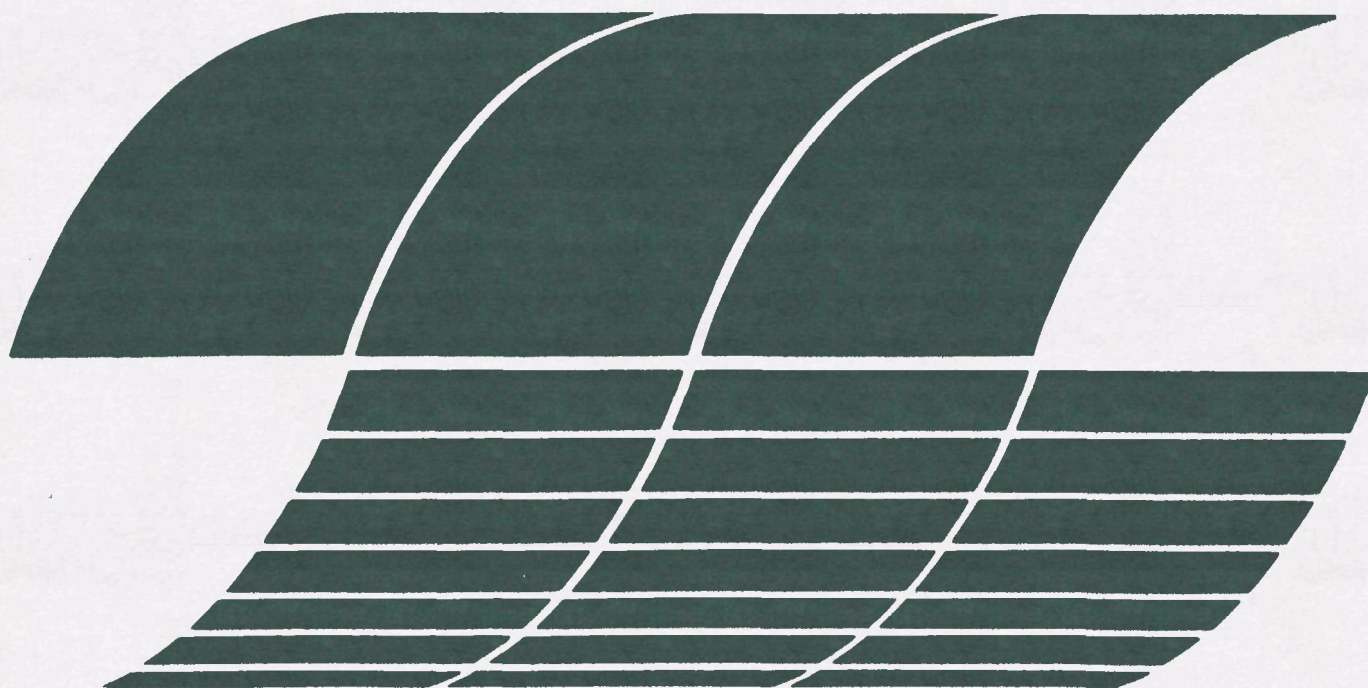


# **Washability Characteristics of Arkansas and Texas Lignites: Report of Investigations**

**Interagency  
Energy/Environment  
R&D Program Report**



## **RESEARCH REPORTING SERIES**

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This report has been assigned to the INTERAGENCY ENERGY-ENVIRONMENT RESEARCH AND DEVELOPMENT series. Reports in this series result from the effort funded under the 17-agency Federal Energy/Environment Research and Development Program. These studies relate to EPA's mission to protect the public health and welfare from adverse effects of pollutants associated with energy systems. The goal of the Program is to assure the rapid development of domestic energy supplies in an environmentally-compatible manner by providing the necessary environmental data and control technology. Investigations include analyses of the transport of energy-related pollutants and their health and ecological effects; assessments of, and development of, control technologies for energy systems; and integrated assessments of a wide range of energy-related environmental issues.

## **EPA REVIEW NOTICE**

This report has been reviewed by the participating Federal Agencies, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

**EPA-600/7-79-149**

**June 1979**

**PMTTC-5(79)**

Distribution Category UC-90b

# **Washability Characteristics of Arkansas and Texas Lignites: Report of Investigations**

by

J. A. Cavallaro and A. F. Baker

U. S. Department of Energy  
Coal Preparation Division  
Pittsburgh Mining Technology Center  
4800 Forbes Avenue  
Pittsburgh, PA 15213

EPA Interagency Agreement No. DXE685-AK  
Program Element No. EHE623A

EPA Project Officer: David A. Kirchgessner

Industrial Environmental Research Laboratory  
Office of Energy, Minerals, and Industry  
Research Triangle Park, NC 27711

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY  
Office of Research and Development  
Washington, DC 20460

and

U.S. Department of Energy  
Division of Fossil Fuel Extraction  
Pittsburgh Mining Technology Center  
Pittsburgh, PA 15213

## CONTENTS

	<u>Page</u>
Abstract .....	1
Introduction .....	1
Acknowledgments .....	3
Test procedure .....	3
Collection of samples .....	3
Sample preparation .....	4
Arkansas lignites .....	7
Geology .....	7
Reserves .....	7
Production .....	10
Texas lignites .....	10
Geology .....	10
Resources .....	11
Production .....	11
Experimental results .....	15
Arkansas lignite .....	15
Texas lignite .....	24
Sodium reduction .....	44
Discussion of results .....	44
Conclusions .....	46
References .....	47

## ILLUSTRATIONS

<u>Fig.</u>	<u>Page</u>
1. Flow diagram showing preparation of face samples .....	5
2. Areas of shallow lignite deposits in Arkansas .....	8
3. Generalized cross section .....	9
4. Distribution of Texas near-surface lignite .....	12

## TABLES

1. Identification of coal samples collected .....	3
2. Estimated original reserves of Arkansas lignite in deposits more than 30 inches thick and lying beneath less than 100 feet of overburden .....	10
3. Stratigraphic occurrence of Texas lignite .....	13
4. Near-surface potential Texas lignite resources .....	14
5. Chemical and physical analyses of raw coal channel samples .	16
6. Detailed washability analyses of sample No. 1 .....	17
7. Detailed washability analyses of sample No. 2 .....	20
8. Detailed washability analyses of sample No. 3 .....	22
9. Detailed washability analyses of sample No. 4 .....	25
10. Detailed washability analyses of sample No. 5 .....	27
11. Detailed washability analyses of sample No. 6 .....	30
12. Detailed washability analyses of sample No. 7 .....	32
13. Detailed washability analyses of sample No. 8 .....	35
14. Detailed washability analyses of sample No. 9 .....	37

	<u>Page</u>
15. Detailed washability analyses of sample No. 10 .....	40
16. Detailed washability analyses of sample No. 11 .....	42
17. Ion exchange test results with minus 14 mesh Arkansas and Texas lignites .....	45

## WASHABILITY CHARACTERISTICS OF ARKANSAS AND TEXAS LIGNITES

by

J. A. Cavallaro<sup>1</sup> and A. F. Baker<sup>2</sup>

### ABSTRACT

This report describes the washability characteristics of eleven channel samples of lignite, four from Arkansas and seven from Texas.

Only two of the samples, those collected from Dallas County, Arkansas, could be upgraded to meet the current EPA new source performance standard (NSPS) of 1.2 pounds SO<sub>2</sub>/MM Btu. The other nine samples, although averaging only a little over 1 percent total sulfur, were relatively high in organic sulfur considering their low Btu/lb value, and could not be upgraded to meet the standard.

Physical coal cleaning of these samples, however, provided significant ash reduction which may reduce boiler fouling.

It was demonstrated that much of the sodium can be removed from these Arkansas and Texas lignites by ion exchange. Analyses showed 37 to 91 percent sodium oxide reduction after treatment with a solution containing calcium ions.

### INTRODUCTION

In 1977 the electric utilities burned 477 million tons of coal with an average sulfur content of 2.0 percent. The amount of coal consumed by electric utilities is anticipated to reach 525 million tons by 1980 and approximately a billion tons by the year 2000 (7). Because coal-fired electric utility plants are the major source of sulfur oxide air pollution in the United States today, EPA and its counterparts have placed major emphasis on developing methods for controlling these emissions.

Since 1965, the Environmental Protection Agency (or its predecessor The National Air Pollution Control Administration) has funded a study by

---

<sup>1</sup>Supervisory Chemical Engineer.

<sup>2</sup>Supervisory Physicist.

the Coal Preparation Division of the U.S. Department of Energy (DOE), formerly the U.S. Bureau of Mines, Department of the Interior, to determine the amount of the various forms of sulfur in major sources of utility steam coals and the washabilities of these coals. The EPA new source performance standard is 1.2 pounds  $\text{SO}_2$ /MM Btu. This means that a coal containing 13,000 Btu/lb can contain only 0.8 percent sulfur in order to meet the standard. However, a lignite averaging 10,000 Btu/lb (moisture free) could only contain 0.6 percent sulfur in order to meet the standard.

Because of our need for increasing coal utilization to meet rapidly growing energy needs, the DOE is expanding its investigation of the preparation characteristics of United States coals to include various low rank coals and lignite.

To date, very little information has been published on the removal of impurities from lignite by coal preparation. The purpose of the present study was to determine the potential of upgrading selected Arkansas and Texas lignites by coal preparation techniques to improve their utilization in combustion and conversion processes.

Physical cleaning can reduce the sulfur in coal which occurs as pyrite, but it leaves the organic sulfur in the clean coal. For some coals, however, coal cleaning may eliminate or minimize the need for stack-gas scrubbing for achieving air quality criteria. Hence, coal washing techniques that remove pyritic sulfur and other impurities cheaply and efficiently can be used as a primary upgrading step before utilization.

The deposition of ash on the heat transfer surfaces in boilers is a problem in lignite combustion. This problem is aggravated by the mineral constituents present in lignite. Sodium, an alkaline metal, has been found to be the element chiefly responsible for accelerating the fouling of boiler tubes (12). At high sodium levels, frequent cleaning of the boilers is often necessary to maintain steam production. Tests have shown, however, that the sodium content of lignite can be reduced by an ion exchange process (8). It has also been found that the rate of boiler fouling depends upon the quantity of ash present in lignite. Tufte et al. (12) have shown that the ash fouling rate of boiler tubes increases exponentially with the ash content regardless of the sodium oxide content of the ash.

This report describes the results from washability tests to determine the ash and sulfur reduction potential of selected Arkansas and Texas lignites by stage crushing and subsequent specific gravity separation. Supplementary data are presented to show the effect of treating these lignites by an ion exchange process to reduce their sodium content. Data are also presented to characterize the chemical and physical properties of the lignite samples collected in this investigation.



## ACKNOWLEDGMENTS

The authors wish to acknowledge the cooperation and help of those engineers, geologists, and mining company officials contacted during this investigation. The assistance of R. B. Stroud, U.S. Bureau of Mines State Liaison Officer, Arkansas, and M. E. Hawkins, U.S. Bureau of Mines State Liaison Officer, Texas, is gratefully acknowledged. The authors also wish to thank R. A. Welsh, U.S. Department of Energy for collecting the samples and W. Dickie, C. Grimes, and U. Weinheimer, U.S. Department of Energy, for performing the washability analyses on the various coal samples.

The work was funded by the Environmental Protection Agency, and the authors wish to acknowledge the assistance of T. Kelly Janes, James Kilgroe, and David A. Kirchgessner from the Industrial Environmental Research Laboratory of the Environmental Protection Agency, Research Triangle Park, N.C.

## TEST PROCEDURE

### Collection of Samples

Face samples were collected from surface mines in Arkansas (four samples) and Texas (seven samples). The mines which were active were producing coal primarily for consumption by electric utilities. The four channel samples from Arkansas ranged from 2 feet 7 inches to 3 feet 1 inch thick; the seven samples from Texas ranged from 5 feet 4 inches to 12 feet thick. Four of the Texas mines sampled produce coal for electric power generation, one produces coal for making activated carbon, and two are prospect mines. Identification of the coal samples collected is presented in table 1.

TABLE 1. - Identification of coal samples collected

Sample No.	State	County	Group
1	Arkansas	Dallas	Wilcox (top bench)
2	"	"	Wilcox (bottom bench)
3	"	Ouachita	"
4	"	Saline	"
5	Texas	Freestone	"
6	"	"	"
7	"	Harrison	"
8	"	Milam	"
9	"	Panola	"
10	"	Titus	"
11	"	Angelina	Claiborne

Face samples were collected according to the procedure recommended by Fieldner and Selvig (2) and Holmes (5), except that the dimensions of each sample cut were expanded to permit 600 pounds of coal to be taken from the face. Partings and impurities were not removed from the samples unless otherwise noted. The face was cleared of loose coal or dirt for a width of approximately 5 feet. Loose pieces of roof were also taken down to prevent them from falling into the sample while it was being collected. Within the cleaned area of the face, the coal was cut from the roof to the floor in a channel 1 inch deep and about 3 feet wide to remove any altered or otherwise inferior coal such as oxidized coal. The floor was then cleared and smoothed, and a sampling cloth was spread to catch the sample.

The channel sample was cut perpendicular to the lay of the coalbed, approximately 10 inches deep, and wide enough to provide a sample of 600 pounds. For example, for a 4-foot-thick coalbed a channel 30.5 inches wide would be collected. The procedure is modified when a strip mine sample is obtained where the overburden has been removed. In this case, the depth and width of the channel would be equal. For example, for the 4-foot-thick bed noted above, the channel would be 17.5 inches deep by 17.5 inches wide. The collected sample includes all partings and other impurities occurring in the channel.

#### Sample Preparation

The 600-pound channel samples collected in the field were loaded into steel drums containing plastic liners and returned to the coal preparation laboratory for processing. The sample preparation procedure is outlined in the flowsheet shown in figure 1. Each sample to be tested was air dried and crushed to 1-1/2-inch top size using a roll crusher. The sample was then coned, long piled, and shoveled into four pans, according to ASTM specifications, and divided into two portions by combining opposite pans. Each sample was divided into two coarse portions. One portion was crushed to 1-1/2 inches top size and sized 1-1/2 inches by 3/8 inch, 3/8 inch by 14 mesh, 14 by 100 mesh, and minus 100 mesh. The other portion was crushed to 3/8 inch top size and sized 3/8 inch by 14 mesh, 14 by 100 mesh, and minus 100 mesh. The cumulative percentage of material retained on each screen was plotted on Rosin and Rammler paper (9), and the size distribution coefficient  $n$  was determined from the slope of the line representing the data. The size distribution constant  $n$  is a measure of the degree of dispersion of particle size. The percentage of fines in a coal tend to increase with decreasing values of  $n$ . The minus 100 mesh material was removed from each portion and analyzed for chemical and physical properties.

Each of the remaining portions was float-sink tested at 1.30, 1.40, and 1.60 specific gravities using CERTIGRAV,<sup>3</sup> a commercial organic

<sup>3</sup>Reference to specific brands does not imply endorsement by the Department of Energy.

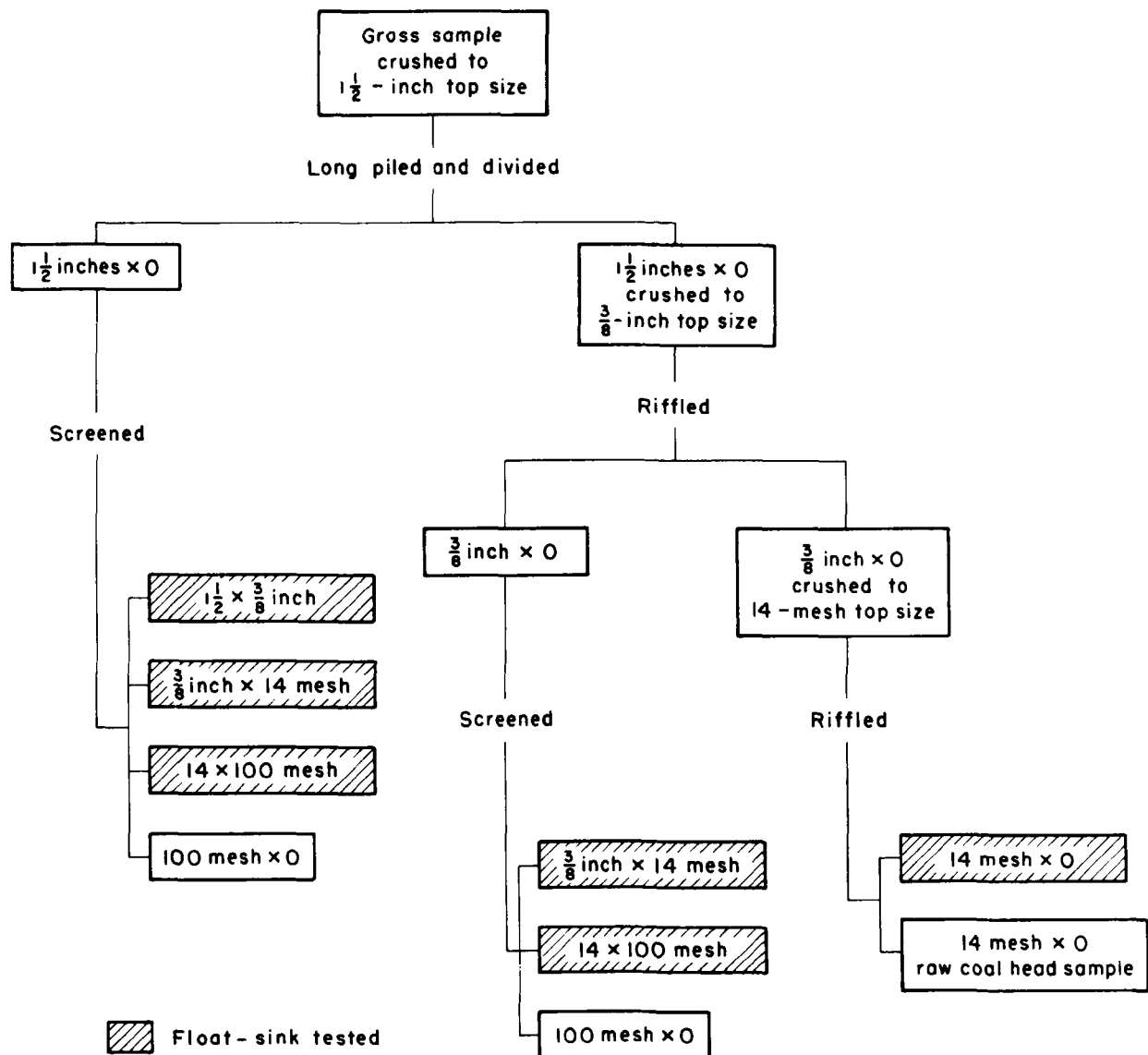


FIGURE 1. - Flow diagram showing preparation of face samples.

liquid of standardized specific gravity produced by American Minechem Corporation; the solution tolerance was  $\pm 0.001$  specific gravity unit and was monitored using a spindle hydrometer. A third portion crushed to 14 mesh top size was float-sink tested in its entirety at the same specific gravities. Analyses of sodium oxide in the ash were obtained on each of the specific gravity fractions of the sample crushed to 14 mesh top size. However, the sodium oxide in the ash was recalculated and is presented on a coal basis in the tables showing washability results.

A head sample was riffled from the 14-mesh by 0 portion for proximate analysis (moisture, ash, volatile matter, and fixed carbon), ultimate analysis (carbon, hydrogen, sulfur, nitrogen, ash, and oxygen) and determination of calorific value, fusibility of ash, major elements in ash, free-swelling index, Hardgrove grindability index, and sulfur forms and content (pyritic, organic, and total).

For the two coarse sized samples, the separation was made in a screen bottom container which is inserted in 10-gallon-capacity vessels containing the organic liquid. The sample was placed in the 1.30 specific gravity bath, in small quantities to prevent entrapment, and was stirred and allowed to separate. The lighter specific gravity coal fraction was removed from the surface of the bath with a screen wire strainer; the heavier specific gravity material settled to the container bottom which was then raised above the liquid level to drain. The container with the heavier specific gravity material was placed in the 1.40 specific gravity solution and the process was repeated. This procedure was continued until the sample was separated into the desired specific gravity fractions.

For the 14-mesh by 0 size sample, the separation was made in glass separatory flasks joined by standard ground taper joints. After the sample separated, a stopper was passed through the float layer and inserted into the neck of the upper section of the separatory flask. The flask was then separated and both products were filtered. The "floats" were dried and prepared for analysis, while the "sinks" were reintroduced into another separatory flask containing a heavier specific gravity liquid and the float-sink procedure was repeated.

Upon completion of the float-sink testing, the specific gravity fractions of the three sized samples were analyzed for calorific value, ash, pyritic sulfur, and total sulfur content. All product analyses are reported on a moisture-free basis unless otherwise noted. Raw coal moisture, as presented in the appendix tables, is the moisture contained in the sample after it was air dried at the coal preparation laboratory. The air dry loss is not included in the moisture determination. It is felt that under normal conditions the moisture content as reported here would closely simulate the moisture content of the coal burned at the powerplant.

Specific gravity separations of fine coal are particularly difficult, especially with coals that are porous and contain high inherent moisture contents, because the heavy liquid used can penetrate the pores displacing the capillary held water, thus causing an increase in the apparent specific gravity of the coal. This may explain the unexpectedly low weight recoveries with some of the minus 14 mesh size fractions at specific gravity 1.30.

The float-sink data from the channel samples do not necessarily represent the quality of the product loaded at the mine where the sample was taken but rather indicate the quality of the bed in that particular geographical location. Float-sink data are based upon theoretically perfect specific gravity separations that are approached but not equaled in commercial practice.

To supplement the washability study, tests were carried out to demonstrate the sodium reduction potential of the lignite samples by ion exchange. In these empirical type tests, the sample was stirred for 5 minutes in a vessel with a solution containing the equivalent of 10 pounds of calcium chloride ( $\text{CaCl}_2$ ) per ton of dry lignite. All tests were performed at room temperature with the minus 14 mesh head samples and float 1.60 specific gravity fractions. After treatment, the products were analyzed for the  $\text{Na}_2\text{O}$  content of the ash.

## ARKANSAS LIGNITES

### Geology

Lignite is known to occur in beds primarily of Tertiary age in a broad zone that extends from southwestern to northeastern Arkansas (figure 2).

Rocks containing lignite are exposed in an area of about 6,125 square miles in the Gulf Coastal Plain of Arkansas. From oldest to youngest, these rocks are the Tokio group of Cretaceous age, and the Wilcox group, Claiborne group, and Jackson group of Eocene age. Beds of lignite are more abundant and generally thicker in the Wilcox group. These rocks contain numerous beds of lignite ranging from a fraction of a foot to more than 22 feet thick. The geology of the Arkansas lignite has been described by Haley (4).

Figure 3 is a generalized cross section of Paleocene and Eocene groups of formations of lignite in the southern part of Arkansas (3).

### Reserves

The estimate of the lignite reserves in Arkansas was prepared on a basis of original reserves of lignite before mining (table 2). The

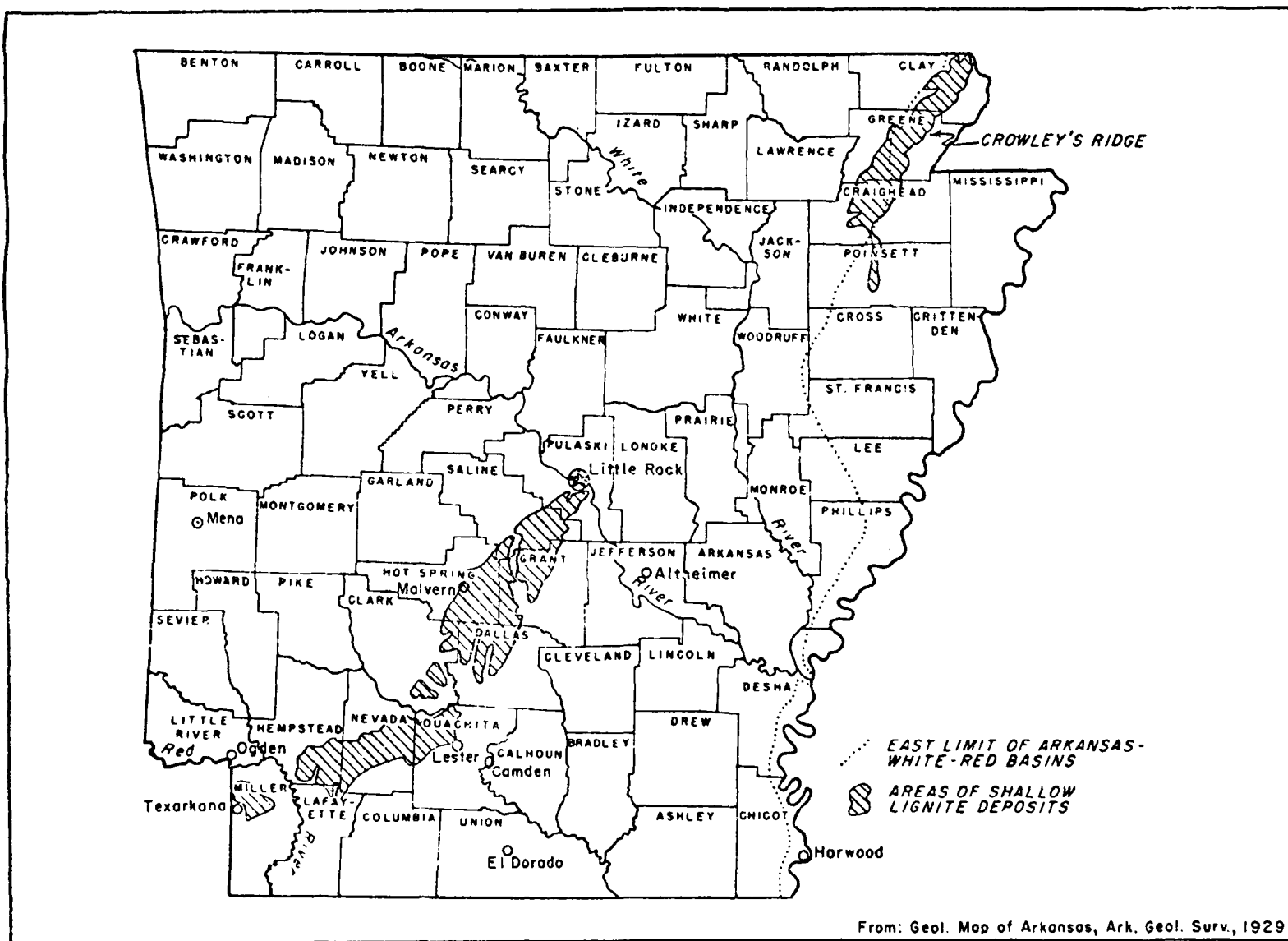


FIGURE 2. - Areas of shallow, lignite deposits in Arkansas.

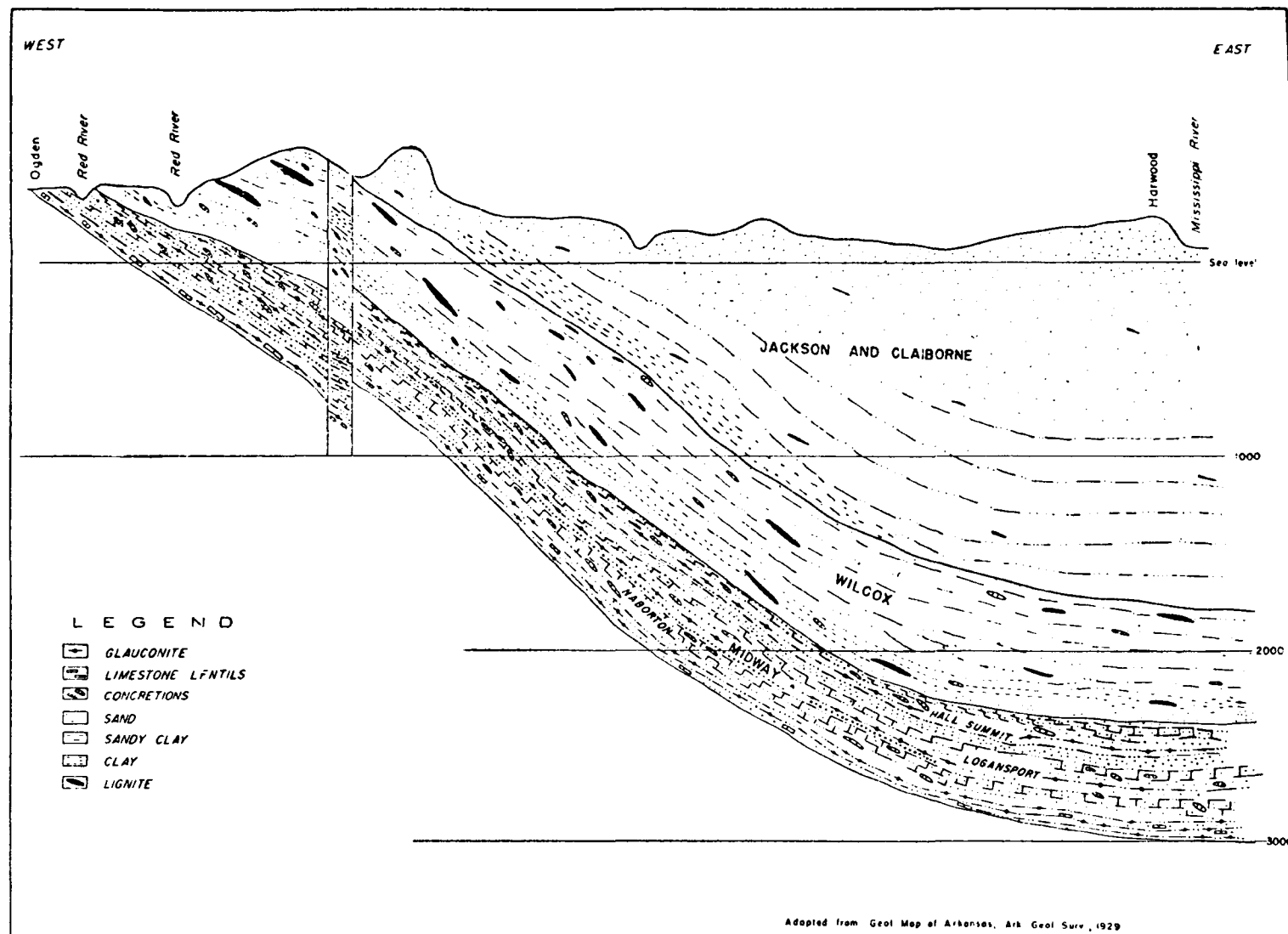


FIGURE 3. - Generalized cross section.  
(Indicated lignite occurrences are not drawn to scale nor are they specifically located)

original reserves of lignite in known deposits are estimated to be 32 million short tons (11). This estimated total pertains to known deposits of lignite thicker than 30 inches and under less than 100 feet of overburden.

TABLE 2. - Estimated original reserves of Arkansas lignite in deposits more than 30 inches thick and lying beneath less than 100 feet of overburden

(In thousands of short tons)

County	Total	County	Total
Ashley.....	( <sup>1</sup> )	Greene.....	200
Bradley.....	300	Hot Spring.....	300
Calhoun.....	200	Nevada.....	400
Clark.....	300	Ouachita.....	5,200
Clay.....	( <sup>1</sup> )	Poinsett.....	700
Cleveland.....	200	Pulaski.....	12,500
Craighead.....	( <sup>1</sup> )	Saline.....	<u>6,500</u>
Cross.....	( <sup>1</sup> )		
Dallas.....	4,900	Total.....	32,000
Grant.....	300		

<sup>1</sup>Incomplete thickness data, or lignite less than 30 inch thick.

Lignite under more than 100 feet of overburden has been found in cores from core drilling and in rock cuttings from wells drilled for oil throughout much of the Gulf Coastal Plain. The total reserves of lignite in Arkansas are tentatively estimated to be 350 million short tons. A more accurate estimate of the lignite reserves in Arkansas would be dependent upon data obtained by an intensive mapping and core-drilling program. Arkansas lignites have the following ranges of composition by proximate analyses: Moisture--23.4 to 52.4 percent; volatile material--12 to 35 percent; fixed carbon--7.4 to 24.7 percent; and ash--6 to 57.2 percent. Heat values range from 2,770 to 7,560 Btu per pound.

#### Production

Lignite has been mined intermittently from about 1947 until 1960. Since then no lignite has been mined in Arkansas. Data pertaining to the amount of lignite mined in Arkansas are incomplete, but total cumulative production is estimated to be less than 100,000 short tons.

#### TEXAS LIGNITES

#### Geology

The principal lignite deposits are found in the Wilcox Group (lower Eocene) which contains approximately 80 percent of the resources, while



deposits of secondary importance are found in the Yegua Formation and Jackson Group (upper Eocene). Lignite occurs as a component facies of ancient fluvial, deltaic, and lagoonal rocks in East, Central, Southeast, and South Texas. Lignite-bearing strata dip coastward at one-half to one degree. The highest grade and most extensive resources occur north of the Colorado River in the Wilcox Group of East and Central Texas (figure 4). There is a correlation between grade and geologic occurrence; deltaic lignite is the best grade, fluvial lignite is intermediate in grade, and lagoonal lignite is poorest in grade. The geology of the Texas lignites have been described by Kaiser (6). A stratigraphic occurrence of the Texas lignites is shown in table 3.

#### Resources

Identified coal resources in Texas as of January 1, 1974, are set at 16,341 million short tons or about 1 percent of the U.S. total (7). Table 4 shows that more than half of the Texas resources are lignite (10,426 million tons) which occur at depths ranging from 0 to 200 feet in the lower Tertiary of the Gulf Coastal Plain. The remainder is bituminous coal (5,915 million tons) found at levels from 0 to 3,000 feet in three areas in Texas: North-Central, Rio Grande Embayment, and Trans-Pecos. The total statewide lignite resources of 10.4 billion short tons was calculated relying on geologic occurrence, past and current production, reported outcrop occurrences, and projection from deep-basin occurrences.

Texas lignites have the following ranges of composition by proximate analyses: moisture--27.5 to 32.3 percent; volatile matter--33.8 to 35.7 percent; fixed carbon--21.8 to 29.5 percent; and ash--9.1 to 11.0 percent. Heating values ranged 7,124 to 7,916 Btu per pound.

#### Production

Since about 1890, lignite has been produced by more than 150 operators in at least 35 Texas counties. Reasonably reliable production figures to date are estimated at 125 million tons (6).

All of the coal currently mined in Texas is strip-mined lignite from north of the Colorado River where zero to 180 feet of unconsolidated overburden is removed. Statewide production in 1976 was 12,300,000 tons, all of which is captive. The oldest producer is ICI America Inc., which has operated a mine in Harrison County at Darco since 1931 for the production of activated carbon. Texas Utilities Generating Company, a subsidiary of Texas Utilities, operates three mines; in Milam County at Alcoa, Freestone County near Fairfield, and Titus County near Monticello. These mines produce 2 to 6 million tons annually for steam-electric plants of 360 to 1,150 MW capacity.

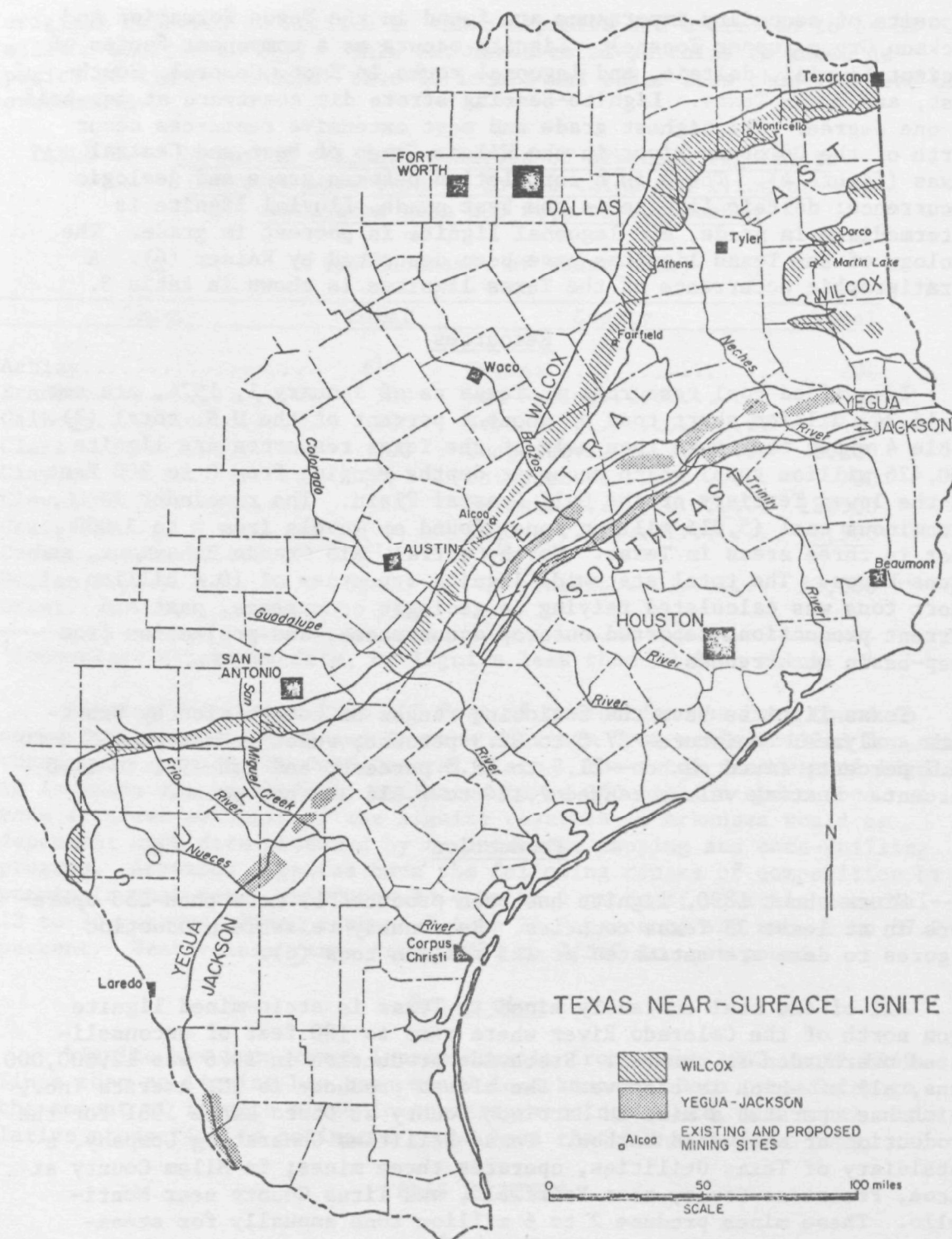


FIGURE 4. - Distribution of Texas near-surface lignite.

TABLE 3. - Stratigraphic occurrence of Texas lignite<sup>1</sup>

		East, Southeast, and Central Texas	South Texas
EOCENE SERIES	Jackson Group	Whitsett Formation Manning Formation* Wellborn Formation Caddell Formation	Upper Middle Lower*
	Claiborne Group	Yegua Formation* Cook Mountain Formation Stone City Formation Sparta Sand Weches Formation Queen City Sand Reklaw Formation Carrizo Sand	Upper Yegua*  Laredo Formation  El Pico Clay Bigford Formation Carrizo
	Wilcox* Group	Calvert Bluff Formation* Simsboro Sand Hooper Formation	Lower Wilcox* Group Indio Formation*

\*Main lignite occurrences.

Terminology from: Barnes, 1967, 1970, 1974b; Eargle, 1968;  
Renick, 1936.

<sup>1</sup>Kaiser, W. R. Texas Lignite: Near-Surface and Deep-Basin  
Resources, Bureau of Economic Geology, R.I.-No. 79, 70 pp.

TABLE 4. - Near-surface potential Texas lignite resources<sup>1</sup>

(In millions of short tons)

By County and Group					By Region and Geology		
County	Wilcox	Yegua	Jackson	Yegua-Jackson		Amount	Percent
Angelina		174			Regions		
Atascosa	26			70	East Texas	5,085	48.77
Bastrop	447				Central Texas	2,846	27.30
Bexar	78				Southeast Texas	1,386	13.29
Bowie	536				South Texas	1,109	10.64
Brazos		39	42			10,426	100.00
Burleson		121	85				
Caldwell	76						
Fayette			102				
Franklin	156				Geologic		
Freestone	967				Occurrence		
Grimes			63		Fluvial	4,709	45.17
Guadalupe	82				Deltaic	4,232	40.59
Harrison	555				Lagoonal	1,485	14.24
Henderson	463					10,426	100.00
Hopkins	434						
Houston		255					
LaSalle				86	Geologic Trend		
Lee	47	95	41		Lower Eocene		
Limestone	169				(Wilcox)	8,606	82.54
Madison		132			Upper Eocene		
Marion	60				(Yegua-Jackson)	1,820	17.46
Maverick	129					10,426	100.00
McMullen				212			
Medina	150						
Milam	813						
Morris	89						
Nacogdoches	90						
Panola	524						
Rains	245						
Robertson	403						
Rusk	275						
Shelby	234						
Starr				33			
Titus	444						
Trinity		20	108				
Uvalde	110						
Van Zandt	782						
Walker			17				
Washington			92				
Wood	198						
Zavala	24						
Zapata				33			
	8,606	836	550	434			

<sup>1</sup>Kaiser, W. R. Texas Lignite: Near-Surface and Deep Basin Resources, Bureau of Economic Geology, University of Texas, RI No. 79, 1974.

Exploration activity during the past two years has been feverish, and several major companies are actively exploring for lignite. Major emphasis continues to be on the Wilcox group; however, significant activity is occurring in the Yegua-Jackson group.

Five new mines at Martin Lake, Forest Grove, Twin Oaks, Bryan, and San Miguel are scheduled to come on line in 1980 (1). They will provide mine-mouth powerplants with 28 million tons of lignite from the Wilcox and Yegua coalfields.

#### EXPERIMENTAL RESULTS

Chemical and physical analyses of the raw coal samples crushed to 14 mesh top size are presented in table 5. The evaluation of the washability data for each coal tested in Arkansas and Texas includes a description of the coalbed section, the washability data, and a short discussion about the data. In some instances a specific gravity of separation is given to illustrate the attainment of a certain quality product. These decisions are arbitrary and should not be construed as suggesting optimum economical plant operating conditions. Results are also presented to show the potential of reducing the sodium-in-ash content of the lignite samples by ion exchange.

#### Arkansas Lignite

Channel sample No. 1 was collected from an uncorrelated formation, Wilcox Group (top bench), Dallas County, Arkansas. This coal was from a prospect mine undergoing a feasibility study. A section of the bed is described as follows:

#### Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
<u>Lignite</u>	3	6
Total thickness of bed and sample	3	6

<sup>1</sup>Overlying bed: sand, gravel, clay;  
floor: fireclay.

Table 6 shows the detailed washability analyses of sample No. 1. The composite washability sample contained an average of 11,275 Btu/lb, 11.2 percent ash, 0.44 percent pyritic sulfur, and 0.93 percent total sulfur. The sodium oxide content in the coal was 0.10 percent. Crushing this coal to 3/8 inch top size and removing the sink 1.30 specific gravity material would provide a product analyzing 11,567 Btu/lb, 8.8

TABLE 5. - Chemical and physical analyses of raw coal channel samples

Type of analysis <sup>1</sup>	Arkansas				Texas						
	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5	Sample No. 6	Sample No. 7	Sample No. 8	Sample No. 9	Sample No. 10	Sample No. 11
Chemical analysis, percent											
Moisture, as received	34.37	31.99	29.19	32.74	25.69	28.35	30.91	29.89	33.03	31.37	32.85
Equilibrium moisture	35.84	32.82	32.59	36.46	30.25	28.24	31.60	31.72	32.75	28.33	37.38
Volatile matter	51.17	52.14	47.30	33.61	45.48	47.63	46.37	41.82	43.69	42.38	48.83
Fixed Carbon	36.98	30.77	35.70	23.28	42.71	38.43	44.16	38.32	47.00	39.86	35.36
Ash	11.85	17.09	17.00	43.11	11.81	13.94	9.47	19.86	9.31	17.76	15.81
Sulfate sulfur	.01	.01	.01	.05	.02	.03	.01	.01	.04	.01	.01
Pyritic sulfur	.42	.02	.77	.14	.08	.22	.07	.19	.36	.09	.09
Organic sulfur	.56	.62	1.00	.85	.97	.86	.70	1.18	.97	.80	1.30
Total sulfur	.99	.65	1.77	1.04	1.07	1.11	.78	1.38	1.37	.90	1.40
Hydrogen	5.14	5.21	5.14	3.16	4.72	4.69	5.00	4.36	4.70	4.34	4.88
Carbon	63.98	57.35	58.57	38.58	65.82	63.03	67.42	58.82	66.37	59.19	59.30
Nitrogen	1.09	1.00	.94	.66	.99	1.12	1.21	.85	1.17	.93	1.03
Oxygen	16.95	18.70	15.88	13.47	15.59	16.11	16.12	14.75	17.08	16.89	17.57
British thermal units per pound	11,423	10,030	10,408	6,672	11,231	10,920	11,487	10,113	11,285	10,126	10,500
Distribution coefficient, $\bar{n}$	.7	.7	.7	.7	.8	.8	.8	.8	.7	.8	.7
Physical Analysis:											
Free-swelling index No.	0	0	0	0	0	0	0	0	0	0	0
Hardgrove grindability index	55	71	53	82	57	57	60	56	63	56	45
Fusibility of ash, °F:											
Initial deformation temperature	2,280	2,350	2,430	2,910	2,140	2,140	2,080	2,400	2,080	2,140	2,300
Softening temperature	2,380	2,400	2,480	2,910	2,170	2,190	2,110	2,450	2,110	2,190	2,350
Fluid temperature	2,490	2,450	2,540	2,910	2,200	2,240	2,140	2,520	2,140	2,250	2,410
Major elements in ash, percent											
SiO <sub>2</sub>	50.71	43.89	51.99	56.68	29.83	39.63	30.77	40.06	28.98	46.88	51.56
Al <sub>2</sub> O <sub>3</sub>	23.38	26.02	24.89	29.04	14.71	16.97	13.41	25.64	12.82	18.86	22.63
Fe <sub>2</sub> O <sub>3</sub>	6.01	7.15	16.59	3.58	5.29	5.43	4.76	2.57	9.15	4.00	4.58
TiO <sub>2</sub>	2.33	1.33	1.00	1.00	2.33	1.00	1.12	1.67	1.67	1.67	1.00
CaO	8.40	11.19	1.12	3.08	18.19	15.39	24.10	12.59	16.79	13.29	7.64
MgO	1.53	1.23	.53	.96	9.12	2.75	4.79	2.72	5.54	2.95	1.69
Na <sub>2</sub> O	.19	.19	.08	.27	.98	.67	1.13	.24	1.06	.65	1.27
K <sub>2</sub> O	.48	.24	.18	1.20	.05	.24	.27	.75	.24	.72	.65
Sulfites	6.11	8.17	.77	3.33	17.78	14.79	16.83	11.34	17.70	8.85	8.76

<sup>1</sup>All analyses are on moisture-free basis unless otherwise indicated.

TABLE 6. - Detailed washability analyses of sample No. 1

STATE: Arkansas  
COUNTY: Dallas

FORMATION: Uncorrelated  
GROUP: Wilcox

Direct								Cumulative							Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Percent				
	Weight	Btu		Ash	Pyritic sulfur	Total sulfur		Weight	Btu		Ash	Pyritic sulfur	Total sulfur	Na <sub>2</sub> O <sup>1</sup>	
TOP SIZE: 1-1/2															
Size fraction: 1-1/2 x 3/8															
Weight percent: 75.1															
Float- 1.30	98.1	98.9	11,539	9.9	0.52	0.74		98.1	98.9	11,539	9.9	0.52	0.74	1.3	
1.30 - 1.40	.7	.6	9,140	26.1	2.16	2.55		98.8	99.5	11,521	10.0	.53	.75	1.3	
1.40 - 1.60	.8	.2	7,046	41.3	3.66	3.87		99.2	99.7	11,506	10.1	.54	.76	1.3	
Sink - 1.60	.8	.3	4,036	61.1	9.45	9.50		100.0	100.0	11,445	10.5	.62	.84	1.5	
Size fraction: 3/8 x 14															
Weight percent: 18.9															
Float- 1.30	92.0	95.2	11,528	9.0	0.17	0.77		92.0	95.2	11,528	9.0	0.17	0.77	1.3	
1.30 - 1.40	3.6	2.9	9,101	25.5	1.20	1.70		95.6	98.2	11,437	9.6	.21	.80	1.4	
1.40 - 1.60	1.9	1.2	6,814	41.4	2.30	2.62		97.5	99.3	11,347	10.2	.25	.84	1.5	
Sink - 1.60	2.5	.7	2,970	69.0	7.75	7.78		100.0	100.0	11,135	11.7	.44	1.02	1.8	
Size fraction: 14 x 100															
Weight percent: 6.0															
Float- 1.30	74.5	80.9	11,571	8.4	0.14	0.83		74.5	80.9	11,571	8.4	0.14	0.83	1.4	
1.30 - 1.40	13.2	12.8	10,296	17.2	.36	1.07		87.8	93.7	11,379	9.7	.17	.87	1.5	
1.40 - 1.60	6.1	4.6	8,078	32.2	.94	1.42		93.9	98.3	11,164	11.2	.22	.90	1.6	
Sink - 1.60	6.1	1.7	2,954	69.4	2.56	2.65		100.0	100.0	10,661	14.8	.37	1.01	1.9	
Size composite: 1-1/2 x 100															
Weight percent: 100.0															
Float- 1.30	95.5	97.4	11,538	9.7	0.44	0.75		95.5	97.4	11,538	9.7	0.44	0.75	1.3	
1.30 - 1.40	2.0	6.2	9,581	22.4	1.13	1.68		97.6	98.9	11,498	9.9	.45	.77	1.3	
1.40 - 1.60	1.0	2.2	7,344	38.0	2.16	2.51		98.5	99.6	11,456	10.2	.47	.79	1.4	
Sink - 1.60	1.5	.8	3,412	65.8	7.15	7.21		100.0	100.0	11,339	11.0	.57	.88	1.6	
Minus 100 mesh	1.7	1.6	10,583	20.9	1.05	1.86		100.0	100.0	11,326	11.2	.58	.90	1.6	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 6. - Detailed washability analyses of sample No. 1 (Con.)

STATE: Arkansas  
COUNTY: Dallas

FORMATION: Uncorrelated  
GROUP: Wilcox

Product	Direct							Cumulative							Pounds, SO <sub>2</sub> /MM Btu
	Recovery, pct. Weight Btu		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	Recovery, pct. Weight Btu		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	
				Ash	Pyritic sulfur	Total sulfur					Ash	Pyritic sulfur	Total sulfur		
TOP SIZE: 3/8															
Size fraction: 3/8 x 14															
Weight percent: 63.9															
Float- 1.30	95.5	97.1	11,529	9.0	0.15	0.77		95.5	97.1	11,529	9.0	0.15	0.77		1.3
1.30 - 1.40	2.4	2.1	9,758	21.5	1.20	1.85		97.9	99.1	11,485	9.3	.18	.80		1.4
1.40 - 1.60	.8	.5	7,110	39.0	4.49	4.71		98.7	99.6	11,451	9.5	.21	.83		1.4
Sink - 1.60	1.3	.4	3,215	66.0	14.64	14.70		100.0	100.0	11,342	10.3	.40	1.01		1.8
Size fraction: 14 x 100															
Weight percent: 36.1															
Float- 1.30	89.3	92.2	11,639	8.5	0.12	0.62		89.3	92.2	11,639	8.5	0.12	0.62		1.1
1.30 - 1.40	6.9	5.9	9,699	21.7	.57	1.03		96.2	98.1	11,500	9.4	.15	.65		1.1
1.40 - 1.60	2.0	1.4	7,728	34.3	1.67	1.78		98.2	99.4	11,424	9.9	.18	.67		1.2
Sink - 1.60	1.8	.6	3,438	64.0	4.36	4.56		100.0	100.0	11,277	10.9	.26	.74		1.3
Size composite: 3/8 x 100															
Weight percent: 100.0															
Float- 1.30	93.3	95.4	11,567	8.8	0.14	0.72		93.3	95.4	11,567	8.8	0.14	0.72		1.2
1.30 - 1.40	4.0	4.4	9,721	21.6	.81	1.35		97.3	98.8	11,490	9.4	.17	.74		1.3
1.40 - 1.60	1.2	1.0	7,477	36.2	2.81	2.97		98.5	99.6	11,441	9.7	.20	.77		1.3
Sink - 1.60	1.5	.5	3,313	65.1	10.10	10.23		100.0	100.0	11,318	10.5	.35	.91		1.6
Minus 100 mesh	10.2	8.8	10,677	15.6	.41	.95		100.0	100.0	11,259	11.0	.35	.92		1.6
TOP SIZE: 14															
Size fraction: 14 x 0															
Weight percent: 100.0															
Float- 1.30	90.3	93.5	11,633	8.6	0.12	0.71	0.09	90.3	93.5	11,633	8.6	0.12	0.71	0.09	1.2
1.30 - 1.40	5.1	4.4	9,776	20.6	.48	1.08	.17	95.4	97.9	11,534	9.2	.14	.73	.09	1.3
1.40 - 1.60	2.3	1.6	7,649	36.1	1.35	1.90	.26	97.7	99.5	11,443	9.9	.17	.76	.09	1.3
Sink - 1.60	2.3	.5	2,609	72.7	9.36	9.40	.20	100.0	100.0	11,239	11.3	.38	.96	.10	1.7

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.



percent ash, 0.14 percent pyritic sulfur, and 0.72 percent total sulfur at a Btu recovery of 95.4 percent. This coal would now meet the current SO<sub>2</sub> emission standard.

Channel sample No. 2 was collected from an uncorrelated formation, Wilcox Group (bottom bench), Dallas County, Arkansas. This coal is from a prospect mine undergoing a feasibility study. A section of the bed is described as follows:

Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
<u>Lignite</u>	9	6
Total thickness of bed and sample	9	6

<sup>1</sup>Overlying bed: clay, floor: silty clay.

Table 7 shows the detailed washability analyses of sample No. 2. The composite washability sample contained an average of 10,344 Btu/lb, 17.2 percent ash, 0.03 percent pyritic sulfur, and 0.69 percent total sulfur. The sodium oxide content in the coal was 0.04 percent. Crushing this coal to 1-1/2 inches top size and removing the sink 1.40 specific gravity material would provide a product analyzing 10,786 Btu/lb, 14.0 percent ash, 0.02 percent pyritic sulfur, and 0.67 percent total sulfur at a Btu recovery of 97.3 percent. This coal would now meet the EPA SO<sub>2</sub> emission standard of 1.2 pounds/MM Btu.

Channel sample No. 3 was collected from an uncorrelated formation, Wilcox Group, Ouachita County, Arkansas. A section of the bed is described as follows:

Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
<u>Lignite</u>	2	7
Total thickness of bed and sample	2	7

<sup>1</sup>Overlying bed: sandstone; floor: fireclay.

Table 8 shows the detailed washability analyses of sample No. 3. The composite washability sample contained an average of 10,602 Btu/lb, 15.5 percent ash, 0.77 percent pyritic sulfur, and 1.59 percent total sulfur. The sodium oxide content in the coal was 0.01 percent. This sample contained an average of 0.82 percent organic sulfur and could not be upgraded to meet the emission standard of 1.2 pounds SO<sub>2</sub>/MM Btu. Crushing to 1-1/2 inches top size and removing the sink 1.30 specific

TABLE 7. - Detailed washability analyses of sample No. 2

STATE: Arkansas  
COUNTY: Dallas

FORMATION: Uncorrelated  
GROUP: Wilcox

Direct								Cumulative								Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>		
	Weight	Btu			Pyritic sulfur	Total sulfur		Weight	Btu			Pyritic sulfur	Total sulfur			
TOP SIZE: 1-1/2																
Size fraction: 1-1/2 x 3/8																
Weight percent: 72.8																
Float- 1.30	87.9	91.8	10,915	13.1	0.02	0.68		87.9	91.8	10,915	13.1	0.02	0.68		1.2	
1.30 - 1.40	8.1	6.6	8,507	29.8	.02	.61		96.0	98.4	10,711	14.5	.02	.67		1.3	
1.40 - 1.60	2.1	1.2	5,723	48.7	.02	.50		98.1	99.6	10,603	15.3	.02	.67		1.3	
Sink - 1.60	1.9	.4	2,491	70.7	.01	.29		100.0	100.0	10,452	16.3	.02	.66		1.3	
Size fraction: 3/8 x 14																
Weight percent: 22.0																
Float- 1.30	85.0	90.6	11,150	11.6	0.02	0.66		85.0	90.6	11,150	11.6	0.02	0.66		1.2	
1.30 - 1.40	7.6	6.5	8,865	27.1	.02	.69		92.7	97.1	10,962	12.9	.02	.66		1.2	
1.40 - 1.60	3.6	2.0	5,854	47.3	.02	.50		96.3	99.1	10,769	14.2	.02	.66		1.2	
Sink - 1.60	3.7	.9	2,397	71.0	.08	.34		100.0	100.0	10,458	16.3	.02	.64		1.2	
Size fraction: 14 x 100																
Weight percent: 5.2																
Float- 1.30	65.3	72.4	11,279	10.9	0.03	0.68		65.3	72.4	11,279	10.9	0.03	0.68		1.2	
1.30 - 1.40	4.7	5.0	10,847	13.5	.04	.69		70.0	77.4	11,250	11.1	.03	.68		1.2	
1.40 - 1.60	21.0	19.3	9,365	20.6	.03	.73		91.0	96.7	10,815	13.3	.03	.69		1.3	
Sink - 1.60	9.0	3.3	3,777	61.8	.29	.63		100.0	100.0	10,183	17.6	.05	.69		1.3	
Size composite: 1-1/2 x 100																
Weight percent: 100.0																
Float- 1.30	86.1	90.8	10,980	12.7	0.02	0.68		86.1	90.8	10,980	12.7	0.02	0.68		1.2	
1.30 - 1.40	7.8	6.5	8,656	28.7	.02	.63		93.9	97.3	10,786	14.0	.02	.67		1.2	
1.40 - 1.60	3.4	7.1	6,909	39.5	.02	.57		97.4	99.3	10,649	14.9	.02	.67		1.3	
Sink - 1.60	2.6	1.1	2,689	69.2	.08	.37		100.0	100.0	10,439	16.4	.02	.66		1.3	
Minus 100 mesh	1.9	1.2	6,696	46.8	.12	.50		100.0	100.0	10,368	16.9	.02	.66		1.3	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 7. - Detailed washability analyses of sample No. 2 (Con.)

STATE: Arkansas  
COUNTY: Dallas

FORMATION: Uncorrelated  
GROUP: Wilcox

Direct								Cumulative							
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.	Btu	Btu/lb	Ash	Percent		Pounds, SO <sub>2</sub> /MM Btu	
	Weight	Btu			Pyritic sulfur	Total sulfur						Weight	Btu		Pyritic sulfur
TOP SIZE: 3/8															
Size fraction: 3/8 x 14															
Weight percent: 69.1															
Float- 1.30	84.8	89.1	11,071	12.3	0.05	0.67		84.8	89.1	11,071	12.3	0.05	0.67	1.2	
1.30 - 1.40	10.0	8.5	8,982	26.4	.04	.64		94.8	97.6	10,851	13.8	.05	.67	1.2	
1.40 - 1.60	2.8	1.8	6,773	41.2	.04	.46		97.5	99.4	10,735	14.6	.05	.66	1.2	
Sink - 1.60	2.5	.6	2,607	68.0	.04	.29		100.0	100.0	10,535	15.9	.05	.65	1.2	
Size fraction: 14 x 100															
Weight percent: 30.9															
Float- 1.30	72.5	78.2	11,230	11.0	0.01	0.71		72.5	78.2	11,230	11.0	0.01	0.71	1.3	
1.30 - 1.40	18.5	17.4	9,751	20.1	.02	.70		91.0	95.5	10,929	12.9	.01	.71	1.3	
1.40 - 1.60	4.9	3.5	7,293	36.3	.02	.53		96.0	99.0	10,742	14.1	.01	.70	1.3	
Sink - 1.60	4.0	1.0	2,617	68.3	.12	.34		100.0	100.0	10,414	16.2	.02	.68	1.3	
Size composite: 3/8 x 100															
Weight percent: 100.0															
Float- 1.30	81.0	86.1	11,115	11.9	0.04	0.68		81.0	86.1	11,115	11.9	0.04	0.68	1.2	
1.30 - 1.40	12.6	12.5	9,331	23.5	.03	.67		93.6	97.0	10,874	13.5	.04	.68	1.2	
1.40 - 1.60	3.4	2.5	7,004	39.0	.03	.49		97.0	99.3	10,737	14.4	.04	.67	1.3	
Sink - 1.60	3.0	.8	2,611	68.1	.07	.31		100.0	100.0	10,497	16.0	.04	.66	1.3	
Minus 100 mesh	11.6	8.4	8,350	33.4	.04	.52		100.0	100.0	10,275	17.8	.04	.65	1.3	
TOP SIZE: 14															
Size fraction: 14 x 0															
Weight percent: 100.0															
Float- 1.30	78.4	84.2	11,157	12.0	0.02	0.68	0.04	78.4	84.2	11,157	12.0	0.02	0.68	0.04	1.2
1.30 - 1.40	14.3	13.0	9,440	22.0	.02	.73	.05	92.6	97.1	10,892	13.5	.02	.69	.04	1.3
1.40 - 1.60	3.9	2.5	6,541	42.4	.02	.41	.03	96.5	99.6	10,717	14.7	.02	.68	.04	1.3
Sink - 1.60	3.5	.4	1,244	81.6	.24	3.32	.01	100.0	100.0	10,389	17.0	.03	.77	.04	1.5

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 8. - Detailed washability analyses of sample No. 3

STATE: Arkansas  
COUNTY: Ouachita

FORMATION: Uncorrelated  
GROUP: Wilcox

Direct								Cumulative								Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>		
	Weight	Btu			Pyritic sulfur	Total sulfur		Weight	Btu			Pyritic sulfur	Total sulfur			
TOP SIZE: 1-1/2																
Size fraction: 1-1/2 x 3/8																
Weight percent: 77.6																
Float- 1.30	93.3	95.2	11,249	11.4	0.24	1.13		93.3	95.2	11,249	11.4	0.24	1.13		2.0	
1.30 - 1.40	4.0	3.2	8,896	26.1	2.24	3.07		97.3	98.5	11,152	12.0	.32	1.21		2.2	
1.40 - 1.60	.9	.7	7,968	30.8	8.23	9.15		98.2	99.1	11,123	12.2	.40	1.28		2.3	
Sink - 1.60	1.8	.9	5,409	46.8	25.84	26.33		100.0	100.0	11,020	12.8	.85	1.73		3.1	
Size fraction: 3/8 x 14																
Weight percent: 16.2																
Float- 1.30	86.1	89.4	11,226	10.5	0.21	1.15		86.1	89.4	11,226	10.5	0.21	1.15		2.0	
1.30 - 1.40	9.4	8.1	9,311	21.3	.86	1.90		95.6	97.6	11,037	11.6	.27	1.22		2.2	
1.40 - 1.60	2.8	2.0	7,771	31.1	4.09	5.45		98.3	99.5	10,945	12.1	.38	1.34		2.5	
Sink - 1.60	1.7	.6	2,920	65.4	13.48	13.95		100.0	100.0	10,810	13.0	.60	1.55		2.9	
Size fraction: 14 x 100																
Weight percent: 6.2																
Float- 1.30	28.4	52.3	11,667	9.2	0.08	1.10		28.4	52.3	11,667	9.2	0.08	1.10		1.9	
1.30 - 1.40	20.1	32.3	10,198	15.3	.21	1.23		48.5	84.5	11,059	11.7	.13	1.15		2.1	
1.40 - 1.60	8.7	10.9	7,964	28.4	.73	1.73		57.2	95.4	10,590	14.3	.22	1.24		2.3	
Sink - 1.60	42.8	4.6	681	92.7	.31	.32		100.0	100.0	6,342	47.9	.26	.85		2.7	
Size composite: 1-1/2 x 100																
Weight percent: 100.0																
Float- 1.30	88.1	93.5	11,253	11.2	0.23	1.13		88.1	93.5	11,253	11.2	0.23	1.13		2.0	
1.30 - 1.40	5.9	10.6	9,278	22.6	1.45	2.38		94.0	97.9	11,130	11.9	.31	1.21		2.2	
1.40 - 1.60	1.7	4.3	7,914	30.1	4.74	5.81		95.7	99.1	11,073	12.2	.39	1.29		2.3	
Sink - 1.60	4.3	3.1	2,347	76.2	9.38	9.57		100.0	100.0	10,697	15.0	.77	1.65		3.1	
Minus 100 mesh	1.5	1.0	7,047	40.8	.43	1.23		100.0	100.0	10,643	15.4	.77	1.64		3.1	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 8. - Detailed washability analyses of sample No. 3 (Con.)

STATE: Arkansas  
COUNTY: Ouachita

FORMATION: Uncorrelated  
GROUP: Wilcox

Direct								Cumulative								Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>		
	Weight	Btu			Pyritic sulfur	Total sulfur		Weight	Btu			Pyritic sulfur	Total sulfur			
TOP SIZE: 3/8																
Size fraction: 3/8 x 14																
Weight percent: 61.6																
Float- 1.30	87.8	91.1	11,269	11.0	0.18	0.96		87.8	91.1	11,269	11.0	0.18	0.96		1.7	
1.30 - 1.40	7.2	6.0	9,083	24.8	1.04	1.85		95.0	97.2	11,103	12.0	.25	1.03		1.9	
1.40 - 1.60	2.7	2.0	7,906	31.3	6.17	6.40		97.7	99.1	11,015	12.6	.41	1.17		2.1	
Sink - 1.60	2.3	.9	4,029	55.7	24.18	24.18		100.0	100.0	10,852	13.6	.96	1.71		3.2	
Size fraction: 14 x 100																
Weight percent: 38.4																
Float- 1.30	55.9	64.9	11,757	8.4	0.13	0.95		55.9	64.9	11,757	8.4	0.13	0.95		1.6	
1.30 - 1.40	27.8	28.0	10,195	16.3	.32	1.16		83.7	92.9	11,238	11.0	.19	1.02		1.8	
1.40 - 1.60	6.5	5.3	8,195	27.6	1.34	2.13		90.2	98.2	11,018	12.2	.28	1.10		2.0	
Sink - 1.60	9.8	1.8	1,843	82.3	2.80	2.95		100.0	100.0	10,121	19.1	.52	1.28		2.5	
Size composite: 3/8 x 100																
Weight percent: 100.0																
Float- 1.30	75.5	83.7	11,407	10.3	0.17	0.96		75.5	83.7	11,407	10.3	0.17	0.96		1.7	
1.30 - 1.40	15.1	21.6	9,868	18.8	.53	1.36		90.6	95.7	11,151	11.7	.23	1.02		1.8	
1.40 - 1.60	4.2	4.0	8,080	29.1	3.26	3.82		94.8	98.8	11,016	12.4	.36	1.15		2.1	
Sink - 1.60	5.2	1.5	2,448	74.9	8.72	8.83		100.0	100.0	10,571	15.7	.79	1.55		2.9	
Minus 100 mesh	12.6	10.8	10,134	18.7	.63	1.44		100.0	100.0	10,522	16.0	.78	1.53		2.9	
TOP SIZE: 14																
Size fraction: 14 x 0																
Weight percent: 100.0																
Float- 1.30	77.7	84.1	11,520	9.5	0.13	1.01	0.01	77.7	84.1	11,520	9.5	0.13	1.01	0.01	1.8	
1.30 - 1.40	12.7	11.5	9,700	18.7	0.31	1.11	.01	90.4	95.6	11,265	10.8	.16	1.02	.01	1.8	
1.40 - 1.60	3.8	2.6	7,322	35.0	2.47	3.20	.01	94.1	98.2	11,107	11.8	.25	1.11	.01	2.0	
Sink - 1.60	5.9	1.8	3,188	67.8	9.14	9.24	.01	100.0	100.0	10,642	15.0	.77	1.59	.01	3.0	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

gravity material would reduce the pyritic sulfur content 70 percent and reduce the SO<sub>2</sub> emissions from 3.1 to 2.0 pounds/MM Btu at a Btu recovery of 93.5 percent. This sample was taken from an outcropping near an abandoned strip mine.

Channel sample No. 4 was collected from an uncorrelated formation, Wilcox Group, Saline County, Arkansas. A section of the bed is described as follows:

Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
Carbonaceous shale	0	2
Lignite	2	11
<hr/>		
Total thickness of bed and sample	3	1

<sup>1</sup>Overlying bed: shale; floor: fireclay.

Table 9 shows the detailed washability analyses of sample No. 4. The composite washability sample contained an average of 6,410 Btu/lb, 41.0 percent ash, 0.15 percent pyritic sulfur, and 1.07 percent total sulfur. The sodium oxide content in the coal was 0.08 percent. This sample could not be upgraded to meet the current SO<sub>2</sub> emission standard since it contained an average of 0.92 percent organic sulfur. This sample was taken from a lignite bed associated with a bauxite mine. The lignite, however, is not being mined at this time.

Texas Lignite

Channel sample No. 5 was collected from the Lower Calvert formation, Wilcox Group, Freestone County, Texas. A section of the bed is described as follows:

Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
Lignite	5	6
<hr/>		
Total thickness of bed and sample	5	6

<sup>1</sup>Overlying bed: shale; floor: fireclay.

Table 10 shows the detailed washability analyses of sample No. 5. The composite washability sample contained an average of 11,213 Btu/lb, 10.2 percent ash, 0.09 percent pyritic sulfur, and 1.02 percent total sulfur. The sodium oxide content of the coal was 0.06 percent. This coal could not be upgraded to meet the current SO<sub>2</sub> emission standard

TABLE 9. - Detailed washability analyses of sample No. 4

STATE: Arkansas  
COUNTY: Saline

FORMATION: Uncorrelated  
GROUP: Wilcox

Product	Direct							Cumulative							Pounds, SO <sub>2</sub> /MM Btu
	Recovery, pct.		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	
	Weight	Btu		Ash	Pyritic sulfur	Total sulfur		Weight	Btu		Ash	Pyritic sulfur	Total sulfur		
TOP SIZE: 1-1/2															
Size fraction: 1-1/2 x 3/8															
Weight percent: 80.8															
Float- 1.30	46.0	62.5	9,072	19.5	0.20	1.59		46.0	62.5	9,072	19.5	0.20	1.59		3.5
1.30 - 1.40	13.1	14.0	7,165	34.6	.15	1.25		59.0	76.5	8,650	22.8	.19	1.51		3.5
1.40 - 1.60	20.9	15.7	5,011	52.8	.10	.77		80.0	92.2	7,697	30.7	.17	1.32		3.4
Sink - 1.60	20.0	7.8	2,592	70.2	.08	.43		100.0	100.0	6,674	38.6	.15	1.14		3.4
Size fraction: 3/8 x 14															
Weight percent: 15.0															
Float- 1.30	32.9	49.7	9,519	17.3	0.14	1.50		32.9	49.7	9,519	17.3	0.14	1.50		3.2
1.30 - 1.40	14.0	17.0	7,655	31.3	.12	1.30		46.9	66.7	8,963	21.5	.13	1.44		3.2
1.40 - 1.60	26.6	23.4	5,556	48.6	.16	.96		73.5	90.1	7,720	31.3	.14	1.27		3.3
Sink - 1.60	26.5	9.9	2,351	71.9	.47	.77		100.0	100.0	6,306	42.0	.23	1.14		3.6
Size fraction: 14 x 100															
Weight percent: 4.1															
Float- 1.30	17.2	30.5	10,042	13.8	0.09	1.56		17.2	30.5	10,042	13.8	0.09	1.56		3.1
1.30 - 1.40	11.3	17.2	8,633	24.4	.11	1.39		28.5	47.7	9,483	18.0	.10	1.49		3.1
1.40 - 1.60	25.1	29.1	6,584	39.3	.18	1.15		53.6	76.9	8,127	28.0	.14	1.33		3.3
Sink - 1.60	46.4	23.1	2,828	67.7	.59	.87		100.0	100.0	5,668	46.4	.35	1.12		3.9
Size composite: 1-1/2 x 100															
Weight percent: 100.0															
Float- 1.30	42.8	60.5	9,139	19.2	0.19	1.58		42.8	60.5	9,139	19.2	0.19	1.58		3.5
1.30 - 1.40	13.1	14.6	7,296	33.7	.14	1.26		55.9	74.6	8,707	22.6	.18	1.50		3.5
1.40 - 1.60	22.0	17.8	5,184	51.4	.11	.82		77.9	91.5	7,714	30.7	.16	1.31		3.4
Sink - 1.60	22.1	9.5	2,569	70.3	.19	.53		100.0	100.0	6,576	39.4	.17	1.14		3.5
Minus 100 mesh	1.0	1.0	6,475	42.4	.67	1.52		100.0	100.0	6,575	39.5	.17	1.14		3.5

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 9. - Detailed washability analyses of sample No. 4 (Con.)

STATE: Arkansas  
COUNTY: Saline

FORMATION: Uncorrelated  
GROUP: Wilcox

Direct								Cumulative							Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Percent				
	Weight	Btu		Ash	Pyritic sulfur	Total sulfur		Weight	Btu		Ash	Pyritic sulfur	Total sulfur	Na <sub>2</sub> O <sup>1</sup>	
TOP SIZE: 3/8															
Size fraction: 3/8 x 14															
Weight percent: 76.0															
Float- 1.30	40.9	58.7	9,552	17.8	0.13	1.52		40.9	58.7	9,552	17.8	0.13	1.52	3.2	
1.30 - 1.40	13.4	14.9	7,418	34.2	.12	1.23		54.3	73.7	9,025	21.8	.13	1.45	3.2	
1.40 - 1.60	21.1	17.4	5,472	50.3	.15	.90		75.3	91.0	8,031	29.8	.13	1.29	3.2	
Sink - 1.60	24.7	9.0	2,423	71.4	.11	.39		100.0	100.0	6,649	40.1	.13	1.07	3.2	
Size fraction: 14 x 100															
Weight percent: 24.0															
Float- 1.30	23.1	38.0	9,873	14.4	.08	1.52		23.1	38.0	9,873	14.4	0.08	1.52	3.1	
1.30 - 1.40	15.5	21.0	8,107	27.6	.12	1.35		38.6	59.0	9,163	19.7	.10	1.45	3.2	
1.40 - 1.60	21.6	22.0	6,118	41.9	.15	.98		60.2	81.0	8,072	27.7	.12	1.28	3.2	
Sink - 1.60	39.8	19.0	2,871	67.4	.24	.61		100.0	100.0	6,002	43.5	.16	1.01	3.4	
Size composite: 3/8 x 100															
Weight percent: 100.0															
Float- 1.30	36.6	55.6	9,600	17.3	0.12	1.52		36.6	55.6	9,600	17.3	0.12	1.52	3.2	
1.30 - 1.40	13.9	16.6	7,602	32.4	.12	1.26		50.5	71.0	9,050	21.5	.12	1.45	3.2	
1.40 - 1.60	21.2	18.5	5,629	48.3	.15	.92		71.7	89.0	8,039	29.4	.13	1.29	3.2	
Sink - 1.60	28.3	12.4	2,574	70.1	.15	.46		100.0	100.0	6,493	40.9	.14	1.06	3.3	
Minus 100 mesh	5.6	4.8	5,880	45.2	.49	1.29		100.0	100.0	6,461	41.1	.16	1.07	3.3	
TOP SIZE: 14															
Size fraction: 14 x 0															
Weight percent: 100.0															
Float- 1.30	26.7	42.3	9,830	16.1	0.09	1.47	0.06	26.7	42.3	9,830	16.1	0.09	1.47	0.06	3.0
1.30 - 1.40	15.7	20.4	8,032	29.4	.10	1.35	.07	42.4	62.7	9,164	21.0	.09	1.43	.06	3.1
1.40 - 1.60	28.3	25.6	5,607	48.1	.14	.95	.09	70.6	88.3	7,741	31.9	.11	1.24	.07	3.2
Sink - 1.60	29.4	11.7	2,479	71.2	.17	.45	.11	100.0	100.0	6,196	43.4	.13	1.00	.08	3.2

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.



TABLE 10. - Detailed washability analyses of sample No. 5

STATE: Texas  
COUNTY: Freestone

FORMATION: Lower Calvert  
GROUP: Wilcox

Product	Direct							Cumulative							Pounds, SO <sub>2</sub> /MM Btu
	Recovery, pct. Weight Btu Btu/lb			Percent			Na <sub>2</sub> O <sup>1</sup>	Recovery, pct. Weight Btu Btu/lb			Percent				
				Ash	Pyritic sulfur	Total sulfur					Ash	Pyritic sulfur	Total sulfur	Na <sub>2</sub> O <sup>1</sup>	
TOP SIZE: 1-1/2															
Size fraction: 1-1/2 x 3/8															
Weight percent: 77.7															
Float- 1.30	96.8	97.2	11,303	9.7	0.01	0.77		96.8	97.2	11,303	9.7	0.01	0.77		1.4
1.30 - 1.40	2.8	2.6	10,331	16.3	.02	.77		99.6	99.8	11,277	9.9	.01	.77		1.4
1.40 - 1.60	.2	.2	8,710	29.2	.35	1.62		99.8	99.9	11,272	9.9	.01	.77		1.4
Sink - 1.60	.2	.1	4,717	50.6	19.99	22.20		100.0	100.0	11,259	10.0	.05	.81		1.4
Size fraction: 3/8 x 14															
Weight percent: 17.9															
Float- 1.30	68.2	70.6	11,419	8.4	0.04	0.97		68.2	70.6	11,419	8.4	0.04	0.97		1.7
1.30 - 1.40	28.2	27.3	10,679	12.6	.02	0.89		96.4	97.9	11,203	9.6	.03	.95		1.7
1.40 - 1.60	2.0	1.6	8,897	25.5	.08	.76		98.4	99.6	11,155	10.0	.04	.94		1.7
Sink - 1.60	1.6	.4	3,004	63.0	8.86	10.01		100.0	100.0	11,024	10.8	.18	1.09		2.0
Size fraction: 14 x 100															
Weight percent: 4.4															
Float- 1.30	7.5	8.4	11,927	7.8	0.13	1.11		7.5	8.4	11,927	7.8	0.13	1.11		1.9
1.30 - 1.40	69.0	74.1	11,311	8.2	.02	.98		76.5	82.5	11,371	8.2	.03	.99		1.7
1.40 - 1.60	15.6	15.1	10,210	14.5	.03	.88		92.1	97.6	11,174	9.2	.03	.97		1.7
Sink - 1.60	7.9	2.4	3,143	55.0	1.06	1.69		100.0	100.0	10,537	12.9	.11	1.03		2.0
Size composite: 1-1/2 x 100															
Weight percent: 100.0															
Float- 1.30	87.7	93.1	11,321	9.5	0.01	0.80		87.7	93.1	11,321	9.5	0.01	0.80		1.4
1.30 - 1.40	10.3	35.9	10,802	12.1	.02	.89		98.0	98.8	11,266	9.8	.02	.81		1.4
1.40 - 1.60	1.2	9.2	9,626	19.7	.09	.94		99.2	99.8	11,247	9.9	.02	.81		1.4
Sink - 1.60	.8	1.2	3,396	57.1	7.56	8.68		100.0	100.0	11,184	10.3	.08	.87		1.6
Minus 100 mesh	.6	.5	9,893	19.8	.13	1.12		100.0	100.0	11,177	10.3	.08	.87		1.6

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 10. - Detailed washability analyses of sample No. 5 (Con.)

STATE: Texas  
COUNTY: Freestone

FORMATION: Lower Calvert  
GROUP: Wilcox

Direct								Cumulative								Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Ash	Percent				
	Weight	Btu			Pyritic sulfur	Total sulfur		Weight	Btu			Pyritic sulfur	Total sulfur			
TOP SIZE: 3/8																
Size fraction:		3/8 x 14														
Weight percent:		65.3														
Float- 1.30	79.1	80.6	11,441	8.0	0.01	0.97		79.1	80.6	11,441	8.0	0.01	0.97		1.7	
1.30 - 1.40	19.1	18.2	10,708	13.3	.01	.95		98.2	98.8	11,298	9.0	.01	.97		1.7	
1.40 - 1.60	1.1	.9	9,217	24.2	.05	.80		99.3	99.8	11,274	9.2	.01	.96		1.7	
Sink - 1.60	.7	.2	4,064	57.8	14.52	15.99		100.0	100.0	11,225	9.5	.11	1.07		1.9	
Size fraction:		14 x 100														
Weight percent:		34.7														
Float- 1.30	20.4	21.9	11,889	6.9	0.05	1.05		20.4	21.9	11,889	6.9	0.05	1.05		1.8	
1.30 - 1.40	67.4	68.4	11,249	8.8	.03	.98		87.8	90.2	11,398	8.4	.03	1.00		1.7	
1.40 - 1.60	10.0	9.0	10,041	16.3	.02	.87		97.8	99.2	11,259	9.2	.03	.98		1.7	
Sink - 1.60	2.2	.8	3,883	57.0	1.70	2.17		100.0	100.0	11,097	10.2	.07	1.01		1.8	
Size composite:		3/8 x 100														
Weight percent:		100.0														
Float- 1.30	58.7	73.5	11,494	7.9	0.01	0.98		58.7	73.5	11,494	7.9	0.01	0.98		1.7	
1.30 - 1.40	35.8	50.9	11,060	10.4	.02	.97		94.6	96.0	11,330	8.8	.02	.98		1.7	
1.40 - 1.60	4.2	7.6	9,894	17.7	.03	.86		98.8	99.6	11,269	9.2	.02	.97		1.7	
Sink - 1.60	1.2	.6	3,949	57.3	6.43	7.27		100.0	100.0	11,180	9.8	.10	1.05		1.9	
Minus 100 mesh	10.3	9.1	10,875	13.2	.06	1.02		100.0	100.0	11,152	10.1	.09	1.04		1.9	
TOP SIZE: 14																
Size fraction:		14 x 0														
Weight percent:		100.0														
Float- 1.30	22.0	23.2	11,975	7.2	0.03	0.97	0.03	22.0	23.2	11,975	7.2	0.03	0.97	0.03	1.6	
1.30 - 1.40	66.7	68.0	11,528	8.6	.02	.98	.08	88.7	91.2	11,639	8.3	.02	.98	.06	1.7	
1.40 - 1.60	9.2	8.2	10,089	16.0	.03	.90	.07	97.8	99.4	11,494	9.0	.02	.97	.06	1.7	
Sink - 1.60	2.2	.6	3,112	63.4	3.06	3.68	.06	100.0	100.0	11,311	10.2	.09	1.03	.06	1.8	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

since the average organic sulfur content was 0.93 percent. This coal contained relatively low ash and there would be little benefit to fine size crushing. None of this coal is washed.

Channel sample No. 6 was collected from the Lower Calvert formation, Wilcox Group, Freestone County, Texas. A section of the bed is described as follows:

Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
<u>Lignite</u>	5	4
Total thickness of bed and sample	5	4

<sup>1</sup>Overlying bed: shale; floor: fireclay.

Table 11 shows the detailed washability analyses of sample No. 6. The composite washability sample contained an average of 10,851 Btu/lb, 13.3 percent ash, 0.36 percent pyritic sulfur, and 1.16 percent total sulfur. The sodium oxide content in the coal was 0.03 percent. Since this coal contained an average of 0.80 percent organic sulfur, it could not be upgraded to meet the current SO<sub>2</sub> emission standard. Crushing to 14 mesh top size and removing the sink 1.40 specific gravity material would provide a product analyzing 9.9 percent ash which would represent an ash reduction of 27 percent. None of this coal is washed.

Channel sample No. 7 was collected from an uncorrelated formation, Wilcox Group, Harrison County, Texas. A section of the bed is described as follows:

Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
<u>Lignite</u>	7	2
Total thickness of bed and sample	7	2

<sup>1</sup>Overlying bed: shale; floor: fireclay.

Table 12 shows the detailed washability analyses of sample No. 7. The composite washability sample contained an average of 11,263 Btu/lb, 9.3 percent ash, 0.07 percent pyritic sulfur, and 0.80 percent total sulfur. The sodium oxide content in the coal was 0.11 percent. This sample could not be upgraded to meet the current SO<sub>2</sub> emission standard since it contained an average of 0.73 percent organic sulfur. The ash content of this coal was low and crushing would provide minimal benefit. None of this coal is washed.

TABLE 11. - Detailed washability analyses of sample No. 6

STATE: Texas  
COUNTY: Freestone

FORMATION: Lower Calvert  
GROUP: Wilcox

Direct							Cumulative							Pounds, SO2/MM Btu	
Product	Recovery, pct.		Btu/lb	Percent			Na2O <sup>1</sup>	Recovery, pct.		Btu/lb	Percent				
	Weight	Btu		Ash	Pyritic sulfur	Total sulfur		Weight	Btu		Ash	Pyritic sulfur	Total sulfur		Na2O <sup>1</sup>
TOP SIZE: 1-1/2															
Size fraction: 1-1/2 x 3/8															
Weight percent: 77.3															
Float- 1.30	84.7	87.5	11,249	10.5	0.11	0.97		84.7	87.5	11,249	10.5	0.11	0.97	1.7	
1.30 - 1.40	11.0	10.0	9,869	20.0	.17	.99		95.8	97.5	11,090	11.6	.12	.97	1.8	
1.40 - 1.60	2.9	1.9	7,112	40.2	.55	1.20		98.7	99.5	10,972	12.4	.13	.98	1.8	
Sink - 1.60	1.3	.5	4,538	53.8	7.81	7.81		100.0	100.0	10,888	13.0	.23	1.07	2.0	
Size fraction: 3/8 x 14															
Weight percent: 18.7															
Float- 1.30	73.0	77.6	11,351	9.1	0.09	0.99		73.0	77.6	11,351	9.1	0.09	0.99	1.7	
1.30 - 1.40	18.9	18.0	10,150	17.6	.22	1.06		91.9	95.6	11,104	10.9	.12	1.00	1.8	
1.40 - 1.60	4.3	3.0	7,515	36.0	.72	1.31		96.2	98.6	10,943	12.0	.14	1.02	1.9	
Sink - 1.60	3.8	1.4	3,907	55.2	10.16	10.19		100.0	100.0	10,678	13.6	.52	1.36	2.6	
Size fraction: 14 x 100															
Weight percent: 3.9															
Float- 1.30	9.0	10.6	11,884	7.2	0.10	1.02		9.0	10.6	11,884	7.2	0.10	1.02	1.7	
1.30 - 1.40	64.1	70.9	11,246	9.8	.09	.98		73.2	81.4	11,325	9.5	.09	.98	1.7	
1.40 - 1.60	14.6	13.6	9,478	20.0	.29	1.06		87.7	95.0	11,018	11.2	.12	1.00	1.8	
Sink - 1.60	12.3	5.0	4,152	54.3	3.09	3.84		100.0	100.0	10,177	16.5	.49	1.35	2.6	
Size composite: 1-1/2 x 100															
Weight percent: 100.0															
Float- 1.30	79.6	85.5	11,269	10.2	0.11	0.97		79.6	85.5	11,269	10.2	0.11	0.97	1.7	
1.30 - 1.40	14.6	22.5	10,175	17.7	.17	1.01		94.2	96.7	11,099	11.4	.12	.98	1.8	
1.40 - 1.60	3.7	4.0	7,572	36.1	.55	1.20		97.8	99.1	10,967	12.3	.13	.99	1.8	
Sink - 1.60	2.2	1.8	4,250	54.4	7.53	7.70		100.0	100.0	10,820	13.2	.29	1.13	2.1	
Minus 100 mesh	.7	.6	9,357	24.0	.61	1.45		100.0	100.0	10,811	13.3	.30	1.14	2.1	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 11. - Detailed washability analyses of sample No. 6 (Con.)

STATE: Texas  
COUNTY: Freestone

FORMATION: Lower Calvert  
GROUP: Wilcox

Direct								Cumulative								Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>		
	Weight	Btu		Ash	Pyritic sulfur	Total sulfur		Weight	Btu		Ash	Pyritic sulfur	Total sulfur			
TOP SIZE: 3/8																
Size fraction: 3/8 x 14																
Weight percent: 63.4																
Float- 1.30	75.2	78.4	11,429	8.8	0.07	0.92		75.2	78.4	11,429	8.8	0.07	0.92		1.6	
1.30 - 1.40	19.2	18.0	10,301	16.3	.16	.97		94.4	96.4	11,200	10.3	.09	.93		1.7	
1.40 - 1.60	3.6	2.6	8,069	32.3	.29	.96		98.0	99.0	11,086	11.1	.10	.93		1.7	
Sink - 1.60	2.0	1.0	5,391	47.9	9.14	9.52		100.0	100.0	10,970	11.9	.28	1.11		2.0	
Size fraction: 14 x 100																
Weight percent: 36.6																
Float- 1.30	39.7	42.8	11,777	7.6	0.06	0.95		39.7	42.8	11,777	7.6	0.06	0.95		1.6	
1.30 - 1.40	50.1	50.4	11,035	11.6	.10	.95		89.8	93.5	11,363	9.8	.08	.95		1.7	
1.40 - 1.60	6.7	5.1	8,337	28.3	.44	1.01		96.5	98.6	11,152	11.1	.11	.95		1.7	
Sink - 1.60	3.5	1.4	4,478	52.4	4.64	5.15		100.0	100.0	10,922	12.5	.26	1.10		2.0	
Size composite: 3/8 x 100																
Weight percent: 100.0																
Float- 1.30	62.2	70.0	11,510	8.5	0.07	0.93		62.2	70.0	11,510	8.5	0.07	.93		1.6	
1.30 - 1.40	30.5	37.7	10,742	13.5	.12	.96		92.7	95.3	11,257	10.1	.09	.94		1.7	
1.40 - 1.60	4.7	3.9	8,208	30.2	.37	.99		97.4	98.8	11,109	11.1	.10	.94		1.7	
Sink - 1.60	2.6	1.2	4,938	50.1	6.91	7.36		100.0	100.0	10,952	12.1	.27	1.10		2.0	
Minus 100 mesh	9.8	8.6	10,437	16.5	.30	1.20		100.0	100.0	10,905	12.5	.28	1.11		2.0	
TOP SIZE: 14																
Size fraction: 14 x 0																
Weight percent: 100.0																
Float- 1.30	56.3	60.6	11,769	8.2	0.08	0.94	0.03	56.3	60.6	11,769	8.2	0.08	0.94	0.03	1.6	
1.30 - 1.40	31.6	31.8	10,984	12.9	.11	.95	.03	87.9	92.4	11,487	9.9	.09	.94	.03	1.6	
1.40 - 1.60	8.1	6.4	8,604	28.2	.33	1.06	.04	96.0	98.8	11,242	11.4	.11	.95	.03	1.7	
Sink - 1.60	4.0	1.2	3,235	63.3	8.93	7.19	.06	100.0	100.0	10,923	13.5	.46	1.20	.03	2.2	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 12. - Detailed washability analyses of sample No. 7

STATE: Texas  
COUNTY: Harrison

FORMATION: Uncorrelated  
GROUP: Wilcox

Direct								Cumulative							
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Pounds, SO <sub>2</sub> /MM Btu
	Weight	Btu			Pyritic sulfur	Total sulfur		Weight	Btu			Pyritic sulfur	Total sulfur		
TOP SIZE: 1-1/2															
Size fraction: 1-1/2 x 3/8															
Weight percent: 79.2															
Float- 1.30	98.8	99.1	11,320	9.2	0.06	0.77		98.8	99.1	11,320	9.2	0.06	0.77		1.4
1.30 - 1.40	.9	.8	9,631	21.9	.17	.80		99.7	99.8	11,305	9.3	.06	.77		1.4
1.40 - 1.60	.2	.1	7,750	34.5	.28	.66		99.9	100.0	11,298	9.4	.06	.77		1.4
Sink - 1.60	.1	.0	3,250	66.3	.66	.95		100.0	100.0	11,289	9.4	.06	.77		1.4
Size fraction: 3/8 x 14															
Weight percent: 17.2															
Float- 1.30	95.2	96.4	11,246	8.7	0.04	0.83		95.2	96.4	11,246	8.7	0.04	0.83		1.5
1.30 - 1.40	3.1	2.7	9,897	18.7	.22	.83		98.3	99.2	11,204	9.0	.05	.83		1.5
1.40 - 1.60	1.0	.7	7,540	36.0	.51	.92		99.3	99.8	11,167	9.3	.05	.83		1.5
Sink - 1.60	.7	.2	2,450	72.0	2.88	2.93		100.0	100.0	11,105	9.7	.07	.85		1.5
Size fraction: 14 x 100															
Weight percent: 3.5															
Float- 1.30	56.2	58.4	11,294	8.2	0.03	0.81		56.2	58.4	11,294	8.2	0.03	0.81		1.4
1.30 - 1.40	32.6	32.9	10,949	10.4	.09	.78		88.7	91.3	11,167	9.0	.05	.80		1.4
1.40 - 1.60	8.4	7.7	9,969	15.4	.20	.83		97.1	99.0	11,064	9.6	.06	.80		1.4
Sink - 1.60	2.8	1.0	3,780	62.6	2.39	2.47		100.0	100.0	10,853	11.1	.13	.85		1.6
Size composite: 1-1/2 x 100															
Weight percent: 100.0															
Float- 1.30	96.7	97.8	11,306	9.1	0.06	0.78		96.7	97.8	11,306	9.1	0.06	0.78		1.4
1.30 - 1.40	2.4	16.6	10,320	15.7	.14	.80		99.1	99.5	11,282	9.3	.06	.78		1.4
1.40 - 1.60	.6	3.9	8,755	25.8	.30	.81		99.7	99.9	11,267	9.4	.06	.78		1.4
Sink - 1.60	.3	.4	3,110	67.3	2.09	2.22		100.0	100.0	11,241	9.5	.07	.79		1.4
Minus 100 mesh	1.0	.9	10,225	16.6	.19	.86		100.0	100.0	11,231	9.6	.07	.79		1.4

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 12. - Detailed washability analyses of sample No. 7 (Con.)

STATE: Texas  
COUNTY: Harrison

FORMATION: Uncorrelated  
GROUP: Wilcox

Product	Direct							Cumulative							Pounds, SO <sub>2</sub> /MM Btu
	Recovery, pct.		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	
	Weight	Btu		Ash	Pyritic sulfur	Total sulfur		Weight	Btu		Ash	Pyritic sulfur	Total sulfur		
TOP SIZE: 3/8															
Size fraction: 3/8 x 14															
Weight percent: 64.9															
Float- 1.30	95.9	96.6	11,291	8.6	0.06	0.82		95.9	96.6	11,291	8.6	0.06	0.82		1.5
1.30 - 1.40	3.1	2.8	10,174	17.1	.20	.84		99.0	99.4	11,256	8.9	.06	.82		1.5
1.40 - 1.60	.7	.5	7,660	35.1	.61	1.14		99.7	99.9	11,229	9.1	.07	.82		1.5
Sink - 1.60	.3	.1	3,160	67.0	3.93	3.96		100.0	100.0	11,208	9.2	.08	.83		1.5
Size fraction: 14 x 100															
Weight percent: 35.1															
Float- 1.30	68.5	69.9	11,415	8.0	0.03	0.78		68.5	69.9	11,415	8.0	0.03	0.78		1.4
1.30 - 1.40	26.1	25.8	11,040	10.0	.06	.82		94.7	95.7	11,311	8.7	.04	.79		1.4
1.40 - 1.60	4.4	3.8	9,690	18.0	.15	.80		99.1	99.5	11,239	9.1	.04	.79		1.4
Sink - 1.60	.9	.5	5,330	50.6	1.57	1.94		100.0	100.0	11,184	9.5	.06	.80		1.4
Size composite: 3/8 x 100															
Weight percent: 100.0															
Float- 1.30	86.3	89.1	11,325	8.4	0.05	0.81		86.3	89.1	11,325	8.4	0.05	0.81		1.4
1.30 - 1.40	11.2	21.7	10,883	11.8	.09	.82		97.5	98.2	11,274	8.8	.06	.81		1.4
1.40 - 1.60	2.0	3.0	9,208	22.1	.26	.88		99.5	99.8	11,232	9.1	.06	.81		1.4
Sink - 1.60	.5	.3	4,589	56.2	2.38	2.63		100.0	100.0	11,199	9.3	.07	.82		1.5
Minus 100 mesh	11.0	9.8	11,047	11.7	.10	.82		100.0	100.0	11,184	9.6	.07	.82		1.5
TOP SIZE: 14															
Size fraction: 14 x 0															
Weight percent: 100.0															
Float- 1.30	80.7	81.7	11,523	7.7	0.04	0.80	0.11	80.7	81.7	11,523	7.7	0.04	0.80	0.11	1.4
1.30 - 1.40	17.1	16.7	11,105	10.6	.09	.73	.11	97.7	98.4	11,450	8.2	.05	.79	.11	1.4
1.40 - 1.60	1.9	1.5	9,183	24.4	.44	.84	.09	99.6	99.9	11,407	8.5	.06	.79	.11	1.4
Sink - 1.60	.4	.1	2,972	72.1	3.08	3.10	.09	100.0	100.0	11,374	8.8	.07	.80	.11	1.4

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

Channel sample No. 8 was collected from the Lower Calvert formation, Wilcox Group, in Milam County, Texas. A section of the bed is described as follows:

Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
Lignite	3	3
Shale		7
Lignite	4	1
Shale		1
Lignite	4	0
<hr/>		
Total thickness of bed and sample	12	0

<sup>1</sup>Overlying bed: shale; floor: fireclay.

Table 13 shows the detailed washability analyses of sample No. 8. The composite washability sample contained an average of 9,948 Btu/lb, 19.8 percent ash, 0.15 percent pyritic sulfur, and 1.31 percent total sulfur. The sodium oxide content in the coal was 0.04 percent. This coal could not be upgraded to meet the current SO<sub>2</sub> emission standard of 1.2 pounds SO<sub>2</sub>/MM Btu since it contained an average of 1.16 percent organic sulfur. Crushing to 3/8 inch top size and removing the sink 1.40 specific gravity material of the composite sample would provide a product analyzing 11.5 percent ash at a Btu recovery of 90.1 percent. The ash reduction would be 42 percent. None of this coal is washed.

Channel sample No. 9 was collected from an uncorrelated formation, Wilcox Group, in Panola County, Texas. A section of the bed is described as follows:

Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
Lignite	7	7
<hr/>		
Total thickness of bed and sample	7	7

<sup>1</sup>Overlying bed: shale, floor; fireclay.

Table 14 shows the detailed washability analyses of sample No. 9. The composite washability sample contained an average of 11,200 Btu/lb, 8.6 percent ash, 0.26 percent pyritic sulfur, and 1.32 percent total sulfur. The sodium oxide content of the coal was 0.08 percent. This sample contained an average of 1.06 percent organic sulfur and could not be upgraded to meet the current SO<sub>2</sub> emission standard. Crushing to 3/8



TABLE 13. - Detailed washability analyses of sample No. 8

STATE: Texas  
COUNTY: Milam

FORMATION: Lower Calvert  
GROUP: Wilcox

Direct								Cumulative								Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>		
	Weight	Btu			Pyritic sulfur	Total sulfur		Weight	Btu			Pyritic sulfur	Total sulfur			
TOP SIZE: 1-1/2																
Size fraction: 1-1/2 x 3/8																
Weight percent: 78.5																
Float- 1.30	79.8	86.6	11,130	11.6	0.04	1.36		79.8	86.6	11,130	11.6	0.04	1.36		2.4	
1.30 - 1.40	10.2	9.3	9,321	24.6	.31	1.61		90.0	95.9	10,925	13.1	.07	1.39		2.5	
1.40 - 1.60	3.7	2.6	7,114	40.6	.25	1.06		93.7	98.4	10,775	14.2	.08	1.38		2.6	
Sink - 1.60	6.3	1.6	2,561	70.9	.78	1.20		100.0	100.0	10,261	17.7	.12	1.36		2.7	
Size fraction: 3/8 x 14																
Weight percent: 17.7																
Float- 1.30	64.6	76.9	10,959	11.8	0.06	1.44		64.6	76.9	10,959	11.8	0.06	1.44		2.6	
1.30 - 1.40	13.9	14.3	9,514	22.7	.15	1.36		78.5	91.2	10,764	13.7	.08	1.43		2.7	
1.40 - 1.60	6.4	5.2	7,437	37.7	.18	1.07		84.9	96.4	10,458	15.5	.08	1.40		2.7	
Sink - 1.60	15.1	3.6	2,215	74.3	1.20	1.73		100.0	100.0	9,210	24.4	.25	1.45		3.1	
Size fraction: 14 x 100																
Weight percent: 3.8																
Float- 1.30	45.5	58.0	11,753	8.6	0.04	1.31		45.5	58.0	11,753	8.6	0.04	1.31		2.2	
1.30 - 1.40	17.8	21.3	11,042	12.0	.07	1.37		63.3	79.3	11,554	9.6	.05	1.33		2.3	
1.40 - 1.60	14.4	13.9	8,876	26.7	.16	1.26		77.8	93.2	11,056	12.7	.07	1.31		2.4	
Sink - 1.60	22.2	6.8	2,828	69.9	.92	1.25		100.0	100.0	9,226	25.5	.26	1.30		2.8	
Size composite: 1-1/2 x 100																
Weight percent: 100.0																
Float- 1.30	75.9	84.5	11,118	11.6	0.04	1.37		75.9	84.5	11,118	11.6	0.04	1.37		2.5	
1.30 - 1.40	11.1	11.1	9,467	23.4	.26	1.54		87.0	94.7	10,907	13.1	.07	1.39		2.6	
1.40 - 1.60	4.6	4.6	7,403	38.2	.22	1.09		91.6	97.9	10,731	14.3	.08	1.38		2.6	
Sink - 1.60	8.4	2.7	2,477	71.9	.93	1.37		100.0	100.0	10,035	19.2	.15	1.38		2.8	
Minus 100 mesh	1.1	1.2	10,979	22.7	.16	.94		100.0	100.0	10,045	19.2	.15	1.37		2.7	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 13. - Detailed washability analyses of sample No. 8 (Con.)

STATE: Texas  
COUNTY: Milam

FORMATION: Lower Calvert  
GROUP: Wilcox

Direct								Cumulative								Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>		
	Weight	Btu			Pyritic sulfur	Total sulfur		Weight	Btu			Pyritic sulfur	Total sulfur			
TOP SIZE: 3/8																
Size fraction: 3/8 x 14																
Weight percent: 70.2																
Float- 1.30	69.0	78.0	11,299	10.0	0.04	1.33		69.0	78.0	11,299	10.0	0.04	1.33		2.4	
1.30 - 1.40	15.0	14.7	9,796	21.0	.17	1.46		84.1	92.7	11,030	12.0	.06	1.35		2.5	
1.40 - 1.60	6.8	5.1	7,481	37.3	.13	1.07		90.9	97.8	10,764	13.9	.07	1.33		2.5	
Sink - 1.60	9.1	2.2	2,367	72.7	1.49	1.72		100.0	100.0	9,998	19.2	.20	1.37		2.7	
Size fraction: 14 x 100																
Weight percent: 29.8																
Float- 1.30	40.6	48.0	11,700	8.3	0.02	1.32		40.6	48.0	11,700	8.3	0.02	1.32		2.3	
1.30 - 1.40	31.4	34.9	11,008	12.3	.05	1.33		72.0	83.0	11,398	10.0	.03	1.32		2.3	
1.40 - 1.60	14.8	13.0	8,662	27.8	.14	1.20		86.8	95.9	10,932	13.1	.05	1.30		2.4	
Sink - 1.60	13.2	4.1	3,070	67.5	.62	.97		100.0	100.0	9,896	20.2	.13	1.26		2.5	
Size composite: 3/8 x 100																
Weight percent: 100.0																
Float- 1.30	60.6	72.0	11,379	9.7	0.04	1.33		60.6	72.0	11,379	9.7	0.04	1.33		2.3	
1.30 - 1.40	19.9	24.2	10,365	16.9	.11	1.40		80.5	90.1	11,128	11.5	.06	1.35		2.4	
1.40 - 1.60	9.2	8.9	8,047	32.7	.13	1.13		89.7	97.3	10,812	13.6	.06	1.32		2.4	
Sink - 1.60	10.3	2.9	2,633	70.7	1.16	1.44		100.0	100.0	9,967	19.5	.18	1.34		2.7	
Minus 100 mesh	9.2	8.1	9,580	24.4	.16	1.20		100.0	100.0	9,935	19.9	.18	1.32		2.7	
TOP SIZE: 14																
Size fraction: 14 x 0																
Weight percent: 100.0																
Float- 1.30	56.1	65.0	11,434	9.6	0.03	1.30	0.03	56.1	65.0	11,434	9.6	0.03	1.30	0.03	2.3	
1.30 - 1.40	23.4	24.5	10,304	17.3	.09	1.29	.03	79.5	89.4	11,101	11.9	.05	1.30	.03	2.3	
1.40 - 1.60	9.9	8.1	8,064	32.6	.14	1.11	.04	89.3	97.5	10,766	14.2	.06	1.28	.03	2.4	
Sink - 1.60	10.7	2.5	2,318	71.9	.75	.97	.09	100.0	100.0	9,865	20.3	.13	1.24	.04	2.5	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 14. - Detailed washability analyses of sample No. 9

STATE: Texas  
COUNTY: Panola

FORMATION: Uncorrelated  
GROUP: Wilcox

Direct								Cumulative								Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>		
	Weight	Btu			Pyritic sulfur	Total sulfur		Weight	Btu			Pyritic sulfur	Total sulfur			
TOP SIZE: 1-1/2																
Size fraction: 1-1/2 x 3/8																
Weight percent: 79.3																
Float- 1.30	97.0	97.5	11,334	6.9	0.09	1.30		97.0	97.5	11,334	6.9	0.09	1.30		2.3	
1.30 - 1.40	2.5	2.1	9,829	20.3	.86	2.90		99.4	99.7	11,297	7.2	.11	1.34		2.4	
1.40 - 1.60	.4	.3	8,974	26.2	1.82	2.78		99.8	100.0	11,288	7.3	.12	1.34		2.4	
Sink - 1.60	.2	.0	2,216	77.8	2.63	2.97		100.0	100.0	11,271	7.4	.12	1.35		2.4	
Size fraction: 3/8 x 14																
Weight percent: 16.5																
Float- 1.30	89.9	92.3	11,310	8.4	0.16	1.08		89.9	92.3	11,310	8.4	0.16	1.08		1.9	
1.30 - 1.40	5.8	5.4	10,290	16.0	.55	1.42		95.7	97.7	11,248	8.9	.18	1.10		2.0	
1.40 - 1.60	2.3	1.7	8,447	29.1	1.26	1.99		98.0	99.5	11,184	9.3	.21	1.12		2.0	
Sink - 1.60	2.0	.5	2,830	66.1	17.70	17.71		100.0	100.0	11,014	10.5	.56	1.46		2.6	
Size fraction: 14 x 100																
Weight percent: 4.2																
Float- 1.30	55.4	59.1	11,708	6.0	0.05	1.03		55.4	59.1	11,708	6.0	0.05	1.03		1.8	
1.30 - 1.40	30.3	31.3	11,325	8.0	.07	.99		85.7	90.4	11,573	6.7	.06	1.02		1.8	
1.40 - 1.60	7.9	7.1	9,868	15.6	.26	1.04		93.6	97.5	11,428	7.5	.07	1.02		1.8	
Sink - 1.60	6.4	2.5	4,294	56.5	11.43	11.68		100.0	100.0	10,975	10.6	.80	1.70		3.1	
Size composite: 1-1/2 x 100																
Weight percent: 100.0																
Float- 1.30	94.1	95.8	11,339	7.1	0.10	1.26		94.1	95.8	11,339	7.1	0.10	1.26		2.2	
1.30 - 1.40	4.2	11.7	10,388	15.6	.55	1.98		98.3	99.0	11,299	7.5	.12	1.29		2.3	
1.40 - 1.60	1.0	3.1	9,073	23.8	1.09	1.91		99.3	99.8	11,276	7.6	.13	1.30		2.3	
Sink - 1.60	.7	1.1	3,226	65.0	12.47	12.63		100.0	100.0	11,216	8.1	.22	1.38		2.5	
Minus 100 mesh	1.2	1.0	9,856	20.1	.49	1.51		100.0	100.0	11,200	8.2	.22	1.38		2.5	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 14. - Detailed washability analyses of sample No. 9 (Con.)

STATE: Texas  
COUNTY: Panola

FORMATION: Uncorrelated  
GROUP: Wilcox

Direct								Cumulative							
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.	Btu	Btu/lb	Ash	Percent		Pounds, SO <sub>2</sub> /MM Btu	
	Weight	Btu			Pyritic sulfur	Total sulfur						Weight	Btu		Pyritic sulfur
TOP SIZE: 3/8															
Size fraction: 3/8 x 14															
Weight percent: 68.5															
Float- 1.30	92.2	93.6	11,448	6.9	0.07	1.09		92.2	93.5	11,448	6.9	0.07	1.09	1.9	
1.30 - 1.40	4.9	4.6	10,383	16.0	.31	1.16		97.1	98.2	11,394	7.4	.08	1.09	1.9	
1.40 - 1.60	2.0	1.6	8,986	25.8	.72	1.46		99.1	99.7	11,346	7.7	.09	1.10	1.9	
Sink - 1.60	.9	.3	3,184	64.9	19.20	19.20		100.0	100.0	11,271	8.3	.27	1.27	2.2	
Size fraction: 14 x 100															
Weight percent: 31.8															
Float- 1.30	70.3	72.9	11,647	6.2	0.04	1.04		70.3	72.9	11,647	6.2	0.04	1.04	1.8	
1.30 - 1.40	20.3	20.2	11,175	9.2	.09	.98		90.6	93.2	11,541	6.9	.05	1.03	1.8	
1.40 - 1.60	6.6	5.8	9,906	16.3	.24	.99		97.2	99.0	11,430	7.5	.06	1.02	1.8	
Sink - 1.60	2.8	1.0	4,022	58.6	9.29	9.34		100.0	100.0	11,219	9.0	.33	1.26	2.2	
Size composite: 3/8 x 100															
Weight percent: 100.0															
Float- 1.30	85.3	88.3	11,499	6.7	0.06	1.08		85.3	88.3	11,499	6.7	0.06	1.08	1.9	
1.30 - 1.40	9.8	14.8	10,900	11.6	.17	1.04		95.0	96.7	11,438	7.2	.07	1.07	1.9	
1.40 - 1.60	3.4	4.2	9,542	20.0	.43	1.18		98.5	99.5	11,371	7.7	.09	1.08	1.9	
Sink - 1.60	1.5	.7	3,677	61.2	13.36	13.39		100.0	100.0	11,255	8.5	.29	1.26	2.2	
Minus 100 mesh	10.1	8.7	10,654	13.7	.29	1.77		100.0	100.0	11,199	9.0	.29	1.31	2.3	
TOP SIZE: 14															
Size fraction: 14 x 0															
Weight percent: 100.0															
Float- 1.30	77.0	78.7	11,449	6.5	0.06	1.03	0.07	77.0	78.7	11,449	6.5	0.06	1.03	0.07	1.8
1.30 - 1.40	19.6	19.3	11,051	10.6	.12	1.19	.10	96.6	98.0	11,368	7.3	.07	1.06	.08	1.9
1.40 - 1.60	2.0	1.6	9,264	23.5	.49	1.07	.08	98.5	99.6	11,326	7.7	.08	1.06	.08	1.9
Sink - 1.60	1.5	.4	2,829	68.6	13.73	14.93	.06	100.0	100.0	11,202	8.5	.28	1.27	.08	2.3

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

inch top size and removing the sink 1.30 specific gravity material would provide a product analyzing 6.7 percent ash at a Btu recovery of 88.3 percent. The ash reduction would be 26 percent. None of this coal is washed.

Channel sample No. 10 was collected from an uncorrelated formation, Wilcox Group, in Titus County, Texas. A section of the bed is described as follows:

Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
Lignite	1	0
Carbonaceous shale		6
Lignite	1	4
Carbonaceous shale		3
Lignite	1	11
<hr/>		
Total thickness of bed and sample	7	0

<sup>1</sup>Overlying bed: shale; floor: fireclay.

Table 15 shows the detailed washability analyses of sample No. 10. The composite washability sample contained an average of 10,122 Btu/lb, 17.0 percent ash, 0.10 percent pyritic sulfur, and 0.83 percent total sulfur. The sodium oxide content in the coal was 0.09 percent. This sample contained an average of 0.73 percent organic sulfur and could not be upgraded to meet the current SO<sub>2</sub> emission standard. Crushing to 3/8 inch top size and removing the sink 1.40 specific gravity material would provide a product analyzing 12.2 percent ash, at a Btu recovery of 91.8 percent. The ash reduction would be 29 percent. None of this coal is washed.

Channel sample No. 11 was collected from a Yegua formation, Clairborne Group, in Angelina County, Texas. A section of the bed is described as follows:

Bed Section<sup>1</sup>

	<u>Feet</u>	<u>Inches</u>
Lignite	4	0
<hr/>		
Total thickness of bed and sample	4	0

<sup>1</sup>Overlying bed: shale; floor: sandstone.

Table 16 shows the detailed washability analyses of sample No. 11. The composite washability sample contained an average of 10,590 Btu/lb,

TABLE 15. - Detailed washability analyses of sample No. 10

STATE: Texas  
COUNTY: Titus

FORMATION: Uncorrelated  
GROUP: Wilcox

Product	Direct							Cumulative							Pounds, SO <sub>2</sub> /MM Btu
	Recovery, pct.		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Percent			Na <sub>2</sub> O <sup>1</sup>	
	Weight	Btu		Ash	Pyritic sulfur	Total sulfur		Weight	Btu		Ash	Pyritic sulfur	Total sulfur		
TOP SIZE: 1-1/2															
Size fraction: 1-1/2 x 3/8															
Weight percent: 78.9															
Float- 1.30	80.0	84.0	10,686	12.7	0.07	0.84		80.0	84.0	10,686	12.7	0.07	0.84		1.6
1.30 - 1.40	12.2	11.4	9,468	22.9	.13	.84		92.2	95.4	10,524	14.1	.08	.84		1.6
1.40 - 1.60	5.0	3.6	7,469	37.7	.48	1.05		97.2	99.1	10,369	15.3	.10	.85		1.6
Sink - 1.60	2.8	.9	3,398	66.6	.24	.55		100.0	100.0	10,172	16.7	.10	.84		1.7
Size fraction: 3/8 x 14															
Weight percent: 17.5															
Float- 1.30	70.4	76.8	10,759	11.7	0.03	0.85		70.4	76.8	10,759	11.7	0.03	0.85		1.6
1.30 - 1.40	16.3	15.8	9,567	20.8	.13	.86		86.7	92.6	10,536	13.4	.05	.85		1.6
1.40 - 1.60	7.3	5.6	7,499	36.4	.48	1.13		94.0	98.1	10,298	15.2	.08	.87		1.7
Sink - 1.60	6.0	1.9	3,079	69.9	.94	1.14		100.0	100.0	9,868	18.5	.13	.89		1.8
Size fraction: 14 x 100															
Weight percent: 3.6															
Float- 1.30	28.0	33.0	11,273	9.3	0.02	0.85		28.0	33.0	11,273	9.3	0.02	0.85		1.5
1.30 - 1.40	38.0	42.3	10,669	12.2	.04	.80		65.9	75.3	10,925	11.0	.03	.82		1.5
1.40 - 1.60	20.1	19.1	9,067	22.9	.17	.82		86.0	94.4	10,491	13.8	.06	.82		1.6
Sink - 1.60	14.0	5.6	3,839	63.5	1.77	2.16		100.0	100.0	9,562	20.7	.30	1.01		2.1
Size composite: 1-1/2 x 100															
Weight percent: 100.0															
Float- 1.30	76.4	82.2	10,705	12.5	0.06	0.84		76.4	82.2	10,705	12.5	0.06	0.84		1.6
1.30 - 1.40	13.9	15.3	9,607	21.4	.12	.84		90.3	94.4	10,536	13.9	.07	.84		1.6
1.40 - 1.60	5.9	6.0	7,671	35.6	.44	1.04		96.2	98.8	10,360	15.2	.09	.85		1.6
Sink - 1.60	3.8	1.8	3,368	67.1	.64	.93		100.0	100.0	10,096	17.2	.12	.86		1.7
Minus 100 mesh	.9	.7	7,775	36.1	.27	.88		100.0	100.0	10,076	17.3	.12	.86		1.7

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 15. - Detailed washability analyses of sample No. 10 (Con.)

STATE: Texas  
COUNTY: Titus

FORMATION: Uncorrelated  
GROUP: Wilcox

Direct								Cumulative							
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.	Btu	Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Pounds, SO <sub>2</sub> /MM Btu
	Weight	Btu			Pyritic sulfur	Total sulfur						Pyritic sulfur	Total sulfur		
TOP SIZE: 3/8															
Size fraction: 3/8 x 14															
Weight percent: 66.7															
Float- 1.30	75.0	80.1	10,850	11.3	0.00	0.80		75.0	80.1	10,850	11.3	0.00	0.80		1.5
1.30 - 1.40	14.2	13.5	9,684	20.1	.06	.75		89.2	93.6	10,665	12.7	.01	.79		1.5
1.40 - 1.60	6.6	5.0	7,766	34.4	.66	.82		95.8	98.7	10,465	14.2	.05	.79		1.5
Sink - 1.60	4.2	1.3	3,227	67.8	.25	.98		100.0	100.0	10,162	16.4	.06	.80		1.6
Size fraction: 14 x 100															
Weight percent: 33.3															
Float- 1.30	52.7	58.0	11,332	9.6	0.14	0.85		52.7	58.0	11,332	9.6	0.14	0.85		1.5
1.30 - 1.40	29.6	30.1	10,462	14.3	.29	.85		82.4	88.1	11,019	11.3	.19	.85		1.5
1.40 - 1.60	11.6	9.6	8,497	27.1	.10	.78		94.0	97.7	10,708	13.2	.18	.84		1.6
Sink - 1.60	6.0	2.3	3,927	63.4	1.30	1.64		100.0	100.0	10,298	16.3	.25	.89		1.7
Size composite: 3/8 x 100															
Weight percent: 100.0															
Float- 1.30	67.6	74.4	10,975	10.9	0.04	0.81		67.6	74.4	10,975	10.9	0.04	0.81		1.5
1.30 - 1.40	19.3	22.0	10,081	17.1	.18	.80		86.9	91.9	10,776	12.3	.07	.81		1.5
1.40 - 1.60	8.3	7.2	8,107	31.0	.40	.80		95.2	98.3	10,544	13.9	.10	.81		1.5
Sink - 1.60	4.8	1.7	3,519	66.0	.69	1.26		100.0	100.0	10,207	16.4	.12	.83		1.6
Minus 100 mesh	8.7	7.0	8,872	27.7	.08	.81		100.0	100.0	10,100	17.3	.12	.83		1.6
TOP SIZE: 14															
Size fraction: 14 x 0															
Weight percent: 100.0															
Float- 1.30	55.2	60.3	11,116	9.8	0.01	0.81	0.09	55.2	60.3	11,116	9.8	0.01	0.81	0.09	1.5
1.30 - 1.40	27.1	27.2	10,242	16.2	.02	.74	.09	82.3	87.5	10,829	11.9	.01	.79	.09	1.5
1.40 - 1.60	13.7	11.3	8,404	28.0	.05	.67	.08	96.1	98.8	10,482	14.2	.02	.77	.09	1.5
Sink - 1.60	3.9	1.2	3,124	69.2	1.12	1.42	.12	100.0	100.0	10,191	16.4	.06	.80	.09	1.6

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

TABLE 16. - Detailed washability analyses of sample No. 11

STATE: Texas  
COUNTY: Angelina

FORMATION: Yegua  
GROUP: Clairborne

Direct								Cumulative								Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>		
	Weight	Btu			Pyritic sulfur	Total sulfur		Weight	Btu			Pyritic sulfur	Total sulfur			
TOP SIZE: 1-1/2																
Size fraction: 1-1/2 x 3/8																
Weight percent: 80.8																
Float- 1.30	92.2	94.4	11,073	10.9	0.04	1.20		92.2	94.4	11,073	10.9	0.04	1.20		2.2	
1.30 - 1.40	5.6	4.9	9,468	21.9	.09	1.29		97.8	99.3	10,982	11.5	.04	1.21		2.2	
1.40 - 1.60	.6	.3	5,436	51.4	.36	1.03		98.4	99.6	10,949	11.8	.04	1.20		2.2	
Sink - 1.60	1.6	.4	2,780	72.6	2.10	2.16		100.0	100.0	10,818	12.7	.08	1.22		2.3	
Size fraction: 3/8 x 14																
Weight percent: 14.9																
Float- 1.30	80.0	87.8	10,852	12.2	0.04	1.27		80.0	87.8	10,852	12.2	0.04	1.27		2.3	
1.30 - 1.40	9.1	8.0	8,610	27.8	.11	1.42		89.1	95.8	10,622	13.8	.05	1.29		2.4	
1.40 - 1.60	5.1	3.1	5,873	46.8	.14	1.07		94.2	98.8	10,363	15.6	.05	1.27		2.5	
Sink - 1.60	5.8	1.2	2,019	75.8	.78	1.07		100.0	100.0	9,882	19.1	.09	1.26		2.6	
Size fraction: 14 x 100																
Weight percent: 4.3																
Float- 1.30	50.0	64.9	11,187	10.3	0.04	1.23		50.9	64.9	11,187	10.3	0.04	1.23		2.2	
1.30 - 1.40	16.4	17.8	9,385	20.7	.07	1.47		66.4	82.8	10,742	12.9	.05	1.29		2.4	
1.40 - 1.60	13.1	10.6	6,985	36.5	.10	1.14		79.5	93.4	10,122	16.8	.06	1.26		2.5	
Sink - 1.60	20.5	6.6	2,780	69.6	.36	.99		100.0	100.0	8,618	27.6	.12	1.21		2.8	
Size composite: 1-1/2 x 100																
Weight percent: 100.0																
Float- 1.30	88.6	92.8	11,046	11.1	0.04	1.21		88.6	92.8	11,046	11.1	0.04	1.21		2.2	
1.30 - 1.40	6.6	6.9	9,281	23.0	.09	1.34		95.2	98.3	10,924	11.9	.04	1.22		2.2	
1.40 - 1.60	1.8	4.7	6,105	44.8	.19	1.08		97.0	99.3	10,834	12.5	.05	1.22		2.2	
Sink - 1.60	3.0	2.4	2,564	72.6	1.22	1.51		100.0	100.0	10,583	14.3	.08	1.23		2.3	
Minus 100 mesh	1.1	.9	8,161	35.7	.26	1.31		100.0	100.0	10,556	14.6	.08	1.23		2.3	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.



TABLE 16. - Detailed washability analyses of sample No. 11 (Con.)

STATE: Texas  
COUNTY: Angelina

FORMATION: Yegua  
GROUP: Clairborne

Direct								Cumulative								Pounds, SO <sub>2</sub> /MM Btu
Product	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>	Recovery, pct.		Btu/lb	Ash	Percent		Na <sub>2</sub> O <sup>1</sup>		
	Weight	Btu			Pyritic sulfur	Total sulfur		Weight	Btu			Pyritic sulfur	Total sulfur			
TOP SIZE: 3/8																
Size fraction: 3/8 x 14																
Weight percent: 73.6																
Float- 1.30	92.7	95.7	11,195	10.0	0.06	1.33		92.7	95.7	11,195	10.0	0.06	1.33		2.4	
1.30 - 1.40	3.8	3.1	8,707	28.4	.14	1.26		96.5	98.8	11,097	10.7	.06	1.33		2.4	
1.40 - 1.60	1.5	.8	5,871	46.6	.18	1.02		98.0	99.6	11,016	11.3	.06	1.32		2.4	
Sink - 1.60	2.0	.4	2,141	75.3	1.44	1.66		100.0	100.0	10,838	12.6	.09	1.33		2.5	
Size fraction: 14 x 100																
Weight percent: 26.4																
Float- 1.30	80.8	87.6	11,480	9.4	0.04	1.21		80.8	87.6	11,480	9.4	0.04	1.21		2.1	
1.30 - 1.40	4.8	4.6	10,041	17.2	.07	1.32		85.6	92.1	11,399	9.8	.04	1.22		2.1	
1.40 - 1.60	6.8	5.4	8,401	26.7	.11	1.24		92.4	97.5	11,177	11.1	.05	1.22		2.2	
Sink - 1.60	7.6	2.5	3,423	64.4	.42	1.11		100.0	100.0	10,589	15.1	.08	1.21		2.3	
Size composite: 3/8 x 100																
Weight percent: 100.0																
Float- 1.30	89.5	93.8	11,262	9.9	0.06	1.30		89.5	93.8	11,262	9.9	0.06	1.30		2.3	
1.30 - 1.40	4.1	3.5	9,121	24.9	.10	1.28		93.6	97.2	11,169	10.5	.06	1.30		2.3	
1.40 - 1.60	2.9	3.7	7,432	34.3	.14	1.16		96.5	99.1	11,056	11.2	.06	1.30		2.3	
Sink - 1.60	3.5	1.6	2,879	69.0	.85	1.34		100.0	100.0	10,772	13.2	.09	1.30		2.4	
Minus 100 mesh	6.2	5.0	9,092	25.5	.12	1.20		100.0	100.0	10,674	14.0	.09	1.29		2.4	
TOP SIZE: 14																
Size fraction: 14 x 0																
Weight percent: 100.0																
Float- 1.30	85.5	91.2	11,239	10.0	0.05	1.29	0.25	85.5	91.2	11,239	10.0	0.05	1.29	0.25	2.3	
1.30 - 1.40	7.0	6.2	9,263	23.6	.12	1.27	.30	92.5	97.3	11,089	11.0	.06	1.29	.25	2.3	
1.40 - 1.60	3.7	2.1	6,040	46.4	.12	.83	.38	96.2	99.4	10,895	12.4	.06	1.27	.25	2.3	
Sink - 1.60	3.8	.6	1,536	81.5	.83	1.04	.58	100.0	100.0	10,540	15.0	.09	1.26	.27	2.4	

<sup>1</sup>Sodium oxide performed only on 14 mesh x 0 sample.

14.5 percent ash, 0.09 percent pyritic sulfur, and 1.26 percent total sulfur. The sodium oxide content in the coal was 0.27 percent. This coal contained an average of 1.17 percent organic sulfur and could not be upgraded to meet the current SO<sub>2</sub> emission standard. Crushing to 14 mesh top size and removing the sink 1.30 specific gravity material would provide a product containing 10.0 percent ash at a Btu recovery of 91.2 percent. The ash reduction would be 33 percent. This is a new mine undergoing a feasibility study.

#### Sodium Reduction

Table 17 summarizes the results of laboratory ion exchange tests with Arkansas and Texas lignites. In these tests, products having lower sodium oxide in the ash were consistently obtained by treating these lignites with a solution containing calcium ions. Because the quantity of exchange ions, particle size distribution and reaction time were constant; the maximum amount of sodium that might be removed from each sample was not determined. The sodium oxide reductions for the coals tested ranged from 37 to 91 percent.

TABLE 17. - Ion exchange test results with minus 14 mesh  
Arkansas and Texas lignites

Sample No.	Raw coal			Float 1.60 specific gravity product			
	Analysis, percent			Recovery, percent Btu's	Analysis, percent		
	Na <sub>2</sub> O in ash				Na <sub>2</sub> O in ash		
	Ash	Untreated	Treated		Ash	Untreated	Treated
<u>Arkansas lignite</u>							
1	11.3	0.19	0.11	99.5	9.9	0.24	0.09
2	17.0	.19	.12	99.6	14.7	.27	.12
3	15.0	.08	.04	98.2	11.8	.08	.05
4	43.4	.27	.17	88.3	31.9	.39	.14
<u>Texas lignite</u>							
5	10.2	0.98	0.22	97.8	9.0	0.91	0.25
6	13.5	.67	.14	98.8	11.4	.54	.14
7	8.8	1.13	.37	99.9	8.5	1.09	.35
8	20.3	.24	.14	97.5	14.2	.30	.12
9	8.5	1.06	.31	99.6	7.7	1.08	.25
10	16.4	.65	.19	98.8	14.2	.73	.23
11	15.0	1.27	.12	99.4	12.4	1.05	.12

## DISCUSSION OF RESULTS

The washability data given in tables 6-9 for the lignite samples collected in Arkansas show that, of the four samples, only samples 1 and 2, from Dallas County, could be upgraded to meet the current EPA SO<sub>2</sub> emission standard of 1.2 pounds SO<sub>2</sub>/MM Btu. Sample No. 1 contained an average of 0.47 percent pyritic sulfur and 0.46 percent organic sulfur. As shown in table 6, it could be upgraded to comply with the EPA emission standard by crushing to 3/8-inch top size and removing the sink 1.30 specific gravity material. Sample No. 2 contained, on the average, 0.05 percent pyritic sulfur and only 0.65 percent organic sulfur. It could be upgraded to meet the standard by crushing to 1-1/2-inch top size and removing the sink 1.30 specific gravity material as shown in table 7.

The washability data for the Texas lignites (tables 10-16) show that none of these samples could be upgraded to meet the EPA standard regardless of the degree of crushing or specific gravity of separation due to the organic sulfur content which ranged from 0.7 to 1.3 percent.

Although physical cleaning generally provided inadequate desulfurization with all but the two Arkansas lignite samples from Dallas County, it did provide significant ash reduction. And as pointed out earlier, boiler fouling increases exponentially with the ash content of a coal for all levels of sodium oxide in the ash. Crushing and gravimetric separation, therefore, may contribute significantly to a reduction in boiler fouling.

The weight-percent yields obtained at the 1.30 specific gravity of separation for the material crushed to 1-1/2 inches top size were high, except for one sample which yielded 42.8 percent. The other 10 samples ranged from 75.9 percent to 96.7 percent yield. This high yield of float 1.30 material is attributable to the low specific gravity of lignite. It is reported that the specific gravity of lignite containing 36 percent moisture is 1.28 and decreases to 1.22 as the moisture decreases to zero (10).

Size analysis of the Arkansas and Texas lignite samples showed that all samples remained relatively coarse after crushing to 1-1/2 inches top size with none containing less than 73 percent of 1-1/2 by 3/8 inch material. The size distribution coefficient  $n$  ranged from 0.7 to 0.8 which is within the normal range for most higher rank coals.

All of these Arkansas and Texas lignite samples were noncoking with free swelling indices of 0. The ash softening temperatures ranged from 2,140 to 2,910° F. Generally, the Btu per pound (moisture free basis) for the raw lignite samples was around 10,000 to 11,500 with the ash contents ranging from 9.3 to 19.3 percent. One of the Arkansas samples, however, contained 43.1 percent ash and 6,672 Btu/lb.

The sodium oxide in the lignites analyzed 0.27 percent or less and thus should not cause much boiler fouling. This low sodium content appears to be typical of Arkansas and Texas lignites. Although boiler fouling caused by the presence of sodium should not be a problem, it is interesting to note that treatment of these lignite samples with calcium ions provided sodium oxide reductions ranging from 37 to 91 percent. The significance of these ion exchange tests is to demonstrate that treatment of lignite with a solution containing calcium ions will reduce its sodium content.

#### CONCLUSIONS

1. Only the two Arkansas samples collected from Dallas County could be upgraded to meet the new source performance standard of 1.2 pounds of SO<sub>2</sub>/MM Btu.
2. None of the samples collected from Texas could be upgraded to meet the EPA standard.
3. Even though the samples collected from Arkansas and Texas averaged only 1.1 percent total sulfur, approximately 80 percent of this was organic sulfur; thus, 9 of the 11 samples could not be physically upgraded to meet EPA's new source performance standard.
4. The size analyses of the Arkansas and Texas lignite samples showed nonfriability with all samples containing more than 73 percent of plus 3/8 inch material after crushing to 1-1/2 inches top size.
5. Except for one sample, crushing and gravimetric separation would provide minimal sulfur reduction but would provide significant ash reduction and increased calorific value.
6. The sodium oxide in the coals analyzed 0.27 percent or less and thus should not cause much boiler fouling. However, since the ash fouling rate is related to the quantity of ash as well as the sodium content, physical coal cleaning to remove ash should reduce boiler fouling.
7. Treatment of these lignite samples with calcium ions would provide sodium oxide reductions ranging from 37 to 91 percent.

#### REFERENCES

1. Corsentino, J. S. Projects to Expand Energy Sources in Western States, SBM I.C. 8719, 208 pp.
2. Fieldner, A. C. and W. A. Selvig. Notes in the Sampling and Analysis of Coal. BuMines Tech. Paper 586, 1938, 48 pp.

3. Hahn, A. D. and B. M. Reynolds. Lignite in the Arkansas-White-Red River Basins, Preliminary Report 1952, 15 pp.
4. Haley, R. B. Coal Resources of Arkansas, 1954, Geological Survey Bulletin 1072-P, 36 pp.
5. Holmes, J. A. The Sampling of Coal in the Mine. BuMines Tech. Paper 1, 1918, 22 pp.
6. Kaiser, W. R. Texas Lignite: Near-Surface and Deep-Basin Resources, Bureau of Economic Geology, University of Texas, R.I. No. 79, 1974, 70 pp.
7. Keystone Coal Industry Manual, McGraw-Hill Publication, 1977.
8. Paulson, L. E. and W. W. Rawkes. Changes in Ash Composition of North Dakota Lignite Treated by Ion Exchange. BuMines, R.I. 7176, 1967, 18 pp.
9. Rosin, P., E. Rammler. The Laws Governing the Fineness of Powered Coal, J Inst Fuel, 7, (1933), pp 29-36.
10. Sondreal, E. A. and R. C. Ellman. Laboratory Determination of Factors Affecting Storage of North Dakota Lignite. BuMines R.I. 7887, 1974, 83 pp.
11. Stroud, R. B. Mineral Resources and Industries of Arkansas, BuMines Bull. 645, 418 pp.
12. Tufte, P. H., G. H. Gronhard, E. A. Sondreal, and S. J. Selle. Ash Fouling Potentials of Western Subbituminous Coals Determined in a Pilot-Plant Test Furnace, Proceedings American Power Conference, Vol. 38, 1976, pp. 661-671.

# **TECHNICAL REPORT DATA**

*(Please read instructions on the reverse before completing)*

1. REPORT NO. <b>EPA-600/7-79-149</b>		2.		3. RECIPIENT'S ACCESSION NO.	
4. TITLE AND SUBTITLE <b>Washability Characteristics of Arkansas and Texas Lignites: Report of Investigations</b>				5. REPORT DATE <b>June 1979</b>	
				6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) <b>J.A. Cavallaro and A.F. Baker</b>				8. PERFORMING ORGANIZATION REPORT NO. <b>PMTC-5(79)</b>	
9. PERFORMING ORGANIZATION NAME AND ADDRESS <b>U.S. Department of Energy Coal Preparation Division of Pittsburgh Mining Technology Center Pittsburgh, Pennsylvania 15213</b>				10. PROGRAM ELEMENT NO. <b>EHE623A</b>	
				11. CONTRACT/GRANT NO. <b>EPA Interagency Agreement IAG-DXE-685AK</b>	
12. SPONSORING AGENCY NAME AND ADDRESS <b>EPA, Office of Research and Development Industrial Environmental Research Laboratory Research Triangle Park, NC 27711</b>				13. TYPE OF REPORT AND PERIOD COVERED <b>Final; 1/77 - 9/78</b>	
				14. SPONSORING AGENCY CODE <b>EPA/600/13</b>	
15. SUPPLEMENTARY NOTES <b>IERL-RTP project officer is David A. Kirchgessner, MD-61,919/541-2851.</b>					
16. ABSTRACT <b>The report describes the washability characteristics of 11 channel samples of lignite: 4 from Arkansas and 7 from Texas. The two samples collected from Dallas County, Arkansas, could be upgraded to meet the current EPA New Source Performance Standard (NSPS) of 1.2 lb SO<sub>2</sub>/million Btu. The other nine samples, although averaging only a little over 1% total sulfur, were relatively high in organic sulfur and could not be upgraded to meet the NSPS. Physically cleaning these samples provided significant ash reduction which may reduce the potential for boiler fouling. It was also shown that much of the sodium can be removed from these lignites. Analyses showed 37 to 91% reductions of sodium oxide after treatment with a solution containing calcium ions.</b>					
17. KEY WORDS AND DOCUMENT ANALYSIS					
a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS		c. COSATI Field/Group	
Pollution Lignite Washing Desulfurization Ash Content Scale (Corrosion)		Sodium Oxides Calcium  Pollution Control Stationary Sources		13B 08G 13H,07A 07D  07B	
18. DISTRIBUTION STATEMENT  <b>Release to Public</b>		19. SECURITY CLASS (This Report) <b>Unclassified</b>		21. NO. OF PAGES	
		20. SECURITY CLASS (This page) <b>Unclassified</b>		22. PRICE	