GEOHYDROLOGIC CROSS-SECTIONS OF THE GRAND GULF AQUIFER SYSTEM IN SOUTHEASTERN MISSISSIPPI

By

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Open-File Report 284

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Mississippi Department of Environmental Quality
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Table of Contents

Contents Page No.

Section I

Geohydrologic Cross-Sections of the Grand Gulf Aquifer System In Southeastern Mississippi

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INTRODUCTION

With the exception of a very minor amount of water being produced from a surface water plant in northeast Jackson County, all of the water used for public and domestic drinking water supplies in southern Mississippi is derived from underground sources. Much of the area is underlain by a thick section of fresh water bearing sediments, and multiple aquifers are available at most locations. The most widely used aquifers in this area are developed in beds of sand that occur within sediments of Oligocene to Pliocene age above the Bucatunna Formation of the Vicksburg Group. The aquifers within this interval have been considered to constitute the Miocene aquifer system. Because of the age range of the geologic units that comprise these aquifers, it is proposed that the name Grand Gulf Aquifer System is more appropriate.

Hilgard (1860) introduced the name, Grand Gulf Group, in describing sediments that were exposed in Mississippi near Grand Gulf in Claiborne County and Fort Adams in Wilkinson County. He was apparently able to trace these beds eastward to the vicinity of the Pascagoula and Chickasawhay Rivers. Hilgard recognized that these deposits were post-Vicksburg and pre-Pleistocene in age. Later authors such as Fisk (1940) referred to the Grand Gulf Group, but it was not designated in the U. S. Geological Survey Lexicon (Wilmarth, 1938) as an accepted term and thus was not used in subsequent geologic literature.

GEOLOGY

The interval from late Oligocene through Miocene and Pliocene time, approximately 29 to 2.59 million years before present, was a period of persistent subsidence and sedimentation in the northern Gulf Coast region. The sedimentary section representing this time interval in Mississippi mainly consists of a continuous sequence of fluvial, deltaic, and shallow nearshore marine sediments that were deposited under conditions that have been largely uninterrupted by significant marine transgressions up to the present time. South-west of a line from Warren County on the west through Wayne County on the east, these sediments dip in a general gulfward direction at rates ranging from 30 to 100 feet per mile and form a wedge that thickens southward to more than 5,000 feet at the southern tip of Hancock County and more than 4,000 feet in southern Wilkinson County (Figure 1).

This sequence of sediments has been subdivided in Mississippi, from oldest to youngest, into the Catahoula, Hattiesburg, Pascagoula, and Graham Ferry Formations (Figure 2). It is mainly an offlapping sequence of sediments, with the landward limit of each younger unit located farther seaward than the updip extent of the older units.

These sediments are exposed at the land surface in much of their area of occurrence in southern Mississippi. Elsewhere, they underlie terrace deposits and loess of Pleistocene age, alluvial deposits along streams in the region, and a thin band of sediments that previous workers have termed coastal deposits that occur in extreme southern Hancock, Harrison, and Jackson Counties.

The upper part of the Catahoula Formation is mainly composed of non-marine sand and clay, while the lower part, in southern Mississippi and the Florida Parishes of Louisiana, contains a marine unit named the Tatum Limestone Member (Eargle, 1964). This unit has often been referred to as the *Heterostegina* or "Het" Limestone, named for fossil Foraminifera that are associated with that interval. It is described as consisting of white to gray sandy limestone and marl and glauconitic calcarenite. This unit may be up to 300 feet in thickness, but it is only known to occur in the subsurface. Dockery (1981) considers the Tatum to represent the uppermost unit of Oligocene age in its area of occurrence.

The non-marine sand and clay beds of the Catahoula Formation are overlain by similar sediments of the Hattiesburg Formation, which represent a continuation of fluvial and deltaic depositional systems that existed during the time that the upper Catahoula sediments were laid down. Recent surface geologic mapping by the MDEQ Office of Geology in southwestern and south-central Mississippi has placed the Catahoula-Hattiesburg contact at the base of a regionally correlatable sand unit assigned to the basal Hattiesburg Formation (Davis and Starnes, 2003a, b, and c). The Pascagoula Formation overlies the Hattiesburg Formation in southern Mississippi and is largely composed of sediments deposited under estuarine and deltaic conditions. Brown, et al. (1944) identified the Hattiesburg-Pascagoula contact in southeastern Mississippi as a transition from non-marine sediments in the Hattiesburg Formation to estuarine sediments in the Pascagoula. Brown, et al. (1944) named the Graham Ferry Formation for a sequence of deltaic deposits overlying the Pascagoula Formation.

Sediments deposited under marine conditions are much easier to correlate locally and regionally than those deposited under fluvial, deltaic, and shallow nearshore marine conditions. The reasons for this are that sedimentary units deposited in marine environments tend to have relatively uniform lithology over a large area and they contain distinctive fossils that tend to facilitate their identification. No key beds or fossils have been found to mark the top or base of any of these late Oligocene to Pliocene formations, and no criteria have been established by previous workers to correlate most of the section.

HYDROGEOLOGY

The Grand Gulf aquifers generally have greater water-transmitting capacity than older deposits in the state. The materials comprising these aquifers range from very fine sand to gravel, but are primarily fine to coarse sand. Because of its thickness, areal extent, and permeability, the U. S. Geological Survey considers this aquifer system to be the largest potential source of groundwater supplies in the state (Wasson, 1986). More than 100 million gallons of water per day are withdrawn from these aquifers in Mississippi, and significantly greater supplies of groundwater could potentially be developed.

Fresh water, herein defined as containing less than 1,000 milligrams per liter (mg/L) of total dissolved solids (TDS), is available from these aquifers nearly everywhere within the 17,000 square mile area of their occurrence in Mississippi. In many places, only portions of the available fresh-water section are being utilized, and many thick beds of sand containing fresh water have not been tapped. The base of the fresh-water section dips southward at a lower rate than the general structural dip of the strata. As a result, the lower part of the Grand Gulf section may contain brackish to saline water in parts of southern Mississippi. The fresh-water section averages approximately 1,500 feet in thickness and can be more than 3,000 feet thick in parts of Pearl River and Hancock Counties.

Although some of these sediments were deposited in a brackish-water environment, later uplifts of the land and recessions of the sea allowed fresh water from upland recharge areas to flush more saline water from the sand beds to significant depths as far offshore as the barrier islands and beyond. Information from water wells and geophysical logs has shown that fresh water is available beneath the barrier islands along Mississippi Sound and beyond, possibly as deep as 2,500 feet at Ship and Cat Islands. Analysis of borehole geophysical logs from the Sapphire Exploration Well No. 1 in Mississippi Sound Block 90 indicates that relatively fresh water (slightly greater than 1,000 mg/L) occurs at a depth of approximately 2,800 feet below sea level immediately south of Ship Island. Such extensive flushing of these sands by fresh water is evidence of the fact that, although individual beds of sand that comprise these aquifers may be limited in extent, the sands within these aquifer intervals often have very good lateral hydraulic interconnection from their areas of recharge into the subsurface, extending many miles downdip.

The Grand Gulf aquifers are recharged through vertical infiltration by precipitation on the land surface where permeable sand beds are exposed or are hydraulically connected to overlying water-bearing material such as terrace deposits, or alluvium, and by movement of water between beds of sand in the subsurface. Under natural conditions, gravity is the primary driving force that influences ground-water flow. In aquifer recharge areas, unconfined (water table) conditions predominate, and most of the water is discharged to springs and streams. The remainder of this water moves downdip from the recharge areas deeper into the subsurface where all of these aquifers are confined under artesian pressure. Movement of water within these aquifers is generally in a gulfward direction except in localized areas in which natural discharge or discharge to wells may alter the direction of flow. Long-term regional rates of water-level declines in the range of one to two feet per year have been noted in some of the heavily pumped sands.

In its movement from recharge areas into the subsurface, ground water undergoes gradual geochemical changes that alter its chemical character. In general, water changes from a calcium bicarbonate type in the vicinity of recharge areas to a sodium bicarbonate type in downdip areas and increases in dissolved solids content with greater depth, eventually becoming a sodium chloride type.

Boswell, et al. (1987) subdivided the aquifers above the Bucatunna Formation in Jones County, Mississippi into the lower, middle, and upper Catahoula aquifer intervals and the Hattiesburg aquifer interval. Utilizing geophysical logs, they correlated these aquifers in the subsurface, assuming that the overlying beds had about the same dip as the Glendon Formation of the underlying Vicksburg Group. Sumner et al. (1989) subdivided the aquifers above the Catahoula Formation at Pascagoula in Jackson County, Mississippi into the Hattiesburg aquifer interval, lower and upper Pascagoula aquifer intervals, and lower and upper Graham Ferry aquifer intervals.

Apart from these two reports, there has been little attempt to systematically subdivide the many sand intervals that function as aquifers within the Grand Gulf system. As a result, an interval that often consists of 1,000 to 3,000 feet of fresh-water bearing sediments has been collectively referred to as the “Miocene aquifer system.” Because of the growing need to make informed decisions concerning water use, the Mississippi Department of Environmental Quality (MDEQ) Office of Land and Water Resources (OLWR) has instituted an effort to delineate the individual aquifer units within this aquifer system.

The OLWR staff has constructed structural geohydrologic cross-sections through southeastern Mississippi by correlating the tops of the Chickasawhay, Glendon, Moodys Branch, and Cook Mountain Formations from interpretations of borehole geophysical logs. The overlying geologic units were assumed to follow essentially the same structural trend. This approach was applied to trace the aquifer delineations of Boswell et al. (1987) and Sumner et al. (1989) into adjoining areas of southern Mississippi. The Hattiesburg and upper Catahoula aquifer intervals were differentiated on the basis of the interpretations of Brown (1944) of the boring logs of nine City of Hattiesburg water wells. The base of the lower Pascagoula aquifer interval was differentiated from the Hattiesburg interval based upon the interpretations of Brown et al. (1944) in the coastal area of Mississippi. The lower Graham Ferry interval and the upper Pascagoula aquifer were differentiated based upon the interpretations of Marble and Crellin (in publication) in Jackson County and the aquifer layers assigned at Pascagoula by Sumner et al. (1989). As a result of this work, eight aquifer intervals within the Grand Gulf aquifer system can be identified in the subsurface. From the base to the top these are the lower and upper Catahoula, lower and upper Hattiesburg, lower and upper Pascagoula, and lower and upper Graham Ferry aquifer intervals.

Three cross-sections are presented herein as shown on the location maps (Figures 3-5). A north-south cross-section was constructed from northern Jones County to a well in the waters of the Gulf of Mexico south of Ship Island. Because of its length, this cross-section is reproduced in three segments which can be joined together by matching well logs that are common to adjoining segments (Plates 1-3). Two west-east cross-sections were constructed, one along the coast from Hancock County through Jackson County (Plate 4), and another from northern Pearl River County through northern George County (Plate 5). The borehole geophysical logs used to construct these cross-sections are reproduced on each plate and are listed in Table 1.

Analyses of borehole geophysical logs from wells in the study area indicate that the thickness and position of sand beds within some aquifer intervals may exhibit considerable variation, while other sand beds can be traced over great distances. An aquifer may be comprised of an individual sand unit that is continuous over hundreds of square miles but it more often consists of a series of discontinuous but interconnected sand beds that constitute a single hydraulic unit. The relative positions of sand beds within different aquifer intervals indicate that there may be local vertical hydraulic connection between these aquifers.

Recent geologic mapping by the MDEQ Office of Geology has placed the contact between the Hattiesburg and Catahoula Formations at the base of the sand unit that Boswell et al. (1987) designated the upper Catahoula aquifer. In order to be consistent with this interpretation it has become necessary to modify the terminology that has been applied to the names of these aquifer intervals. Boswell's Hattiesburg aquifer interval is now called the upper Hattiesburg aquifer, and his upper Catahoula aquifer interval is now called the lower Hattiesburg aquifer. The middle Catahoula aquifer interval of Boswell is now called the upper Catahoula aquifer interval.

THICKNESS OF THE FRESH WATER SECTION OF THE GRAND GULF AQUIFERS ALONG THE LINES OF CROSS SECTIONS

Numerous sands were deposited within the Grand Gulf aquifer system in the counties of southeastern Mississippi. These sands range in thickness from just a few feet to more than 200 feet. The depositional system in which these sands were laid down causes them to generally thicken from east to west and north to south, with the depositional center in southwest Hancock County. The number of individual sands within this system is greatest in Hancock County and the fewest sands were deposited in Wayne County. It follows that the principal aquifers in these counties vary from one area to the next, depending upon the location in which the sands were deposited.

The base of the fresh-water section generally increases in depth toward the south and west in the same manner that the aquifers thicken. From northern Jones County southward to Hattiesburg, the base of fresh water in the Grand Gulf aquifers is within the lower Catahoula aquifer interval, increasing from a depth of about 400 feet near Laurel, to approximately 700 feet south of Ellisville, and to 1,000 feet in the Hattiesburg area. From just south of Hattiesburg to northern Stone County, the base of fresh water is within the upper Catahoula aquifer. In this area, the base of fresh water is at a depth of about 1,500 feet between Brooklyn and Maxie in southern Forrest County.

In the northern parts of George, Stone, and Pearl River counties, the base of fresh water is within the lower Hattiesburg interval, ranging from a depth of about 1,000 feet in northeastern George County to approximately 2,000 feet in northwestern Pearl River County. Along the coast, the base of fresh water increases in depth from east to west from nearly 1,600 feet in southeastern Jackson County to more than 2,800 feet in southwestern Hancock County. The base of fresh water is within the lower Pascagoula interval from southeastern Jackson County to near Ocean Springs and within the upper Hattiesburg interval from the Ocean Springs area to southwestern Hancock County.

SUMMARY

The geology of the post-Vicksburg deposits of Oligocene to Pliocene age in southern Mississippi is complex and has discouraged attempts to systematically subdivide the sand intervals that function as aquifers within this thick and extensive aquifer system. Following the basic methodology of earlier authors, the staff of the OLWR has delineated aquifer units in southeastern Mississippi utilizing borehole geophysical logs of water wells and oil tests and other information. Three structural geohydrologic cross-sections have been prepared for this report illustrating the aquifer intervals.

This effort to systematically delineate sand units in the subsurface is progressing westward and is essentially complete in the area east of the Pearl River. By correlating these individual aquifers, it is now possible to evaluate the response of the aquifers to the stress of pumpage. Even though there appear to be satisfactory ground-water supplies available throughout the area of southern Mississippi, having a better understanding of the relationship between the aquifers will allow for better management of these water resources.

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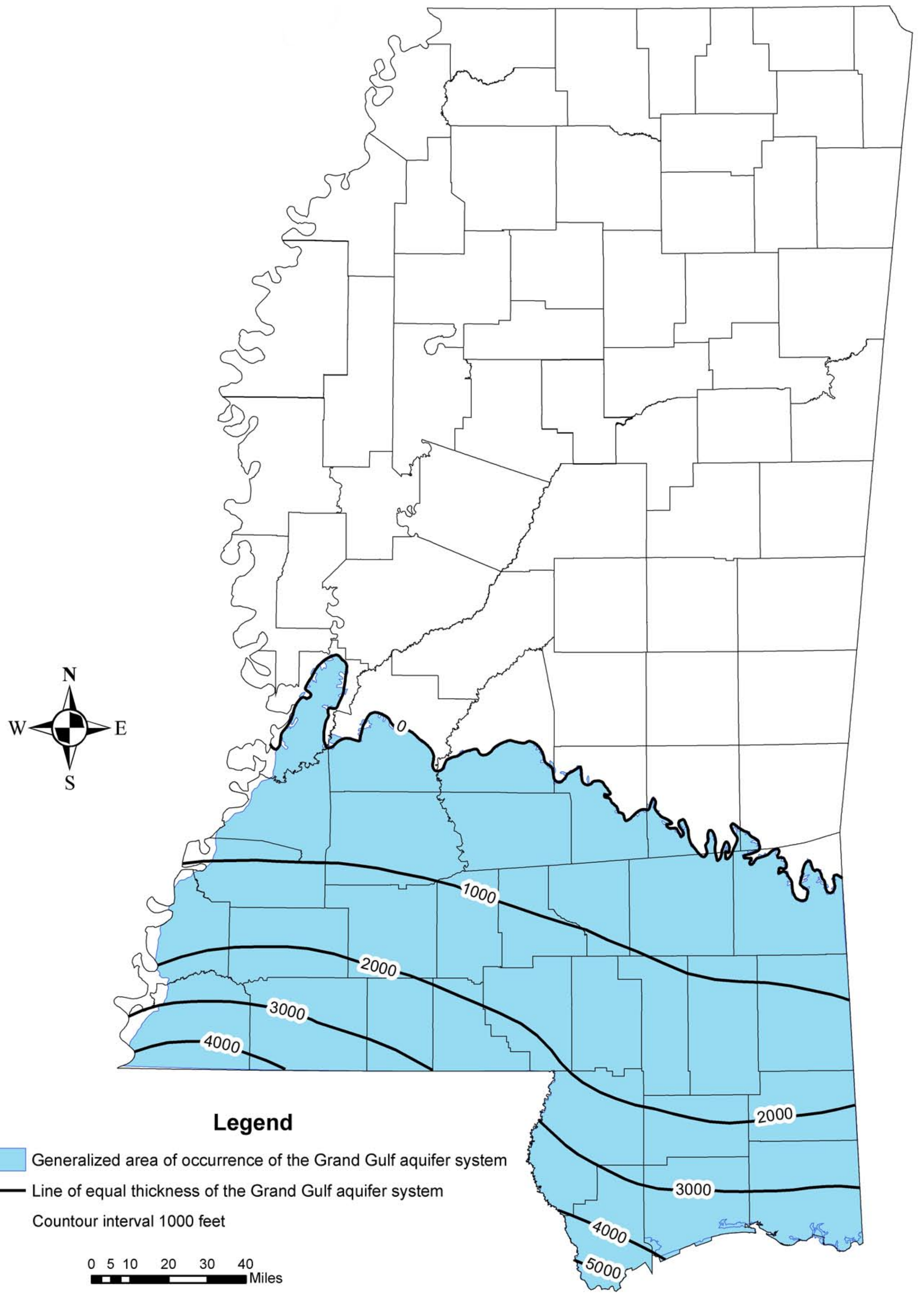
Section II

Figures



(modified from Gandl, 1982)

Figure 1: Generalized Thickness of the Grand Gulf Aquifer System

System	Series	Geologic Unit			Aquifer	
Quaternary	Holocene	Alluvium	Post Graham Ferry		Post Graham Ferry Undifferentiated	
	Pleistocene	Pamlico				
		Terraces				
Tertiary	Pliocene	Graham Ferry			Grand Gulf Aquifer System	Upper Graham Ferry
						Lower Graham Ferry
	Miocene	Pascagoula				Upper Pascagoula
						Lower Pascagoula
		Hattiesburg				Upper Hattiesburg
						Lower Hattiesburg
		Catahoula	Upper Catahoula			Upper Catahoula
	Oligocene		Tatum Limestone			Lower Catahoula
			Paynes Hammock Fm.	Chick.-Vicksburg-Jackson Undif.		
			Chickasawhay Ls.			
		Vicksburg Group	Bucatunna & Byram Undif.		Minor aquifers	
			Glendon Ls.			
			Marianna & Mint Spring Undif.			
			Forest Hill & Red Bluff Undif.			
	Eocene	Jackson Group	Yazoo Fm. Undif.			
			Moodys Branch Fm.			
		Claiborne Group	Cockfield Fm.		Cockfield	
			Cook Mountain Fm.		Not an aquifer	

Figure 2: Stratigraphic Section and Geohydrologic Subdivision of Grand Gulf Aquifer System in Southeastern Mississippi

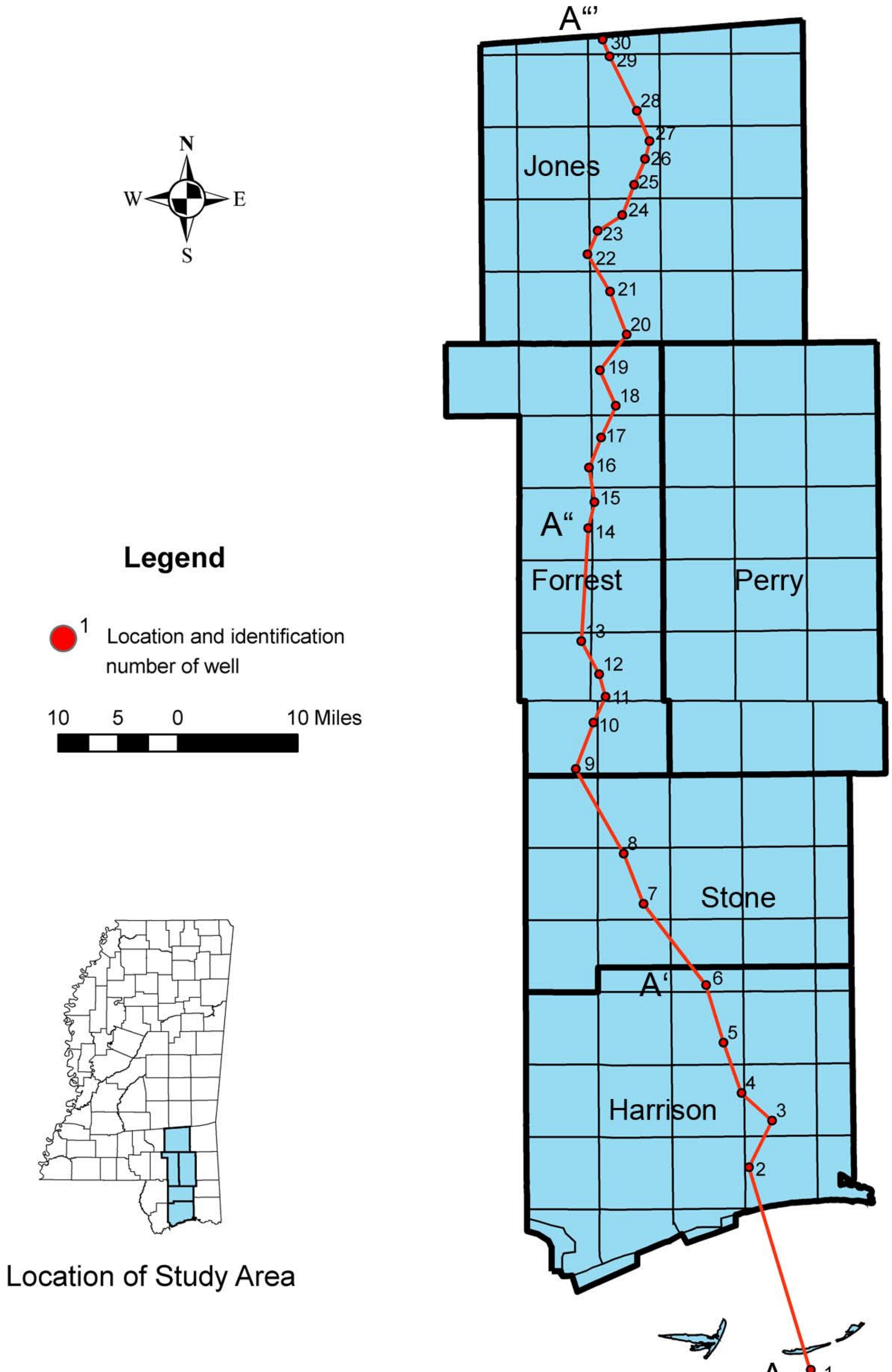


Figure 3: Location of Cross-Section A-A'''

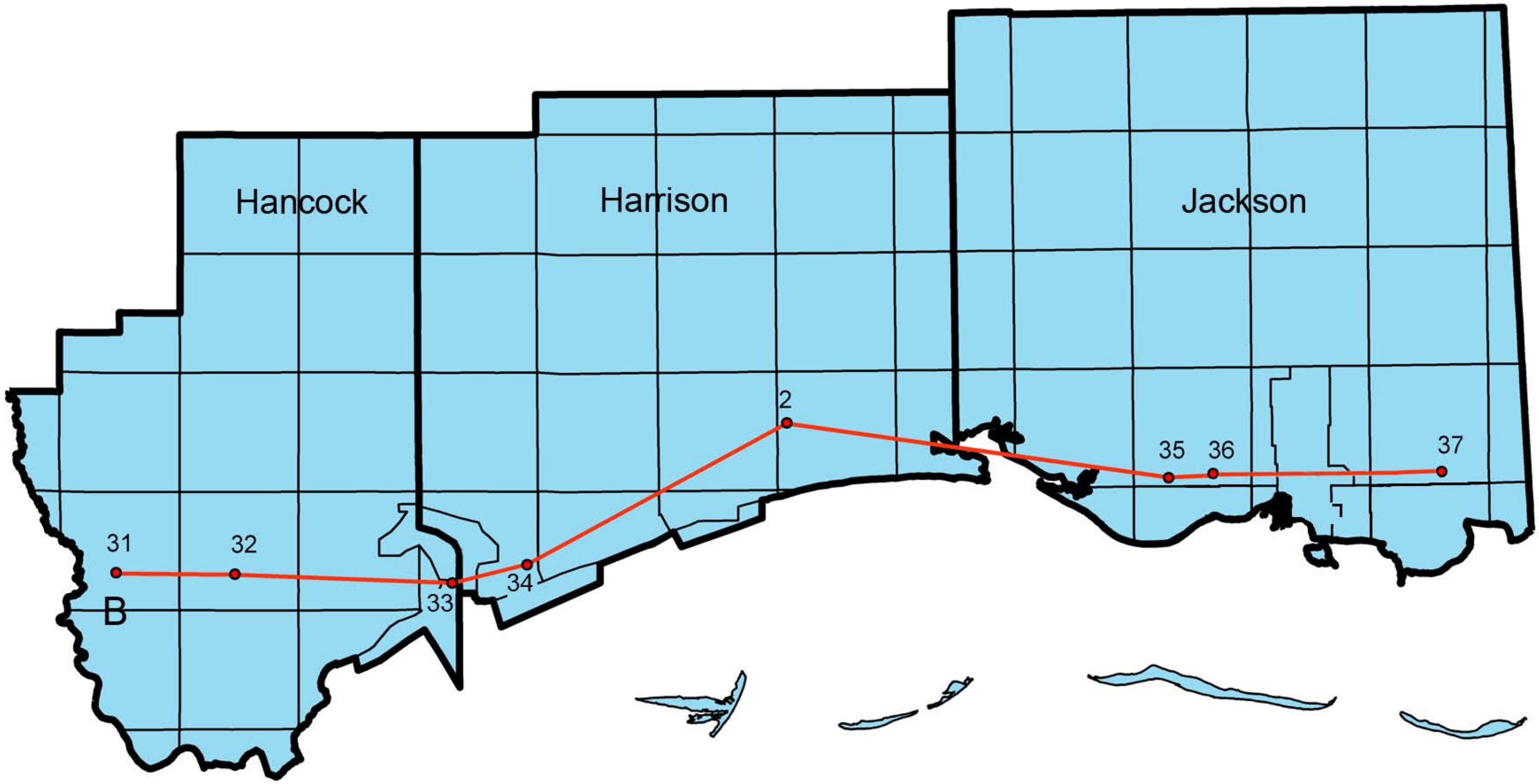


Figure 4: Location of Cross-Section B-B’

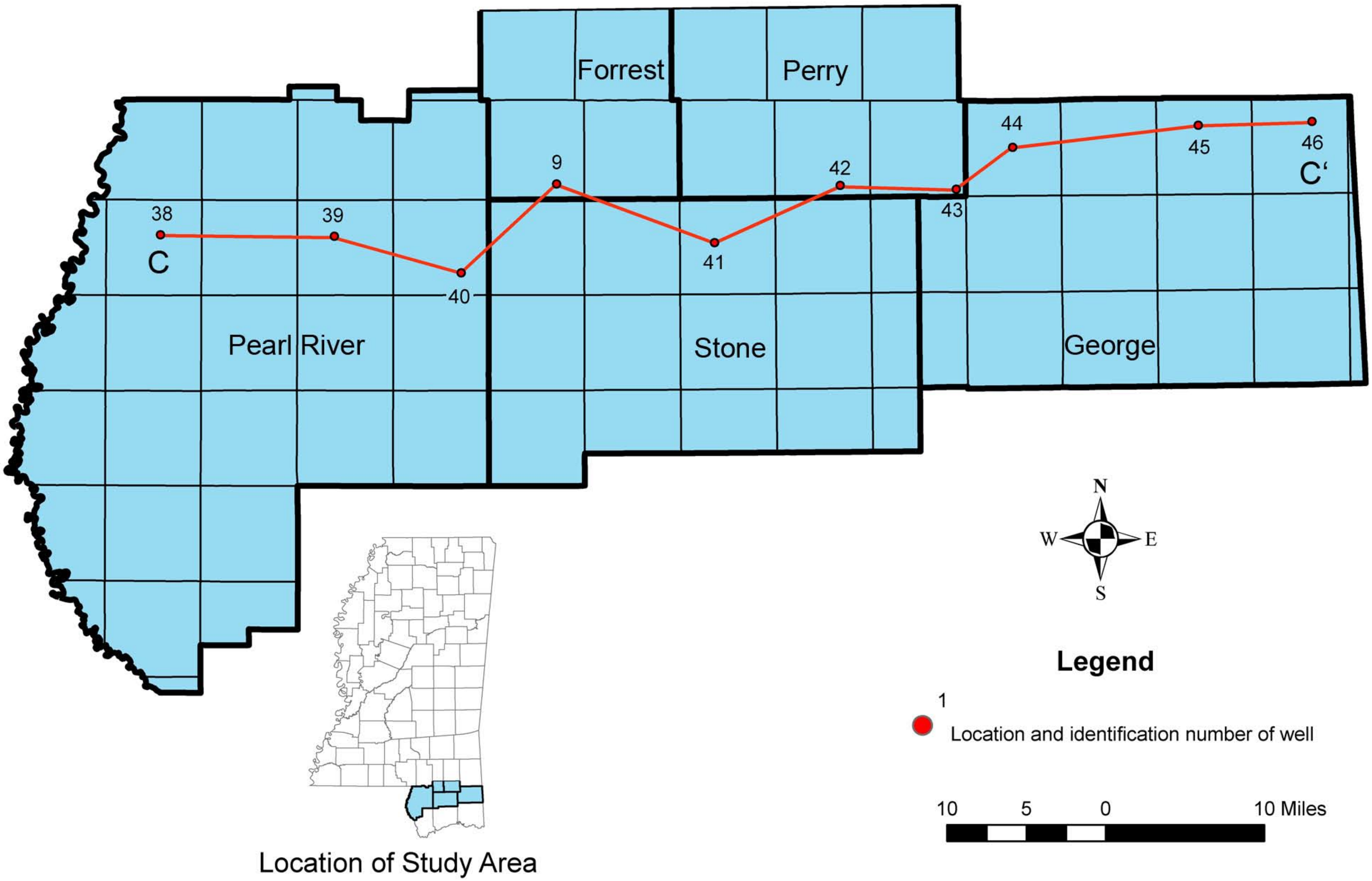


Figure 5: Location of Cross-Section C-C'

Section III

Tables

Cross-Section A-A'

Log Number	Owner-Company Well Name & Number	County	Location	Elevation
1	Sapphire #1 MS Sound Blk 90	State Waters	Offshore	111' DF
2	USGS Test Hole #1	Harrison	S18 T7S R10W	25' GL
3	Bradco Oil #1 International Paper	Harrison	S28 T6S R10W	62' GL
4	Hollemon & Sparks #1 Elmendorf 13-4	Harrison	S13 T6S R11W	57' DF
5	Jett Drilling Co. #1 Dantzler Lbr. Co.	Harrison	S26 T5S R11W	195' DF
6	Humble Oil #1 Dantzler Lbr. Co.	Harrison	S33 T4S R11W	156' DF

Cross-Section A'-A''

Log Number	Owner-Company Well Name & Number	County	Location	Elevation
6	Humble Oil #1 Dantzler Lbr. Co.	Harrison	S33 T4S R11W	156' DF
7	Mobil Expl. #1 International Paper 27-10	Stone	S27 T3S R12W	230' DF
8	Ohio Oil Co. #1 Dantzler	Stone	S4 T3S R12W	192' DF
9	Placid #1 Batson	Forrest	S35 T1S R13W	210' DF
10	A. T. Teague #3 Maxie Unit SW-S1	Forrest	S12 T1S R13W	277' KB
11	Ohio #2 Coleman-Powe Acct.	Forrest	S32 T1N R12W	288' KB
12	Humble Oil #1 Batson	Forrest	S19 T1N R12W	289' DF
13	Seaboard #1 Currie	Forrest	S1 T1N R13W	175' DF
14	Humble Oil #1-A Shelby Park, Inc.	Forrest	S24 T3N R13W	227' GL

Cross-Section A''-A'''

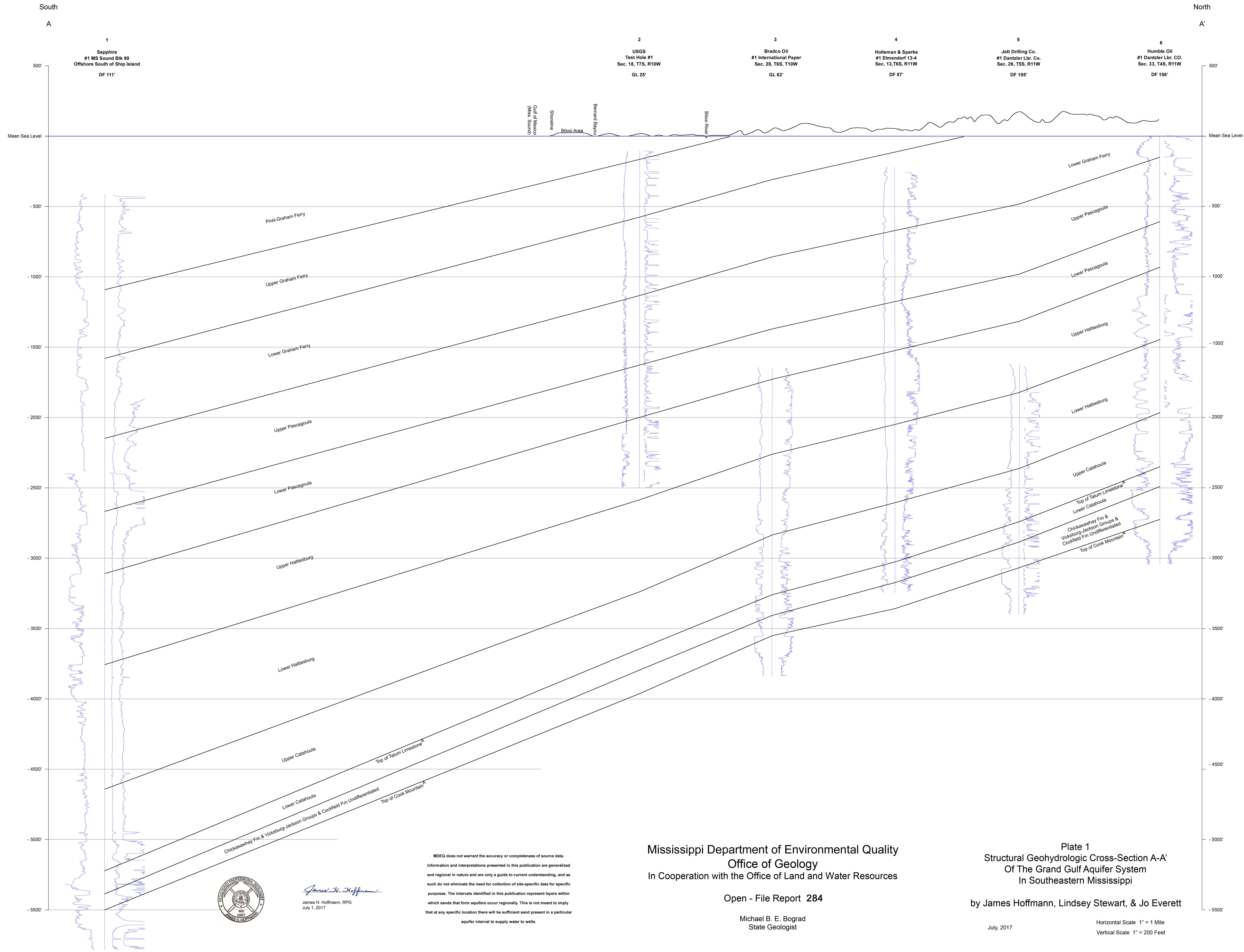
Log Number	Owner-Company Well Name & Number	County	Location	Elevation
14	Humble Oil #1-A Shelby Park, Inc.	Forrest	S24 T3N R13W	227' GL
15	Coquina & Forest #1 Sabine	Forrest	S7 T3N R12W	215' KB
16	Humble Oil #1-A Burkett	Forrest	S25 T4N R13W	144' GL
17	Humble Oil #1-A Travis	Forrest	S7 T4N R12W	207' GL
18	Humble Oil #1-A Barron	Forrest	S33 T5N R12W	270' GL
19	Humble Oil #1-A McMichael	Forrest	S18 T5N R12W	314' GL
20	Humble Oil #1-A Davis	Jones	S34 T6N R12W	189' GL
21	Humble Oil #1-A Ellzey	Jones	S8 T6N R12W	287' GL
22	Humble Oil #1-A Harrison	Jones	S25 T7N R13W	344' GL
23	Humble Oil #2-A State	Jones	S18 T7N R12W	258' GL
24	Humble Oil #1-A Junior College	Jones	S9 T7N R12W	231' GL
25	Humble Oil #14-A Masonite	Jones	S27 T8N R12W	201' GL
26	City of Laurel Well #1	Jones	S14 T8N R12W	210' GL
27	Gen. American Oil Co. of Texas #1 City of Laurel Botteler Unit	Jones	S12 T8N R12W	282' DF
28	Premier & Hutchings #1 McKinley	Jones	S26 T9N R12W	290' DF
29	Humble #1-A Mathews	Jones	S5 T9N R12W	294' GL
30	Humble Oil #1-A Welborn	Jones	S29 T10N R12W	310' GL

Cross-Section B-B'

Log Number	Owner-Company Well Name & Number	County	Location	Elevation
31	Sun Oil Co. #1 Weston Lbr. Co.	Hancock	S28 T8S R16W	31' DF
32	Marshall Young #1 Zengarling	Hancock	S28 T8S R15W	26' DF
33	J. W. Hughes #3 State of MS	Hancock	T8S R13W	18' DF
34	USGS Test Hole #2	Harrison	S24 T8S R13W	10' DF
2	USGS Test Hole #1	Harrison	S18 T7S R10W	25' DF
35	Imperial Resources Co. #1 Allar	Jackson	S38 T7S R7W	31' DF
36	Gautier Well # O286	Jackson	S35 T7S R7W	21' GL
37	Browning & Welch #1 Green	Jackson	S33 T7S R5W	11' KB

Cross-Section C-C'

Log Number	Owner-Company Well Name & Number	County	Location	Elevation
38	La Grange Petr. Co. et al Powe-Fornea #1	Pearl River	S15 T2S R17W	238' DF
39	MS Carbamate Co. Poplarville Test Hole #1	Pearl River	S17 T2S R15W	280' DF
40	Magnolia Petroleum Co. L. O. Crosby et al	Pearl River	S26 T2S R14W	258' DF
9	Placid Oil Co. #1 R. Batson	Forrest	S35 T1S R13W	210' DF
41	Danciger Oil & Ref. Stone Co. #1	Stone	S16 T2S R11W	212' RT
42	Phillips Petr. Co. Josephine A-#1	Perry	S35 T1S R10W	107' DF
43	FL Gas Expl. Co. #1 Collie O'Neal	Perry	S36 T1S R9W	230' KB
44	Sunnyland Contr. Co. USA #1	George	S21 T1S R8W	102' DF
45	Sinclair O&G Co. #1 Luce Packing Co.	George	S10 T1S R6W	262' DF
46	Southern Prod. Co. Hibernia Bank #1	George	S11 T1S R5W	133' DF



MDEQ does not warrant the accuracy or completeness of source data. Information and interpretations presented in this publication are generalized and regional in nature and are only a guide to current understanding, and as such do not eliminate the need for collection of site-specific data for specific purposes. The intervals identified in this publication represent layers within which sands that form aquifers occur regionally. This is not meant to imply that at any specific location there will be sufficient sand present in a particular aquifer interval to supply water to wells.

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Office of Geology
In Cooperation with the Office of Land and Water Resources

Open - File Report 284

Michael B. E. Bograd
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Plate 1
Structural Geohydrologic Cross-Section A-A' Of The Grand Gulf Aquifer System In Southeastern Mississippi

by James Hoffmann, Lindsey Stewart, & Jo Everett

July, 2017

Horizontal Scale 1" = 1 Mile
Vertical Scale 1" = 200 Feet

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Plate 2
Structural Geohydrologic Cross-Section A'-A''
Of The Grand Gulf Aquifer System
In Southeastern Mississippi

by James Hoffmann, Lindsey Stewart, & Jo Everett

July, 2017

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Vertical Scale 1" = 200 Feet

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Plate 3
Structural Geohydrologic Cross-Section A''-A'''
Of The Grand Gulf Aquifer System
In Southeastern Mississippi

by James Hoffmann, Lindsey Stewart, & Jo Everett

July, 2017

Horizontal Scale 1" = 1 Mile
Vertical Scale 1" = 200 Feet

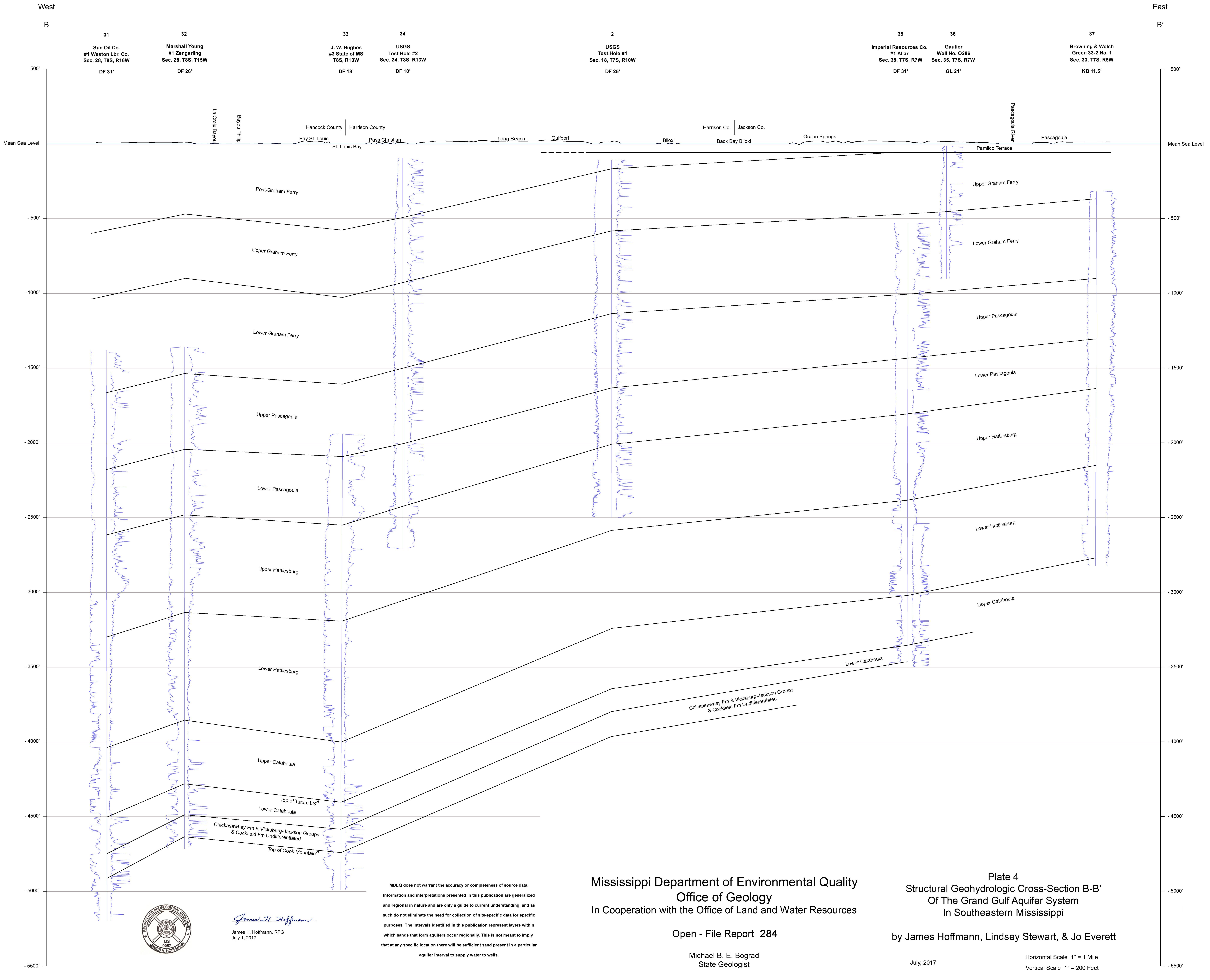

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Plate 4
Structural Geohydrologic Cross-Section B-B' Of The Grand Gulf Aquifer System In Southeastern Mississippi

by James Hoffmann, Lindsey Stewart, & Jo Everett

July, 2017

Horizontal Scale 1" = 1 Mile
Vertical Scale 1" = 200 Feet

James H. Hoffmann, RPG
July 1, 2017

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Plate 5
Structural Geohydrologic Cross-Section C-C' Of The Grand Gulf Aquifer System In Southeastern Mississippi

by James Hoffmann, Lindsey Stewart, & Jo Everett

July, 2017

Horizontal Scale 1" = 1 Mile
Vertical Scale 1" = 200 Feet