STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
OFFICE OF PUBLIC WORKS

WATER RESOURCES
TECHNICAL REPORT
NO. 41

PREMINING HYDROLOGY OF THE LOGANSPORT LIGNITE AREA, DE SOTO PARISH, LOUISIANA

Prepared by
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
In cooperation with
LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
OFFICE OF PUBLIC WORKS

1987

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UNITED STATES GEOLOGICAL SURVEY

Water Resources

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By

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U.S. Geological Survey

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FACTORS FOR CONVERTING INCH-POUND UNITS TO
INTERNATIONAL SYSTEM (SI) OF UNITS

For readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
foot (ft)	0.3048	meter (m)
square mile (mi^2)	2.590	square kilometer (km^2)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
foot per day (ft/d)	0.3048	meter per day (m/d)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
gallon per minute (gal/min)	0.06308	liter per second (L/s)
gallon per minute per foot [(gal/min)/ft]	0.2070	liter per second per meter [(L/s)/m]
million gallon per day (Mgal/d)	0.4381	cubic meter per second (m^3/s)
ton, short, per day (ton/d)	0.9072	megagram per day (Mg/d)
ton, short, per square mile (ton/mi^2)	0.3503	metric ton per square kilometer (ton/km^2)
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)
micromhos per centimeter at 25 degrees Celcius (µmhos/cm)	1	microsiemens per centimeter at 25 degrees Celcius (µS/cm)

Temperature

degree Fahrenheit (°F) to degree Celsius (°C): °C = 5/9 (°F - 32).

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level of 1929."

PREMINING HYDROLOGY OF THE LOGANSPORT LIGNITE AREA,
DE SOTO PARISH, LOUISIANA

By John L. Snider, and Kenneth J. Covay

ABSTRACT

Surface mining of lignite would involve dewatering and removing aquifers above the lignite beds in the Logansport area, De Soto Parish, Louisiana. Documentation of the premining hydrologic system is necessary to determine changes that would be caused by the mining.

The major lignite bed occurs near the base of the Naborton Formation (of the Wilcox Group) at depths ranging from 180 to 230 feet below land surface. The lignite ranges from 4 to 17 feet in thickness and averages about 9 feet.

The principal aquifers that will be affected are the Naborton and Dolet Hills zones of the Carrizo-Wilcox aquifer. Sand in the Naborton zone is mostly very-fine to fine grained, and sand beds average 35 feet in thickness. The Dolet Hills zone in the Dolet Hills Formation overlies the Naborton and has coarser sand, much of which is fine to medium grained; sand beds average 20 feet in thickness. Hydraulic conductivity for the Naborton zone averages 17 feet per day and transmissivity averages 940 feet squared per day. Hydraulic conductivity for the Dolet Hills zone averages 11 feet per day and transmissivity averages 300 feet squared per day.

Water in aquifers of the Carrizo-Wilcox aquifer moves from interstream recharge areas to discharge areas in the Sabine River valley (mostly covered by Toledo Bend Reservoir). There is also lateral movement into the project area from potentiometric highs in the south-central part of De Soto Parish.

The Naborton zone contains water with a high chloride concentration near Toledo Bend Reservoir and in the northeastern part of the Logansport area. Fluoride concentrations are high in parts of the area, and at many wells the Naborton zone contains odorless, flammable gas. The source of the gas may be oil or gas wells, or the gas may be methane from the decomposition of organic matter.

Water in the Dolet Hills zone in the central part of the area contains high hardness and chloride concentrations which may be derived from contamination from oil or gas wells.

Streamflow at Bayou Castor and Bayou Grand Cane is sustained from ground-water sources but also reflects direct runoff from rainfall. The greatest total discharge, 39,306 cubic feet per second, occurred at Bayou Castor near Funston during the 1983 water year. Flow equal to or greater than the average flow, 67 cubic feet per second, can occur 21 percent of the days each year at Bayou Castor near Funston, and flow equal to or greater than the average flow, 69.3 cubic feet per second, can occur 15 percent of the days each year at Bayou Castor near Logansport.

Description and Development of the Project Area

The Logansport lignite area comprises about 100 mi² in western and southwestern De Soto Parish (fig. 1). Most of the project area is rural; the major land use is tree farms for paper and lumber mills. About 75 percent of the rural land is woodland, and the remainder is mostly pasture. The two major industries are a plywood plant north of Logansport and a sawmill north of Stanley. The Logansport Oil and Gas Field is in the project area (fig. 2). Land adjacent to Toledo Bend Reservoir is used for homes and trailer parks. Fishing and other reservoir recreation are popular.

The population of the project area is about 4,100. The urban population centers are Logansport (population 1,565) and Stanley (population 151). The rural population is about 2,400.

The town of Logansport, which uses water from the Toledo Bend Reservoir, serves a population of about 1,700. The Stanley Water System uses ground water and serves about 400 people. The Mansfield Water System obtains water from the Toledo Bend Reservoir from an intake near the south end of the project area and serves a population of about 50. The Keatchie Water System uses water from wells north of the project area and serves a population of about 250 in the northern part of the project area. These water systems serve about 20 percent of the rural population, and the remainder of the rural population obtains water from private wells. Most of the wells are less than 60 ft deep.

Toledo Bend Reservoir forms the southwestern boundary of the Logansport lignite area. The reservoir was built in 1966 by the construction of a dam on the Sabine River. The principal uses of the reservoir are for generation of electric power and sport fishing. The average pool altitude is 172 ft above sea level.

Climate

The average annual temperature at Logansport for the period 1953-80 was about 18.5°C. Average monthly temperatures ranged from 8.0°C in January to 28.0°C in July.

The average monthly precipitation (in inches) at Logansport, 1951-80, is summarized below:

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
4.27	3.93	4.27	4.87	6.03	3.56	3.65	3.12	4.12	2.87	3.80	4.49

The average annual precipitation is 49 in.

Over half (57 percent) of this precipitation occurs during the months of December through May. From June through November recharge to aquifers is relatively low. Water levels in wells screened in surficial aquifers decline, and streams have reduced flow or no flow during these months.

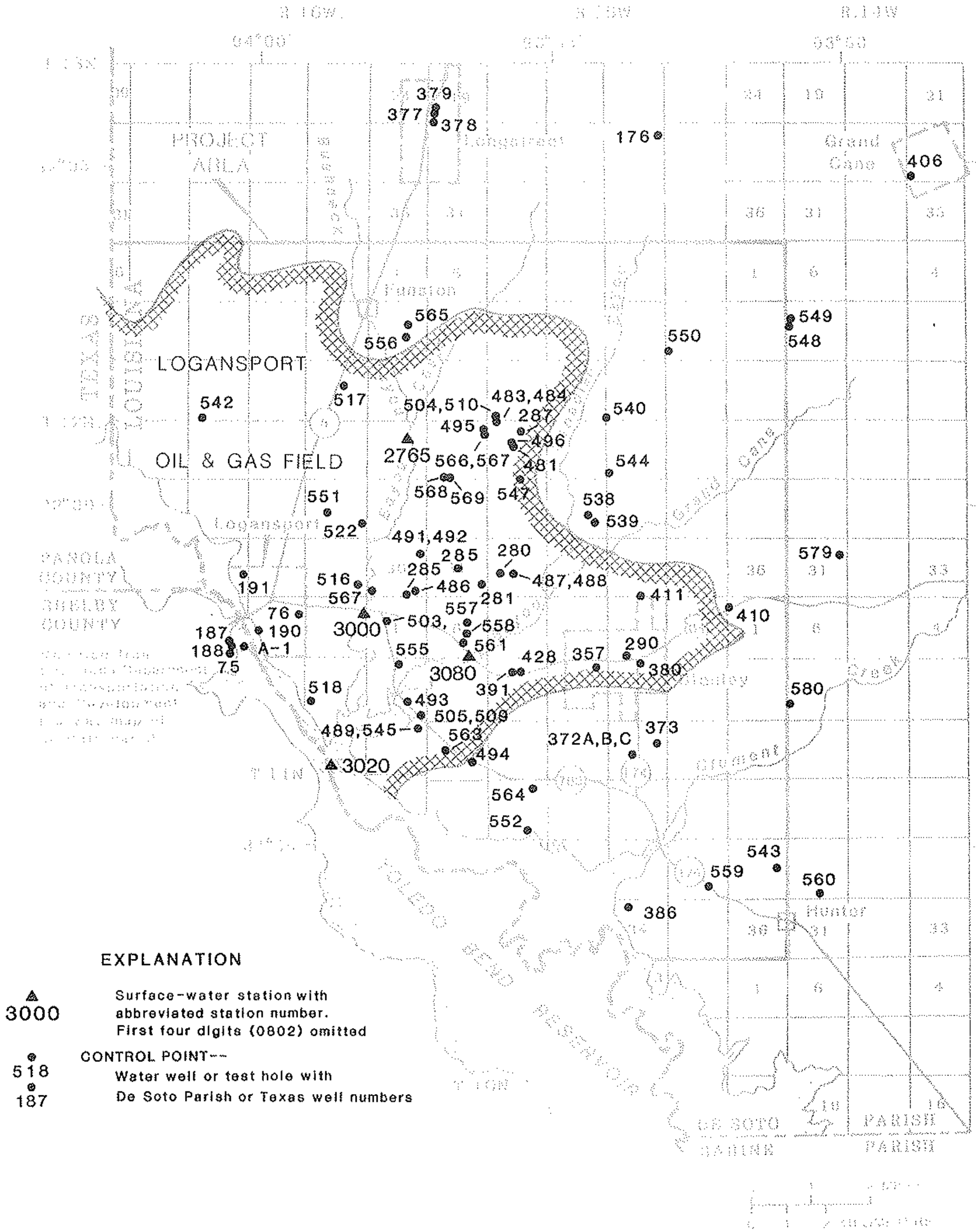


Figure 2.--Location of drainage features, surface-water and water-quality stations, and water wells or test holes, Logansport lignite area, De Soto Parish, Louisiana, and Shelby County, Texas.

The greatest monthly rainfall for the 1951-80 period was 16.26 in. and occurred in May 1953. Monthly rainfall exceeded 7 in. 14 percent of the time. The greatest precipitation for 1 day was 7.78 in. on April 12, 1980.

Topography

Toledo Bend Reservoir covers most of the flat, alluvial valley of the Sabine River. The submerged valley floor slopes transversly from 172 ft (normal pool altitude) to 160 ft above sea level at the edge of the submerged river channel.

The Prairie and Montgomery terraces (Murray, 1948, pl. 1) extend along the reservoir, with the Prairie terrace also extending along tributary stream valleys. The gently sloping terrace surface along the reservoir ranges from 1 to 3 mi in width and slopes to the southwest towards the reservoir. The altitude of the highest part of the Montgomery terrace surface is about 245 ft above sea level at the Texas-Louisiana State line, and the altitude of the highest part of the Prairie surface is about 205 ft above sea level near Hunter (fig. 1). The Bentley terrace (Murray, 1948, pl. 1) occurs in a discontinuous belt 1 to 3 mi wide northeast of the Prairie and Montgomery terraces. Hilltop altitudes on the dissected Bentley terrace surface are as high as 300 ft above sea level.

Most of the northeastern two-thirds of the Logansport lignite area is upland. Hilltops are as high as 180 ft above adjacent valleys. The highest altitude is 374 ft on a hilltop about 1.8 mi north of Hunter. Stream valleys are mostly about 0.3 mi wide but can be about 1 mi wide locally.

Drainage

The two major streams, Bayou Grand Cane and Bayou Castor, flow to the south and southwest across the project area of potential mining and into an estuary of Toledo Bend Reservoir. Clement Creek drains the southeastern part of the project area and flows into the reservoir 3 mi west-northwest of Hunter. Bushneck Bayou is a tributary of Bayou Castor and flows into Bayou Castor 2 mi south-southeast of Funston (fig. 2). Canadian Bayou is an important tributary to Bayou Grand Cane and flows into Bayou Grand Cane northwest of Stanley. The locations of surface-water gaging stations also are shown in figure 2.

Acknowledgments

The authors wish to express appreciation to the water well owners and drillers, landowners, and water-supply managers who contributed data for the project. The Dow Chemical Company supplied data on their test wells and gave permission to measure water levels. The Louisiana Department of Natural Resources, Office of Conservation, made available electrical logs of oil-test wells.

GEOLOGY

Stratigraphy

The Logansport lignite area is underlain by the Wilcox Group of Tertiary (Paleocene and Eocene) age. The Wilcox Group is underlain by the Midway Group of Tertiary (Paleocene) age and is overlain by terrace deposits and alluvium of Quaternary (Pleistocene and Holocene) age (table 1). Roland and others (1976, p. 15-18) describe depositional environments of lignite in the Wilcox Group.

Mining will affect lignite beds and the associated three units of the Wilcox Group. From the base upward, the two formations are the Naborton Formation, the Dolet Hills Formation, and the third unit is the undifferentiated upper part of the Wilcox Group.

Midway Group, Undifferentiated

The Midway Group has been divided into the Porters Creek Clay, which comprises most of the Midway Group, and the Clayton Formation at the base. On electric logs, the Clayton Formation cannot be readily distinguished from the overlying Porters Creek Clay (Page and Preé, 1964, p. 60). The Midway Group is considered undifferentiated in this report.

The Midway Group occurs in the subsurface throughout the project area. The top few feet of the Midway Group consist of gray and brown silty clay, with thin indurated layers, thin lignite beds, and glauconitic clay occurring in places. The resistivity differences between the massive clay of the Midway Group and the sandy Wilcox are easily distinguished on electrical logs. This distinctive lithologic change is used to map the geologic structure of the Logansport area. The clay acts as a confining bed.

Naborton Formation (Wilcox Group)

The Paleocene Naborton Formation occurs in the subsurface throughout the Logansport lignite area and ranges from 160 to 240 ft in thickness.

Generally, the Naborton Formation is clay with beds of sand and lignite. Indurated layers are common. Clays of the Naborton Formation are commonly dark gray and silty but may be brown, tan, or black and contain sandy or glauconitic beds. Locally, thin silt layers occur in the clays.

Sand ranges from very fine to fine in grain size and is gray or white. Sand percentage ranges from about 20 to 60 and averages about 40. The highest sand percentage occurs in the northwestern corner of the area and south and southeast of Stanley. The lowest sand percentage occurs in the southern part of T. 12 N., R. 15 W.; in the northern part of T. 11 N., R. 15 W. including most of Stanley north of U.S. Highway 84; and at well DS-505, southeast of Logansport (fig. 2). At places, sand beds are silty and locally contain thin clay or lignite layers. The sand beds and the intervening clays and lignites of the Naborton Formation comprise the Naborton zone.

Table 1.--Geohydrology of aquifers, Logansport lignite area, Louisiana

Aquifer		Description and typical thickness	Hydrologic characteristics	Series	Geologic unit	
Alluvial aquifer		Mostly fine sand. Sand-bed thickness as great as 30 feet.	Artesian conditions in aquifer as it is covered by Toledo Bend Reservior. Estimated hydraulic conductivity ranges from 6 to 40 feet per day	Holocene	Alluvium	
Terrace aquifer		Fine to very-coarse sand, graveliferous in places. Aggregated sand thickness ranges from 10 to 40 feet	Water-table condition. Hydraulic conductivity 120 feet per day north-east of study area.	Pleistocene	Terrace deposits	
Carrizo-Wilcox aquifer	Upper Wilcox zone	Mostly fine sand. Sand-bed thickness ranges from 4 to 20 feet	Water-table aquifer where sands are near land surface, artesian down-dip.	Eocene	Wilcox Group	Undifferentiated upper part
	Dolet Hills zone	Very-fine to medium sand. Aggregated sand thickness averages 50 feet. Sand-bed thickness averages 20 feet.	Water-table condition in central part of study area near outcrop, artesian downdip. Hydraulic conductivity ranges from 3.6 to 20 feet per day and averages 11 feet per day.	? Paleocene		Dolet Hills Formation
	Naborton zone	Very-fine to fine sand. Aggregated sand thickness averages 70 feet. Sand-bed thickness averages 35 feet.	Artesian throughout study area. Hydraulic conductivity ranges from 9.6 to 39 feet per day and averages 17 feet per day. Storage coefficient 3.2×10^{-4}			Naborton Formation
Confining bed		Clay. Thickness about 840 feet.	Does not yield water to wells.		Midway Group	Undifferentiated

The major lignite bed occurs near the base of the Naborton Formation (pl. 1), at depths ranging from 180 to 230 ft below land surface in the southern two-thirds of the proposed mining area (fig. 1). The interval between the base of the lignite and the base of the formation generally ranges from 20 to 50 ft and averages about 40 ft in thickness. The lignite ranges from 4 to 17 ft in thickness and averages about 9 ft. The thickest occurrence observed is at test well DS-503 (fig. 2), 2 mi east of Logansport.

The altitude of the base of the Wilcox Group (base of the Naborton Formation) ranges from about 20 ft below sea level at well DS-410, northeast of Stanley, to about 240 ft below sea level at the northwestern corner and at the southern edge of the project area (fig. 3). The altitude of the top of the Naborton Formation (fig. 4) ranges from about 200 ft above sea level along the eastern border of the project area northeast of Stanley to about 20 ft below sea level in the northwestern and southern parts of the study area.

Dolet Hills Formation (Wilcox Group)

The Paleocene Dolet Hills Formation occurs throughout the project area, but part of the formation has been removed by erosion in an east-west trending strip through the central part of the area (fig. 5). Only 15 ft of the Dolet Hills Formation remains at the site of U.S. Geological Survey test hole DS-503 (fig. 5). Where the Dolet Hills Formation is not eroded, the thickness ranges from about 90 to 150 ft and averages about 110 ft, with the thinnest occurrence near the western border, about 2 to 5 mi southwest of Funston and the thickest occurrence at test well DS-372 (fig. 5), about 1.5 mi south of Stanley.

North of the area where the top of the Dolet Hills is eroded, the altitude of the top dips from about 280 ft above sea level near well DS-504, 3 mi southeast of Funston, to about 80 ft above sea level in the northwest corner of the project area. South of the area where the top of the Dolet Hills is eroded, the altitude of the top dips from about 280 ft above sea level to about 110 ft above sea level along the southern border of the project area (fig. 5).

The Dolet Hills Formation consists of gray, very-fine to medium sand (coarser than sand in the Naborton Formation) interbedded with gray silty or sandy clay. The sand percentage of the Dolet Hills Formation, where it is not eroded, ranges from about 10 to 90 and averages about 50. The greatest sand percentage is at test hole DS-380 (fig. 5) in Stanley; the least sand percentage is about 7 mi northeast of Logansport. The Dolet Hills Formation comprises the Dolet Hills zone.

The drillers log of test well DS-504, 3 mi southeast of Funston (fig. 5), shows that a hard, black lignite bed, 4 ft in thickness, occurs 40 ft above the base of the Dolet Hills Formation (pl. 1). This lignite bed occurs generally at a depth of 120 ft or less below land surface in the northern third of the proposed mining area. There are no thick water-bearing sands above this shallow lignite bed. A lignite bed, 3 ft in thickness, occurs at test hole DS-410, 1.5 mi northeast of Stanley (fig. 5). Indurated layers in the Dolet Hills Formation are mostly 2 ft or less in thickness and are composed of sandstone. Silt beds occur locally and are as great as 50 ft in thickness.

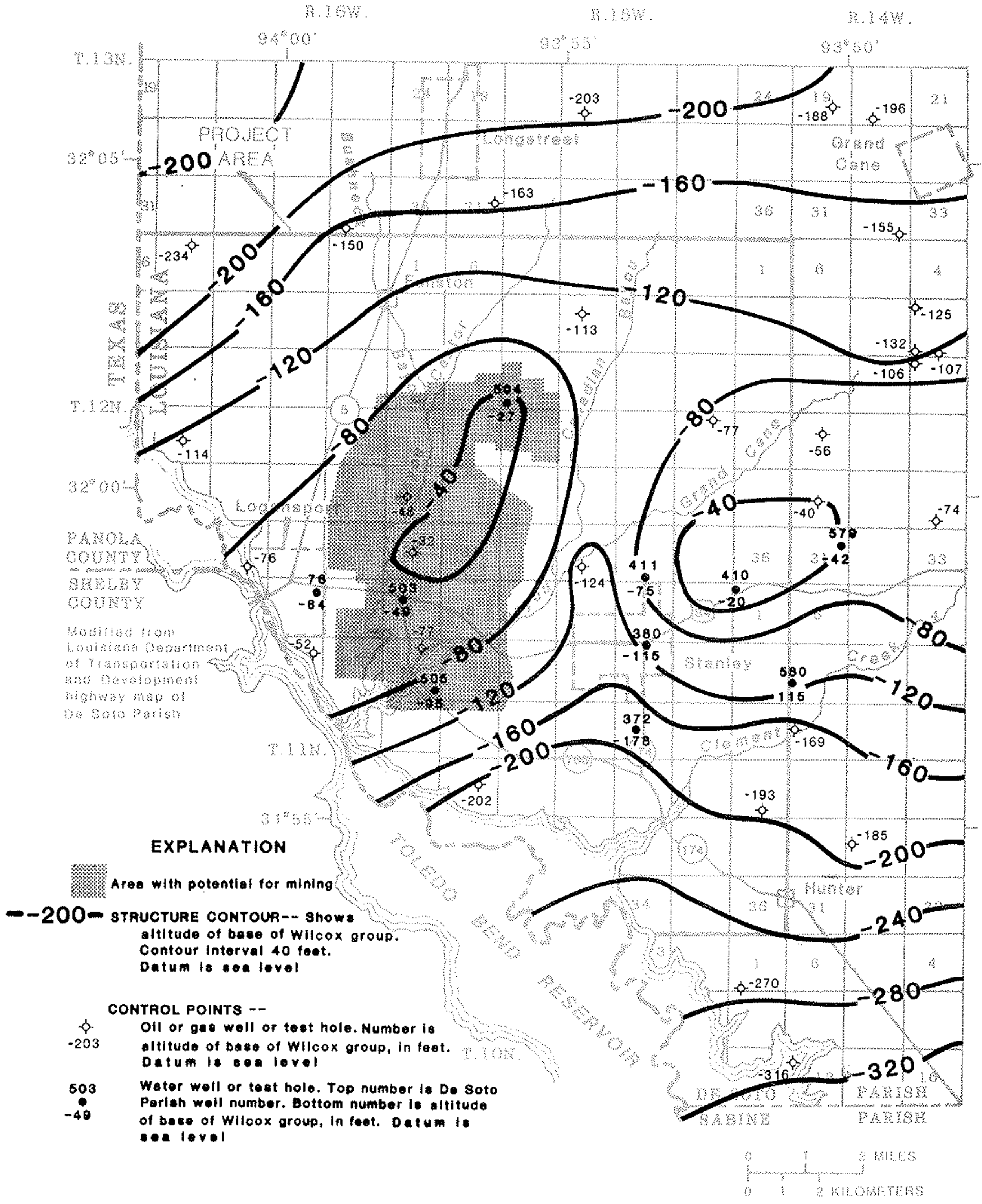


Figure 3.--Altitude of the base of the Wilcox Group, Logansport lignite area, De Soto Parish, Louisiana.

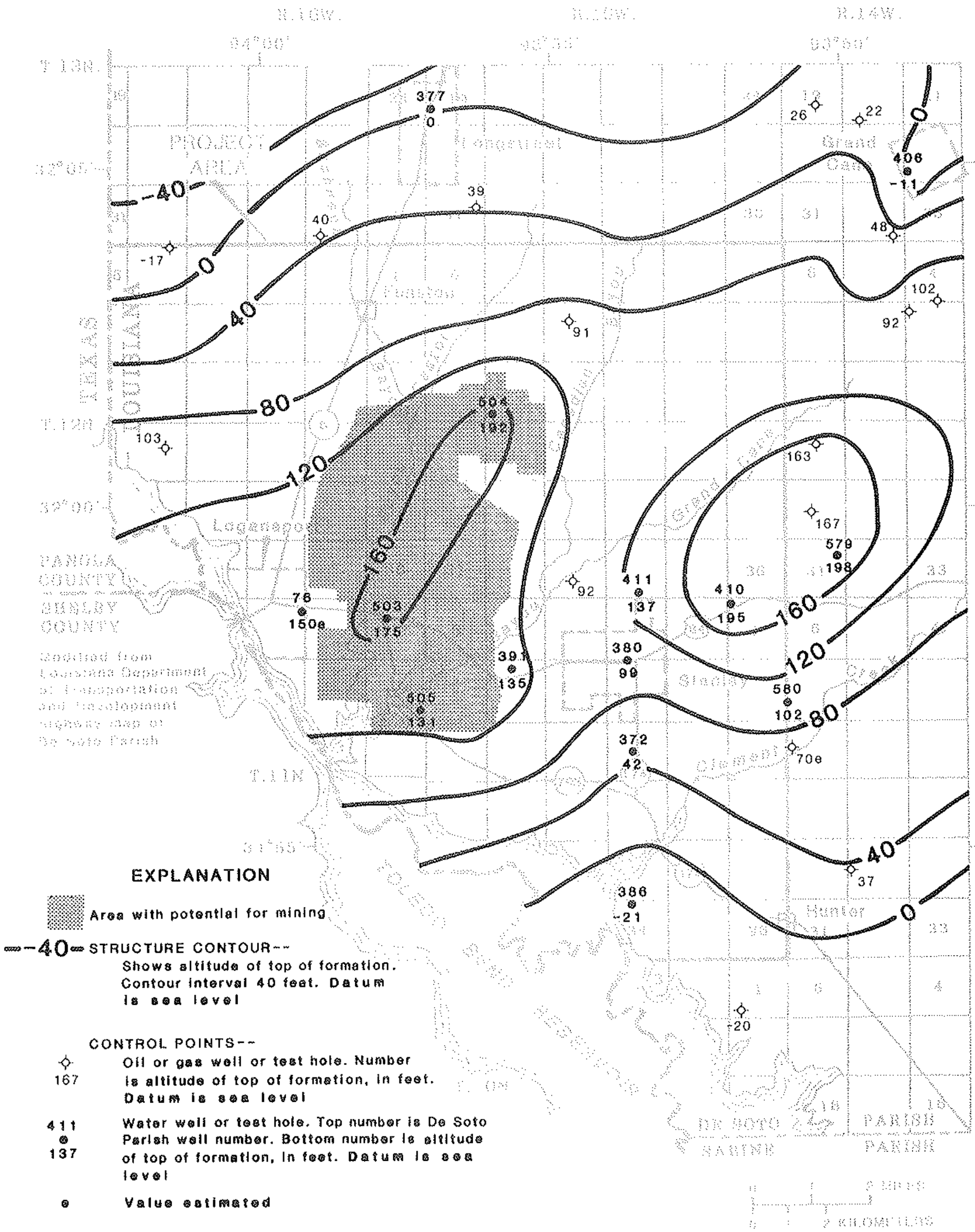


Figure 4.--Altitude of the top of the Naborton Formation, Logansport lignite area, De Soto Parish, Louisiana.

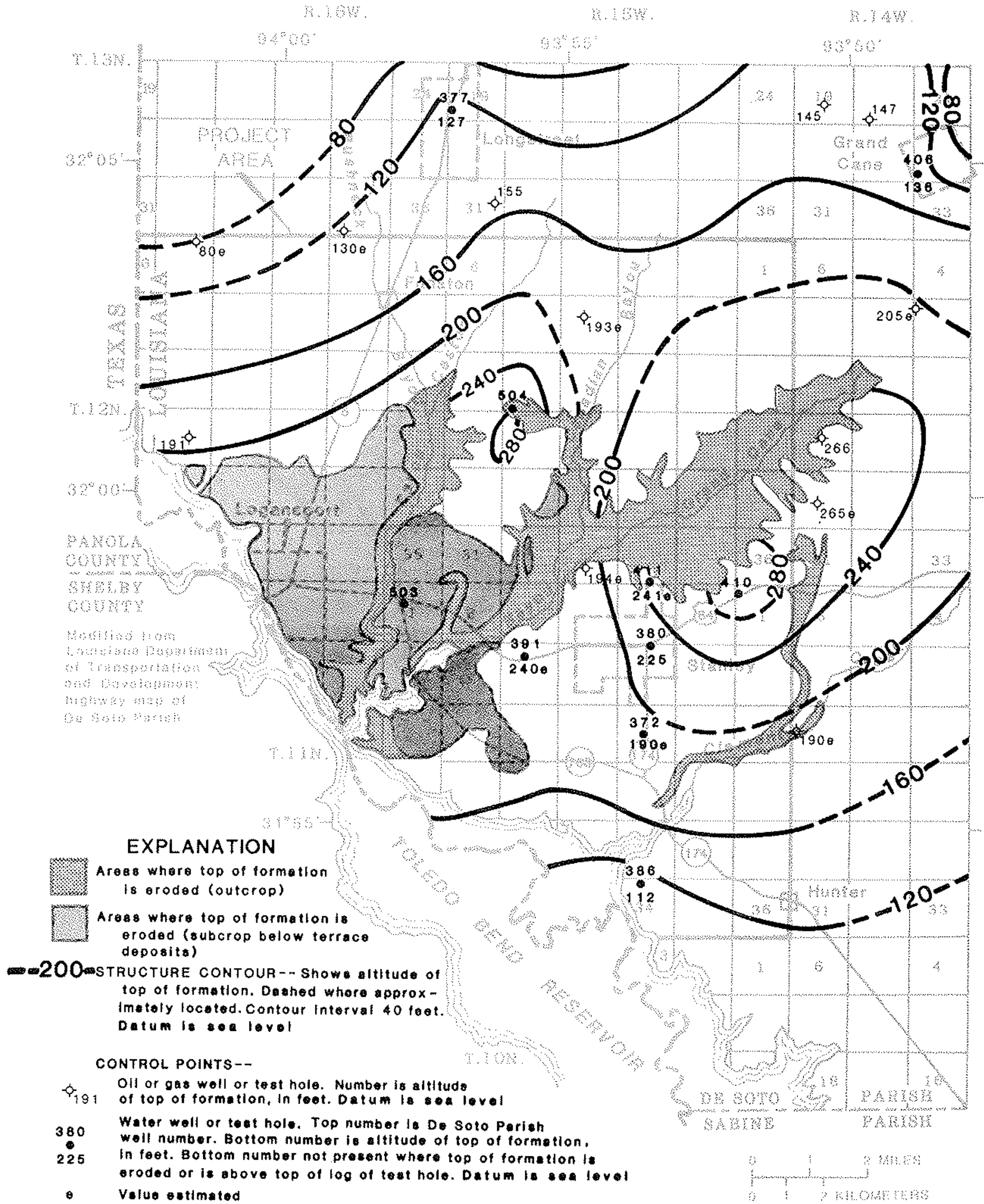


Figure 5.--Altitude of the top of the Dolet Hills Formation, Logansport lignite area, De Soto Parish, Louisiana.

Undifferentiated Upper Part (Wilcox Group)

The undifferentiated upper part of the Wilcox Group of Eocene age occurs on the surface in most of the northern and southern parts of the project area but has been removed by erosion in an east-west trending strip through the central part of the project area where the top of the Dolet Hills Formation has been eroded (fig. 5). The undifferentiated Wilcox ranges in thickness from 0 at the edge of the outcrop to about 200 ft near the northwestern and southeastern corners of the project area.

Based on electric-log interpretations, the undifferentiated Wilcox is mostly clay. Clays are silty and sandy and are gray, and contain indurated layers and thin lignite beds.

Sands are mostly fine and range from very fine to medium in grain size and are gray and tan. Sand beds, which range from 4 to 20 ft in thickness, in the undifferentiated upper part of the Wilcox Group constitute the upper Wilcox zone.

Terrace Deposits and Alluvium

The terrace deposits occur in a belt 3 to 4 mi wide, parallel to the flood plain of the Sabine River, and along other stream valleys. The maximum thickness of the terrace deposits is about 40 ft.

The deposits consist of beds of graveliferous clay and sand. The clay is sandy or silty and is mostly orange or tan. An upper clay layer and a lower sand layer (the terrace aquifer) are at some test sites. The sand layer may grade in grain size from fine or medium at the top to medium or very coarse at the base and is generally tan or red in color. At other sites, the deposits consist entirely of clay or entirely of sand; either the clay or sand may be graveliferous. The gravel is mostly 0.25 to 0.50 in. in diameter.

The thickness of the alluvium probably ranges from 30 to 40 ft in the Logansport area. No data are available on alluvium in the valleys of streams tributary to Toledo Bend Reservoir. In Sabine Parish, the alluvium in small valleys is thin with a high proportion of clay and silt (Page and others, 1963, p. 85). The alluvial aquifer consists mostly of sand.

At well A-1 in Shelby County, Texas, (Page and Preé, 1964, p. 135), at a U.S. Geological Survey auger test hole (fig. 2) on the west bank of the Sabine River (now Toledo Bend Reservoir) across from Logansport, the Sabine River valley alluvium consists of 30 ft of fine-grained yellow sand with some clayey sand.

In northern Sabine Parish, outside the project area, at U.S. Geological Survey test holes 12 to 15 mi south-southeast of Hunter, the alluvium consists of about 40 ft of beds of clay and sand (Page and others, 1963, table 13). The sand is fine grained with some fine to medium grained and is yellow, white, brown, and gray. The clay is yellow, gray, brown, and tan. Locally, in the area of these northern Sabine Parish test holes, the sand is missing.

Structure

The Logansport lignite area is approximately in the center of the southern part of the Sabine uplift, a large dome in northwestern Louisiana and eastern Texas (fig. 1). The map of the altitude of the base of the Wilcox Group shows a smaller domal structure on the Sabine uplift centered about 2 mi east-northeast of Logansport (fig. 3). East of this domal structure is another uplift. The dip in the project area is away from the crests of these two uplifts at 20 to 60 ft/mi. Structural relief on the base of the Naborton Formation (base of the Wilcox Group) is about 220 ft from the crest of the dome near Logansport to the southern border of the project area. Because of the uplift near Logansport the lignite bed near the base of the Naborton Formation is near enough to land surface to be strip mined.

GROUND-WATER HYDROLOGY

Description of Aquifers

The Naborton, Dolet Hills, and upper Wilcox zones are all parts of the Carrizo-Wilcox aquifer (table 1). Sands of the Carrizo-Wilcox aquifer are generally thin and fine grained and yield only moderate supplies of water (well yields of about 40 to 100 gal/min) for public-supply or industrial wells. Because of the irregular thickness and lateral extent of the sands, test drilling at some sites is needed to locate enough sand for a public-supply or industrial well. Sands of the terrace and Sabine River valley alluvial aquifers will yield enough water (about 10 gal/min) for domestic or stock wells but do not have sufficient saturated thickness for a public-supply or industrial well.

The Naborton zone is comprised of 55 percent clay layers, 40 percent sand beds, and 5 percent lignite deposits. Sand beds of the Naborton zone generally interconnect. Locally, clay beds act as confining beds. The top of the uppermost sand in the Naborton zone generally is separated from the top of the Naborton Formation by a clay interval that ranges from 10 to 60 ft in thickness and averages about 30 ft. The aggregated thickness of the sands of the Naborton zone ranges from about 10 to 140 ft and averages about 70 ft. Individual sand beds are as great as 80 ft in thickness and average about 35 ft. The thickest sand is at well DS-386 in sec. 34, T. 11 N., R. 15 W. The base of the Naborton zone generally is at the base of the formation or less than 25 ft above the base.

The base of freshwater in the Logansport lignite area (fig. 6) is generally in the Naborton zone. In most of the project area, the upper one-third to two-thirds of the Naborton zone contains freshwater. The base of the freshwater is highest in the northeastern part of the project area and at Logansport and east of Stanley. The base of freshwater is lowest in the northwestern corner of the project area.

A sand at the base of the Naborton zone contains saltwater in most of the Logansport area and generally is about 15 ft below the major lignite bed. The sand is very fine to fine grained, silty, and averages about 20 ft in thickness.

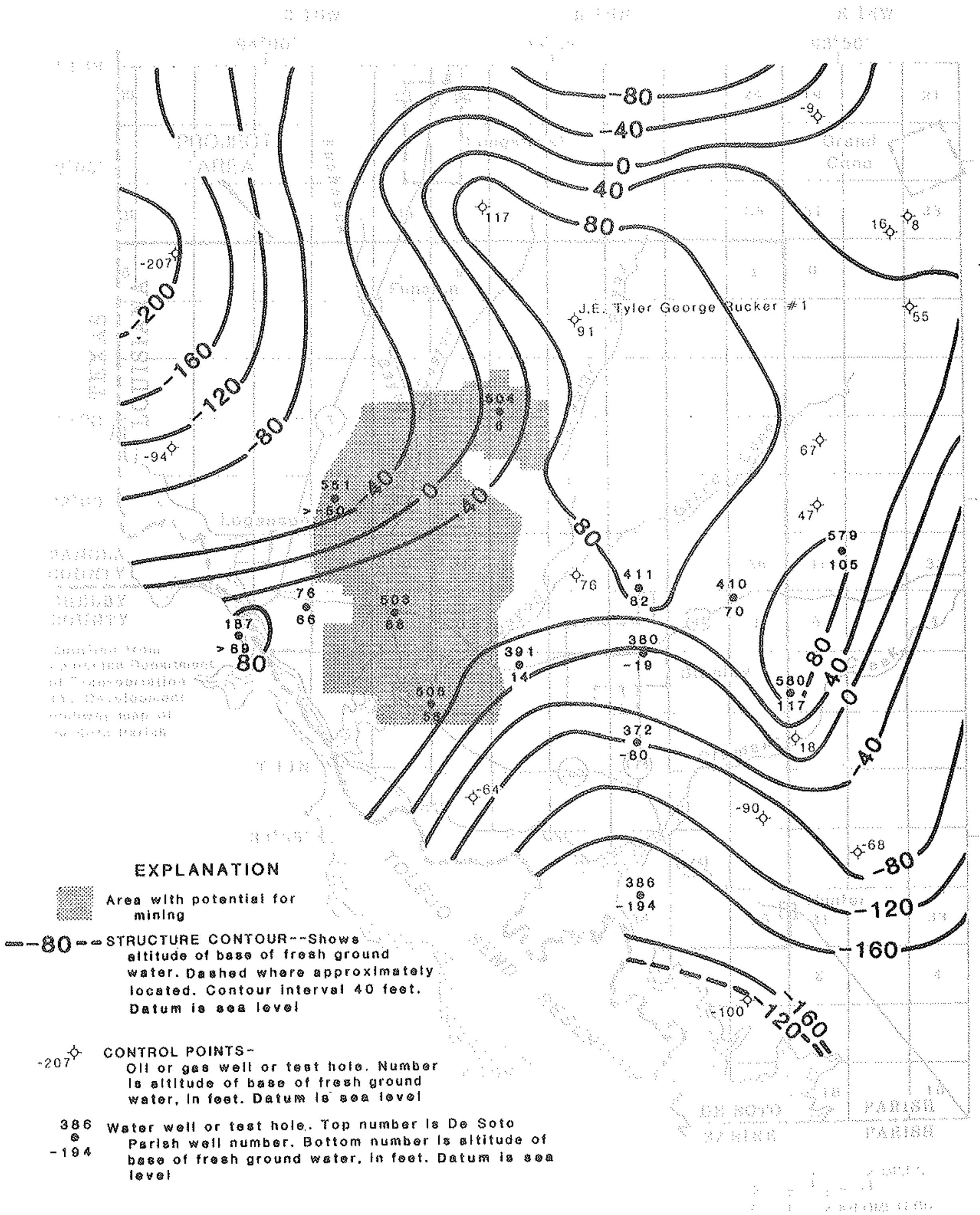


Figure 6.--Altitude of the base of fresh ground water, Logansport lignite area, De Soto Parish, Louisiana.

The top and base of the Dolet Hills zone coincide with the top and base of the Dolet Hills Formation in most of the project area. Forty-five percent of the Dolet Hills zone is comprised of sand beds. The aggregated thickness of these sand beds ranges from about 10 to 120 ft and averages about 50 ft. Individual sand beds range from about 5 to 110 ft and average about 20 ft.

Only that part of the undifferentiated upper part of the Wilcox Group that contains thin sand beds is considered as the upper Wilcox zone. The aggregated thickness of these sands averages about 30 ft. Individual sand beds range from about 4 to 20 ft in thickness.

Aggregated thickness of the sands of the terrace aquifer ranges from about 10 to 40 ft. Sands are discontinuous; at some sites there are no sands in the terrace deposits. Sand beds of the Sabine River valley alluvial aquifer are as great as 30 ft in thickness.

Water-Bearing Characteristics of Aquifers, Well Yields, and Specific Capacities

The Naborton zone is under artesian conditions in all of the Logansport lignite area. The Dolet Hills zone is under artesian conditions in the northern and southern parts of the project area. In and near the central east-west strip, where part of the Dolet Hills Formation has been eroded (fig. 5), the Dolet Hills generally is a water-table condition although clay beds in the Dolet Hills Formation, overlying terrace deposits, and upper Wilcox can cause artesian conditions locally. Surficial or shallow sandbeds of the upper Wilcox zone are locally under water-table conditions. Downdip, the sand beds of the upper Wilcox zone are artesian. The terrace aquifer is surficial and is generally a water-table condition. The Sabine River valley alluvial aquifer is artesian. The aquifer is mostly covered by Toledo Bend Reservoir and is in hydraulic connection with the reservoir.

Values of the hydraulic characteristics for the Naborton and Dolet Hills zones were obtained from aquifer tests. Hydraulic conductivity (from results of four tests) of the Naborton zone ranges from 9.6 to 39 ft/d and averages 17 ft/d. Transmissivity of the Naborton zone ranges from about 200 to 1,800 ft^2/d and averages about 940 ft^2/d. The coefficient of storage for the Naborton zone from a two-well interference test at Logansport is 3.2×10^{-4} (Page and Preé, 1964, p. 72).

Hydraulic conductivity (from results of five tests) of the Dolet Hills zone ranges from 3.6 to 20 ft/d and averages 11 ft/d. Transmissivity of the Dolet Hills zone ranges from 91 to 615 ft^2/d and averages 300 ft^2/d.

The potential yield for sands of the Naborton and Dolet Hills zones can be indicated by an example. Assume that a 1-foot diameter, fully developed well is screened in the total thickness of a 42-foot sand with a hydraulic conductivity of 14 ft/d. The transmissivity would be about 590 ft^2/d. Assume the storage coefficient is 1×10^{-4}, typical of artesian conditions in the aquifer. The theoretical specific capacity of the well, after pumping 24 hours, would be 2.3 (gal/min)/ft drawdown. If the well were pumped for 24 hours at 100 gal/min, the drawdown would be 44 ft. In most of the project area, available drawdown is sufficient for a larger yield to be pumped.

There are no data on hydraulic characteristics for the terrace or alluvial aquifers in the Logansport lignite area. The transmissivity of the terrace aquifer is low in most of the study area because the sand in the formation is not fully saturated, discontinuous, irregular in thickness, and clayey at places. However, where the terrace aquifer consists of medium- to coarse-grained sand, the hydraulic conductivity is probably high. Hydraulic conductivity of the terrace aquifer in Bossier Parish, northeast of the study area, is 120 ft/d (Page and May, 1964, p. 51).

As the alluvial aquifer is mostly fine-grained sand with some clayey sand, the hydraulic conductivity probably is lower than that of the terrace aquifer. The hydraulic conductivities for fine-grained aquifers in northwestern Louisiana mostly range from about 6 to 40 ft/d.

Most of the water wells in the Logansport lignite area are used for domestic and stock puposes, and yields probably are about 10 gal/min. Higher yields are pumped by the few public-supply and industrial wells in the project area (table 2). Well yields are as high as 93 gal/min, and specific capacities are as high as 3.4 (gal/min)/ft drawdown.

Table 2.--Selected well-yield and specific-capacity data for the Logansport lignite area, Louisiana

Date	Local well number	Owner	Yield (gallons per minute)	Specific capacity (gallons per minute per foot of drawndown)	Pumping period (hours)
6- 8-55	Texas- 75	Logansport, La----	55	---	--
6- 7-55	Texas-187	Logansport, La----	54	---	--
6- 7-55	Texas-188	Logansport, La----	31	---	--
1952	DS-280	Southern Natural Gas Co.	87	---	--
1952	DS-281	Southern Natural Gas Co.	93	---	--
5-18-70	DS-387	Toledo Bend Authority.	73	3.4	3
7-25-72	DS-428	Stanley Water System.	50	.8	1

Ground-Water Flow

The source of ground water in the Logansport lignite area is precipitation. Aquifers in the Carrizo-Wilcox aquifer receive recharge by infiltration of precipitation through the clayey surficial material in the interstream areas.

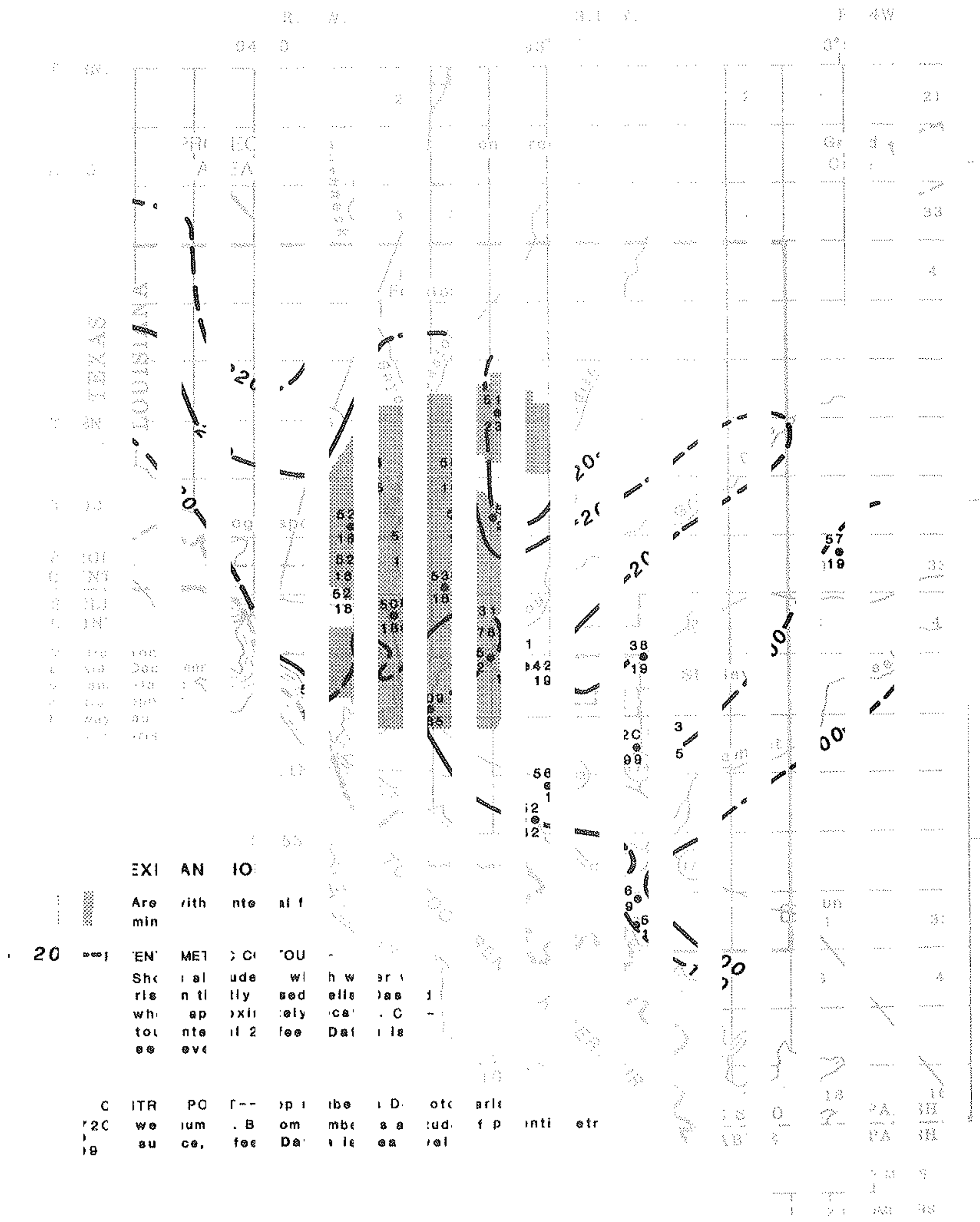
The altitude of the potentiometric surface of the Naborton zone (fig. 7) ranges from about 220 ft above sea level in the northern part of the project area to about 180 ft above sea level near the Toledo Bend Reservoir in the Sabine River valley. The potentiometric surface is above ground level near the Toledo Bend Reservoir (fig. 7). The map shows the potentiometric surface is low in the stream valleys. Although the Naborton zone is not in direct contact with the streams, it does discharge to the overlying aquifers in the stream valley. Another low in the potentiometric surface has developed in the pumping cone around well DS-428 near Stanley.

In most of the project area, water levels in wells completed in the Naborton zone range from 1 to 110 ft below land surface. Near Toledo Bend Reservoir, water levels are above land surface.

In two wells screened in the lower part of the Naborton zone, the water levels are unusually low when compared to water levels of nearby wells also screened in the aquifer. Well DS-76, at the eastern edge of Logansport (fig. 2), is completed in the major lignite bed. Well DS-504, 3 mi southeast of Funston (fig. 2), is completed in a sand bed above the lignite. The sand and lignite beds in the lower part of the Naborton zone are separated from sands in the middle and upper parts of the Naborton by clay beds. The clay beds retard recharge to water-bearing beds in the lower part of the Naborton, which results in the beds in the lower part of the Naborton having a lower water level.

Figure 8 shows hydrographs for wells DS-506 near Logansport, and DS-504 near Funston, and monthly precipitation at Logansport. Well DS-506 is a 56-foot well screened near the top of the Naborton zone, and well DS-504 is a 260-foot well screened near the base of the Naborton zone. Both hydrographs show response to seasonal variation in precipitation, and neither hydrograph shows a decline caused by pumpage. A large part of the recharge occurs during the winter and spring. The water level of well DS-506 was high in April and May 1980, reflecting high precipitation early in 1980. From June 1980 to November 1982, the water level of well DS-506 was low, reflecting low precipitation during the winter-spring periods of 1980-82. Two small "peaks" in July 1981 and May 1982 seem to reflect high precipitation. High water levels in the first half of 1983 reflect high monthly precipitation during the fall of 1982 and winter-spring of 1983. The hydrograph of DS-504 is similar but shows subdued fluctuations.

The water-level rise illustrated by the hydrographs (fig. 8) indicate periods when recharge to the aquifers near the wells exceeds discharge, and water is entering storage; the water-level decline represent periods when discharge exceeds recharge. The relatively flat segments of the hydrographs indicate recharge is about equal to discharge. Erosion in the valley of Bayou Castor has almost cut into the upper part of the Naborton zone in which well DS-506 is screened. Consequently, recharge to the upper part of the



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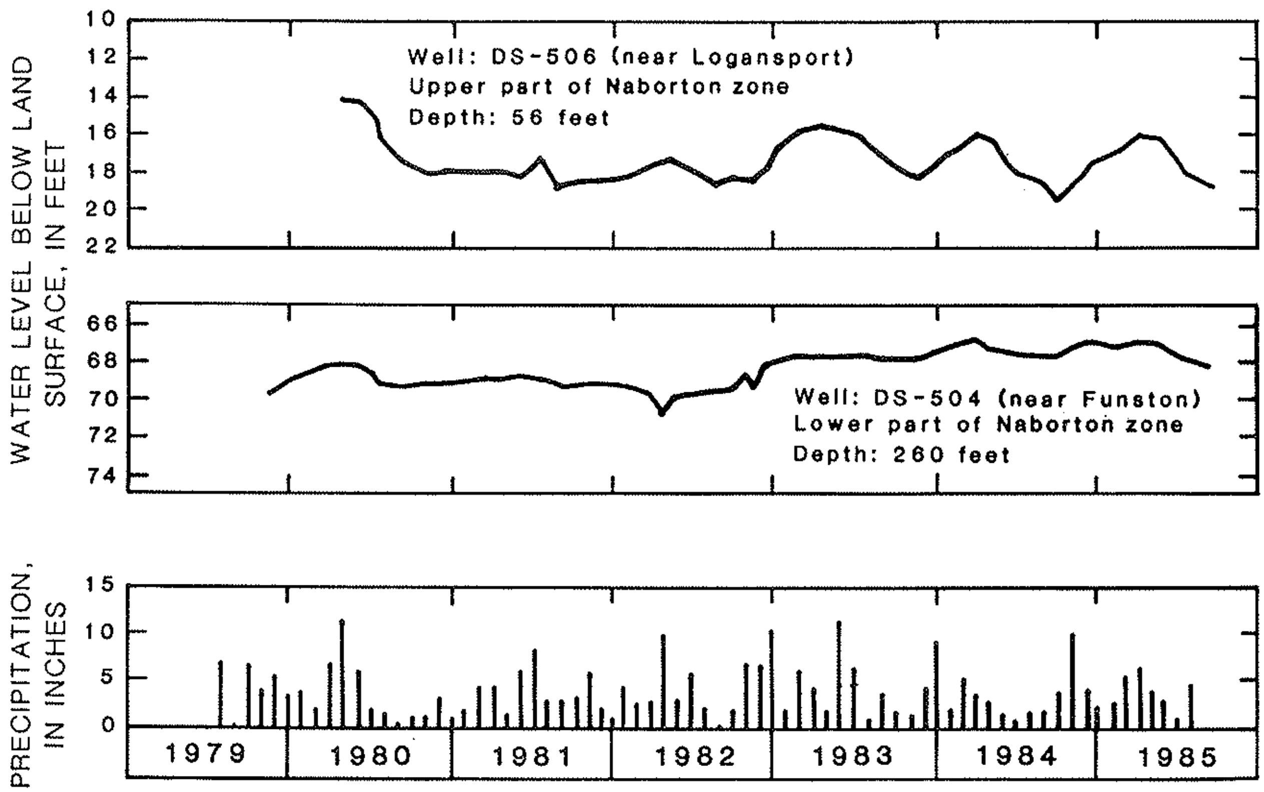

Figure 8.--Hydrographs for wells in the Naborton zone and monthly precipitation at Logansport, Louisiana.

aquifer from precipitation and discharge from the upper part of the aquifer to the streams are relatively rapid. Clay beds overlying the lower part of the Naborton zone in which well DS-504 is screened retard the rate of recharge to and discharge from the lower part of the aquifer near well DS-504. Consequently, fluctuations on the hydrograph of DS-506 are more pronounced than fluctuations on the hydrograph of DS-504.

The altitude of the potentiometric surface of the Dolet Hills zone (fig. 9) ranges from about 180 to 240 ft above sea level. Water levels in wells completed in the Dolet Hills zone range from about 10 to 70 ft below land surface. Contours on the potentiometric surface of the Dolet Hills zone are influenced by the streams, especially in the area where the aquifer is under water-table conditions. The potentiometric surface is highest in the northeastern corner of the Logansport lignite area and lowest near Toledo Bend Reservoir.

The altitude of the potentiometric surface of the upper Wilcox zone ranges from about 210 to 300 ft above sea level. Water levels in wells completed in the upper Wilcox zone range from about 5 to 40 ft below land surface. Data are insufficient for mapping the potentiometric surface of the aquifer.

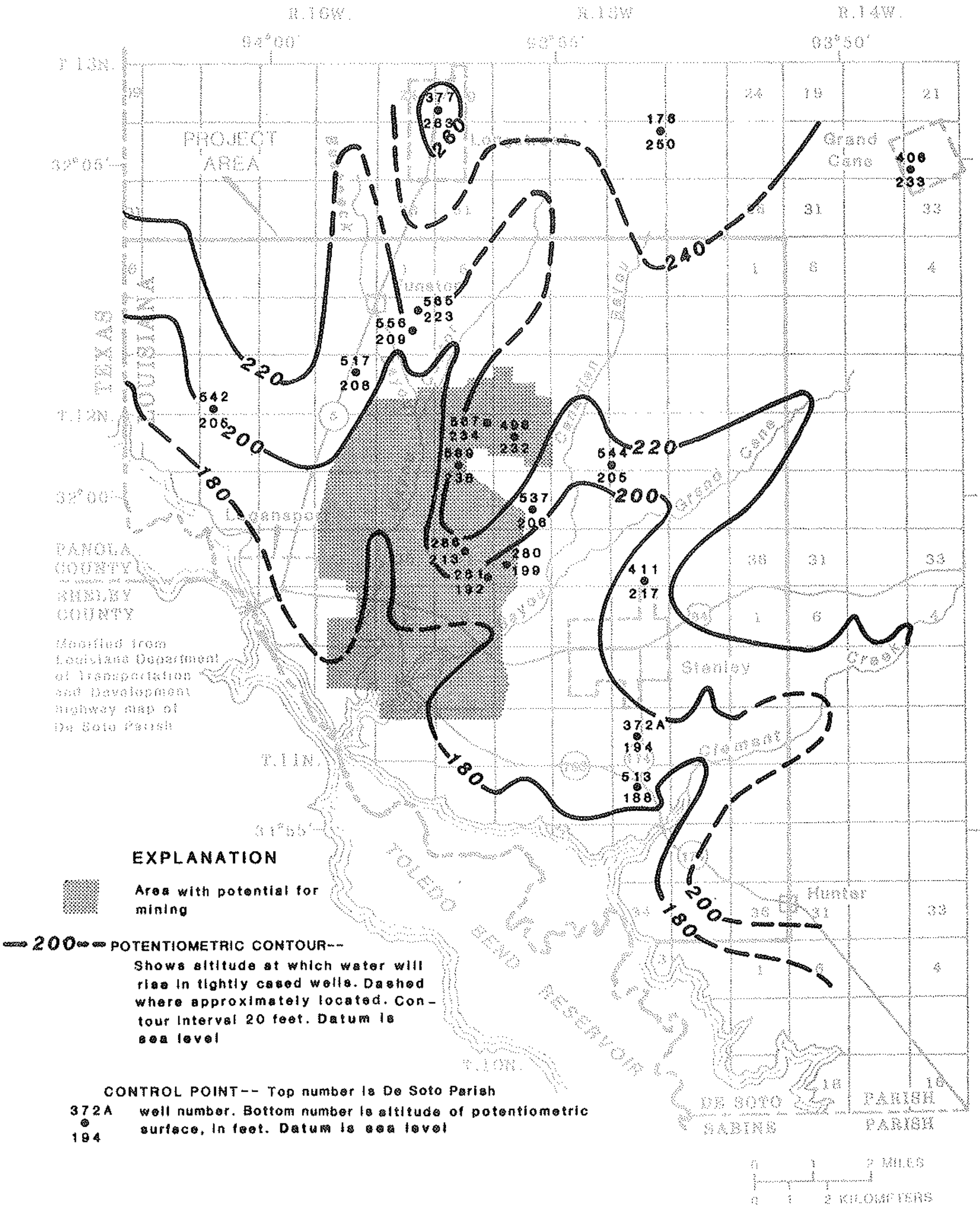

Figure 9.--Altitude of the potentiometric surface of the Dolet Hills zone, Logansport lignite area, De Soto Parish, Louisiana.

Water levels in wells completed in the terrace aquifer mostly range from 1 to 30 ft below land surface. However, the water level in well DS-285 (fig. 2) is above land surface and, hence is a flowing well. In the lower terrace deposits, the altitude of the potentiometric surface of the terrace aquifer ranges from about 175 to 210 ft above sea level. The potentiometric surface of the terrace aquifer in the lower terrace deposits is about 1 to 5 ft higher than the potentiometric surface of the Dolet Hills zone.

In the higher terrace deposits, the altitude of the potentiometric surface of the terrace aquifer ranges from about 240 to 255 ft above sea level. The potentiometric surface of the aquifer in the higher terrace deposits is about 40 to 60 ft above the potentiometric surface of the Dolet Hills zone.

The direction of water movement in the aquifers is at right angles to the potentiometric contours of the Naborton and Dolet Hills zones (figs. 7 and 9). Water in the aquifers moves toward discharge areas in the valleys of the Sabine River and its tributaries. There also is lateral movement of water in aquifers in the Carrizo-Wilcox aquifer into the project area from potentiometric highs in the south-central part of De Soto Parish (Page and Preé, 1964, pls. 10, 12, and 13).

In parts of the Logansport lignite area, vertical movement of water occurs between the Naborton and Dolet Hills zones. In the western part of the area between Bayou Grand Cane and Bayou Castor north of U.S. Highway 84, and in the eastern part of the project area, the potentiometric surface of the Dolet Hills zone is higher than that of the Naborton zone. The greatest difference in altitude between the two potentiometric surfaces is almost 50 ft in the southern part of sec. 19, T. 12 N., R. 15 W. (figs. 7 and 9). Where the potentiometric surface of the Dolet Hills zone is higher, water moves downward into the Naborton zone. The potentiometric-surface maps show that in the valleys of Bayou Castor, Bayou Grand Cane, and Clement Creek, within 3 mi of the Toledo Bend Reservoir, the potentiometric surface of the Naborton zone is as much as 20 ft higher than that of the Dolet Hills zone. This indicates that in these valleys water in the Naborton zone moves upward into the Dolet Hills zone.

Water movement in the upper Wilcox zone is from interstream areas to stream valleys. The potentiometric surface of the upper Wilcox zone ranges from about 20 to 90 ft above that of the Dolet Hills zone, so there is potential for vertical water movement from the upper Wilcox zone downward to the Dolet Hills zone.

Some water in the terrace aquifer moves downward and recharges the Dolet Hills zone. Most water in the terrace aquifer moves from interstream areas to stream valleys where it is discharged to streams or moves into the alluvial aquifer.

Before the construction of Toledo Bend Reservoir, the alluvial aquifer was recharged mostly by infiltration of water from precipitation and by upward and lateral movement of water from aquifers of the Carrizo-Wilcox aquifer and the terrace aquifer. Most of the year, water movement in the alluvial aquifer was to the Sabine River, where the water was discharged. During high stages of the river and its tributaries, this gradient would be locally reversed.

At present, the alluvial aquifer is almost covered by the Toledo Bend Reservoir. Upward and lateral movement of water occurs from the Carrizo-Wilcox aquifer and the terrace aquifer into the alluvial aquifer and subsequently into the reservoir. Occasionally, flow from the reservoir to the alluvial aquifer may occur when the reservoir level is at high stage.

Water Quality

Many wells in the Logansport lignite area yield water with high concentrations of chloride, fluoride, iron, manganese, and other dissolved solids. Results of chemical analyses of water samples collected from wells in the Logansport lignite area are presented in tables 3 and 4.

Results of chemical analyses of trace elements for wells DS-504, DS-517, and DS-522 (fig. 2) also are given in table 3. Concentrations of arsenic, barium, cadmium, chromium, lead, mercury, and selenium were lower than the maximum contaminant levels of the U.S. Environmental Protection Agency (1976b). The U.S. Environmental Protection Agency has not established a maximum contaminant level for aluminum, antimony, beryllium, cobalt, copper, lithium, molybdenum, nickel, or zinc. Trace elements generally are those mineral constituents which occur in concentrations of less than 1.0 mg/L (Hem, 1985, p. 129).

Water samples from wells DS-517 and DS-522 were analyzed for concentrations of gross-beta activity; results are reported in table 3. Concentrations of gross-beta activity were lower than 50 picocuries per liter, the maximum allowed contaminant level of the U.S. Environmental Protection Agency (1976b).

General Characteristics

Chloride concentrations in the Naborton zone ranged from 16 to 1,100 mg/L with several wells yielding water with chloride concentrations higher than 250 mg/L[2]. The sample with the highest chloride concentration was from well DS-493, which is screened in the basal sand of the Naborton zone.

From interpretation of electric logs, it appears that water in the basal sand has a high chloride concentration in most of the project area. Chloride concentrations from most wells screened in the Naborton zone above the basal sand ranged from 100 to 500 mg/L. The higher chloride concentrations mostly occur within 3 mi of the Toledo Bend Reservoir. Interpretation of the electric log of the J.E. Tyler #1 George Rucker oil-test well located in sec. 9, T. 12 N., R. 15 W. (fig. 6) indicates that all sands of the Naborton zone at that site contain water with a high (greater than 250 mg/L) chloride concentration.

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[2] In this report, freshwater is defined as that containing 250 mg/L or less of chloride. Freshwater also has been defined as containing 1,000 mg/L or less of dissolved solids.

TABLE 3.--CHEMICAL ANALYSES OF WATER FROM WELLS IN THE LOGANSPORT LIGNITE AREA, DE SOTO PARISH, LOUISIANA, AND SHELBY COUNTY, TEXAS

[MG/L, MILLIGRAMS PER LITER; UG/L, MICROGRAMS PER LITER; US/CM, MICROSIEMENS PER CENTIMETER AT 25°C; PCI/L, PICOCURIES PER LITER]

WELL NUMBER	STATION NUMBER	DATE	DEPTH OF WELL (FEET)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE WATER (DEG C)	COLOR (PLAT-INUM-COBALT UNITS)	HARD-NESS (MG/L AS $CACO_3$)
				DE SOTO PARISH				
DS- 176	320531093530901	03-04-55[a]	237	874	7.7	--	0	180
DS- 281	315852093561101	11-04-55[b]	99	115	6.9	20.0	5	16
		08-02-79	99	121	5.8[d]	--	200	15
DS- 282	315852093544301	11-04-55[c]	175	638	8.3	20.0	20	5
DS- 290	315747093534001	08-24-64	320	599	8.1	--	--	16
		10-29-73	320	--	--	--	--	130
DS- 357	315739093534901	05-21-68	358	1620	8.0[d]	22.0	50	10
DS- 372A	315622093533501	12-03-65	130	189	6.3	--	15	11
DS- 372B	315622093533502	12-07-65	265	1160	7.5[d]	21.5	80	1
DS- 372C	315622093533503	11-29-65	332	1310	7.5[d]	21.5	80	4
DS- 373	315622093531701	11-19-65	268	1340	7.9	20.5	50	2
DS- 377	320553093570201	05-20-68	282	772	8.2[d]	22.0	20	14
DS- 378	320549093570201	05-10-68	203	162	6.8[d]	18.5	30	37
DS- 379	320555093570101	05-10-68	317	645	8.1	20.0	20	20
DS- 380	315742093533001	06-07-68	311	1800	8.7	23.5	50	5
DS- 386	315405093534001	04-08-70	304	1510	8.8	20.5	45	2
DS- 387	315405093534002	05-18-70	312	1510	8.8	20.5	35	2
DS- 391	315728093553901	05-19-71	259	1800	8.6	21.5	50	6
DS- 406	320454093484501	06-25-73	300	570	8.8[d]	21.0	5	5
DS- 411	315837093533301	01-03-74	100	207	6.4[d]	--	40	17
DS- 459	320650093564101	05-01-78	337	779	8.8[d]	22.0	40	1
DS- 493	315709093573401	08-02-79	287	4740	8.0[d]	--	15	20
DS- 504	320118093555601	11-05-79	260	1820	--	--	15	6
		07-01-80	260	1520	8.3	--	--	4
DS- 513	315540093534001	11-02-82	78	109[d]	6.1[d]	20.5	0	17
DS- 517	320153093583601	09-03-82	131	1160	8.7[d]	21.5	15	12
DS- 518	315704093590301	09-01-82	28	67[d]	5.4[d]	19.5	40	7
DS- 522	315945093581501	09-02-82	240	2510[d]	8.7[d]	21.0	20	6
DS- 538	315944093541901	03-03-83	160	3470	8.5[d]	--	20	15
DS- 542	320117094005601	03-10-83	135	89	5.2	--	0	8
DS- 543	315441093510401	03-23-83	253	996	9.2[d]	--	10	2
DS- 544	320027093540201	03-22-83	152	743	8.2[d]	--	0	7
DS- 545	315650093571503	03-23-83	70	373	6.2[d]	--	0	36
DS- 547	320023093563601	07-19-83	175	625[d]	8.0[d]	--	20	5
DS- 560	315420093502301	06-02-83	210	1240[d]	8.1[d]	--	30	31
DS- 562	315545093550901	06-02-83	335	2590[d]	8.6[d]	--	30	6
DS- 565	320244093572501	06-01-83	160	638[d]	8.7[d]	--	5	3
				SHELBY COUNTY, TEXAS				
TX- 75	315757094003401	04-03-37	208	--	--	--	--	31
		11-03-55	208	1300	7.9	19.5	30	24
TX- 187	315810094003101	11-03-55	154	2400	8.0	20.5	35	12

TABLE 3.--CHEMICAL ANALYSES OF WATER FROM WELLS IN THE LOGANSPORT LIGNITE AREA, DE SOTO PARISH, LOUISIANA, AND SHELBY COUNTY, TEXAS--CONTINUED

WELL NUMBER	HARD-NESS NONCARB TOT FLD (MG/L AS $CACO_3$)	CALCIUM, DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	BICAR-BONATE TOTAL FIELD (MG/L AS HCO_3)	CAR-BONATE TOTAL FIELD (MG/L AS CO_3)
				DE SOTO PARISH--CONTINUED					
DS- 176	0	50	13	110	57	4	3.8	260	0
DS- 281	0	2.9	2.1	17	66	2	2.2	50	0
	0	3.5	1.5	16	66	2	2.3	42	0
DS- 282	0	1.8	0.1	150	98	31	0.9	340	--
DS- 290	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
DS- 357	0	3.3	0.4	380	99	55	1.4	680	0
DS- 372A	0	2.8	1.0	36	86	5	0.9	98	0
DS- 372B	0	0.4	0.0	280	100	130	1.2	570	0
DS- 372C	0	1.0	0.4	290	99	64	2.3	590	0
DS- 373	0	0.4	0.2	330	99	110	1.6	630	0
DS- 377	0	3.6	1.2	180	96	22	1.4	430	0
DS- 378	0	7.9	4.2	21	53	2	2.3	88	0
DS- 379	0	6.0	1.2	150	94	15	1.7	380	0
DS- 380	0	2.0	0.0	400	99	82	2.2	630	42
DS- 386	0	0.2	0.4	360	99	110	1.7	550	41
DS- 387	0	0.9	<.1	360	99	110	1.7	590	34
DS- 391	0	1.6	0.5	430	99	79	4.3	700	35
DS- 406	0	2.0	<.1	140	98	27	0.8	340	0
DS- 411	0	4.5	1.4	42	83	5	1.2	100	0
DS- 459	0	0.3	0.1	190	99	79	1.6	390	7
DS- 493	0	5.0	1.8	1100	99	110	3.9	950	0
DS- 504	0	2.2	0.1	440	99	83	3.5	700	17
	0	1.2	0.2	350	99	78	1.9	630	10
DS- 513	0	3.6	1.9	12	56	1	2.7	--	--
DS- 517	0	3.6	0.7	280	97	37	3.2	--	--
DS- 518	0	1.6	0.7	6.0	62	1	1.0	--	--
DS- 522	0	2.0	0.2	600	99	110	4.3	--	--
DS- 538	0	3.6	1.5	780	99	90	6.6	--	--
DS- 542	5	2.0	0.7	12	75	2	0.7	--	--
DS- 543	0	0.4	0.2	230	99	76	1.1	--	--
DS- 544	0	2.0	0.5	180	98	31	1.2	--	--
DS- 545	0	8.9	3.3	58	77	4	1.6	--	--
DS- 547	0	1.8	0.2	150	98	30	1.3	--	--
DS- 560	0	6.6	3.5	280	94	23	5.5	--	--
DS- 562	0	1.2	0.7	600	99	110	5.7	--	--
DS- 565	0	1.1	0.1	160	98	41	2.8	--	--
				SHELBY COUNTY, TEXAS--CONTINUED					
TX- 75	--	11	1.0	--	--	--	--	43	--
	--	8.2	.8	288	--	--	2.0	440	0
TS- 187	--	3.2	1.0	546	--	--	3.2	775	0

TABLE 3.--CHEMICAL ANALYSES OF WATER FROM WELLS IN THE LOGANSPORT LIGNITE AREA, DE SOTO PARISH, LOUISIANA, AND SHELBY COUNTY, TEXAS--CONTINUED

WELL NUMBER	ALKALINITY TOTAL FIELD (MG/L AS $CACO_3$)	CARBON DIOXIDE DISSOLVED (MG/L AS CO_2)	SULFATE DISSOLVED (MG/L AS SO_4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)
DE SOTO PARISH--CONTINUED								
DS- 176	209	8.1	78	98	0.1	40	530	520
DS- 281	41	10	2.6	8.5	0.1	60	121	120
	34	106	2.8	8.9	0.2	49	133	110
DS- 282	276	2.7	12	37	0.2	11	388	380
DS- 290	--	0	--	--	--	--	--	--
	--	--	--	230	3.6	--	--	--
DS- 357	--	11	1.4	200	3.2	12	--	940
DS- 372A	80	78	0.4	9.1	0.1	51	162	150
DS- 372B	466	29	0	110	2.2	8.7	738	680
DS- 372C	--	29	0.2	120	2.8	11	805	720
DS- 373	--	13	0.4	130	3.0	10	820	780
DS- 377	--	4.3	0.2	45	0.3	14	463	460
DS- 378	--	22	1.4	7.1	0.6	67	150	160
DS- 379	313	4.8	0	23	0.6	39	411	410
DS- 380	590	2.0	0.4	210	3.6	10	--	1000
DS- 386	520	1.4	<1	180	2.6	10	889	910
DS- 387	540	1.5	0.2	180	2.7	14	918	920
DS- 391	629	2.8	<1	220	4.2	12	1070	1100
DS- 406	279	0.9	9.2	19	0.4	11	341	350
DS- 411	82	63	6.2	12	0.4	48	181	170
DS- 459	328	--	0.6	51	0.5	11	457	460
DS- 493	778	15	40	1100	2.8	11	2810	2700
DS- 504	604	--	2.8	230	2.8	9.5	1080	1100
	520	--	2.0	170	0.4	12	--	860
DS- 513	34	52	0.6	6.0	0.1	47	104	97
DS- 517	486[d]	1.8	1.0	85	2.1	11	688	680
DS- 518	14[d]	108	1.0	4.7	0.1	30	62	57
DS- 522	582[d]	2.2	3.0	490	3.2	12	1500	1500
DS- 538	791[d]	4.8	0.6	640	3.7	10	2000	1900
DS- 542	3	--	4.8	18	<.1	44	95	84
DS- 543	420[d]	0.5	0.6	74	1.0	12	587	570
DS- 544	251[d]	3.0	49	50	0.2	15	446	450
DS- 545	64	78	5.6	67	<.1	54	230	240
DS- 547	308	5.9	0.2	16	0.8	15	395	370
DS- 560	531	8.1	33	76	3.4	18	753	740
DS- 562	709	3.4	0.6	440	5.6	11	1520	1500
DS- 565	309	1.2	8.0	20	0.6	12	381	390
SHELBY COUNTY, TEXAS--CONTINUED								
TX- 75	--	--	19	28	--	--	--	110
	--	--	3.7	208	1.0	16	756	--
TX- 75	--	--	1.8	410	3.6	12	1420	--

TABLE 3.--CHEMICAL ANALYSES OF WATER FROM WELLS IN THE LOGANSPORT LIGNITE AREA, DE SOTO PARISH, LOUISIANA, AND SHELBY COUNTY, TEXAS--CONTINUED

WELL NUMBER	NITROGEN, NITRATE DISSOLVED (MG/L AS N)	NITROGEN, NITRATE TOTAL (MG/L AS NO_3)	NITROGEN, NITRATE DISSOLVED (MG/L AS NO_3)	PHOSPHATE, ORTHO, DISSOLVED (MG/L AS PO_4)	IRON, TOTAL RECOVERABLE (UG/L AS FE)	IRON, DISSOLVED (UG/L AS FE)	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)
DE SOTO PARISH--CONTINUED								
DS- 176	0.72	--	3.2	0.07	5900	--	100	--
DS- 281	0.00	--	0.0	0.01	5400	--	100	--
	--	0.32	--	--	--	6000	--	90
DS- 282	0.27	--	1.2	0.8	610	--	0	--
DS- 290	--	--	--	--	680	--	--	--
	--	--	--	--	--	--	--	--
DS- 357	0.34	--	1.5	--	--	180	--	--
DS- 372A	0.00	--	0.0	0.7	--	1800	--	50
DS- 372B	0.14	--	0.62	2.9	--	800	--	0
DS- 372C	--	--	0.0	3.7	--	440	--	50
DS- 373	--	--	0.0	4.8	--	200	--	30
DS- 377	--	--	0.10	--	--	120	--	--
DS- 378	--	--	0.20	--	--	7400	--	--
DS- 379	0.00	--	0.0	--	--	370	--	--
DS- 380	0.00	--	0.0	--	--	120	--	--
DS- 386	--	0.20	--	--	--	70	--	20
DS- 387	--	0.40	--	--	--	130	--	30
DS- 391	--	0.30	--	--	--	40	--	20
DS- 406	--	0.10	--	--	--	110	--	<10
DS- 411	--	<.01	--	--	--	4200	--	100
DS- 459	--	0.76	--	--	--	90	--	20
DS- 493	--	0.30	--	--	--	120	--	20
DS- 504	--	0.43	--	--	--	50	--	0
	--	<.01	--	--	--	50	--	10
DS- 513	--	0.30	--	--	--	2900	--	95
DS- 517	--	0.24	--	--	--	30	--	5
DS- 518	--	0.45	--	--	--	3000	--	250
DS- 522	--	0.40	--	--	--	40	--	10
DS- 538	--	0.55	--	--	--	90	--	0
DS- 542	--	1.3	--	--	--	20	--	9
DS- 543	--	1.7	--	--	--	30	--	0
DS- 544	--	1.5	--	--	--	40	--	19
DS- 545	--	0.16	--	--	--	4300	--	75
DS- 547	--	1.4	--	--	--	330	--	17
DS- 560	--	0.46	--	--	--	40	--	23
DS- 562	--	0.40	--	--	--	20	--	63
DS- 565	--	1.4	--	--	--	0	--	11
SHELBY COUNTY, TEXAS--CONTINUED								
TX- 75	--	--	--	--	--	--	--	--
	--	--	--	--	--	160	--	20
TX- 187	--	--	--	--	--	30	--	0

TABLE 3.--CHEMICAL ANALYSES OF WATER FROM WELLS IN THE LOGANSPORT LIGNITE AREA, DE SOTO PARISH, LOUISIANA, AND SHELBY COUNTY, TEXAS--CONTINUED

WELL NUMBER	STATION NUMBER	DATE	ALUMINUM, DISSOLVED (UG/L AS AL)	ANTIMONY, DISSOLVED (UG/L AS SB)	ARSENIC, DISSOLVED (UG/L AS AS)	BARIUM, DISSOLVED (UG/L AS BA)	BERYLLIUM, DISSOLVED (UG/L AS BE)
DE SOTO PARISH--CONTINUED							
DS-504	320118093555601	07-01-80	20	<1	<1	20	<1
DS-517	320153093583601	09-03-82	30	1	1	77	<1
DS-522	315945093581501	09-02-82	30	<1	1	100	<10

WELL NUMBER	CADMIUM DISSOLVED (UG/L AS CD)	CHROMIUM, DISSOLVED (UG/L AS CR)	COBALT, DISSOLVED (UG/L AS CO)	COPPER, DISSOLVED (UG/L AS CU)	LEAD, DISSOLVED (UG/L AS PB)	LITHIUM, DISSOLVED (UG/L AS LI)	MERCURY, DISSOLVED (UG/L AS HG)	MOLYBDENUM, DISSOLVED (UG/L AS MO)
DE SOTO PARISH--CONTINUED								
DS-504	1	<10	<3	2	3	30	0.4	<10
DS-517	<1	10	<1	6	5	21	0.1	<1
DS-522	<1	10	<1	5	5	60	0.2	5

WELL NUMBER	NICKEL, DISSOLVED (UG/L AS NI)	SELENIUM, DISSOLVED (UG/L AS SE)	SILVER, DISSOLVED (UG/L AS AG)	ZINC, DISSOLVED (UG/L AS ZN)	GROSS ALPHA, DISSOLVED (UG/L AS U-NAT)	GROSS BETA, DISSOLVED (PCI/L AS CS-137)	GROSS BETA, DISSOLVED (PCI/L AS SR/YT-90)
DE SOTO PARISH--CONTINUED							
DS-504	11	<1	<1	180	--	--	--
DS-517	<1	<1	1	70	<20	<11	<11
DS-522	1	<1	2	<10	<39	<27	<25

[a] DISSOLVED BORON, 240 UG/L.
[b] DISSOLVED BORON, 100 UG/L.
[c] DISSOLVED BORON, 600 UG/L.
[d] FIELD ANALYSIS.

Table 4.--Analyses of concentrations of chloride and hardness in water from wells in the Logansport lignite area, De Soto Parish, Louisiana

[mg/L, milligrams per liter]

Well number	Station number	Depth of well, total (feet)	Date of sample	Hardness (mg/L as $CACO_3$)	Chloride, dissolved (mg/L as CL)
DS-287	320104093553401	86	4-27-83	540	230
DS-481	320049093554001	48	7-25-79	810	850
DS-483	320117093555401	20	9-30-79	640	400
DS-484	320116093555301	100	9-30-79	340	150
DS-485	315840093573201	42	8- 1-79	64	10
DS-486	315847093565101	39	8- 1-79	42	12
DS-487	315901093554201	28	8- 1-79	140	300
DS-488	315901093554202	115	8- 1-79	110	170
DS-489	315650093571501	20	8- 1-79	120	68
DS-491	315916093571301	30	8- 1-79	14	22
DS-492	315916093571601	110	8- 1-79	270	200
DS-494	315615093563201	70	8- 2-79	250	26
DS-496	320057093554201	59	8-13-79	120	56
		59	4-27-83	180	80
DS-515	315736093561401	147	7-15-82	6	210
DS-539	315946093541901	87	3-09-83	16	6.0
DS-540	320115093535901	140	3-09-83	260	14
DS-548	320256093505901	80	4-26-83	96	84
DS-549	320246093505801	145	4-26-83	20	36
DS-550	320219093525101	97	4-26-83	10	24
DS-551	315950093585001	190	4-26-83	12	360
DS-552	315518093552101	300	4-27-83	6	200
DS-554	315332093533901	230	4-27-83	8	400
DS-555	315740093573901	117	4-27-83	14	260
DS-557	315813093562801	200	4-27-83	16	340
DS-558	315810093563001	32	4-27-83	12	16
DS-559	315419093522101	32	4-27-83	64	56
DS-561	315755093563501	128	4-28-83	20	210
DS-563	315630093565501	180	4-28-83	44	16
DS-564	315553093552101	100	4-28-83	32	12

Chloride concentration of water in the Naborton zone has increased near Logansport. At well 75 in Shelby County, Texas, across the Sabine River from Logansport (fig. 2), the chloride concentration increased from 28 mg/L, April 14, 1937, to 210 mg/L, November 3, 1955. Water with a high chloride concentration downdip in the Naborton zone may have moved upward in response to the declining water level caused by pumpage.

Concentration of fluoride in water in the Naborton zone ranged from about 0.8 to 5.6 mg/L. For an annual average of maximum daily air temperature of 25.5°C, the maximum recommended concentration of fluoride for public-supply water is 1.6 mg/L (U.S. Environmental Protection Agency, 1976b). The concentration of fluoride in water from most wells completed in the Naborton zone exceeded this limit.

The concentration of iron ranged from 20 to 800 µg/L but generally was below 300 µg/L. This water, with the exception of water from some wells near Stanley, from the Naborton zone would not require treatment for reduction of iron concentration to be satisfactory for public-supply.

Concentration of manganese ranged from below the limit of detection to 63 µg/L. Water from most wells had a manganese concentration lower than the 50 µg/L limit recommended by the U.S. Environmental Protection Agency (1976b).

Water in the Naborton zone generally is soft[3]. Hardness ranged from 1 to 130 mg/L, but water from most wells had a hardness of 20 mg/L or less. In Louisiana, water that is hard or very hard that contains an iron concentration exceeding 300 µg/L generally is treated for public-supply use.

Concentration of sulfate ranged from below the level of detection to 40 mg/L but was generally less than 4 mg/L. The highest concentration of sulfate was from well DS-493 which is screened in the basal sand of the Naborton zone.

Concentration of dissolved solids ranged from 372 to 2,730 mg/L. In most of the area, concentration of dissolved solids was higher than the 500 mg/L concentration recommended as a maximum by the U.S. Environmental Protection Agency (1976b, p. 206).

The color of water from the Naborton zone ranged from 10 to 80 units. A color value of 10 is almost colorless; whereas, water with a color value of 50 or 80 units has a noticeable yellow, brown, or yellow-brown tint. The source of the color may be lignite or other organic material in the sands. Temperatures of water from the Naborton zone ranged from 21.0 to 21.5°C, and the pH ranged from 7.5 to 9.2 units. Water in many wells screened in the Naborton zone contains a large amount of odorless, flammable gas. The gas may be methane from the decomposition of organic matter.

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[3] The U.S. Geological Survey (Hem, 1985, p. 159) classifies hardness as follows: Water having a hardness of 0-60 mg/L is considered soft, 61-120 mg/L is moderately hard, 121-180 mg/L is hard, and more than 180 mg/L is very hard.

Chloride concentrations in the Dolet Hills zone ranged from 5 to 850 mg/L but most values were less than 100 mg/L. Some of the high values were in water from the part of the project area where chloride concentrations from five wells (DS-287, DS-481, DS-483, DS-484, and DS-496; fig. 2) ranged from 80 to 850 mg/L (table 3). The highest concentrations were from two shallow wells completed in the upper part of the Dolet Hills zone. Water from well DS-481 (a 48-foot well) had a chloride concentration of 850 mg/L, July 25, 1979, and water from well DS-483 had a chloride concentration of 400 mg/L, September 30, 1979. Chloride concentrations have increased in the lower part of the Dolet Hills zone. At well DS-496 (a 59-foot well near DS-481), chloride concentration increased from 56 mg/L, August 13, 1979, to 80 mg/L, April 27, 1983. The water with the high chloride concentration may have migrated from the upper part of the Dolet Hills zone to the lower part. The source of the water with the high chloride concentration in the upper part of the Dolet Hills zone could be upward intrusion through oil or gas wells. It is not coming from the Naborton zone because an electric log of test hole DS-504 shows that the Naborton contains freshwater-bearing sands in this area.

Fluoride concentrations ranged from below the limit of detection to 3.4 mg/L with most concentrations lower than 0.7 mg/L. Concentrations of iron and manganese were variable. Iron concentrations ranged from below the detection limit to 6,000 µg/L with most concentrations less than 1,800 µg/L. Manganese concentrations ranged from 5 to 100 µg/L with most concentrations lower than 75 µg/L.

Hardness of water in the Dolet Hills zone ranged from 5 to 810 mg/L. Typical concentrations of hardness were 40 mg/L or less. Some of the high concentrations are in secs. 17 and 20, T. 12 N., R. 15 W. (fig. 2), where they may result from contamination by oil-field activity. In sections 17 and 20 hardness of water ranged from 180 to 810 mg/L. Outside of the area of possible contamination, hardness concentrations ranged from 10 to 260 mg/L, with most wells yielding water with a hardness of less than 75 mg/L.

Sulfate concentration in water in the Dolet Hills zone was low, ranging from 0.4 to 78 mg/L. Most sulfate values were less than 3 mg/L. Concentrations of dissolved solids in the Dolet Hills zone ranged from about 100 to 750 mg/L with most concentrations lower than 500 mg/L.

Color of water from the Dolet Hills zone ranged from 0 to 200 units. Most color values were less than 30 units. Water temperature for the Dolet Hills zone was 20.0°C.

The pH of water in the Dolet Hills zone ranged from 5.2 to 8.7 units. A pH lower than 7 units could indicate that the water is corrosive. Corrosive water can react with iron in the well casing and water pipes. This may cause water to have a high iron concentration (resulting in red stains on fixtures) even though water in the aquifer may have a low iron concentration.

Water samples for partial analysis were collected from two wells completed in the upper Wilcox zone. Chloride concentrations were 84 mg/L for the sample from well DS-548 and 100 mg/L for the sample from well DS-495 (fig. 2). Concentrations of hardness were 96 mg/L for the sample from well DS-548 and 210 mg/L for the sample from well DS-495.

Chloride concentrations of water in the terrace aquifer (table 3) ranged from 5 to 300 mg/L, but most concentrations were less than 60 mg/L. Hardness of water in the terrace aquifer ranges from 7 to 140 mg/L, but most wells yield soft water. The water sample from well DS-518 (fig. 2) (the only sample collected for complete analysis) has high concentrations of iron and manganese (3,000 and 250 µg/L, respectively) and a low pH of 5.4 units.

Development of Aquifers

The Naborton and Dolet Hills are the most developed aquifers in the project area. Until 1958, the Naborton zone was the source of water for the town of Logansport. Estimated pumpage was about 0.07 Mgal/d. Several test holes, including wells DS-76, DS-190, and DS-191 (fig. 2), were drilled to locate additional sources of water, but sands with the potential of yielding enough water were not found. Because of concerns over the high chloride concentration in the Naborton at their well field and over the failure to find enough sand for a new water-well field, the town began using water from the Sabine River in 1958.

The Naborton zone is the source of water for the Stanley Water System. The system uses one well, DS-428, which was completed in 1972. Average annual pumpage was 0.02 Mgal/d in 1980.

In addition to the water-supply well at Stanley, the Naborton zone is the source of water for domestic and stock wells in the area. Pumpage for rural-domestic and stock use is estimated to be about 0.05 Mgal/d. Public-supply development of the Naborton zone near Stanley would not be desirable because of high concentrations of fluoride and iron. There probably would be no development of the aquifer for public-supply use in most of the northern part of the Logansport lignite area because the aquifer contains salty water. In the northwestern and southeastern parts of the study area, where the base of freshwater is deep, the Naborton zone may have the potential for yielding large supplies of freshwater. Test drilling prior to development would be desirable to find the thicker sands and to determine water quality.

The Dolet Hills and upper Wilcox zones are mostly sources of water for domestic and stock wells. Average daily pumpage is 0.06 Mgal/d from the Dolet Hills zone and 0.02 Mgal/d from the upper Wilcox zone. There is little potential for future development of the Dolet Hills zone in the area of outcrop or subcrop beneath the terrace deposits (fig. 5). Dolet Hills sands capable of yielding large amounts of water may be found near the southern and northern borders of the project area where the aquifer occurs at greater depths.

The upper Wilcox zone is surficial in most of the project area, and there is little potential for future development. The greatest aggregate sand thickness probably is in the northwestern and southeastern corners of the project area where the upper Wilcox beds are thickest. Where the Dolet Hills and the upper Wilcox zones occur at the surface, each is susceptible to contamination from waste-disposal pits or wells.

The terrace aquifer is used as a source of water for domestic and stock wells. Many wells in the aquifer are shallow with large diameters. Estimated pumpage is 0.03 Mgal/d. As the sand of the terrace aquifer is discontinuous and the saturated zone is thin, a large water supply could not be developed in the aquifer in the Logansport lignite area. The terrace aquifer is surficial and is susceptible to contamination from waste-disposal pits or wells.

SURFACE-WATER HYDROLOGY

Streamflow

Surface runoff in northwestern Louisiana results mostly from long-duration, high-intensity rainstorms which occur in the winter and spring months. Short-duration, high-intensity rainstorms often augment streamflow in the summer months. Most of the time, however, streamflow in the area is sustained from ground-water discharge.

Bayou Castor near Funston and Bayou Grand Cane near Stanley (fig. 2) are classified as intermittent streams. Discharge summaries for the 1980-83 water years and representative mean daily discharge hydrographs for the 1982 water year for these stations are shown in table 5 and in figure 10. The data (table 5) indicate that for Bayou Castor, the discharge was about nine times greater in the 1983 water year than in the 1982 water year. At Bayou Grand Cane, discharge was least in the 1981 water year and greatest in the 1983 water year. This station was not in operation during the entire 1980 water year; therefore, the time periods for data collection do not completely match.

The slope of the flow-duration curve gives some indication of the hydrologic characteristics of the basin and the flow characteristics of the stream (Searcy, 1959). Flow-duration curves for three streamflow stations are shown in figure 11. The steep curves for Bayou Castor near Logansport (fig. 11) and Bayou Castor near Funston (fig. 11) indicate that the flow is variable and influenced by direct runoff. The lower end of the curve at Bayou Castor near Funston begins to flatten out, indicating ground-water outflow from a shallow aquifer in the basin above this station. Flow equal to or greater than the average flow (67 ft^3/s) can be expected to occur about 21 percent of the days each year. At the downstream station, Bayou Castor near Logansport, the lower end of the curve is steep, indicating negligible storage and little base flow. Flow equal to or greater than the average flow (69.3 ft^3/s) can be expected to occur about 15 percent of the days each year. Bayou Castor near Funston is located about 3 mi upstream from Bayou Castor near Logansport (fig. 2) and has a drainage area of 5 mi^2 less than the Logansport station.

The shape of the upper end of the flow-duration curve at Bayou Grand Cane near Stanley (fig. 11) indicates that some of the runoff is being stored in the swamps and subsequently drained. The middle section indicates variable flow from direct runoff while the lower end starts to flatten out because of ground-water outflow from a shallow aquifer in the basin. No average discharge has been determined because this station has been in operation for less than 5 years. Streamflow is equal to or less than 1.0 ft^3/s about 50 percent of the time.

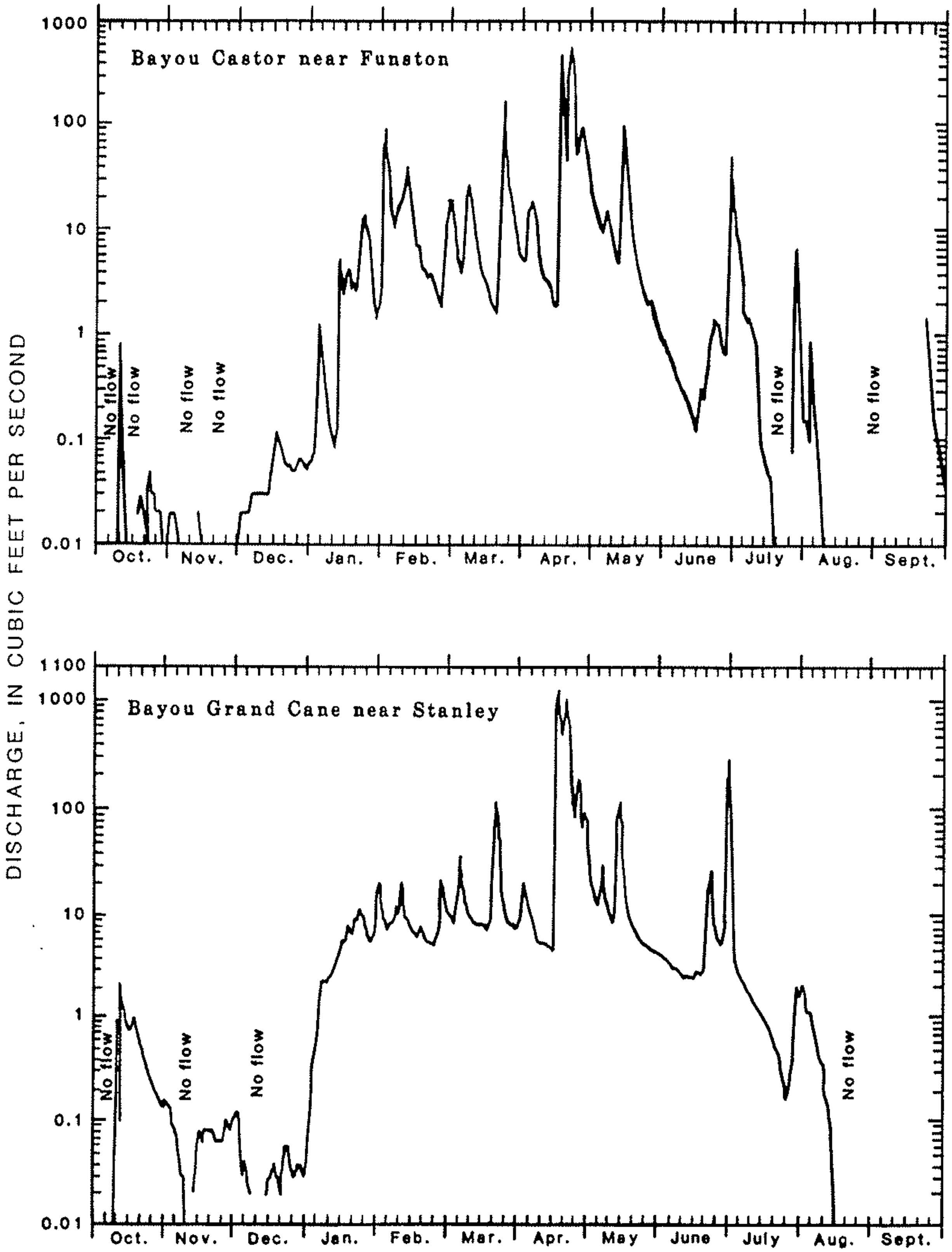

Figure 10.--Stream discharge at Bayou Castor near Funston, and at Bayou Grand Cane near Stanley, Louisiana, 1982 water year.

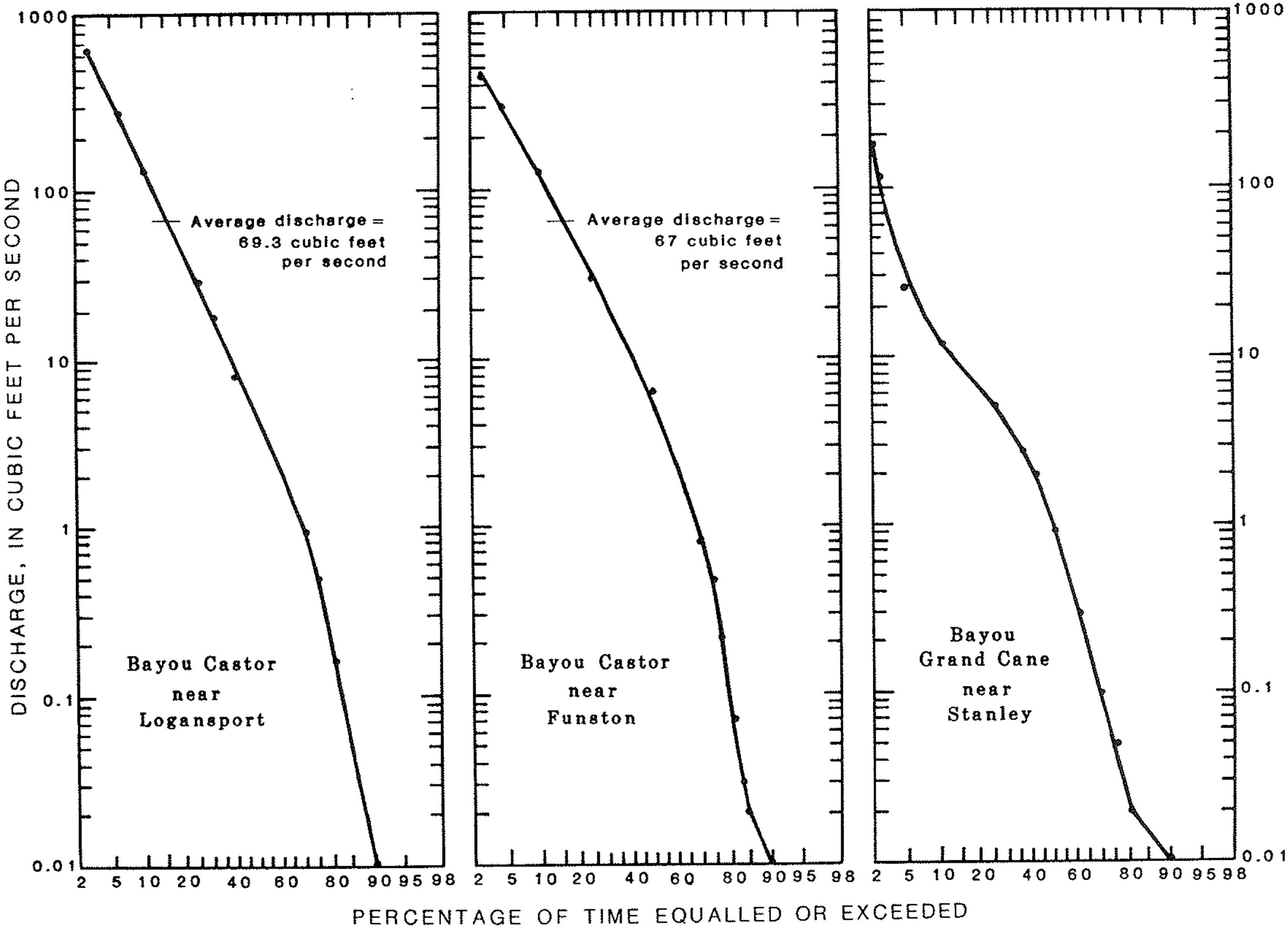

Figure 11.--Flow-duration curve for Bayou Castor near Logansport, and Funston, and for Bayou Grand Cane near Stanley, Louisiana.

Table 5.--Summary of streamflow data at Bayou Castor near Funston and Bayou Grand Cane near Stanley, Louisiana, 1980-83 water years

Station number	Drainage area (square miles)	Water year	Daily mean discharge (minimum)	Daily mean discharge (maximum)	Mean daily discharge	Maximum instan-taneous discharge	Total discharge	Streamflow (acre feet)
			cubic feet per second					
				Bayou Castor near Funston				
08022765	91.5	1980	0	3,230	84	4,210	30,710	60,910
		1981	0	2,340	24	2,880	8,565	16,990
		1982	0	527	12	575	4,244	8,420
		1983	0	2,420	108	3,560	39,306	77,960
				Bayou Grand Cane near Stanley				
08023080	27.5	1980[a]	0	5,670	---	6,200	-------	------
		1981	0	1,810	14	2,440	5,262	10,440
		1982	0	1,220	24	1,530	8,743	17,340
		1983	0	2,300	106	2,390	38,632	76,630

[a] Data for the 1980 water year is based on operation of the station for 9 months.

The flow-duration curves for the Bayou Castor stations (fig. 11) indicate that flows greater than 100 ft³/s occur 12 percent of the time or less. Flows greater than the base peak of 900 ft³/s occur 2 percent of the time or less. At Bayou Grand Cane (fig. 11), flows greater than 100 ft/s occur 3 percent of the time or less.

Low-flow statistics were determined for Bayou Castor near Funston and Bayou Castor near Logansport. The average annual minimum discharge (in cubic feet per second) for the indicated recurrence interval and number of days are listed below. These data, after adjustment for zero values, indicate that there are long periods of no flow.

Recurrence interval	Bayou Castor near Funston (days)					Bayou Castor near Logansport (days)				
(years)	7	14	30	60	120	7	14	30	60	120
2	0	0	0.06	0.23	1.8	0	0	0.02	0.26	2.4
10	0	0	0	0	.09	0	0	0	0	0
20	0	0	0	0	.03	0	0	0	0	0

Water Quality

Suspended Sediment

Suspended sediment consists of sand, silt, clay, and biological materials which enter a stream either from hillslope erosion and entrainment or directly from the streambed. The sediments are transported in suspension by the turbulent components of flow. The interacting factors which affect sediment discharge are streamflow, channel geometry, geology, climate, topography, soil type, vegetative cover, and land use. Soil type is a result of climate and geology, while vegetation is a result of soil type and climate. Friable sedimentary rocks with large amounts of rainfall and runoff will increase sediment discharge; however, dense vegetation will inhibit erosion.

Variations in suspended-sediment concentration and load are generally due to variations in streamflow. Suspended-sediment data for the 1981-83 water years at Bayou Grand Cane near Stanley and for the 1983 water year at Bayou Castor near Logansport are summarized in tables 6 and 7. Daily mean concentrations ranged from 0 mg/L (during no flow) at both sites to 372 mg/L at Bayou Grand Cane and 214 mg/L at Bayou Castor. Total monthly loads ranged from 0 tons at both sites to 3,090 tons or 43 tons/mi² at Bayou Grand Cane to 2,750 tons or 28 tons/mi² at Bayou Castor. Maximum total monthly loads generally occur in the winter and spring, corresponding with maximum monthly stream discharge. Because of the greater discharge (table 5), the suspended-sediment yield at Bayou Grand Cane was more than twice as much in the 1983 water year as compared to the 1982 water year. Particle-size analyses at Bayou Grand Cane indicate that the greatest percentage of suspended sediment being transported is in the clay-silt range.

Table 6.--Summary of suspended-sediment data at Bayou Grand Cane near Stanley, Louisiana

[mg/L, milligrams per liter; mm, millimeter]

Month	Daily mean concentration (minimum) (mg/L)	Daily mean concentration (maximum) (mg/L)	Daily mean suspended load (minimum) (tons per day)	Daily mean suspended load (maximum) (tons per day)	Total suspended monthly load (tons)	Suspended-sediment sieve diameter, percent finer than 0.062 mm[1]	
						Range	Average
1981 water year[2]							
February--	24	132	0.11	1.1	10	58- 99	86
March-----	22	68	.18	4.1	23	60-100	86
April-----	---	58	0	.20	1.5	50-100	79
May-------	18	221	.11	126	239	50- 96	79
June------	28	236	.29	259	743	76-100	85
July------	24	82	.04	.41	5.3	48-100	86
August----	---	78	0	.09	.82	73- 92	83
September-	---	---	----	------	3/3.4	------	--
1982 water year							
October---	---	84	0	0.29	2.1	69- 98	87
November--	25	90	0	.02	.2	68-100	91
December--	---	---	---	------	3/.5	72- 96	86
January---	---	---	---	------	80	83- 99	94
February--	38	218	.47	12	92	70- 99	90
March-----	55	312	1.2	99	295	77-100	94
April-----	114	188	1.6	583	2,690	69-100	95
May-------	73	291	1.8	92	298	61-100	94
June------	72	274	.65	151	308	69-100	94
July------	131	350	.14	50	79	77-100	87
August----	---	372	0	1.7	8.5	70- 99	85
September-	---	0	0	0	0	------	--

	1983 water year						
October---	---	177	0	0.83	4.1	81-100	95
November--	---	197	0	32	104	66-100	92
December--	71	264	1.0	482	3,090	68-100	95
January---	52	181	3.7	86	500	85-100	96
February--	17	196	1.2	454	2,840	52-100	85
March-----	18	134	.86	126	715	66- 96	83
April-----	30	104	.82	3.1	46	------	--
May-------	30	210	.63	354	1,370	------	--
June------	42	168	.67	133	298	------	--
July------	82	112	.01	.90	10	------	--
August----	---	263	0	1.2	3.1	------	--
September-	---	119	0	.10	.21	------	--

	1982 water year	1983 water year
Suspended-sediment load, in tons-----------	3,850	8,980
Yield,[4] in tons/mi²-----------------------	53	124

1 Percent finer than 0.062 mm values are based on instantaneous samples.
2 Suspended-sediment record incomplete for the 1981 water year.
3 Monthly total estimated from sediment-transport curve.
4 Drainage area is 72.5 mi².

Table 7.--Summary of suspended-sediment data at Bayou Castor near Logansport, Louisiana, 1983 water year

Month	Daily mean concentration (minimum)	Daily mean concentration (maximum)	Daily mean suspended load (minimum)	Daily mean suspended load (maximum)	Total suspended monthly load
	milligrams per liter		tons per day		tons
February----	20	208	1.0	507	2,750
March-------	30	131	1.7	134	665
April-------	50	92	1.3	4.9	78
May---------	50	214	1.3	330	1,540
June--------	87	198	1.2	25	175
July--------	106	145	.19	2.3	26
August------	107	141	0	.21	3.0

Because of the limited amount of data at Bayou Castor as compared to Bayou Grand Cane, these two sites are not readily comparable. However, when summing and comparing the total suspended monthly load for the period February through September 1983 at both sites (tables 6 and 7), it was determined that Bayou Grand Cane transported 45 tons more of suspended sediment than Bayou Castor. Even though the drainage area at Bayou Castor is 24 mi^2 greater than at Bayou Grand Cane, Bayou Grand Cane contributes more sediment.

Dispersion of suspended-sediment load throughout the entire range of discharge primarily is attributed to the interacting geomorphic, climatic, and natural sediment-producing processes in the streams. The sediment transport curves for Bayou Grand Cane (fig. 12) and Bayou Castor (fig. 12) show this dispersion. Dispersion could be a reflection of the particle size of the material being transported. Because the velocities of these two streams are low, clay and silt readily will be transported. Sand particles are transported when the velocity and, hence, the energy is great enough to support them. The amount of material available for transport in the basin will affect the suspended-sediment load. It is possible that these channels may not be in adjustment with the sediment being transported. The dense riparian vegetation could influence the sediment-discharge relation. At higher discharges, such as channel overflow, this vegetation could reduce sediment transport, but only in the overflow area.

The slope of the cumulative monthly discharge and cumulative suspended-sediment yield curves (fig. 13) show the rate of change with respect to time. These curves are shown for Bayou Grand Cane for the 1981-83 water years (fig. 13) and for Bayou Castor for the 1983 water year (fig. 13). Periods of greatest amounts of discharge and suspended-sediment yield are represented by nearly vertical lines, and periods of least amounts of discharge and suspended-sediment yield are represented by nearly horizontal lines (Reed, 1980).

Cumulative monthly suspended-sediment yield varies directly with cumulative monthly discharge (fig. 13). In December 1982 at Bayou Grand Cane (fig. 13), 22 percent of the total cumulative discharge transported 22 percent of the total cumulative suspended-sediment yield. In February 1983, 24 percent of the total cumulative discharge transported 21 percent of the total cumulative suspended-sediment yield. Based on the limited amount of data at Bayou Castor near Logansport (fig. 13), similar trends are observed. For example, in May 1983, 32 percent of the total cumulative discharge transported 29 percent of the total cumulative suspended-sediment yield. The greatest amount of transported suspended sediment coincides with and responds to the greatest amount of water discharge.

Double-mass curves (Searcy and Hardison, 1960) indicate the consistency of trends in discharge and suspended-sediment yield. Figure 14 show double-mass curves of cumlative monthly discharge compared to cumulative monthly suspended-sediment yield at Bayous Grand Cane and Castor. The change in slope at Bayou Grand Cane (fig. 14) represents a change in the proportionality between the two variables. The proportionality may not always be constant because of basin processes which affect rates of cumulation.

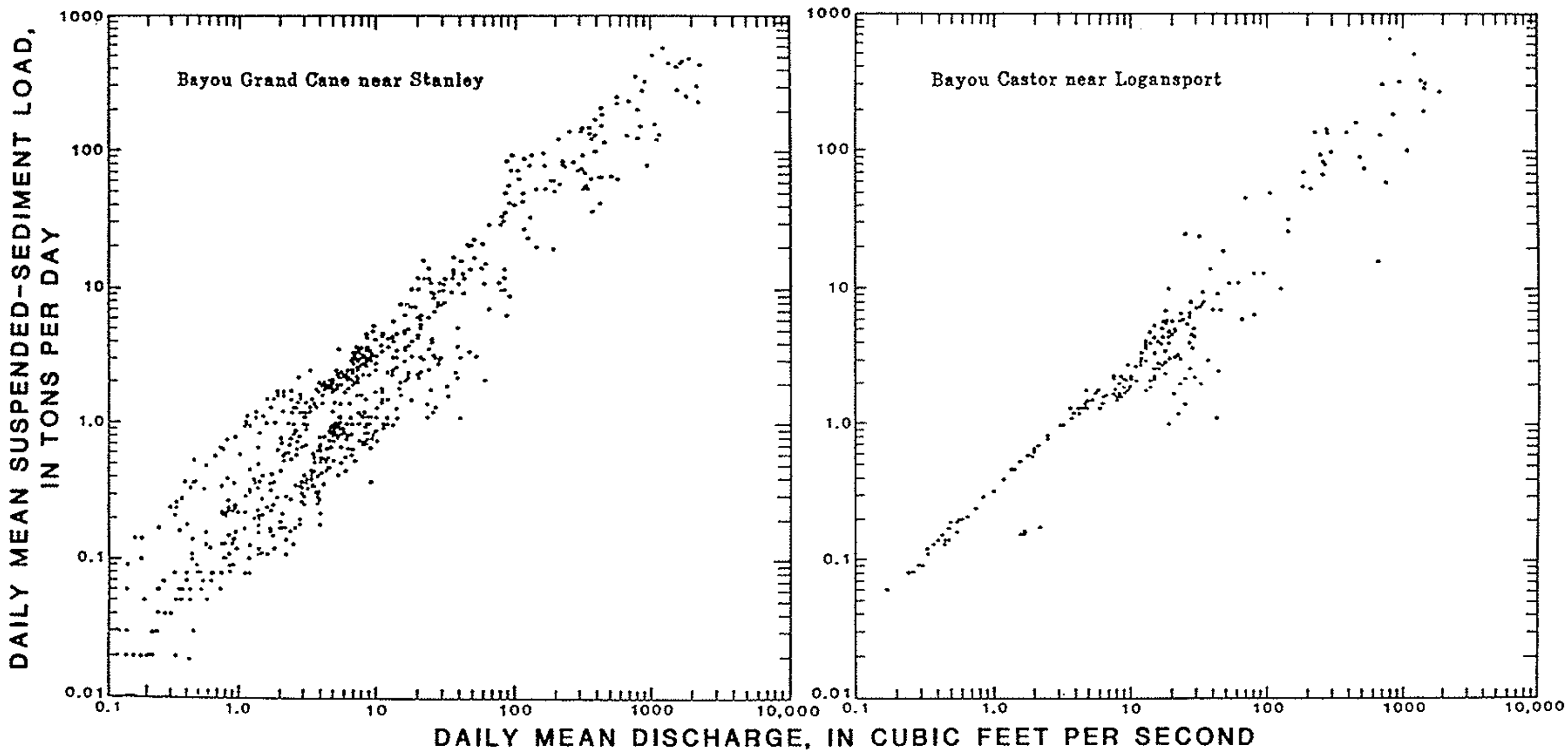

Figure 12.--Relation of daily mean discharge and daily mean suspended-sediment load at Bayou Grand Cane near Stanley, 1981-83, and at Bayou Castor near Logansport, Louisiana, 1983 water years.

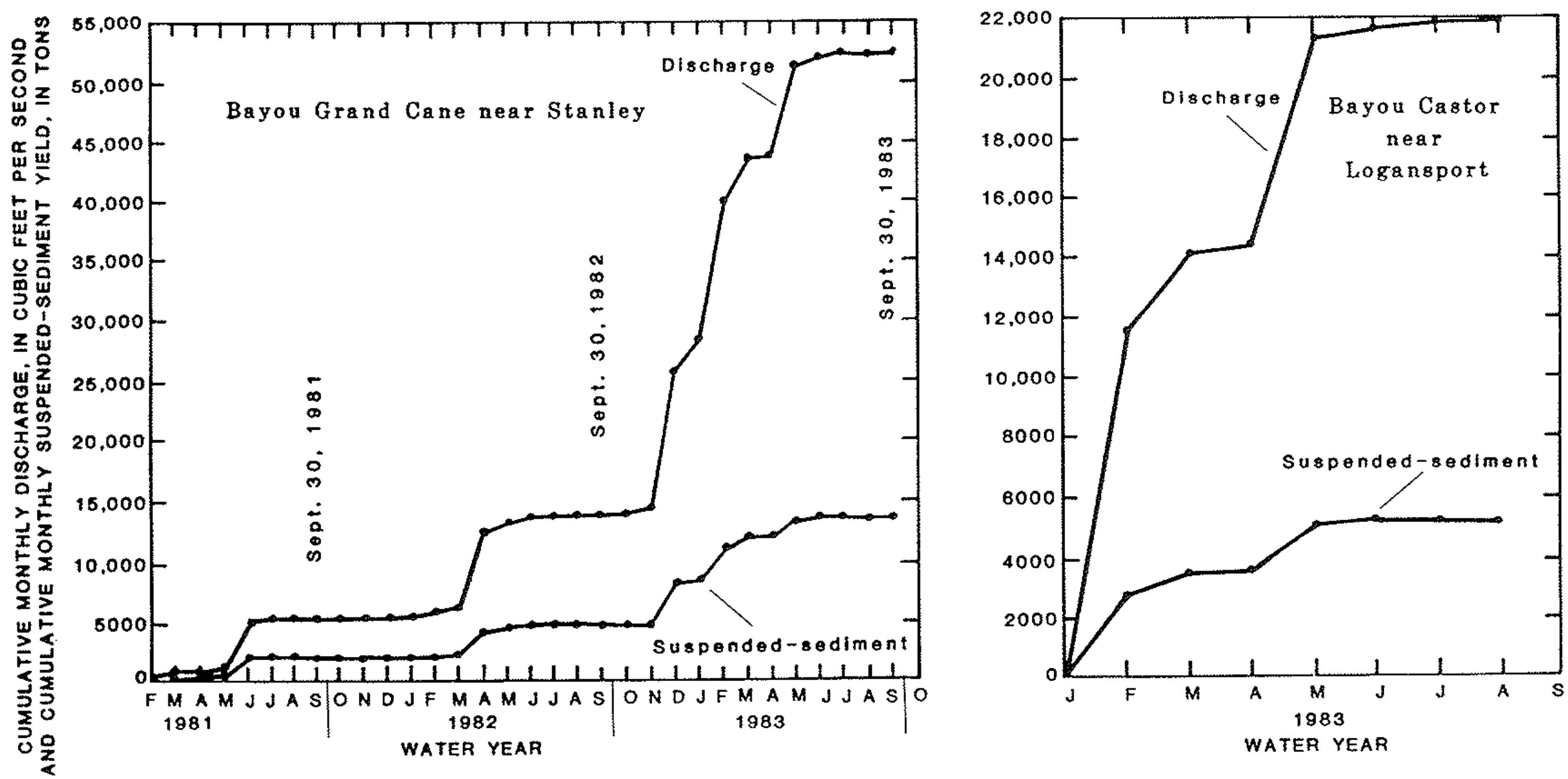

Figure 13.--Cumulative monthly discharge and cumulative monthly suspended-sediment yield at Bayou Grand Cane near Stanley, 1981-83 and at Bayou Castor near Logansport, Louisiana, 1983 water years.

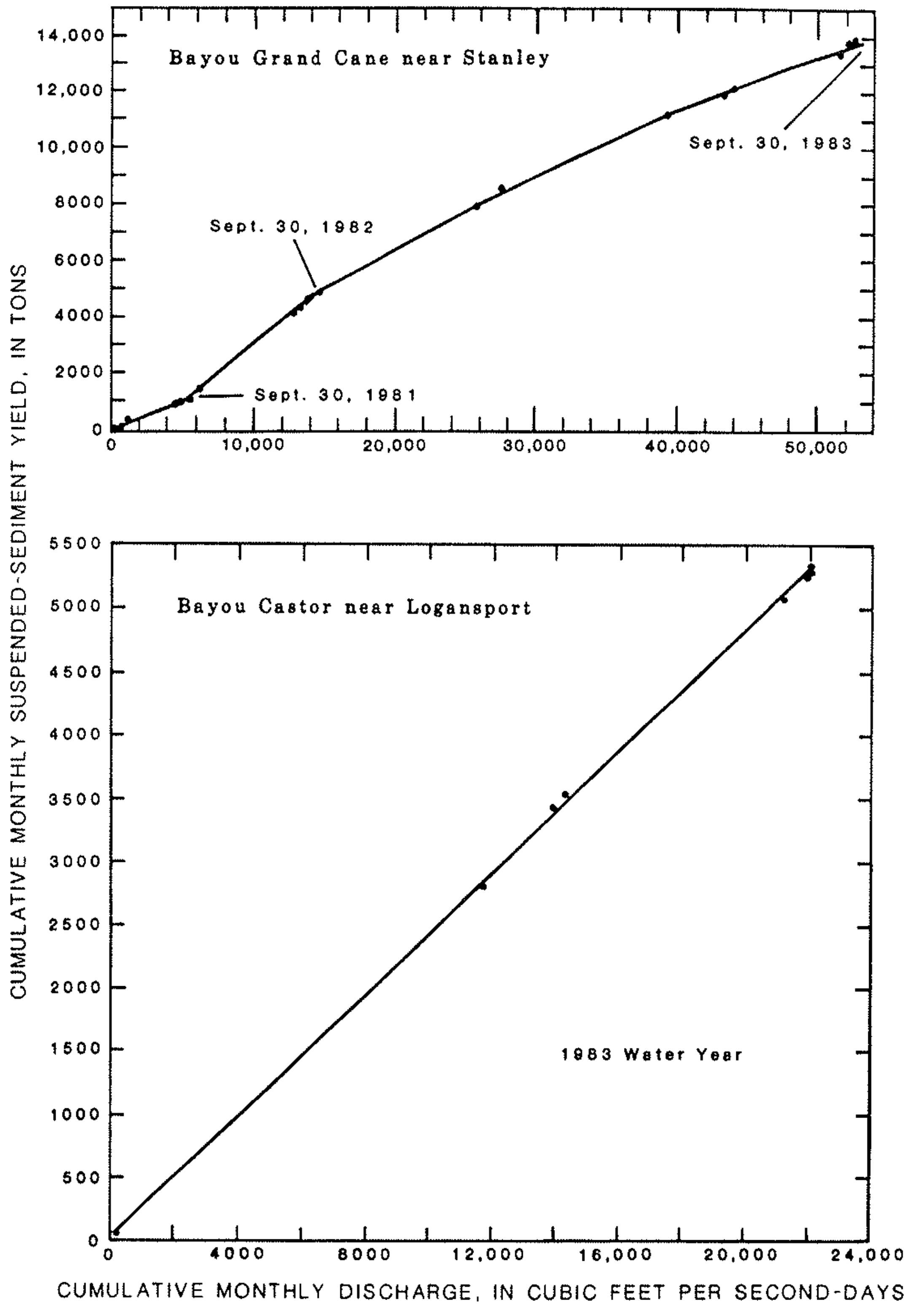

Figure 14.--Double-mass curves of cumulative monthly discharge versus cumulative monthly suspended-sediment yield at Bayou Grand Cane near Stanley, and at Bayou Castor near Logansport, Louisiana.

During the 1982 water year, at Bayou Grand Cane (fig. 14), the slope of the double-mass curve is steeper when compared to the 1983 water year. Close examination of the curve shows that about 8,750 ft^3/s-days transported about 3,850 tons of sediment in the 1982 water year. In the 1983 water year, 38,600 ft^3/s-days transported 8,980 tons of sediment. Cubic feet per second-day is the volume of water represented by flow of 1 ft^3/s for 24 hours. In comparing the two water years, an increase in water discharge of more than four times resulted in an increase in suspended-sediment load of more than two times. In the 1982 water year, 2.3 ft^3/s-days transported 1 ton of suspended sediment; whereas, in the 1983 water year, 4.3 ft^3/s-days transported the same amount of sediment. This suggests that the amount of material in the basin available for transport possibly decreased during the two water years. At Bayou Castor (fig. 14), the curve is linear throughout the range of discharge and suspended-sediment load transport.

Major Dissolved Inorganic Constituents

The types and amounts of dissolved constituents in the water are the basis for chemical classification of surface water in this report. The following criteria are used:

Water Types

[Modified from Piper and others, 1953, p. 26]

Milliequivalents per liter	
Cations	Anions
Single cation used when it amounts to 50 percent or more of the total cations; when the above does not exist, the two cations with the highest equivalent concentrations are used.	Single anion used when it amounts to 50 percent or more of the total anions; when the above does not exist, the two anions with the highest equivalent concentrations are used.

The most common major ions used in classifying water are:

Cations (positive charge)	Anions (negative charge)
Calcium (Ca)	Bicarbonate (HCO_3)
Magnesium (Mg)	Chloride (Cl)
Potassium (K)	Sulfate (SO_4)
Sodium (Na)	

Chemical data for Bayou Grand Cane near Stanley (table 8) and Bayou Castor near Logansport (table 9), indicate that sodium-calcium, bicarbonate water type occurred most often. Magnesium or potassium never occurred as a dominant or codominant cation. The bicarbonate anion was dominant or codominant in all but 7 of 31 samples collected during the 1980-83 water years.

Table 8.--Summary of dissolved cations and anions at Bayou Grand Cane near Stanley, Louisiana, 1980-83 water years

[ft^3/s, cubic feet per second; mg/L, milligrams per liter]

Date	Discharge (ft^3/s)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate (mg/L as HCO_3)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)
10-24-79	-----	9.2	4.0	13	5.7	55	14	10
1-10-80	14	14	7.6	31	4.6	30	44	52
4-23-80	16	10	5.3	22	2.4	30	28	35
7- 9-80	.02	13	6.2	20	3.9	83	22	3.4
1-14-81	.03	19.	9.1	27	5.4	40	19	81
4- 8-81	.98	11	4.7	19	6.4	54	22	22
7-15-81	1.9	11	5.0	13	4.3	54	19	7.2
10-21-81	.58	7.7	3.1	9.7	4.6	34	9.0	9.6
1- 6-82	.94	8.0	3.4	8.4	4.8	50	8.9	3.0
4-14-82	5.0	14	7.6	28	4.6	50	38	33
7- 8-82	1.9	11	4.3	14	3.8	40	17	19
10-20-82	.16	7.2	2.8	11	5.9	18	9.6	24
1-12-83	29	12	6.2	25	3.0	23	33	35
4- 5-83	11	12	6.3	28	2.2	30	35	37
7-13-83	.76	13	5.4	23	4.3	61	31	16
Range----------------		7.2-19	2.8-9.1	8.4-31	2.2-6.4	18-83	8.9-44	3.0-81
Mean-----------------		11	5.1	18	4.2	40	21	18
Standard deviation---		±1.3	±1.4	±1.5	±1.4	±1.5	±1.7	±2.6

Table 9.--Summary of dissolved cations and anions at Bayou Castor near Logansport, Louisiana, 1980-83 water years

[ft^3/s, cubic feet per second; mg/L, milligrams per liter]

Date	Discharge (ft^3/s)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate (mg/L as HCO_3)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)
2- 2-66	-----	9.9	2.7	18	2.1	18	25	27
5- 2-68	-----	7.5	2.7	14	.7	26	16	15
11-13-68	-----	9.9	4.2	24	2.9	48	33	11
3-26-69	-----	4.8	2.4	7.8	2.7	21	10	10
9-11-72	-----	14	4.6	17	4.9	78	18	4.4
10-24-79	17	9.8	4.9	12	6.0	66	11	8.5
1-10-80	22	13	6.9	31	6.2	41	44	37
4-23-80	19	9.7	4.9	22	2.2	37	31	23
7- 9-80	3.4	13	5.7	25	3.6	80	30	4.6
12- 2-80	.09	17	7.2	18	8.4	46	23	46
1-14-81	24	14	5.6	24	6.4	50	30	29
4- 8-81	2.8	13	6.4	24	4.7	77	35	7.8
7-15-81	18	12	4.5	16	4.8	56	21	8.0
10-21-81	12	10	4.3	11	5.1	55	14	9.0
1- 6-82	20	11	4.7	15	5.3	70	16	3.6
4-14-82	7.8	16	7.4	32	5.9	66	46	19
7- 8-82	5.1	13	5.4	18	5.1	57	22	28
10-20-82	9.7	10	3.2	9.5	4.6	24	11	22
1-12-83	16	12	5.7	24	2.9	32	34	30
4- 5-83	17	11	5.7	25	2.0	36	32	26
7-13-83	1.7	13	5.2	19	4.8	63	24	10
Range---------------		4.8-17	2.4-7.4	7.8-32	0.7-8.4	18-80	10-46	3.6-46
Mean-----------------		11	4.7	18	3.9	46	23	13
Standard deviation--		$\pm$1.3	$\pm$1.4	$\pm$1.5	$\pm$0.6	$\pm$1.6	$\pm$1.6	$\pm$2.2

At Bayou Grand Cane, bicarbonate was not dominant or codominant when the specific conductance exceeded 300 µS/cm. Sulfate periodically occurred as the dominant or codominant anion, and chloride often occurred as the dominant or codominant anion when the specific conductance equalled or exceeded 184 µS/cm.

At Bayou Grand Cane, bicarbonate was not dominant when the discharge was greater than 10 ft^3/s. The chloride-sulfate combination occurred only when the discharge was greater than 10 ft^3/s. Cation concentrations were generally greatest in January (except 1982) and were least in October.

At Bayou Castor, bicarbonate was dominant or codominant in all but 2 of the 16 samples. Chloride was not dominant or codominant when the specific conductance was less than 200 µS/cm, and sulfate was not dominant or codominant when the specific conductance was greater than 300 µS/cm. The anion combination of chloride and sulfate occurred in 6 of the 31 samples.

At Bayou Castor, there was no consistant relation of cation or anion occurrence with discharge. Cation concentrations generally were greatest in January and were least in October.

The percent of cation and anion concentrations at Bayou Grand Cane that fell within plus or minus one standard deviation of the mean ranged from 60 percent for magnesium to 73 percent for calcium, bicarbonate, and sulfate. At Bayou Castor, the percent of ion concentrations that fell within plus or minus one standard deviation of the mean ranged from 62 percent for sulfate to 86 percent for calcium.

Correlations of values of specific conductance with concentrations of dissolved solids are shown in fig. 15. These correlations and corresponding regression equations provide a means of estimating dissolved solids within a given range of measured specific-conductance values. Data from 14 chemical analyses from Bayou Grand Cane near Stanley indicate that concentrations of dissolved solids ranged from 72 to 185 mg/L. The data indicate that values of dissolved solids may be estimated from specific conductance within the range of 115 to 320 µS/cm. Data from 16 chemical analyses from Bayou Castor near Logansport indicate that concentrations of dissolved solids ranged from 84 to 178 mg/L. The data indicate that values of dissolved solids may be estimated from specific conductance within the range of 140 to 310 µS/cm. Although not shown, correlations of specific conductance with stream discharge indicated no apparent relation or trend.

Trace Elements

Trace elements are derived mainly from rocks and soils within a drainage basin. In high concentrations, certain trace elements can be toxic, but in low concentrations many are beneficial as micronutrients to animals and plants.

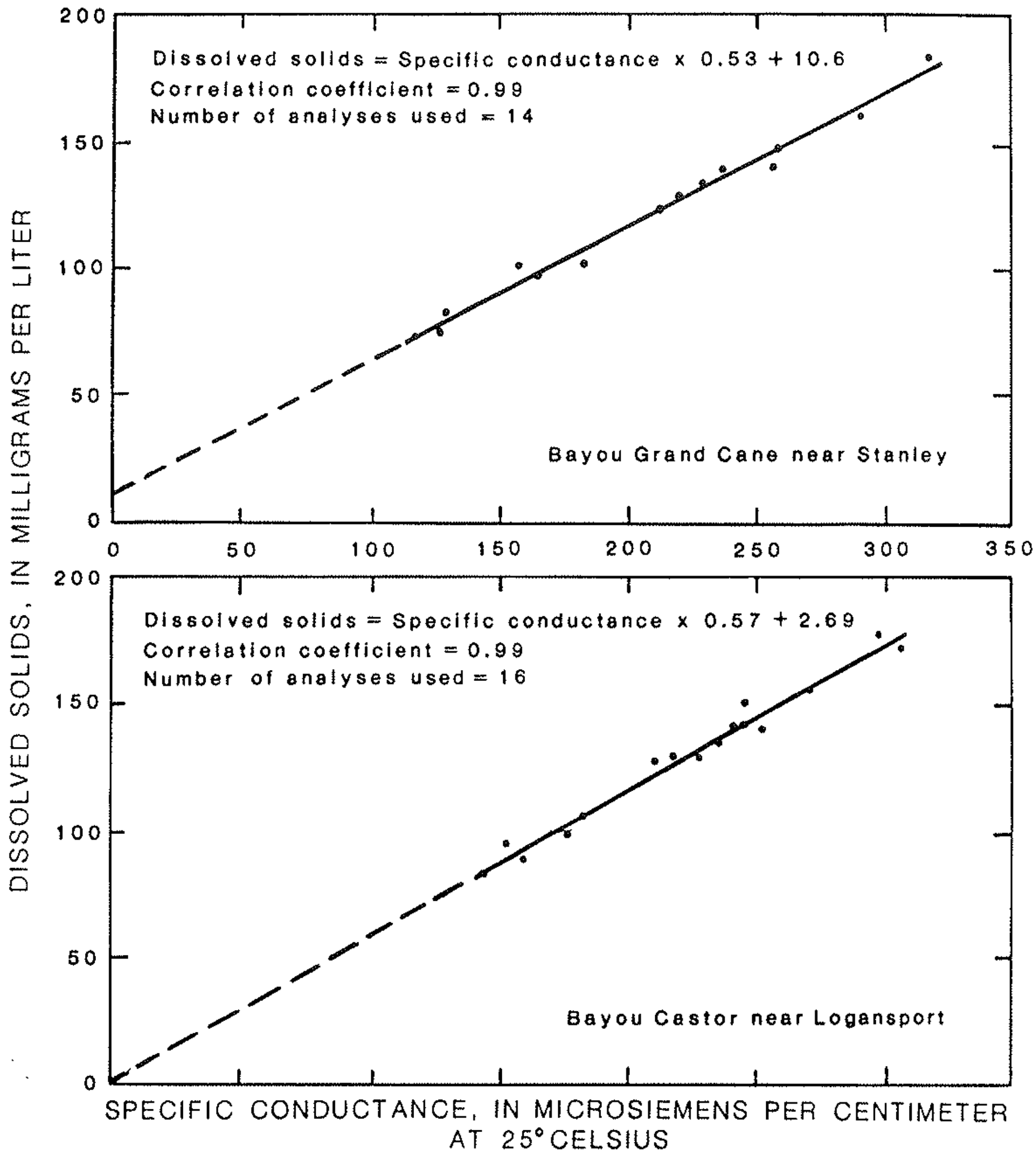

Figure 15.--Correlations and regressions between specific conductance and dissolved solids at Bayou Grand Cane near Stanley and at Bayou Castor near Logansport, Louisiana.

Concentrations for selected dissolved trace elements for Bayou Grand Cane near Stanley and Bayou Castor near Logansport are listed in table 10. Because the data are for dissolved trace elements, the concentrations do not represent what is actually present in the stream in a total water-sediment mixture. Concentrations of iron and manganese are not considered anomalies as they favorably agree with values from other nearby chemical sampling stations (Snider, 1982).

Table 10.--Summary of concentrations of dissolved trace elements at Bayou Grand Cane near Stanley and Bayou Castor near Logansport, Louisiana, 1972-82 water years

[Concentration in micrograms per liter]

Trace elements, dissolved	9-11-72	10-24-79	12-2-80	10-21-81	7-8-82	10-20-82
Bayou Grand Cane near Stanley						
Arsenic	---	2	-----	1	1	1
Cadmium	---	1	-----	4	<1	1
Copper	---	0	-----	7	12	2
Iron	---	570	-----	720	650	470
Lead	---	0	-----	5	3	<1
Manganese	---	1,200	-----	430	-----	-----
Nickel	---	-----	-----	---	6	1
Vanadium	---	-----	-----	---	.7	5.5
Zinc	---	10	-----	18	15	6
Bayou Castor near Logansport						
Arsenic	---	2	0	1	1	1
Cadmium	5	1	<1	4	<1	2
Copper	0	0	7	4	9	4
Iron	---	470	300	740	670	590
Lead	<10	0	4	3	4	2
Manganese	700	2,700	1,300	1,900	-----	-----
Nickel	<5	-----	-----	-----	4	4
Vanadium	---	-----	-----	-----	.8	4.4
Zinc	50	7	20	16	15	16

Bottom sediments act as integrators of trace elements because they are in continuous contact with trace elements in the dissolved and suspended state. Concentrations of trace elements in the bed material are listed in table 11. Accumulation of trace elements in bed material also is attributed to bottom-sediment transport rates, which are less than the average stream velocity (Wentz and Steele, 1980). Additional sampling for trace elements would be necessary before any potential impact from lignite mining could be determined.

Nutrients

Nitrogen and phosphorus are nutrients important for aquatic plant growth. Nutrient concentrations are affected by land use, seasons, streamflow characteristics, and stream biology (Hynes, 1970; Odum, 1971). Detailed discussions of the nitrogen and phosphorus cycles are presented in Wetzel (1975).

Table 11.--Summary of concentrations of trace elements in bed material at Bayou Grand Cane near Stanley and Bayou Castor near Logansport, Louisiana, 1979-82 water years

[Concentration in micrograms per gram]

Trace elements, bottom material	10-24-79	10-16-80	12-2-80	10-21-81	1-6-82	10-20-82
			Bayou Grand Cane near Stanley			
Chromium----------	4	1	-----	10	-----	2
Copper------------	5	4	-----	1	-----	2
Iron--------------	3,700	2,400	-----	1,500	-----	1,700
Lead--------------	0	10	-----	10	-----	<10
Manganese---------	330	250	-----	60	-----	260
Zinc--------------	8	65	-----	10	-----	4
			Bayou Castor near Logansport			
Chromium----------	4	-----	2	-----	9	3
Copper------------	2	-----	3	-----	1	2
Iron--------------	4,700	-----	2,500	-----	13,000	1,100
Lead--------------	60	-----	10	-----	70	20
Manganese---------	240	-----	96	-----	51	26
Zinc--------------	16	-----	6	-----	6	7

Samples for nutrient analyses were collected quarterly from Bayou Grand Cane near Stanley (table 12) and Bayou Castor near Logansport (table 13). Nutrients in these streams are derived primarily from livestock, from water fowl, and possibly from septic-tank discharge. Nutrient concentrations appear to be related to seasons; the higher concentrations generally occur during the summer. This could be the result of fertilizer application in the basin. The lower concentrations primarily occur during the winter months with some variation. The data are insufficient to make any conclusions on the relation between nutrient concentrations and discharge.

The percent of nutrient concentrations at Bayou Grand Cane that fell within plus or minus one standard deviation of the mean ranged from 67 percent for nitrate, total as nitrogen, to 80 percent for phosphorus, total as phosphorus. At Bayou Castor, the percent of nutrient concentrations that fell within plus or minus one standard deviation of the mean ranged from 77 percent for all of the nitrogen species to 88 percent for all of the phosphorus species.

Table 12.--Summary of the nutrients (nitrogen, and phosphorus) at Bayou Grand Cane near Stanley, Louisiana, 1980-83 water years

[ft^3/s, cubic feet per second; mg/L, milligrams per liter]

Date	Discharge (ft^3/s)	Nitrogen, total (mg/L as N)	Nitrogen, ammonia plus organic, total (mg/L as N)	Nitrogen, nitrite plus nitrate, total (mg/L as N)	Nitrogen, total (mg/L as NO_3)	Phosphorus, total (mg/L as P)	Phosphorus, total (mg/L as PO_4)
10-24-79	-----	1.0	1.0	0.03	4.6	0.18	0.55
1-10-80	14	1.6	1.3	.25	6.9	.14	.43
4-23-80	16	1.4	1.2	.16	6.0	.10	.31
7- 9-80	.02	1.4	1.4	0	6.2	.08	.25
1-14-81	.03	1.2	1.1	.06	5.1	.05	.15
4- 8-81	.98	2.0	1.9	.06	8.7	.28	.86
7-15-81	1.9	1.3	1.2	.07	5.6	.17	.52
10-21-81	.58	.78	.73	.05	3.5	.29	.89
1- 6-82	.94	.55	.52	.03	2.4	.18	.55
4-14-82	5.0	1.2	.81	.35	5.1	.18	.55
7- 8-82	1.9	1.3	1.0	.28	5.7	.20	.61
10-20-82	.16	1.1	.90	.20	4.9	.18	.55
1-12-83	29	.70	.40	.30	3.1	.11	.34
4- 5-83	11	.60	.40	.20	2.7	.11	.34
7-13-83	.76	1.2	1.0	.20	5.3	.17	.52
Range----------------		0.55-2.0	0.40-1.9	0-0.35	2.4-8.7	0.05-0.29	0.15-0.89
Mean-----------------		1.12	0.94	0.16	4.8	0.16	0.47
Standard deviation--		±0.20	±0.22	±0.10	±1.4	±0.06	±0.14

Table 13.--Summary of the nutrients (nitrogen and phosphorus) at Bayou Castor near Logansport, Louisiana, 1980-83 water years

[ft^3/s, cubic feet per second; mg/L, milligrams per liter]

Date	Discharge (ft^3/s)	Nitrogen, total (mg/L as N)	Nitrogen, ammonia plus organic, total (mg/L as N)	Nitrogen, nitrite plus nitrate, total (mg/L as N)	Nitrogen, total (mg/L as NO_3)	Phosphorus, total (mg/L as P)	Phosphorus, total (mg/L as PO_4)
10-24-79	17	1.5	1.4	0.08	6.6	0.20	0.61
1-10-80	22	1.3	1.1	.20	5.8	.11	.34
4-23-80	19	1.0	0.77	.23	4.4	.12	.37
7- 9-80	3.4	2.2	2.2	.04	9.9	.28	.86
12- 2-80	.09	1.3	1.3	0	5.8	.50	1.5
1-14-81	24	1.5	1.4	.11	6.7	.09	.28
4- 8-81	2.8	1.4	1.4	.04	6.4	.17	.52
7-15-81	18	1.3	1.1	.16	5.6	.22	.67
10-21-81	12	1.1	1.1	.03	5.0	.20	.61
1- 6-82	20	.68	.63	.05	3.0	.15	.46
4-14-82	7.8	1.1	.74	.38	5.0	.17	.52
7- 8-82	5.1	1.5	1.3	.24	6.8	.26	.80
10-20-82	9.7	1.5	1.4	.10	6.6	.16	.49
1-12-83	16	.80	.40	.40	3.5	.13	.40
4- 5-83	17	.60	.50	.10	2.7	.11	.34
7-13-83	1.7	1.2	1.0	.20	5.3	.28	.86
Range----------------		60-2.2	0.40-2.2	0-0.40	2.7-9.9	0.09-0.28	0.28-1.5
Mean-----------------		1.22	1.05	0.14	5.3	0.20	0.58
Standard deviation--		±0.19	±0.23	±0.11	±1.4	±0.08	±0.18

Dissolved Oxygen, Water Temperature, and Hydrogen-Ion Activity

Dissolved oxygen, water temperature, and hydrogen-ion activity (pH) are important measurements for assessing metabolic rates of a stream (Evans and Tobin, 1979). Dissolved oxygen and pH are interrelated by photosynthesis and respiration processes. The solubility of oxygen in water is dependent on atmospheric pressure and temperature. Dissolved-oxygen concentration decreases with increasing altitude and with increasing water temperature. Hydrogen-ion activity (pH) is a measure of the acid-base properties of water. Natural water containing dissolved solids range approximately between a pH of 5.0 and 9.0 units.

Fifteen dissolved-oxygen measurements were made at Bayou Grand Cane near Stanley. Dissolved-oxygen concentrations ranged from 0.8 to 11.0 mg/L, and percent saturation ranged from 7 to 99 percent. Twelve of the measurements were less than the minimum allowable rate of 6.0 mg/L for cold-water biota, and 11 measurements were less than the minimum limit of 5.0 mg/L for warm-water biota. Low dissolved-oxygen concentrations probably can be attributed to oxygen consumption exceeding reaeration and from biochemical oxygen demand. Biochemical oxygen demand values ranged from 0.4 to 4.8 mg/L. Water temperatures ranged from 7.5 to 29.5°C; four of the 16 values exceeded 20°C, which could be harmful to cold-water biota. Ranges in pH were from 5.8 to 6.8 units. Seven pH measurements were below 6.5 units, which could be harmful to fish and aquatic invertebrates (U.S. Environmental Protection Agency, 1976a).

Sixteen dissolved-oxygen measurements were made at Bayou Castor near Logansport. Dissolved-oxygen concentrations ranged from 2.0 to 10.0 mg/L, and percent saturation ranged from 20 to 91 percent. Eleven of the measurements were less than 6.0 mg/L and nine were less than 5.0 mg/L. Low dissolved-oxygen concentrations again probably are due to oxygen use exceeding reaeration and from oxidation of biodegradable waste. Biochemical oxygen demand values ranged from 0.5 to 5.6 mg/L. Water temperatures ranged from 2.8 to 30.0°C. Six of the water temperatures exceeded 20.0°C. Ranges of pH were from 5.8 to 7.3. units. Seven of the pH measurements were below 6.5 units.

Benthic Invertebrates

Benthic invertebrates are animals without backbones that live in or on the bottom of an aquatic environment. They most often consist of the immature forms of insects but also include aquatic worms, mites, leeches, clams, snails, and scuds.

Benthic invertebrates have certain characteristics which make them useful for analysis of water quality. These characteristics include relative immobility, long life in aquatic stages, and sensitivity to changes in the aquatic environment. Benthic invertebrates fill the primary and secondary consumer levels in the aquatic food chain. They consume abiotic substances and primary producers but in turn are preyed upon by higher level consumers.

Benthic-invertebrates data for Bayou Grand Cane near Stanley, Bayou Castor near Logansport, and Bayou Castor southeast of Logansport are summarized in table 14. The least number of taxa in a sample was seven and occurred at Bayou Grand Cane southeast of Logansport. The greatest number of taxa in a sample was 15 and occurred at Bayou Castor. The least number (16) of organisms in a sample occurred at Bayou Grand Cane, and the greatest number (168) of organisms occurred at Bayou Castor.

Chironomus, Cryptochironomus, Limnodrilus, and an unidentified tubificid were the most frequently observed taxa. *Strictochironomus* was the most abundant organism, and *Chaoborus* was the second most abundant organism. The greatest percentage of genera in any of the samples belonged to the order Diptera, specifically the family Chironomidae. The substrate at these sites primarily consists of clay, silt, and detritus. These conditions enhance the colonization of the chironomids and the tubificids. Because of the minimum amount of available data, no further analyses are justified.

Fecal-Coliform and Fecal-Streptococci Bacteria

Fecal-coliform bacteria are present in the intestines and feces of warm blooded animals, and fecal-streptococci bacteria are present in the intestines of man and animals. These bacteria are used as indicator organisms; the presence of these bacteria indicates that disease-producing organisms may be present in the water. The fecal-coliform to fecal-streptococci ratio gives some indication about the origin of the bacteria (Geldreich, 1969). Interpretation of these ratios for freshwater are listed below:

Ratio	Source
≥ 4	Human waste
≥ 2 - 4	Mixed, mainly human
≥ 1 - 2	Uncertain
≥ .7 - 1	Mostly animal
< .7	Livestock or poultry

Fecal-coliform counts ranged from 30 to 900 colonies/100 mL (colonies per 100 milliliters) at Bayou Castor and from 5 to 170 colonies/100 mL at Bayou Grand Cane. Counts of fecal streptococci ranged from 60 to 5,000 colonies/100 mL at Bayou Castor and from 40 to 4,000 colonies/100 mL at Bayou Grand Cane. Fecal-coliform and fecal-streptococci bacteria data for these sites are summarized in table 15. Examination of these data with stream discharge indicated no apparent trend. Counts of bacteria generally were least in January and greatest in July at Bayou Castor. There is no apparent seasonal trend in fecal-coliform counts at Bayou Grand Cane. Counts of fecal streptococci generally were least in January and greatest in July, except for the maximum count which occurred in October 1981.

Fecal-coliform to fecal-streptococci ratios indicate that animals and birds are major sources of bacterial contamination in the streams. This is probably the result of the inhabitation of dairy cattle and waterfowl, mainly egrets, in the drainage basin.

Table 14.--Taxonomy and numbers of benthic invertebrates at Bayou Grand Cane near Stanley, Bayou Castor near Logansport, and Bayou Castor southeast of Logansport, Louisiana (this station is in Toledo Bend Reservoir)

Order Family Genus species	5-2-83[a]	5-2-83[b]	11-2-82[c]	5-2-83[c]
	Number of organisms			
Diptera (true flies)				
Ceratopogonidae				
Bezzia sp.	1		2	2
Palpomyia sp.	1			
Chaoboridae				
Chaoborus sp.			57	9
Chironomidae				
Chironomus sp.		26	3	1
Cryptochironomus sp.		2	4	2
Dicrotendipes sp.		1		
Microtendipes sp.	2	1		
Orthocladius sp.		1		
Polypedilum sp.		2		1
Procladius sp.	1		1	
Psectrocladius sp.	2			
Strictochironomus sp.	2	70		
Tanytarsus sp.		13		
Tribelos sp.		7		
Tanypodinae[d]				
unidentified	3	13		
Megaloptera (alder flies)				
Sialidae				
Sialis sp.	4			
Trichoptera (caddis flies)				
Polypentropodidae				
Polycentropus sp.		1		
Isopoda (isopod crustaceans)				
Asellidae				
Lirceus sp.		2		
Plesiopora (aquatic worms)				
Tubificidae				
Limnodrilus sp.		15	3	3
Unidentified sp.		7	14	20

Table 14.--Taxonomy and numbers of benthic invertebrates at Bayou Grand Cane near Stanley, Bayou Castor near Logansport, and Bayou Castor southeast of Logansport, Louisiana (this station is in Toledo Bend Reservoir) --Continued

Order Family Genus species	5-2-83[a]	5-2-83[b]	11-2-82[c]	5-2-83[c]
	Number of organisms			
Rhynchobdellidae (leeches)				
Glossiphoniidae				
Unidentified *sp.*		7		
Number of taxa------------	8	15	7	7
Number of organisms-------	16	168	84	38

[a] Bayou Grand Cane near Stanley.
[b] Bayou Castor near Logansport.
[c] Bayou Castor Southeast of Logansport.
[d] Subfamily of the Chironomidae.

Table 15.--Concentrations of fecal-coliform and fecal-streptococci and fecal-coliform/fecal streptococci ratios at Bayou Grand Cane near Stanley, and Bayou Castor near Logansport, Louisiana

[FC, fecal-coliform bacteria; FS, fecal streptococci bacteria; FC/FS, fecal coliform-fecal streptococci ratio; units are in colonies per 100 milliliters]

Date	Bayou Grand Cane near Stanley			Bayou Castor near Logansport		
	FC	FS	FC/FS	FC	FS	FC/FS
10-24-79	---	1,200	----	---	1,300	----
1-10-80	45	40	1.13	95	60	1.58
4-23-80	75	140	.54	90	140	.64
7- 9-80	15	1,400	.01	400	680	.59
1-14-81	12	360	.03	30	120	.25
4- 8-81	84	60	1.40	88	110	.80
7-15-81	170	1,700	.10	300	2,400	.13
10-21-81	56	4,000	.01	76	240	.32
1- 6-82	5	240	.02	100	540	.19
4-14-82	90	1,200	.08	250	1,200	.21
7- 8-82	120	2,900	.04	900	5,200	.17
10-20-82	22	600	.04	320	520	.62
1-12-83	110	320	.34	90	420	.21
4- 5-83	28	1,100	.03	40	2,000	.02
7-13-83	22	1,400	.02	120	1,200	.10
Minimum-----	5	40	----	30	60	----
Maximum-----	170	4,000	----	900	5,200	----
Mean--------	41	589	----	134	541	----
Standard deviation-	±2.78	±3.92	----	±2.55	±3.64	----

SUMMARY AND CONCLUSIONS

Potential surface mining of lignite in the Logansport area will involve dewatering and removal of aquifers (Naborton, Dolet Hills, upper Wilcox, and terrace and alluvial) above the lignite. Knowledge of the premining hydrology of the area is essential to evaluate changes in the hydrologic system caused by mining.

The major lignite bed occurs near the base of the Naborton Formation of the Wilcox Group at depths ranging from 180 to 230 ft below land surface. The lignite ranges from 4 to 17 ft in thickness and averages about 9 ft.

The Naborton zone and the overlying Dolet Hills zone, both of the Carrizo-Wilcox aquifer, are the principal aquifers in the area. Sand beds in the Naborton zone average 35 ft in thickness and sands are mostly very fine to fine grained. Sand beds in the Dolet Hills zone average 20 ft in thickness and are coarser than sand beds in the Naborton zone. Much of the sand is fine to medium grained. Hydraulic conductivity averages 17 ft/d for sands in the Naborton zone, and transmissivity averages 940 ft^2/d. Hydraulic conductivity for sands in the Dolet Hills zone averages 11 ft/d and transmissivity averages 300 ft^2/d.

Recharge infiltrates to the Naborton zone from overlying aquifers in interstream areas. Water in the Naborton zone moves to discharge areas in the valleys of Toledo Bend Reservoir and its tributaries. Water also moves from a potentiometric high in south-central De Soto Parish, east of the Logansport area, through the Naborton and other aquifers of the Carrizo-Wilcox aquifer to discharge areas underlying Toledo Bend Reservoir.

Toledo Bend Reservoir covers most of the Sabine River valley alluvial aquifer. Water moves upward and laterally from aquifers of the Carrizo-Wilcox aquifer and the terrace aquifer into the alluvial aquifer and subsequently to discharge into the reservoir. Water would move from the reservoir to the alluvial aquifer when the reservoir level is at high stage.

Water in the Naborton zone contains high concentrations of chloride in the northeastern part of the project area and near Toledo Bend Reservoir. In most of the Logansport area, water in the Naborton is soft and has low concentrations of iron and manganese. Water in many wells in the Naborton zone has odorless, flammable gas. The source of the gas may be oil or gas wells, or the gas may be methane from the decomposition of organic matter. Some wells screened in the Naborton zone yield water with high concentrations of fluoride.

Water in the Dolet Hills zone, which overlies the Naborton zone, has high hardness and chloride concentrations in the central part of the Logansport area. Here, the hardness ranges from 180 to 810 mg/L and the concentrations of chloride range from 80 to 850 mg/L.

Streamflow primarily is sustained from ground-water sources most of the time. Long-duration, high intensity rainstorms often augment streamflow during the winter and spring months. Flow-duration curves for Bayou Castor near Funston, Bayou Castor near Logansport, and Bayou Grand Cane near Stanley show that the flow is variable and influenced by direct runoff. The curves also show the possibility of some storage in these streams.

The greatest total discharge (39,306 ft^3/s) occurred at Bayou Castor near Funston during the 1983 water year. Flow equal to or greater than the average flow of 67 ft^3/s can occur 21 percent of the days each year at Bayou Castor near Funston, and flow equal to or greater than the average flow of 69.3 ft^3/s can occur 15 percent of the days each year at Bayou Castor near Logansport.

Suspended-sediment analysis is based on data collected in the 1981-83 water years. Suspended-sediment data for Bayou Grand Cane indicate that the maximum daily mean concentration was 372 mg/L, and the maximum daily mean load was 583 tons/d. The maximum total monthly load was 3,090 tons or about 43 $tons/mi^2$.

Suspended-sediment data for Bayou Castor indicate that the maximum daily mean concentration was 214 mg/L, and the maximum daily mean load was 507 tons/d. The maximum monthly load was 2,750 tons or about 28 $tons/mi^2$. Maximum suspended-sediment discharge occurs in the winter and spring corresponding to periods of maximum streamflow.

Chemical data at Bayou Grand Cane near Stanley and Bayou Castor near Logansport indicate that sodium and calcium are the dominant cations and that bicarbonate is the dominant anion. Sulfate and chloride occassionally can be codominant anions. Comparisons of cation and anion concentrations indicated no definite relation to either discharge or time. Concentrations of iron and manganese, although high, were in the range of concentrations at surrounding stations.

Estimates of dissolved solids can be made within defined ranges of specific conductance, using regression functions derived from available data for water samples. Dissolved solids ranged from 72 to 185 mg/L at Bayou Grand Cane near Stanley and ranged from 84 to 178 mg/L at Bayou Castor near Logansport. Analysis of data from Bayou Grand Cane near Stanley indicates that concentrations of dissolved solids can be estimated from specific conductance within the range of 115 to 320 µS/cm. Concentrations of dissolved solids can be estimated for Bayou Castor near Logansport when the specific conductance ranges from 140 to 310 µS/cm.

Concentrations of dissolved oxygen measured in Bayou Grand Cane near Stanley and Bayou Castor near Logansport were frequently lower than 5.0 mg/L. Temperature and pH can exceed U.S. Environmental Protection Agency limits cold-water biota. Temperature sometimes exceeded 20.0°C and pH sometimes was less than 6.5 units.

Benthic invertebrates consist primarily of the order Diptera and the tubificid worms. Substrate conditions enhance colonization of these organisms.

Fecal-coliform counts ranged from 30 to 900 colonies/100 mL at Bayou Castor and from 5 to 170 colonies/100 mL at Bayou Grand Cane. Counts of fecal streptococci ranged from 60 to 5,000 colonies/100 mL at Bayou Castor and from 40 to 4,000 colonies/100 mL at Bayou Grand Cane. Livestock and waterfowl are probably the primary sources of bacterial contamination.

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