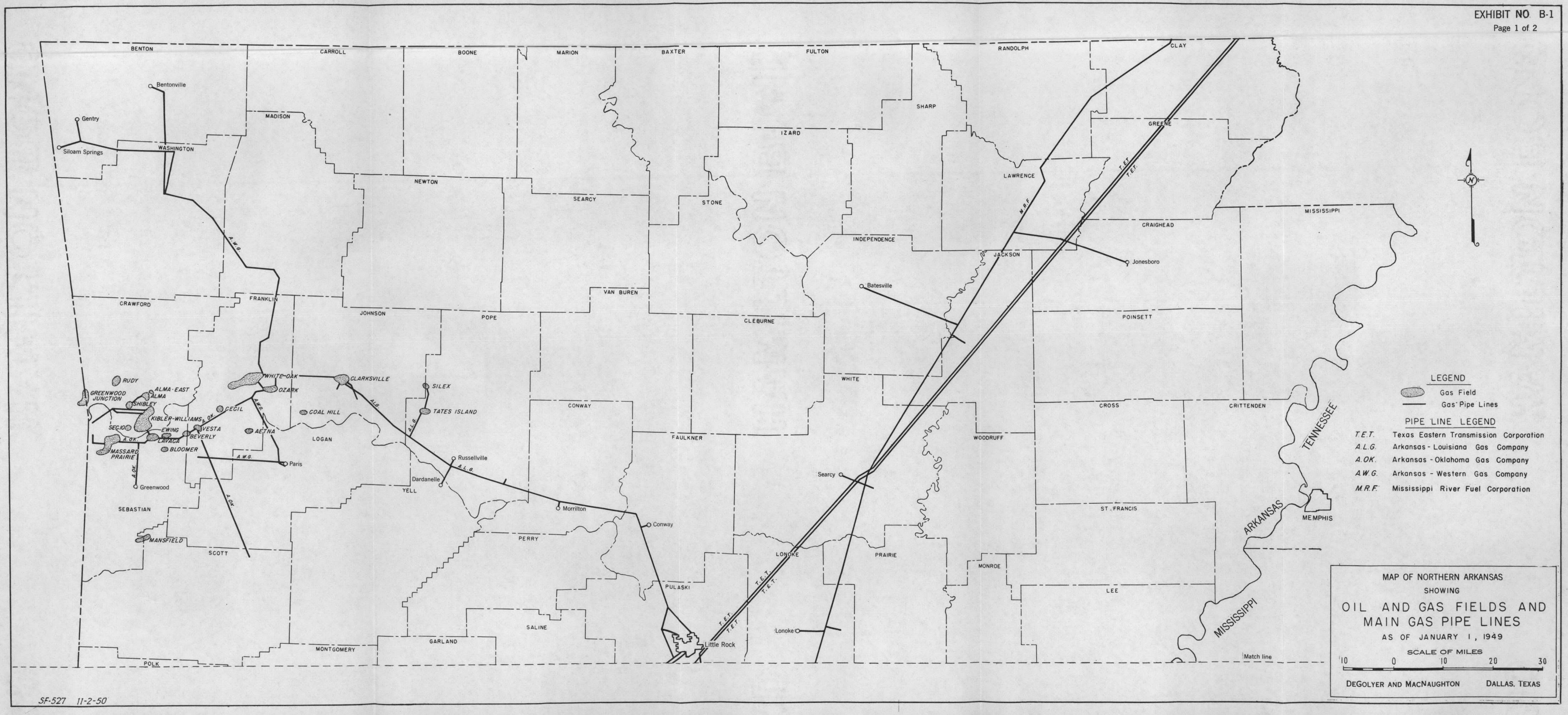
Most of the gas reserves are under contract to plants or gas pipe line companies for domestic, commercial, and industrial use. The weighted average field price for gas under contract ranged from 2.3 to 5.5 cents per Mcf, depending upon the field under consideration and the life of the contract.

The undedicated gas reserve amounted to only 37,300,000 Mcf, so that there were no available undedicated reserves in Arkansas as of January 1, 1949 containing at least 225 trillion Btu (225,000,000 Mcf of 1,000 Btu) gas producible within a radius of 40 miles and having a heating value of not less than 400 Btu per cubic foot at standard conditions.

Ark In the McKamie-Patton field, although the gas reserves are estimated to be 214,000,000 Mcf, they will not be available until
B13 the present gas injection program is completed. At that time, most
.10 of this reserve will be sold to gas pipe lines under existing con-
70021 tracts.

It is therefore concluded that there are no undedicated reserves of natural gas in Arkansas presently available for synthetic liquid fuel plants. Discoveries of new fields and extensions of known fields in the interim between January 1, 1949, and the date of this report warrant no changes in this conclusion.

EXHIBIT NO. B-1
Page 1 of 2



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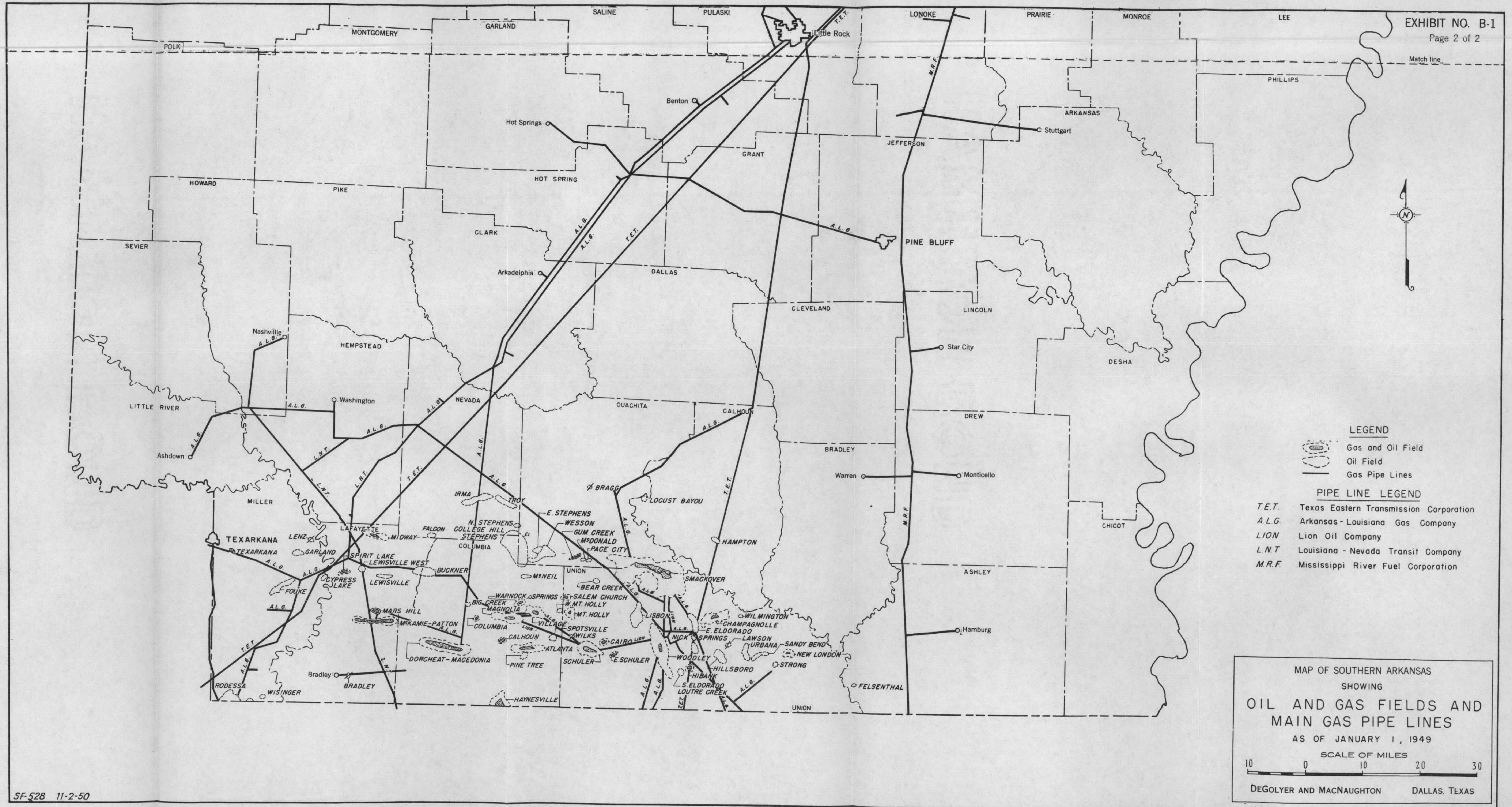
EXHIBIT NO. B-1
Page 2 of 2
Match line
SALINE
PULASKI
LONOKE
PRAIRIE
MONROE
LEE
PHILLIPS
POLK
MONTGOMERY
GARLAND
Little Rock
Benton
Hot Springs
HOT SPRING
GRANT
JEFFERSON
ARKANSAS
Stuttgart
HOWARD
PIKE
CLARK
SEVIER
Arkadelphia
DALLAS
PINE BLUFF
CLEVELAND
LINCOLN
Star City
DESHA
Nashville
HEMPSTEAD
Washington
NEVADA
OUACHITA
CALHOUN
LITTLE RIVER
Ashdown
BRADLEY
Warren
DREW
Monticello
MILLER
TEXARKANA
LAFAYETTE
COLUMBIA
UNION
HAMPTON
SMACKOVER
ASHLEY
CHICOT
Hamburg
FELSENTHAL
Bradley
UNION
LEGEND
Gas and Oil Field
Oil Field
Gas Pipe Lines
PIPE LINE LEGEND
T.E.T. Texas Eastern Transmission Corporation
A.L.G. Arkansas - Louisiana Gas Company
LION Lion Oil Company
L.N.T Louisiana - Nevada Transit Company
M.R.F. Mississippi River Fuel Corporation
MAP OF SOUTHERN ARKANSAS
SHOWING
OIL AND GAS FIELDS AND
MAIN GAS PIPE LINES
AS OF JANUARY 1, 1949
SCALE OF MILES
10 0 10 20 30
DEGOLYER AND MACNAUGHTON
DALLAS, TEXAS
SF-528 11-2-50

So. Ark.

Exhibit No. B-2

State of Arkansas
Data Concerning Natural Gas Reserves
As of
January 1, 1949

Location	Year of Discovery	Name of Producing Series or System	Depth of Production (feet)	Kind of Gas	Reservoir Pressure (Psia) Original	Reservoir Pressure (Psia) As of 1-1-49	Average Heating Value (Btu Per Cu ft)	Analysis of Gas (Percent) Methane	Ethane	Sulphur	Other	Number of Wells as of 1-1-49: Producing Gas	Producing Oil	Shut-In Gas	Shut-In Oil	Estimated Additional Required for Development Gas	Estimated Additional Required for Development Oil
Ashley County																	
Felsenthal Field	1948	Jurassic	5,870	Dissolved	2,850	-						0	0	0	1	0	2
Calhoun County																	
Hampton Field	1943	Gulf	2,480	Dissolved	1,205	-						0	8	0	0	0	2
Columbia County																	
Atlanta and West Field	1943	Jurassic	7,010	Dissolved	3,100	2,715						0	5	0	0	0	15
	1938	Jurassic	8,210	Dissolved	(3,835	2,590	1,006	98.16	0.92	0.0	0.92)	0	51	0	0	0	0
				Associated	(						)	0	0	2	0	0	0
Total Atlanta and West Field												0	56	2	0	0	15
Columbia County																	
Buckner Field	1946	Comanche	4,710	Dissolved	2,100	2,035						0	21	0	0	0	0
	1937	Jurassic	7,210	Dissolved	3,210	1,935	1,011	68.03	13.18	0.60	8.00	0	24	0	0	0	0
										Propane	10.19						
Total Buckner Field												0	45	0	0	0	0
Calhoun Field	1944	Jurassic	8,260	Dissolved	(3,465	2,920						0	3	0	1	0	0
				Associated	(							0	0	0	0	0	0
Total Calhoun Field												0	3	0	1	0	0
Columbia Field	1942	Jurassic	8,030	Non-Associated	3,765	3,765						0	0	2	0	1	0
Dorcheat-Macedonia Field	1942	Jurassic	6,760	Associated	(3,630	-						38	0	13	0	0	0
				Dissolved	(							0	25	0	10	0	0
	1939	Jurassic	8,830	Associated	(4,260	1,900	1,081	77.14	5.83	3.10	8.23	40	0	7	0	0	0
				Dissolved						Nitrogen	5.70	0	0	0	0	0	0
Total Dorcheat-Macedonia Field												78	25	20	10	0	0
Haynesville Field (A) (C)	1942	Comanche	5,400	Dissolved	2,360	705	1,102	87.13	3.57	0	9.30	0	34	0	0	0	0

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NOTE: (A) Gas Repressuring or Cycling Project in Operation
(B) Net Gas Production
(C) Water Flooding Project in Operation

State of Arkansas
Data Concerning Natural Gas Reserves
As of
January 1, 1949

	Gas Production Statistics in Thousand Cubic Feet				Estimated Remaining Recoverable Gas Reserves In Million Cubic Feet as of 1-1-49						Estimated Remaining Recoverable Gas Reserves Available in Million Cubic Feet As of 1-1-49			
	Average Daily Rate, 1948	Estimated Daily Allowable Productive Capacity Of Shut-In Wells	Estimated Total Open Flow Capacities Of all Wells In Field	Estimated Daily Gas Production Available For a Synthetic Fuel Plant, 1-1-49	Proved Drilled	Proved Undrilled	Probable	Total	Under Contract	To be Used In Field	Drilled	Undrilled	Probable	Total
	0	0	0	0	50	0	40	90	0	90	0	0	0	0
	16	0	100	0	50	10	0	60	0	60	0	0	0	0
	54	0	150	0	110	330	0	440	0	440	0	0	0	0
	6,377	0	6,400	0	19,200	0	0	19,200	19,000	200	0	0	0	0
	0	0	0	0	13,000	0	0	13,000	10,000	3,000	0	0	0	0
	6,431	0	6,550	0	32,310	330	0	32,640	29,000	3,640	0	0	0	0
	62	0	110	45	1,500	0	0	1,500	0	500	1,000	0	0	1,000
	348	0	610	270	2,600	0	0	2,600	0	600	2,000	0	0	2,000
	410	0	720	315	4,100	0	0	4,100	0	1,100	3,000	0	0	3,000
	961	80	1,040	0	2,600	0	0	2,600	2,100	500	0	0	0	0
	0	0	0	0	2,500	0	0	2,500	2,000	500	0	0	0	0
	961	80	1,040	0	5,100	0	0	5,100	4,100	1,000	0	0	0	0
	0	7,000	28,000	0	11,100	0	5,500	16,600	16,100	500	0	0	0	0
	(22,496	13,000	64,000	0)	28,000	0	0	28,000	27,000	1,000	0	0	0	0
	(			)	18,000	0	0	18,000	17,500	500	0	0	0	0
	(41,286	18,000	400,000	0)	110,000	0	0	110,000	108,000	2,000	0	0	0	0
Ark	(			)	28,000	0	0	28,000	27,000	1,000	0	0	0	0
	63,782	31,000	464,000	0	184,000	0	0	184,000	179,500	4,500	0	0	0	0
	1,644	0	1,700	0	5,500	0	0	5,500	5,000	500	0	0	0	0

State of Arkansas
Data Concerning Natural Gas Reserves
As of
January 1, 1949

Location	Year of Discovery	Name of Producing Series or System	Depth of Production (feet)	Kind of Gas	Reservoir Pressure (Psia) Original	Reservoir Pressure (Psia) As of 1-1-49	Average Heating Value (Btu Per Cu ft)	Analysis of Gas (Percent) Methane	Ethane	Sulphur	Other	Number of Wells as of 1-1-49 Producing Gas	Producing Oil	Shut-In Gas	Shut-In Oil	Estimated Additional Required for Development Gas	Estimated Additional Required for Development Oil
Columbia County (Cont'd)																	
Magnolia Field (C)	1943	Comanche	5,660	Dissolved	2,765	2,475						0	6	0	0	0	6
	1938	Jurassic	7,350	Associated	(3,480	2,795	1,059	65.12	13.57	0.89	16.20)	0	0	0	0	0	0
				Dissolved	(					CO_2	4.22)	0	106	0	0	0	0
Total Magnolia Field												0	112	0	0	0	6
Village Field	1946	Commanche	4,150	Associated	(1,815	1,165	1,074	44.50	34.80	0	1.10)	4	0	0	0	4	0
										CO_2	3.60)						
				Dissolved	(					Nitrogen	16.00)	0	36	0	3	0	0
	1946	Jurassic	5,430	Dissolved								0	9	0	0	0	3
	1938	Jurassic	7,320	Associated	(3,365	2,840	1,352	84.71	6.13	0.56	4.96)	0	0	0	0	0	0
				Dissolved	(					CO_2	3.64)	0	43	0	1	0	8
Total Village Field												4	88	0	4	4	11
Warnock Springs Field	1946	Jurassic	7,400	Non-Associated	2,915	2,880	1,075	77.00	5.75	0.15	9.90)	5	0	0	0	5	0
										Nitrogen	7.20)						
Crawford County																	
Alma Field (Shallow)	1916	Pennsylvanian	2,070	Non-Associated	345	80						4	0	0	0	0	0
(Deep)	1922	Pennsylvanian	2,600	Non-Associated	440	45						3	0	0	0	0	0
(East)	1924	Pennsylvanian	2,400	Non-Associated	395	50						2	0	0	0	0	0
Total Alma Field												9	0	0	0	0	0
Greenwood Junction Field	1927	Pennsylvanian	2,300	Non-Associated	210	30						4	0	0	0	0	0
Kibler Field (Shallow)	1915	Pennsylvanian	1,260	Non-Associated	235	60						1	0	0	0	0	0
(Deep)	1915	Pennsylvanian	2,290	Non-Associated	280	60						11	0	0	0	0	0
Total Kibler Field												12	0	0	0	0	0
Section 10 Field	1920	Pennsylvanian	2,440	Non-Associated	280	100						4	0	0	0	0	0
Shibley Field (Shallow)	1926	Pennsylvanian	1,250	Non-Associated	235	30						0	0	4	0	0	0
(Deep)	1927	Pennsylvanian	2,630	Non-Associated	210	115						2	0	0	0	0	0
Total Shibley Field												2	0	4	0	0	0

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NOTE: (A) Gas Repressuring or Cycling Project in Operation
(B) Net Gas Production
(C) Water Flooding Project in Operation

State of Arkansas
Data Concerning Natural Gas Reserves
As of
January 1, 1949

	Gas Production Statistics in Thousand Cubic Feet				Estimated Remaining Recoverable Gas Reserves In Million Cubic Feet as of 1-1-49						Estimated Remaining Recoverable Gas Reserves Available in Million Cubic Feet As of 1-1-49			
	Average Daily Rate, 1948	Estimated Daily Allowable Productive Capacity Of Shut-In Wells	Estimated Total Open Flow Capacities Of all Wells In Field	Estimated Daily Gas Production Available For a Synthetic Fuel Plant, 1-1-49	Proved Drilled	Proved Undrilled	Probable	Total	Under Contract	To be Used In Field	Proved Drilled	Proved Undrilled	Probable	Total
	622	0	2,000	0	1,600	1,800	0	3,400	3,000	400	0	0	0	0
	(13,390	0	14,000	0)	71,000	0	0	71,000	70,000	1,000	0	0	0	0
	(			)	128,000	0	0	128,000	126,000	2,000	0	0	0	0
	14,012	0	16,000	0	200,600	1,800	0	202,400	199,000	3,400	0	0	0	0
	(3,330	300	3,700	0)	5,600	5,800	0	11,400	11,000	400	0	0	0	0
	(			)										
	(			)	8,000	0	0	8,000	7,500	500	0	0	0	0
	510	0	600	0	2,200	900	0	3,100	3,000	100	0	0	0	0
	(6,490	150	6,700	0)	31,000	10,000	0	41,000	40,000	1,000	0	0	0	0
	(			)	13,000	3,200	0	16,200	16,000	200	0	0	0	0
	10,330	450	11,000	0	59,800	19,900	0	79,700	77,500	2,200	0	0	0	0
	1,696	0	20,000	0	20,000	0	22,000	42,000	41,000	1,000	0	0	0	0
	47	0	200	0	400	0	0	400	400	0	0	0	0	0
	44	0	200	0	100	0	0	100	100	0	0	0	0	0
	14	0	120	0	30	0	0	30	30	0	0	0	0	0
	105	0	520	0	530	0	0	530	530	0	0	0	0	0
	5	0	20	0	20	0	0	20	20	0	0	0	0	0
	16	0	80	0	120	0	0	120	120	0	0	0	0	0
	216	0	1,300	0	1,200	0	0	1,200	1,200	0	0	0	0	0
	232	0	1,380	0	1,320	0	0	1,320	1,320	0	0	0	0	0
Ark	189	0	1,000	0	900	0	0	900	900	0	0	0	0	0
	0	80	300	0	10	0	0	10	10	0	0	0	0	0
	167	0	800	0	1,000	0	0	1,000	1,000	0	0	0	0	0
	167	80	1,100	0	1,010	0	0	1,010	1,010	0	0	0	0	0

State of Arkansas
Data Concerning Natural Gas Reserves
As of
January 1, 1949

Location	Year of Discovery	Name of Producing Series or System	Depth of Production (feet)	Kind of Gas	Reservoir Pressure (Psia) Original	Reservoir Pressure (Psia) As of 1-1-49	Average Heating Value (Btu Per Cu ft)	Analysis of Gas (Percent) Methane	Ethane	Sulphur	Other	Number of Wells as of 1-1-49 Producing Gas	Producing Oil	Shut-In Gas	Shut-In Oil	Estimated Additional Required for Development Gas	Estimated Additional Required for Development Oil
Crawford County (Cont'd)																	
Williams Field (Shallow)	1916	Pennsylvanian	1,310	Non-Associated	350	70						5	0	0	0	0	0
(Deep)	1918	Pennsylvanian	2,150	Non-Associated	300	60						21	0	0	0	0	0
Total Williams Field												26	0	0	0	0	0
Franklin County																	
Aetna Field	1928	Pennsylvanian	1,680	Non-Associated	655	140						1	0	0	0	0	0
Beverly Field	1937	Pennsylvanian	2,590	Non-Associated	455	310						4	0	0	0	0	0
Ozark Field (Shallow)	1938	Pennsylvanian	1,820	Non-Associated	685	125						1	0	0	0	0	0
(Anderson)	1937	Pennsylvanian	2,170	Non-Associated	655	120						2	0	0	0	0	0
(Deep)	1930	Pennsylvanian	3,760	Non-Associated	890	245						5	0	0	0	0	0
Total Ozark Field												8	0	0	0	0	0
Vesta Field	1932	Pennsylvanian	2,270	Non-Associated	540	210						9	0	0	0	0	0
White Oak Field	1943	Pennsylvanian	3,000	Non-Associated	1,010	900						20	0	0	0	0	0
Johnson County																	
Clarksville Field	1926	Pennsylvanian	2,450	Non-Associated	995	395	1,007	98.70	0.40	0	0.90	8	0	0	0	0	0
Lafayette County																	
Mars Hill Field	1947	Jurassic	9,030	Associated	2,365	2,100						2	0	0	0	2	0
McKamie-Patton Field (A)	1940	Jurassic	9,100	Associated	(4,380	3,595	1,006	63.00	7.24	6.70	6.86)	21	0	0	0	0	0
				Dissolved	(						CO_2 4.30)	0	10	0	0	0	0
											Nitrogen 11.90)						
Total McKamie-Patton Field												21	10	0	0	0	0
Midway Field (C)	1942	Jurassic	6,340	Dissolved	2,935	2,720	666	39.61	7.90	0	15.96)	0	45	0	0	0	0
											Nitrogen 36.53						
Spirit Lake Field	1947	Comanche	3,730	Dissolved	1,660	840						0	11	0	0	0	5
	1946	Comanche	4,100	Dissolved	1,800	1,350						0	9	0	0	0	0
Total Spirit Lake Field												0	20	0	0	0	5

NOTE: (A) Gas Repressuring or Cycling Project in Operation
(B) Net Gas Production
(C) Water Flooding Project in Operation

Ark

State of Arkansas
Data Concerning Natural Gas Reserves
As of
January 1, 1949

	Gas Production Statistics in Thousand Cubic Feet				Estimated Remaining Recoverable Gas Reserves In Million Cubic Feet as of 1-1-49						Estimated Remaining Recoverable Gas Reserves Available in Million Cubic Feet As of 1-1-49			
	Average Daily Rate, 1948	Estimated Daily Allowable Productive Capacity Of Shut-In Wells	Estimated Total Open Flow Capacities Of all Wells In Field	Estimated Daily Gas Production Available For a Synthetic Fuel Plant, 1-1-49	Proved Drilled	Proved Undrilled	Probable	Total	Under Contract	To be Used In Field	Proved Drilled	Proved Undrilled	Probable	Total
	214	0	1,500	0	900	0	0	900	900	0	0	0	0	0
	466	0	2,600	0	2,700	0	0	2,700	2,700	0	0	0	0	0
	680	0	4,100	0	3,600	0	0	3,600	3,600	0	0	0	0	0
	1	0	10	0	15	0	0	15	15	0	0	0	0	0
	219	0	1,200	0	2,900	0	0	2,900	2,900	0	0	0	0	0
	22	0	1,400	0	100	0	0	100	100	0	0	0	0	0
	25	0	120	0	230	0	0	230	230	0	0	0	0	0
	367	0	1,700	0	700	0	0	700	700	0	0	0	0	0
	414	0	3,220	0	1,030	0	0	1,030	1,030	0	0	0	0	0
	277	0	1,240	0	1,300	0	0	1,300	1,300	0	0	0	0	0
	7,720	0	35,000	0	53,000	0	0	53,000	53,000	0	0	0	0	0
	4,170	0	23,000	0	15,000	0	0	15,000	15,000	0	0	0	0	0
	952	0	1,000	0	6,000	4,300	0	10,300	0	1,000	5,000	4,300	0	9,300
	(27,120	100,000	450,000	0)	204,000	0	0	204,000	164,000	40,000	0	0	0	0
	(			)	10,000	0	0	10,000	9,000	1,000	0	0	0	0
	27,120	100,000	450,000	0	214,000	0	0	214,000	173,000	41,000	0	0	0	0
Ark	7,800	0	8,000	0	30,000	0	0	30,000	28,000	2,000	0	0	0	0
	391	0	400	0	800	200	0	1,000	0	1,000	0	0	0	0
	625	0	700	0	1,200	0	0	1,200	0	1,200	0	0	0	0
	1,016	0	1,100	0	2,000	200	0	2,200	0	2,200	0	0	0	0

State of Arkansas
Data Concerning Natural Gas Reserves
As of
January 1, 1949

Location	Year of Discovery	Name of Producing Series or System	Depth of Production (feet)	Kind of Gas	Reservoir Pressure (Psia) Original	Reservoir Pressure (Psia) As of 1-1-49	Average Heating Value (Btu Per Cu ft)	Analysis of Gas (Percent) Methane	Ethane	Sulphur	Other	Number of Wells as of 1-1-49 Producing Gas	Producing Oil	Shut-In Gas	Shut-In Oil	Estimated Additional Required for Development Gas	Estimated Additional Required for Development Oil
Miller County																	
Cypress Lake Field	1947	Comanche	3,970	Dissolved	1,785	1,485						0	11	0	0	0	5
Fouke Field	1940	Comanche	3,700	Dissolved	1,500	365						0	53	0	0	0	0
Rodessa Field	1943	Comanche	5,860	Associated	1,815	1,435						3	0	0	0	0	0
	1937	Comanche	6,050	Dissolved	2,800	210	1,004	93.40	3.85	0	2.75	0	52	0	0	0	0
Total Rodessa Field												3	52	0	0	0	0
Texarkana Field	1942	Jurassic	7,350	Non-Associated	3,411	2,915	590	38.00	4.82	0	6.95) Nitrogen 50.23)	2	0	0	0	0	0
Ouachita County																	
Gum Creek Field	1941	Gulf	2,260	Non-Associated	1,050	900						1	0	0	0	2	0
Pace City Field	1946	Comanche	2,780	Dissolved	1,140	735						0	16	0	0	0	0
Wesson Field	1945	Gulf and Comanche	2,340	Dissolved	1,225	1,180	420					0	65	0	0	0	10
(C)	1946	Comanche	3,100	Dissolved	1,475	1,295	385					0	71	0	0	0	0
Total Wesson Field												0	136	0	0	0	10
Pope County																	
Silex Field	1942	Pennsylvanian	2,550	Non-Associated	950	475	987	95.00	1.40	0	3.60	1	0	0	0	0	0
Tates Island Field	1929	Pennsylvanian	1,030	Non-Associated	555	255	1,026	95.60	3.20	0	1.20	3	0	0	0	0	0
Sebastian County																	
Bloomer Field	1945	Pennsylvanian	2,730	Non-Associated	265	240						1	0	0	0	0	0
Ewing Field	1936	Pennsylvanian	2,850	Non-Associated	275	245						4	0	0	0	0	0
Lavaca Field	1921	Pennsylvanian	1,120	Non-Associated	285	195	998	98.50	0	0	1.50	2	0	0	0	0	0
Mansfield Field	1902	Pennsylvanian	2,200	Non-Associated	330	190						13	0	0	0	0	0
Massard Prairie Field	1904	Pennsylvanian	2,260	Non-Associated	300	23						49	0	0	0	0	0

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NOTE: (A) Gas Repressuring or Cycling Project in Operation
(B) Net Gas Production
(C) Water Flooding Project in Operation

State of Arkansas
Data Concerning Natural Gas Reserves
As of
January 1, 1949

	Gas Production Statistics in Thousand Cubic Feet				Estimated Remaining Recoverable Gas Reserves In Million Cubic Feet as of 1-1-49						Estimated Remaining Recoverable Gas Reserves Available in Million Cubic Feet As of 1-1-49			
	Average Daily Rate, 1948	Estimated Daily Allowable Productive Capacity Of Shut-In Wells	Estimated Total Open Flow Capacities Of all Wells In Field	Estimated Daily Gas Production Available For a Synthetic Fuel Plant, 1-1-49	Proved Drilled	Proved Undrilled	Probable	Total	Under Contract	To be Used In Field	Proved Drilled	Proved Undrilled	Probable	Total
	139	0	150	0	500	200	0	700	0	700	0	0	0	0
	644	0	700	0	4,400	0	0	4,400	0	4,400	0	0	0	0
	2,920	0	20,000	0	2,500	0	0	2,500	2,300	200	0	0	0	0
	3,620	0	3,700	0	3,100	0	0	3,100	2,100	1,000	0	0	0	0
	6,540	0	23,700	0	5,600	0	0	5,600	4,400	1,200	0	0	0	0
	2,680	0	40,000	10,000	26,000	0	0	26,000	0	1,000	25,000	0	0	25,000
	948	0	10,000	0	1,000	2,200	0	3,200	3,200	0	0	0	0	0
	100	0	100	0	300	0	0	300	0	300	0	0	0	0
	1,178	0	1,760	0	4,000	800	0	4,800	0	4,800	0	0	0	0
	551	0	1,000	0	4,100	0	0	4,100	0	4,100	0	0	0	0
	1,729	0	2,760	0	8,100	800	0	8,900	0	8,900	0	0	0	0
	263	0	1,000	0	1,300	0	0	1,300	1,300	0	0	0	0	0
	211	0	800	0	3,700	0	0	3,700	3,700	0	0	0	0	0
	25	0	300	0	150	0	0	150	150	0	0	0	0	0
	126	0	1,000	0	3,000	0	0	3,000	3,000	0	0	0	0	0
Ark	1,001	0	4,000	0	700	0	0	700	700	0	0	0	0	0
	107	0	1,000	0	650	0	0	650	650	0	0	0	0	0
	598	0	1,000	0	1,100	0	0	1,100	1,100	0	0	0	0	0

State of Arkansas
Data Concerning Natural Gas Reserves
As of
January 1, 1949

Location	Year of Discovery	Name of Producing Series or System	Depth of Production (feet)	Kind of Gas	Reservoir Pressure (Psia) Original	Reservoir Pressure (Psia) As of 1-1-49	Average Heating Value (Btu Per Cu ft)	Analysis of Gas (Percent) Methane	Ethane	Sulphur	Other	Number of Wells as of 1-1-49: Producing Gas	Producing Oil	Shut-In Gas	Shut-In Oil	Estimated Additional Required for Development Gas	Estimated Additional Required for Development Oil
Union County																	
Bear Creek Field	1948	Jurassic	6,330	Dissolved	2,765	2,740						0	5	0	0	0	5
Cairo Field	1948	Jurassic	7,200	Dissolved	3,290	3,235						0	7	0	0	0	7
Champagnolle Field	1927	Gulf	2,690	Dissolved	1,215	100						0	79	0	0	0	0
El Dorado, South Field	1920	Gulf	2,100	Dissolved	1,170	645	1,091	87.35	11.50	0	1.15	0	138	0	0	0	0
Highbank Field	1942	Gulf	2,075	Dissolved	1,430	500						0	6	0	0	0	0
Mt. Holly Field	1941	Jurassic	7,140	Associated	(3,194	1,900						0	0	0	0	0	0
				Dissolved	(							0	11	0	0	0	0
Total Mt. Holly Field												0	11	0	0	0	0
New London Field	1942	Jurassic	5,320	Dissolved	2,235	1,640						0	16	0	0	0	0
Salem Church Field	1944	Jurassic	6,940	Associated	3,150	2,815	818	54.62	6.25	0.13	8.86)	4	0	0	0	0	0
										Nitrogen	30.14)						
Schuler, 6900' Field	1937	Jurassic	6,900	Dissolved	2,265	1,980						0	25	0	0	0	0
Schuler, 7530' (Jones) (A) (C)	1937	Jurassic	7,530	Associated	(3,535	1,645	1,078	79.08	8.71	0	6.88)	0	0	5	0	0	0
				Dissolved						Nitrogen	5.33)	0	111	0	9	0	0
Schuler, 7600'	1937	Jurassic	7,600	Associated	(3,565	2,980	1,028	61.30	22.70	0	0.40)	0	0	0	0	0	0
				Dissolved	(					CO_2	4.10)	0	11	0	0	0	0
Schuler, East	1941	Jurassic	5,580	Dissolved	2,523	2,100				Nitrogen	11.50)	0	4	0	0	0	0
Total Schuler Field												0	151	5	9	0	0
Smackover Field	1922	Gulf	2,260	Dissolved								0	1,502	0	0	0	0
TOTALS												300	2,629(D)	33	25	14	68
							Non-Associated Gas					188	0	6	0	8	0
							Associated Gas					112	0	27	0	6	0
							Dissolved Gas					0	2,629	0	25	0	68

NOTE:
(A) Gas Repressuring or Cycling Project in Operation
(B) Net Gas Production
(C) Water Flooding Project in Operation
(D) This figure does not include 820 producing oil wells in latter stages of depletion.

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State of Arkansas
Data Concerning Natural Gas Reserves
As of
January 1, 1949

Gas Production Statistics in Thousand Cubic Feet				Estimated Remaining Recoverable Gas Reserves In Million Cubic Feet as of 1-1-49						Estimated Remaining Recoverable Gas Reserves Available in Million Cubic Feet As of 1-1-49			
Average Daily Rate, 1948	Estimated Daily Allowable Productive Capacity Of Shut-In Wells	Estimated Total Open Flow Capacities Of all Wells In Field	Estimated Daily Gas Production Available For a Synthetic Fuel Plant, 1-1-49	Proved Drilled	Proved Undrilled	Probable	Total	Under Contract	To be Used In Field	Proved Drilled	Proved Undrilled	Probable	Total
11	0	20	0	200	200	0	400	0	400	0	0	0	0
333	0	1,600	0	2,800	2,900	0	5,700	4,500	1,200	0	0	0	0
580	0	600	0	1,400	0	0	1,400	1,200	200	0	0	0	0
627	0	700	0	1,400	0	0	1,400	1,300	100	0	0	0	0
159	0	200	0	350	0	0	350	300	50	0	0	0	0
795	0	1,000	0)	1,450	0	0	1,450	0	1,450	0	0	0	0
			)	5,000	0	0	5,000	0	5,000	0	0	0	0
795	0	1,000	0	6,450	0	0	6,450	0	6,450	0	0	0	0
325	0	350	0	1,400	0	0	1,400	0	1,400	0	0	0	0
1,968	0	80,000	0	18,000	0	0	18,000	17,000	1,000	0	0	0	0
252	0	500	0	3,200	0	0	3,200	2,000	1,200	0	0	0	0
41 (B)	0	120,000	0)	26,000	0	0	26,000	11,000	15,000	0	0	0	0
			)	13,000	0	0	13,000	8,000	5,000	0	0	0	0
3,805	0	4,100	0)	2,600	0	0	2,600	2,500	100	0	0	0	0
			)	4,000	0	0	4,000	3,800	200	0	0	0	0
102	0	100	0	300	0	0	300	0	300	0	0	0	0
4,200	0	124,700	0	49,100	0	0	49,100	27,300	21,800	0	0	0	0
1,781	0	1,800	0	4,500	0	0	4,500	4,400	100	0	0	0	0
176,239	138,610	1,378,480	10,315	997,335	32,840	27,540	1,057,715	907,025	113,390	33,000	4,300	0	37,300
21,834	7,080	178,890	10,000	149,325	2,200	27,500	179,025	151,525	2,500	25,000	0	0	25,000
124,593	131,450	1,164,500	0	521,650	20,100	0	541,750	464,800	67,650	5,000	4,300	0	9,300
29,812	80	35,090	315	326,360	10,540	40	336,940	290,700	43,240	3,000	0	0	3,000

Exhibit No. B-3

Gas Purchase Contract Data

Location	Name of Gas Purchaser	Weighted Average Term of Contracts (Years)	Weighted Average Price per Mcf during Contract Period(A)
Northwest Arkansas			
Dry Gas Fields	Arkansas-Oklahoma Gas Co. Arkansas-Western Natural Gas Arkansas-Louisiana Gas Co.	(B)	$0.045
Columbia County			
Atlanta Field	Arkansas-Louisiana Gas Co.	10	0.025
Haynesville Field	Arkansas-Louisiana Gas Co.	10	0.050
Magnolia Field	Lion Oil Refining Co.	10	0.055
Salem Church Field	Arkansas-Louisiana Gas Co.	10	0.036
Warnock Springs Field	Arkansas-Louisiana Gas Co.	10	0.036
Dorcheat-Macedonia Field	Arkansas-Louisiana Gas Co.	10	0.023 (Sour) 0.050 (Sweet)
Village Field	Arkansas-Louisiana Gas Co.	10	0.036
Lafayette County			
McKemie-Patton Field	Arkansas-Louisiana Gas Co. Arkansas Power & Light Co.	(C)	(C)
Miller County			
Rodessa Field	Arkansas-Louisiana Gas Co.	10	0.036
Union County			
Schuler Field	Lion Oil Refining Co. Arkansas-Louisiana Gas Co.	(D)	(D)

Note:
(A) Price calculated per Mcf at 14.65 psi and 60° F.
(B) Varies from year to year, to life of field.
(C) Gas purchase contracts will be in effect after recycling is completed.
(D) Gas purchase contracts will be in effect after repressuring is completed.

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1. Arkansas Oil and Gas Commission, "Factual Data No. 55," Engineers Report of Oil and Gas Reservoir under State Control, 1949, Annual Report.

2. Branner, G.C., "List of Arkansas Oil and Gas Wells," Information Circular No. 10, Arkansas Geological Society, Little Rock, Arkansas, 1937.

3. Croneis, Corey, "Natural Gas in Interior Highlands of Arkansas," Geology of Natural Gas, A Symposium, American Association of Petroleum Geologists, Tulsa, Oklahoma, 1935. pp. 533-574.

4. Fancher, G. H. and Mackay, D.K., Secondary Recovery of Petroleum in Arkansas - A Survey, Arkansas Oil and Gas Commission, 1946.

5. Mackay, D. K. and Danforth, L. F., "Oil and Gas Development in Arkansas in 1948," Statistics of Oil and Gas Development and Production, Covering 1948, Petroleum Branch, Am. Inst. Min. Eng., Dallas, Texas, 1949. pp. 1-30.

6. Spooner, W.C., "Oil and Gas Geology of the Gulf Coastal Plain in Arkansas," Bulletin No. 2, Arkansas Geological Society, Parke-Harper Printing Co., Little Rock, Arkansas, 1935.

7. Certain public records of the Federal Power Commission, Washington, D.C.

Acknowledgments for Technical Information

1. Bailey, O.C., Chairman, Arkansas Oil and Gas Commission, El Dorado, Arkansas.
2. Benton, Jessie Ruth, Arkansas Oil and Gas Commission, El Dorado, Arkansas.
3. Fletcher, W.C., Executive Director, Arkansas Resources and Development Commission, Little Rock, Arkansas.
4. Howell, John E., Lion Oil Refining Company, El Dorado, Arkansas.
5. Murphy, Eunice, Arkansas Oil and Gas Commission, El Dorado, Arkansas.
6. Sanders, J.W., Chief Engineer, Arkansas Oil and Gas Commission, El Dorado, Arkansas.
7. Steele, Eugene E., Lion Oil Refining Company, El Dorado, Arkansas.

APPENDIX C

REPORT BY MAX W. BALL
ON
OIL-IMPREGNATED
STRIPPABLE DEPOSITS IN ARKANSAS
AS OF MAY 22, 1950

APPENDIX C

REPORT BY MAX W. BALL
ON
OIL-IMPREGNATED
SPRIPPABLE DEPOSITS IN ARKANSAS
AS OF MAY 22, 1950

SUMMARY

Surface or near-surface oil-impregnated deposits outcrop in southwestern Arkansas in Pike and Sevier Counties, and in western Arkansas in Scott County.

The available information reveals no 10-million-ton deposit in any 5-square-mile area, in vertically continuous beds 15 feet thick, yielding 10 gallons of oil per ton of raw material, and overlain by less than its own thickness of overburden.

It is therefore concluded that there are no oil-impregnated strippable deposits in Arkansas available for synthetic liquid fuels manufacture

PART I - INTRODUCTION

Authorization

This report on oil-impregnated strippable deposits in Arkansas is part of a study of such deposits in the United States made under a contract dated June 1, 1949, between Ford, Bacon & Davis, Inc., and Max W. Ball. The contract, duly approved for the Government by a Contracting Officer, is identified as Subcontract No. 5 of the principal Contract No. W 49-129 eng-137, dated May 3, 1949, between the United States of America and Ford, Bacon & Davis, Inc.

Purpose and Scope of Survey

The purpose of the study is to present an inventory of raw materials that meet certain minimum standards as to quantity, quality, and occurrence as herein defined.

The investigation has been confined to a review of available data and to a general determination therefrom of the nature and extent of deposits. No field investigation has been made of the oil-impregnated strippable deposits.

The report is confined to the nature and extent of the raw materials and no consideration is given to processing facilities.

PART II - GENERAL

Definitions

Oil-impregnated Strippable Deposits are deposits of sedimentary rocks impregnated, or intimately intermixed, with mineral oils, asphalts, or other liquid or solid hydrocarbons that are soluble in organic solvents. Such rocks are commonly known as oil sands, tar sands, bituminous sands, or rock asphalt. As used herein, the term also includes deposits of pure hydrocarbons, such as gilsonite occurring in sedimentary rocks.

Minimum Requirements - Oil-impregnated strippable deposits are not considered reserves for the purpose of this report unless they contain at least 10,000,000 tons in an area of not more than 5 square miles, occur in vertically continuous series of beds not less than 15 feet thick amenable to opencut mining by removing a cover not more than the thickness of the beds, and with an oil content of at least 10 gallons per ton.

Classification of Reserves According to Oil Content

Primary Reserves - Deposits meeting minimum requirements as stated above and with an average yield of not less than 25 gallons per ton.

Secondary Reserves - Deposits in addition to Primary Reserves meeting minimum requirements as stated above and with an average yield of not less than 15 gallons per ton.

Tertiary Reserves - Deposits in addition to Primary and Secondary Reserves meeting minimum requirements as stated above and with an average yield of not less than 10 gallons per ton.

Sources of Information

All known publications on oil-impregnated strippable deposits in Arkansas have been consulted, particularly the publications of Federal and State agencies. Exhibit No. C-1 shows approximate location of the deposits and Exhibit No. C-2 summarizes their descriptions. The most useful references are listed in Exhibit No. C-3.

Information has also been obtained personally from a number if Federal and State officials and men engaged in private industry, whose cooperation is gratefully acknowledged. The names and affiliations of these individuals are given in Exhibit No. C-4.

PART III - DESCRIPTION OF DEPOSITS

General Occurrence

Deposits of asphaltic sands, sandstones, and sandy limestones are known in southwestern Arkansas in Pike and Sevier Counties (Exhibit No. C-1). Here, asphalt impregnates nearly horizontal beds in the northern edge of the Lower Cretaceous Trinity formation. A deposit of asphaltic sandstone is also known in the Jackfork sandstone of Mississippian age in southwestern Scott County, at the northern base of Fourche Mountain. The quantity of asphalt in each of these deposits is probably small.

In Pike and Sevier Counties deposits, the layers of asphalt range from feather edges of several inches to 12 feet in thickness, the Pike County beds being generally thicker than those of Sevier County. The other asphaltic exposures are not thick enough or situated so as to be mined.

Location numbers here given in the text refer to corresponding numbers on Exhibit No. C-1.

Pike County

The principal Pike County deposits lie in the southern part of the county near Pike, Delight, and Murfreesboro. The largest is near Pike and is the only one in the State that has been mined commercially.

Pike Deposit. The Pike deposit (Location 1) is located 2-1/2 miles southeast of Pike City, on the west side of the Pike-Delight Highway, on a branch of Wolf Creek, in T. 7 S., R. 24 W. It lies in a depression between two hills. Only the lower part of the Trinity is exposed. The formation consists chiefly of coarse sand, in some places quite calcareous, with interbedded clay. Beds from 8 inches to 4 feet thick are more or less thoroughly saturated with asphalt. The character of the sandstone varies considerably, as does the asphalt content, which by weight ranges from 4.58 percent to 16.53 percent and averages around 6 percent.

Delight Deposit. The Delight deposit (Location 2) is exposed in a hollow in T. 8 S., R. 24 W., approximately 4 miles northwest of Delight. The asphalt bed is 3 to 5 feet thick and shows thin seams of liquid oozing from within. The bitumen content is high, approximating 17 percent by weight. The overburden is 30 to 35 feet thick.

Murfreesboro Deposit. A viscous asphaltic deposit is exposed at the water's edge of Prairie Creek in T. 8 S., R. 25 W., approximately 1 mile northeast of Murfreesboro (Location 3). The thickness and extent are not known. The nature of the neighboring deposits and the lack of commercial interest shown in this particular area indicate that the deposit is small.

Sevier County

Small scattered deposits exist in Sevier County between DeQueen and Dierks, near Lebanon (Location 4). These deposits are reported to be a few inches to a foot or so thick and small in areal extent.

Scott County

No more information is available about the Scott County occurrence than is given above. The deposit is probably of negligible importance.

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PART IV - CONCLUSION

Although the various known deposits contain oil-impregnated material, and although some of them might conceivably be mined at a profit if the price of oil was high enough in relation to operating costs, none of them is an oil-impregnated strippable deposit as defined above.

It is therefore concluded that there are no oil-impregnated strippable deposits in Arkansas available for synthetic liquid fuels manufacture.

EXHIBIT NO. C-1

ARKANSAS

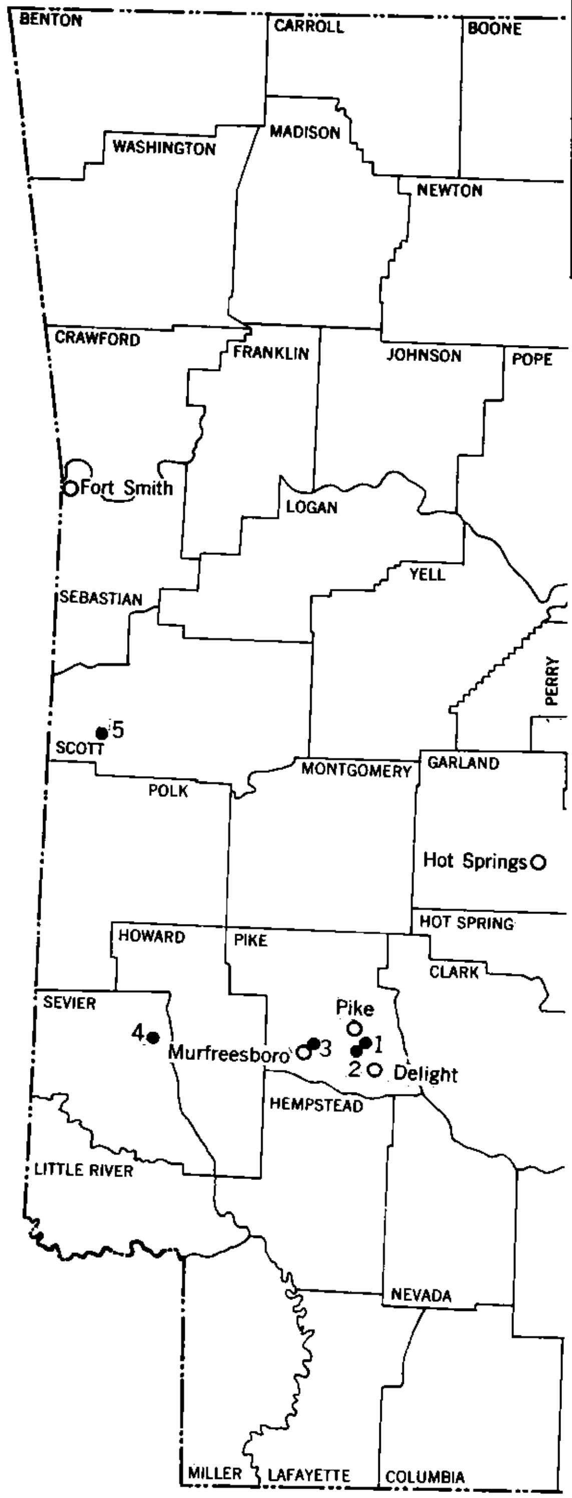
LOCATION OF

OIL - IMPREGNATED STRIPPABLE DEPOSITS

SCALE OF MILES
10 0 10 20 30 40

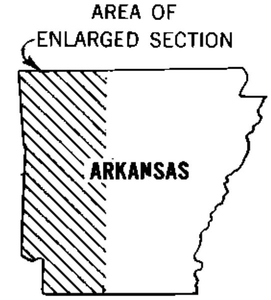
MAX W. BALL - WASHINGTON, D. C.

MAY 1950



LEGEND

● 1 etc. Deposit or group of deposits
See Exhibit No.C-2 for descriptions of locations



SF-252 12-1-50

ARK

Data on Surface or Near-surface Oil-impregnated Deposits
in
Arkansas

Location Number (Exhibit No. C-1)	County	General Location	Thickness (Feet) Beds	Thickness (Feet) Overburden	Approximate Yield Gallons per Ton	Reference Number (Exhibit No. C-3)	Remarks
1	Pike	2-1/2 mi SE. Pike T. 7 S., R. 24 W.	3/4-4	-	14	1, 2, 5	Sand and clay beds 6-12 feet in total thickness and variable in character and bitumen content
2	Pike	4 mi NW. Delight, T. 8 S., R. 24 W	3-5	30-35	40	1, 4, 5	Asphaltic bed 3-5 feet thick with thin seams of liquid asphalt
3	Pike	1 mi NE. Murfreesboro; T. 8 S., R. 25 W.	-	-	-	1, 5	Viscous asphaltic deposit; probably small; information meager
4	Sevier	Near Lebanon	1+	-	-	1, 4, 5	Small scattered deposits
-	Scott	Northern base Fourcke Mountain	-	-	-	1	Asphaltic sandstone; deposit probably small; information meager.

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5. Miser, H.D., and Purdue, A.H., "Geology of De Queen and Caddo Gap Quadrangles, Arkansas" U.S. Geological Survey Bulletin 808, 1928.

Exhibit No. C-4

Acknowledgments

1. Wayne, C. Fletcher, Executive Director,
Arkansas Resources & Development Commission,
Little Rock, Arkansas.

2. H.B. Foxhall, Director,
Arkansas Geological Survey,
Little Rock, Arkansas.

3. Scott D. Hamilton, Manager,
Arkansas Chamber of Commerce,
Little Rock, Arkansas.

4. Grover Owens,
Owens, Ehrman & McHaney, Pyramid Building,
Little Rock, Arkansas.

5. Percey Upton and Elbert Smith,
The Arkansas Stripping Co.,
Little Rock, Arkansas.

6. Snow Wilson,
The Big Rock Stone & Materials Co.,
Little Rock, Arkansas.

We, the undersigned subcontractors have read and are severally familiar with the over-all contents of this report on The Synthetic Liquid Fuel Potential of Arkansas. Each of us individually approves, by his appended signature, of the report as written, insofar as it relates to conditions, conclusions, and recommendations with respect to the raw material forming his responsibility under his subcontract.

COAL

Paul Weir Company

Paul Weir Company, Incorporated

NATURAL GAS

De Golyer and MacNaughton

DeGolyer and MacNaughton

OIL SHALE

De Golyer and MacNaughton

DeGolyer and MacNaughton

WATER

Malcolm Pirnie Engineers

Malcolm Pirnie Engineers

OIL-IMPREGNATED STRIPPABLE DEPOSITS

Max W. Ball

Max W. Ball