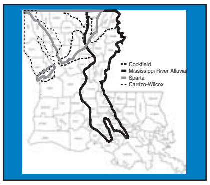

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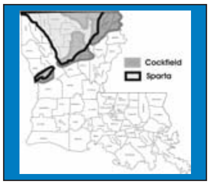

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Louisiana Geological Survey

NewsInsights

July 2004 • Volume 14, Number 2

Louisiana Ecoregions Defined

Richard P. McCulloh

On November 20, 2003, the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) and Region VI of the U.S. Environmental Protection Agency (EPA) convened an organizational meeting at the Abdalla Hall, 635 Cajundome Boulevard in Lafayette to begin a process of collaborative inter-agency effort to refine and subdivide Louisiana's ecoregions. The attendees returned for a second meeting at the same facility on April 1, 2004. The framework of patterns referred to as ecoregions promotes holistic resource management that considers the natural capacities and potentials of ecosystems and transcends agency and political boundaries, such that it promotes the sharing of data and resource assessments among neighboring states. This is contrasted with traditional management practices that consider individual resources in isolation. Participants at both meetings surveyed Louisiana geography and reviewed its essential biotic, abiotic, terrestrial, and aquatic attributes, seeking to discern distinctive patterns potentially related to those in adjacent states. Mr. Jim Omernik of the U.S. Geological Survey (USGS), with the EPA's National Health and Environmental Effects Research Laboratory in Corvallis, Oregon, one of the pioneers of the ecoregion concept, led and facilitated both meetings. The LGS participants in the ongoing effort launched with these meetings are Paul V. Heinrich and Richard P. McCulloh.

Ecoregions can be delineated based on biotic assemblages, on the physical framework that supports and configures those assemblages, or both. The EPA's Western Ecology Division (Corvallis, Oregon) website (http://www.epa.gov/wed/pages/ecoregions/ecoregions.htm) characterizes ecoregions as follows:

"Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing the spatial differences in the capacities and potentials of ecosystems, ecoregions stratify the environment by its probable response to disturbance. These general purpose regions are critical for structuring and implementing ecosystem management strategies across federal agencies, state agencies, and nongovernment organizations that are responsible for different types of resources within the same geographical areas."

The "ecosystem components" referred to in the above quote are physical attributes that could include climate, physiography, soils, and geology. While it can be said that the definition of an ecoregion is still evolving, in practice it tends to be pragmatic, to reflect "what works" for a given area as opposed to some standard listing of particular characteristics. Usefulness, not derivation, is paramount, and an ecoregion boundary characteristically reflects no single characteristic. Watersheds, for example, do not correspond necessarily to ecoregions, but tend to overlap them. The coincidence of a combination of things in some recognizable pattern is what is essential, and the definition is based on weight of evidence rather than fixed rules. The ultimate purpose of recognizing ecoregions is one of integration, of apprehending their myriad attributes in a holistic context rather than separately and reductively. Various websites, including the following, provide additional perspectives on the issue of ecoregion definitions:

http://en.wikipedia.org/wiki/Ecoregion
http://www.nearctica.com/ecology/ecoreg/ecoreg.htm

At the second meeting Omernik amplified the concept of ecoregions for the assembled group as follows:

- Ecoregions are "[a]reas of similarity regarding patterns in the mosaic of biotic, abiotic, aquatic, and terrestrial ecosystem components, with humans being considered as part of the biota."

LEVEL I ECOREGIONS

The Louisiana
Geological Survey
NewsInsights

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The LGS NewsInsights is published semiannually and distributed to professionals, state agencies, federal agencies, companies, and other organizations associated with geological research and applications. Call the main office for extra copies. It is also accessible on the website.

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LGS Mission Statement

The goals of the Geological Survey are to perform geological investigations that benefit the state of Louisiana by:

(1) encouraging the economic development of the natural resources of the state (energy, mineral, water, and environmental);

(2) providing unbiased geologic information on natural and environmental hazards; and

(3) ensuring the effective transfer of geological information.

The Louisiana Geological Survey was created by Act 131 of the Louisiana Legislature in 1934 to investigate the geology and resources of the State. LGS is presently a research unit affiliated with the Louisiana State University and reports through the Executive Director of the Center for Energy Studies to the Vice Chancellor for Research and Graduate Studies.

- Their general purpose is to provide "[a] spatial framework to allow resource management agencies and programs with different responsibilities for the same geographic areas to integrate their research, assessment, and management activities regarding environmental resources."
- "Ecoregions were not designed to serve a single purpose or to correspond specifically to patterns of specific components such as macroinvertebrates, fish, vegetation, or soils."
- "Ecoregions are intended to serve as the geographic organizational tool for 'ecosystem management.' "
- General-purpose ecological regions are "[b]ased on spatial coincidence of numerous geographic phenomena affecting or reflecting ecosystem characteristics."
- Specific-purpose regions (e.g., alkalinity, soils, or geologic regions) are "[b]ased on patterns of one characteristic and spatial associations with causal or reflective geographical phenomena."

The socioeconomic value of the recognition of ecoregions lies in their collaborative use as a framework for managing natural resources-one that will meet the needs of all federal, state, local, and private resource-management organizations-and in the application of the holistic, integrated approach to resource management across organizational and political boundaries, and ultimately as a basis for developing indices of ecosystem health and integrity. Additional information about the ecoregion initiative can be found at the EPA's Western Ecology Division (Corvallis, Oregon) website listed above.

Individual attendees were invited to the meetings with a view toward putting together a group with knowledge and expertise that would enable a collective understanding of ecosystems, the ecosystem components underpinning them, and the human activities impacting them; and to provide specific coverage for certain subject areas, including wildlife biology, aquatic biology, terrestrial and aquatic ecology, bedrock and surficial geology, geomorphology and physiography, soils science, botany, surface hydrology and water quality, and land use. The participants were 20 technical professionals with backgrounds in a range of subjects including coastal processes, environmental science, forestry, geology, soils science, wetland ecology, and wildlife biology and conservation. They represented organizations including, in addition to NRCS (Alexandria, Louisiana office) and EPA, the Dynamac Corporation; the Kisatchie National Forest; the Louisiana Department of Agriculture and Forestry (LDAF) the Louisiana Department of Environmental Quality (including NPS, its Nonpoint Source Pollution Program); the Louisiana Department of Natural Resources, Coastal Restoration Division; the Louisiana Department of Wildlife and Fisheries, Louisiana National Heritage Program; the Louisiana Geological Survey; NASA (Regional Application Center, the University of Louisiana at Lafayette); the U.S. Fish and Wildlife Service (Lafayette, Louisiana); and the USGS (including the National Mapping Division, and the National Wetlands Research Center, Lafayette, Louisiana; and the Water Resources Division District Office in Baton Rouge).

The November meeting initiated an involvement among state and federal agencies to develop a common framework of ecological regions and for the delineation of Level IV ecoregions in Louisiana. At the April meeting Glenn Griffith (Dynamac/EPA), a long-time co-worker with Omernik, presented a first draft of the Louisiana Level IV Ecoregion Map, which he had prepared based in part on ecoregion compilations already completed for adjacent states. The participants reviewed and discussed the draft in an interstate and national context and planned for the amplification and completion of it by the group assembled, with Jerry Daigle (Louisiana NRCS) assuming the lead for the effort overall, and Brad Spicer (LDAF) coordinating text revisions and compilation.

The ultimate end of the interagency collaboration to delineate level IV ecoregions in other states has been the development of a map poster and other products, made available to the public, documenting a state's ecoregions and the patterns of attributes on which they are based. While the main purpose of the Louisiana effort is to help complete the national map of ecoregions, the Louisiana participants are interested in the development of the same state-centered products these other states have produced. It is expected that once these products are completed they will be available at least electronically; printing of hard copies will be contingent on acquisition of funds to support traditional publication.

Characterization/ Conductivities of Louisiana Aquifers Explored

Douglas Carlson

INTRODUCTION

This article is a first in a series of articles which will appear in the Louisiana Geological Survey's newsletter considering the properties of aquifers in Louisiana. Aquifers are units of rock or sediment which provide an economically useful amount of water for consumers (Fetter, 2001). The determination of Louisiana aquifers' properties is part of a larger goal of the Louisiana Geological Survey (LGS) to develop a series of groundwater models of major aquifer systems throughout Louisiana, first of which is the Chicot Aquifer. The Chicot Aquifer groundwater model and future models will provide policy makers a tool for better understanding of how these various aquifers respond to possible future scenarios of groundwater demand.

However, before the construction of the conceptual and mathematical model of an aquifer is started there is need to gather and analyze existing information available for the aquifer and determine the physical properties of the aquifer. The results of aquifer properties analysis provides a reasonable range of parameter values to create the model framework and/or test when calibrating a groundwater model. One of the most important properties of an aquifer, is what is its hydraulic conductivity? This is often a property of an aquifer that groundwater models are very sensitive to (Anderson and Woesnner, 1992). For this reason before the start of any groundwater modeling project it is necessary to gather a large set of hydraulic conductivity values for aquifers and analyze the results.

HYDRAULIC CONDUCTIVITY

Hydraulic conductivity is the property of how easy is it for water to move through a material (Fetter, 2001). If this material is a porous medium then hydraulic conductivity is generally dependent upon the size and shape of the pore spaces, size and arrangement of the individual earth materials (particles), the effectiveness of the interconnections between the pores, and the physical properties of the fluid (determined by temperature) (Fetter, 2001). For example, if the interconnections between the pores are small, and restricted by the presence of finer grained materials, the resulting hydraulic conductivity is low (Figure 1). If the aquifer material is comprised of coarse grained material such as gravel (Figure1), then resulting hydraulic conductivity will be quite high. In general, sand and sandstones are considered porous media (Schulze-Makuch and others, 1999), which means Louisiana's aquifers which are sand and sandstones are considered porous media (Renkin, 1998).

The units that express hydraulic conductivity are those of length/time, often feet per day, abbreviated ft/day. Although the units of hydraulic conductivity are the same as velocity, hydraulic conductivity and velocity are not the same unless the hydraulic gradient is one. The velocity of groundwater is dependent on two other unitless properties of an aquifer: hydraulic gradient (slope of water-table or potentiometric surface) and porosity (fraction of an aquifer that is empty space for fluids to fill).

Natural geologic materials have a range of hydraulic conductivities that is 10 orders of magnitude. That is, gravel can have a hydraulic conductivity about 10 billion times that of unfractured shale. For naturally occurring properties of materials on earth probably the only other property with a range value that is larger is the electrical resistivity of materials. The resistivity of a good electrical insulator like quartz/glass is about million billion billion times larger than that of a good electrical conductor like a copper wire (Dohr, 1981).

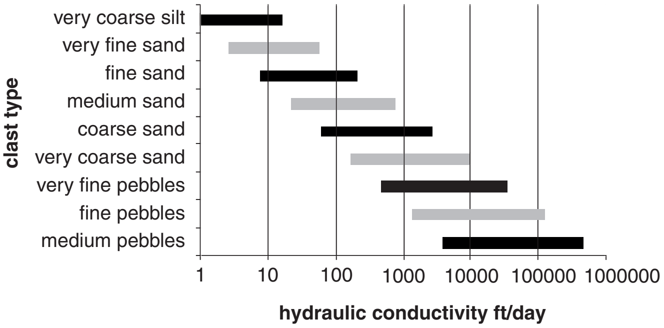

Figure 1. The influence of grain size on resulting hydraulic conductivity of a given unit of rock or soil (modification of Figure 3.15 of Fetter, 2001).

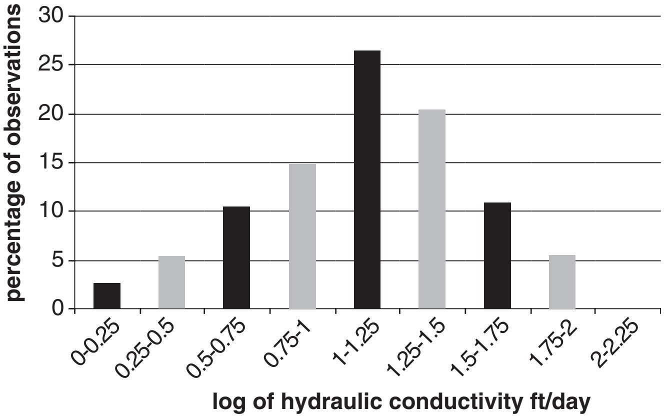

Figure 2. The Sparta Aquifer of northern Louisiana is typical of sand aquifers in that the distribution of hydraulic conductivity values of this unit is log normally distributed.

Hydraulic conductivity value for any aquifer will vary significantly depending on point selected within the aquifer (Fetter, 2001). In general, because the aquifers of Louisiana are sands the distribution of hydraulic conductivity values will be log normally distributed, for example Sparta Aquifer (Figure 2). What this means is the number of observed hydraulic conductivity values will form a standard normal curve "bell-shaped curve" of the frequency of observations (dependent variable on the Y axis) plotted against values of hydraulic conductivity (independent variable on the X axis) when hydraulic conductivity values are divided into equal steps on a log scale. So, with this in mind the values which appear in Figures 5, 7, 9 and 12 are geometric mean values. In general, hydraulic conductivity values for Louisiana major aquifers have a range that yields a standard deviation of about 0.5 on a log scale. For example the Sparta Aquifer has a geometric mean value of hydraulic conductivity of 12.4 ft/day and the range of values within one standard deviation is 4.2 ft/day to 36.6 ft/day. For a normally distributed data set approximately two thirds of observations will fall within one standard deviation of the mean (Kirk, 1990).

HYDRAULIC CONDUCTIVITY VALUES FOR LOUISIANA AQUIFERS

This study of aquifer hydraulic conductivity values of Louisiana aquifers is probably the largest to date. This study includes hydraulic conductivity results from about 3300 specific capacity tests. The hydraulic conductivity values determined for this study of Louisiana aquifers were derived by using the Bradbury and Rothschild

Figure 3. The above figure displays which parishes fal within each of the four regions used to divide the aquifers of Louisiana: northern, central, southwestern and southeastern.

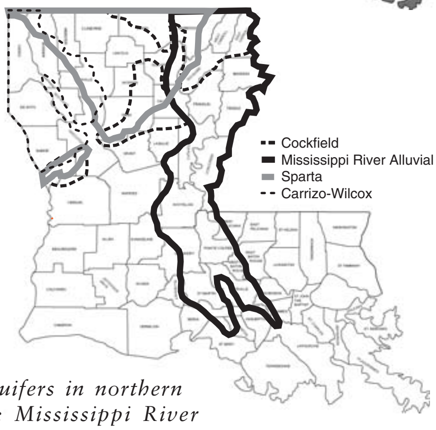

Figure 4. The extent of four aquifers in northern Louisiana: Mississippi River Alluvial, Carrizo-Wilcox, Cockfield and Sparta.

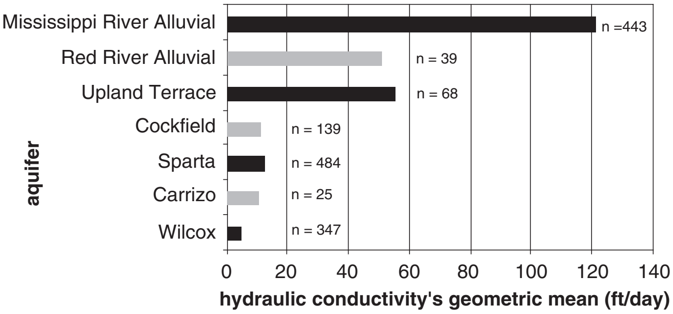

Figure 5. The hydraulic conductivity values of select major aquifers in northern Louisiana. These seven aquifer sands have about 98 % of 1576 hydraulic conductivity values for this region's data set. The hydraulic conductivities have been determined from analysis of U.S. Geological Survey (2003) specific capacity data by using the Bradbury and Rothschild (1985) technique.

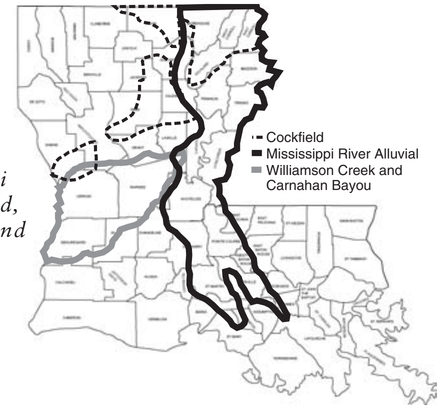

Figure 6. The extent of four aquifers in central Louisiana: Mississippi River Alluvial, Cockfield, Williamson Creek and Carnahan Bayou.

(1985) technique for analyzing specific capacity tests. This study's source of specific capacity test data is the U.S. Geological Survey (2003). Results will be considered for four regions within Louisiana: northern, central, southwestern and southeastern (Figure 3).

NORTHERN LOUISIANA

There are five major aquifers: Cockfield, Mississippi River Alluvial, Sparta, Upland Terrace and Carrizo-Wilcox and two local aquifers: Ouachita River Alluvial and Red River Alluvial in northern Louisiana. Four of the major aquifer's locations can be seen in Figure 4. Four of these aquifers are Quaternary in age (Lovelace and Lovelace, 1995): Mississippi River Alluvial, Ouachita River Alluvial, Red River Alluvial and Upland Terrace. These are also the aquifers that have the larger values of hydraulic conductivity (Figure 5) than the older (Lovelace and Lovelace, 1995) and finer grained aquifers (Renken, 1998): Cockfield, Sparta and Carrizo-Wilcox, which lack the coarse sands and gravels of the younger aquifers. The Cockfield and Sparta Aquifers are Eocene units and the Carrizo-Wilcox is an Eocene-Paleocene unit (Lovelace and Lovelace, 1995).

CENTRAL LOUISIANA

There are six aquifers in this region: Catahoula, Cockfield, Evangeline, Jasper (Williamson Creek and Carnahan Bayou), Mississippi River Alluvial, and Upland Terrace. Three of these aquifer's locations are shown in Figure 6. The Mississippi River Alluvial and Upland Terrace are by far the most conductive aquifers of the six (Figure 7). The typical hydraulic conductivity for these two aquifers is about five to ten times larger than for the others. Upland Terrace and Mississippi River Alluvial are both Quaternary age. The Evangeline Aquifer is Pliocene-Miocene in age, Jasper Aquifer is Miocene in age, Catahoula Aquifer is Miocene-Oligocene in age, and Cockfield Aquifer is Eocene in age (Lovelace and Lovelace, 1995). Often the Jasper Aquifer is divided into three units: Williamson Creek and Carnahan Bayou Aquifers and the Dough Hills clay (aquitard) in between (Lovelace and Lovelace, 1995). In general, the aquifers of this region have higher hydraulic conductivities than those in northern Louisiana (Figures 5 and 7).

SOUTHWESTERN LOUISIANA

Southwest Louisiana is dominated by a single aquifer, the Chicot Aquifer, while Evangeline Aquifer is clearly a secondary source of water (Figure 8). The Chicot Aquifer is a thick Quaternary aquifer composed of sands and gravels and interbedded silts and clays (Lovelace, 1998). It is a variable aquifer in terms of how well connected the clay layers are. In Calcasieu and Cameron Parishes the Chicot Aquifer has been divided into three sands "200 foot sand",

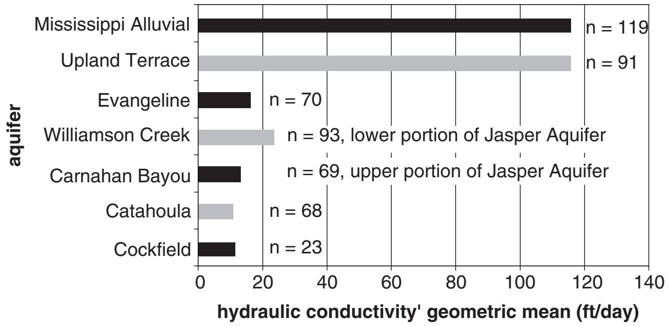

Figure 7. The hydraulic conductivity values of select major aquifers in central Louisiana. These seven aquifer sands have about 98 % of 546 hydraulic conductivity values for this region's data set. The hydraulic conductivities have been determined from analysis of U.S. Geological Survey (2003) specific capacity data by using the Bradbury and Rothschild (1985) technique.

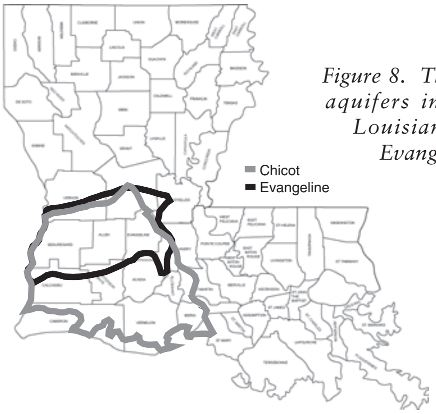

Figure 8. The extent of two aquifers in southwestern Louisiana: Chicot and Evangeline.

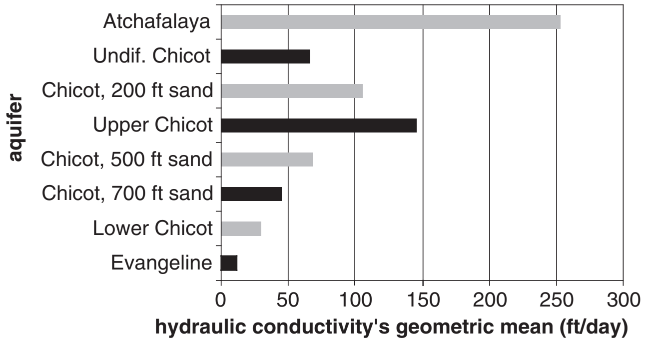

Figure 9. The hydraulic conductivity values of major aquifers in southwestern Louisiana. This regions 608 hydraulic conductivities have been determined from analysis of U.S. Geological Survey (2003) specific capacity data by using the Bradbury and Rothschild (1985) technique.

“500 foot sand”, and “700 foot sand” (Sargent and McGee, 1998). In Allen, Beauregard, Evangeline and St. Landry Parishes the Chicot Aquifer is usually considered a single undifferentiated unit (U.S. Geological Survey, 2003). Lastly in Acadia, Iberia, Jefferson Davis, Lafayette, St. Martin, and Vermilion the Chicot is divided into upper and lower Chicot (Lovelace and Lovelace, 1995). In general, the Chicot Aquifer has a higher hydraulic conductivity in the north and near to the surface (Figure 9). However, even the lowest hydraulic conductivity value of Chicot Aquifer for the “700 foot sand” and lower Chicot is still higher than all but the Upland Terrace and Mississippi River Alluvial (Figure 5 and 7). The Evangeline Aquifer is a source of water for Allen, Beauregard, Evangeline and St. Landry Parishes, however, in general, parishes to the south of these four parishes the Evangeline is no longer a potable aquifer, Evangeline’s waters are too saline to be a source of water for human consumption (Jones and others, 1954). Lastly, the Evangeline Aquifer’s typical hydraulic conductivity is about 1/6 th of the Chicot Aquifer’s hydraulic conductivity (Figure 9).

SOUTHEASTERN LOUISIANA

Lastly the southeastern portion of Louisiana has the most complex set of aquifers. Fetter (2001) notes there are 10 different aquifers noted for the Baton Rouge part of this region, while Lovelace and Lovelace (1995) in their Figure 1 note 29 aquifers in the entire southeastern Louisiana area. All of these units are Miocene to Quaternary in age (Lovelace and Lovelace, 1995). However, a large number of these aquifers can be classed by their ages into a fairly systematic system of aquifers (Figure 10): Chicot, Evangeline and Jasper

Aquifer System	Baton Rouge area	St. Tammany Tangipahoa and Washington Parishes	New Orleans area and lower Mississippi River Parishes
Chicot Equivalent	400 ft sand 600 ft sand	Upper Pontchatoula	Gramercy Norco Gonzales-New Orleans 1200 ft sand
Evangeline Equivalent	800 ft sand 1000 ft sand 1200 ft sand 1500 ft sand 1700 ft sand	Lower Pontchatoula Big Branch Kentwood Abita Covington Slidell	
Jasper Equivalent	2000 ft sand 2400 ft sand 2800 ft sand	Tchefuncta Hammond Amite Ramsey Franklinton	

Figure 10. Hydrostratigraphy of aquifers of southestern Louisiana as is defined by Lovelace and Lovelace (1995). This figure is a modification of Figure 1 in Lovelace and Lovelace (1995).

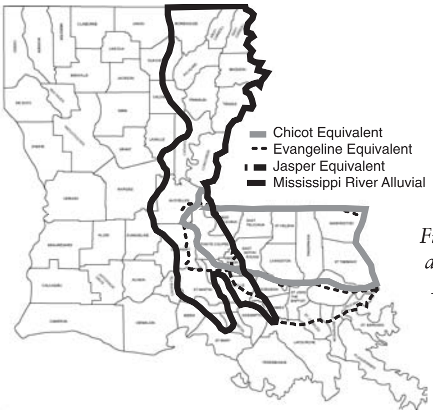

Figure 11. The extent of four aquifers in southeastern Louisiana: Chicot Equivalent, Evangeline Equivalent, Jasper equivalent and Mississippi River Alluvial.

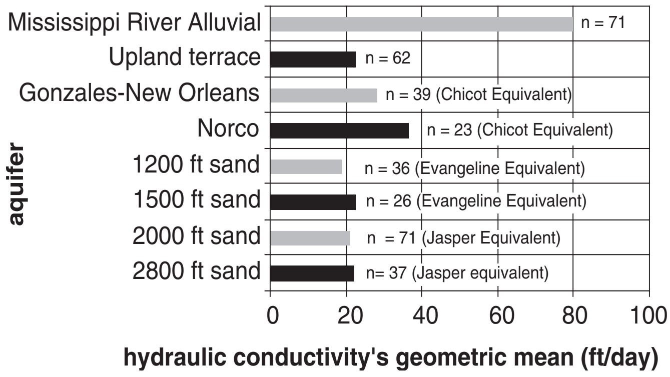

Figure 12. The hydraulic conductivity values of select major aquifers in southeastern Louisiana. These eight aquifer sands have about 67% of the 543 hydraulic conductivity values for this region’s data set. The hydraulic conductivities have been determined from analysis of U.S. Geological Survey (2003) specific capacity data by using the Bradbury and Rothschild (1985) technique.

Equivalents. Their location in Louisiana is displayed in Figure 11.

The Chicot Equivalent Aquifer of southeastern Louisiana has a lower hydraulic conductivity than the Chicot Aquifer of southwestern Louisiana, while the reverse is true about the comparison of Evangeline Equivalent Aquifer's hydraulic conductivity to Evangeline Aquifer's hydraulic conductivity (Figures 9 and 12). This is probably a result of each aquifer's position relative to the position of the dominate axes sediment deposition during the Miocene, Pliocene and Pleistocene (Galloway, et al., 2000). The source of material for the southeastern aquifers is the Appalachians to the northeast (Rosen, 1969), while the source of material for the southwestern aquifers is the Mississippi River's watershed (Taylor and others, 1995).

This study has included 543 values of specific capacity data for 24 different named aquifer units as defined by (Lovelace and Lovelace, 1995). However, the vast majority of these results can be included within Chicot Equivalent (109 values), Evangeline Equivalent (116 values), and Jasper Equivalent (151 values) as defined by Lovelace and Lovelace (1995). All three of these major aquifer groups have similar hydraulic conductivities. The geometric mean of hydraulic conductivity is 27.5 ft/day for Chicot Equivalent, 19.1 ft/day for Evangeline Equivalent, and 22.9 ft/day for Jasper Equivalent.

Acknowledgment

I would like to thank Charlie Demas and Wendy Lovelace among others at the Baton Rouge office of the U.S. Geological Survey for their gracious help and access to their vast set of records. Without this information many of the data sets analyzed and presented in this report would be either impossible or far more difficult to access.

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Sparta Aquifer: First-Year Study Completed

Douglas Carlson

INTRODUCTION

This is the first year in a multiple year study that will ultimately include the development of a regional groundwater model of the Sparta Aquifer. The Sparta Aquifer is the principal aquifer of northern Louisiana. The Sparta Aquifer has been experiencing a nearly continuous decline of water level throughout most of the aquifer over the past forty years (Figure 1). The Sparta Aquifer and adjacent aquifers are composed mainly of sands (Page, et al., 1963): Cockfield, Carrizo-Wilcox, and Mississippi River Alluvial. Between these aquifers lie several aquitards which are dominately composed of clays (Page et al., 1963): Cane River, Cook Mountain and Vicksburg-Jackson. These aquitards vary in terms of: thickness, amount of sand included and presence between the four major aquifers of northern Louisiana. Because of this, the Sparta Aquifer will be modeled as a part of a multiple layer model that includes four aquifers and three aquitards. This model will be composed mainly of Eocene age units. Three of these aquifers Carrizo-Wilcox, Sparta and Cockfield are Eocene in age and two of the aquitards Cane River and Cook Mountain are Eocene in age. Only the Vicksburg-Jackson and Mississippi River Alluvium are not Eocene in age. The Sparta Aquifer and other aquifers all are within the northern portion of Louisiana (Figure 2).

This first year included work to define the hydraulic conductivity and porosity of aquifers; stratigraphy of aquifers and aquitards; and lastly recharge rate, which is one major flux into the model.

PAST WORK

The model planned will be a major advance over previous models in number of ways. First this model will be far more detailed. The size of cells within the model will be 1/4 of a square mile, while previous models tend to have significantly larger cells which are 1 square mile or larger (Trudeau and Buono, 1985; Arthur and Taylor, 1990; McWreath III et al., 1991; and Meyers, et al., 2002). Second the model is only the second to consider the Sparta as an aquifer within a larger system. Only Arthur and Taylor (1990) considered the Sparta among a series of hydrostratigraphic units. However, their study was less detailed than the future model for this study. Third, this model will be far more detailed than McWreath et al.'s (1991) model of Sparta Aquifer in northern Louisiana given that in this study's model the average cell size will be far smaller and these small cells will cover more of the model so as a result there will be a vast increase in number of cells than previous models (Figure 3), about 1 million cells versus fifty thousand or less. Past models tended to focus on one or two parishes within the Sparta. This study will treat all parishes as equal with all having 1/4 square mile cells. Fourth, the base data sets considered will be far larger than previous models. For example in terms of hydraulic conductivity past work yielded only dozens of values using typical aquifer test analysis techniques such as Theis (1935). This study includes analysis of specific capacity tests using the Bradbury and Rothschild (1985) technique, which allows analysis of about 1600 specific tests. Fifth, this model appears to be the first to consider in detail recharge and surface water-groundwater interactions. Past models either considered a few rivers at most and in general there was no reference to recharge rate to be expected from analysis of other data sets.

HYDRAULIC CONDUCTIVITY OF AQUIFERS

During this first year of study about 1600 values of hydraulic conductivity were determined for aquifers to be included within this study's model. This study included analysis of specific capacity tests using the Bradbury and Rothschild (1985). A total of 484 hydraulic conductivity values were determined for Sparta Aquifer (Figure 4), 563 hydraulic conductivity values were determined for Mississippi Alluvial Aquifer, 349 hydraulic conductivity values were determined for the Wilcox portion of the Carrizo-Wilcox and another 30 values for the Carrizo portion of that aquifer, and lastly 159 values of hydraulic conductivity were determined for Cockfield. All of these sands have a distribution of hydraulic conductivity values similar to Sparta Aquifer's in that values are log normally distributed about the geometric mean value of hydraulic conductivity for that sand. The observations used to determine the hydraulic conductivity are generally distributed throughout the full extent of each of the aquifers. Seen in Figure 5 are the results for the Sparta Aquifer.

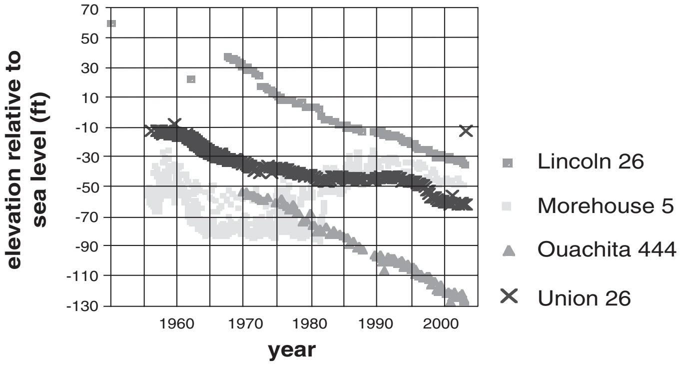

Figure 1. Decline of water levels throughout the Sparta Aquifer in the past forty years, all water-level elevations are relative to mean sea level. Lincoln 26 is north of Ruston, Louisiana; Morehouse 5 is in Bastrop, Louisiana; Ouachita 444 is west of West Monroe, Louisiana; and Union 26 is in Sterlington, Louisiana. Source of data is USGS (2002).

STRATIGRAPHY OF AQUIFERS

Initial work of this past year includes a start on determining the tops and bottoms of the various hydrostratigraphic units within this model. This includes analysis of 2867 geophysical logs. The base depths have been determined for 2169 sites for Sparta (Figure 6), 2025 sites for Cane River, 1758 sites for Carrizo-Wilcox, 1749 Cook Mountain, 1382 sites for Cockfield and 627 sites for Jackson-Vicksburg. In general, all of these units tend to thicken southwards and eastwards. These units also dip towards the south and east.

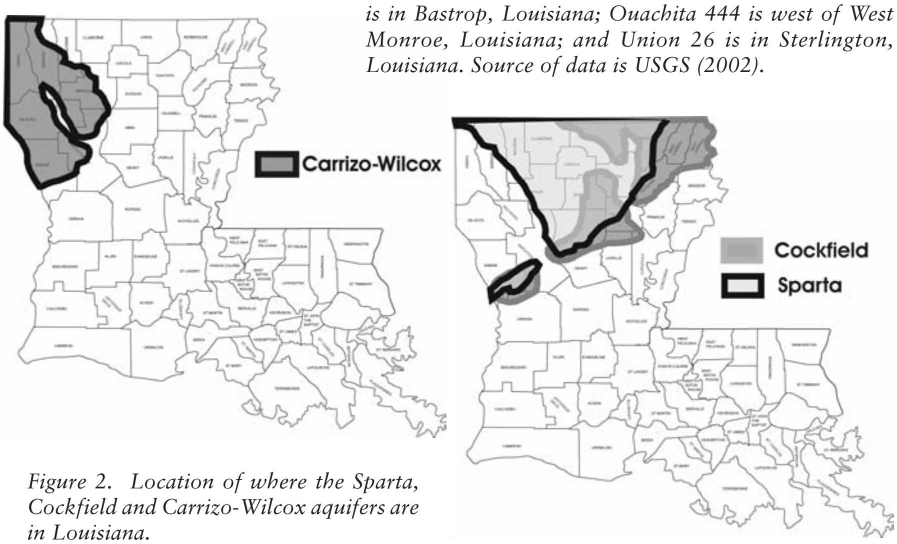

Figure 2. Location of where the Sparta, Cockfield and Carrizo-Wilcox aquifers are in Louisiana.

RECHARGE RATES

There are a variety of techniques for determining recharge rates from stream discharge data (Meyboom, 1961; and Rorabaugh, 1964). These techniques involve analysis of seasonal recessional curves. However, a simpler technique using flow-rate ranking is used for this initial determination of recharge rates in northern Louisiana. In general, recharge rates can be estimated using anywhere between the 50% and 80% discharge value for a stream (Feinstein, oral commun., 2001). Rank of discharge is from the top down. So the 50% rank of discharge is the median discharge while the 80% rank of discharge means 80% of the days have a greater discharge and 20% have a lower discharge.

The procedure used to calculate baseflow/recharge rates for this study includes three steps. The first step is to determine the 50% or 80% discharge rank by sorting daily discharges for a hydrologic year listed in USGS yearly stream discharge reports between 1966 and 2001. The second step is to determine the total baseflow discharge for a year by multiplying discharge rate expressed in cfs (cubic feet per second) by the number of seconds in a year. The third step is to divide the resulting baseflow volume of water by the watershed's area to yield a baseflow (recharge rate) expressed in ft/yr, which lastly is multiplied by 12 to yield the recharge rates of in/yr as reported.

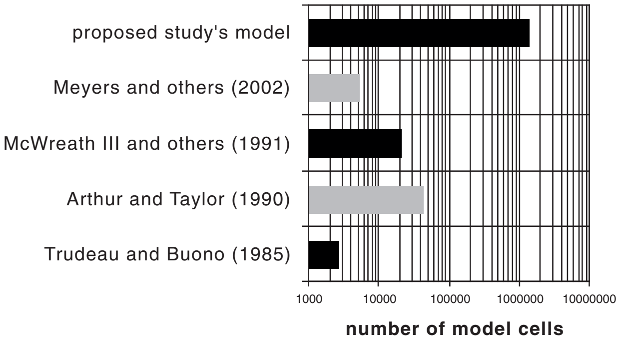

Figure 3. The numbers of cells that are within this proposed study are compared to previous models.

First year of work includes a start on determining recharge rates from baseflow data. Currently 882 years of daily discharge data has been analyzed for 66 streams in northern Louisiana that have watersheds covering the earth's surface above the aquifers that will be included within this study's groundwater model (Figure 7). In general, the recharge rates for aquifers above the Sparta/Cockfield/Carrizo-Wilcox are far smaller than precipitation in this area and the recharge rate in southwestern Louisiana over the

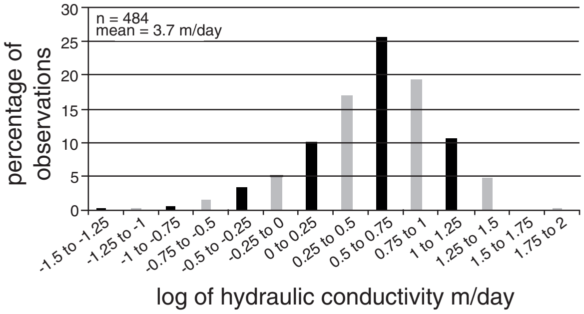

Figure 4. Distribution of hydraulic conductivity values for Sparta Aquifer.

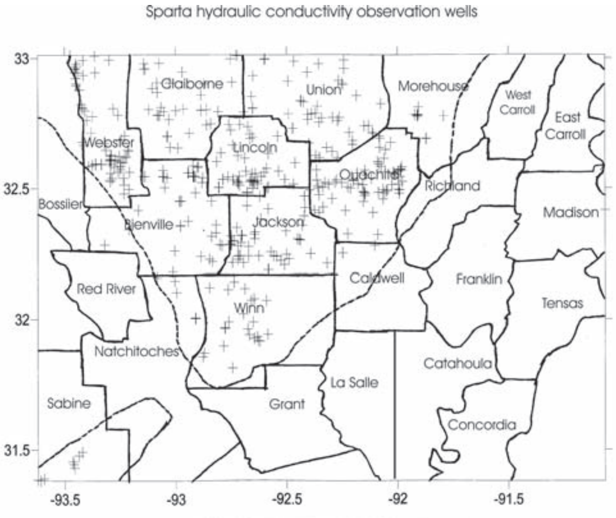

Figure 5. Each of the crosses represents the location of a specific capacity test analyzed for determination of hydraulic conductivity of Sparta Aquifer.

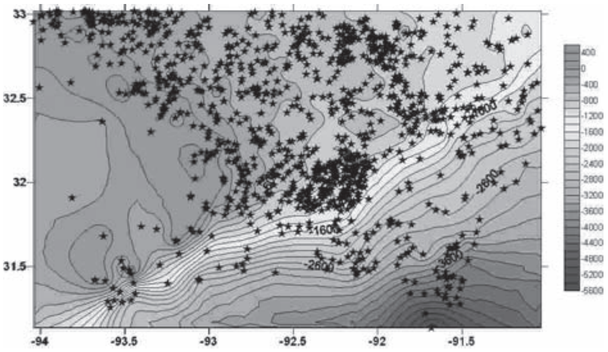

Figure 6. Location of geophysical logs used to determine the base of the Sparta Aquifer. Each star is the location of geophysical log used within Sparta base data set. Values for the base of Sparta are the elevations relative to sea level in feet.

Chicot Aquifer (Carlson, et al., 2003). Using the 50% rank of discharge for the recharge rate the average recharge rate is 5.77 + 7.38 inch/yr., while for the 80% rank of discharge the average recharge rate is 1.52 + 2.29 inch/yr. The average precipitation throughout northern Louisiana is 48 inch/yr to 54 inch/yr (Garrison, 1997). Lastly Sparta Aquifer recharge rates are lower than those for the Chicot Aquifer in southwestern Louisiana where the 50% rank of discharge for the recharge rate yields an average recharge rate is 8.38 + 6.18 inch/yr., while for the 80% rank of discharge the average recharge rate is 3.13 + 3.37 inch/yr (Carlson, et al., 2003). Thus recharge rate over the Sparta Aquifer is about 33% to 50% less than over the Chicot Aquifer. As indicated by the standard deviations listed above, listed after +, being larger than mean values, listed before +, recharge rate is not normally distributed but is skewed. The results are such that recharge is concentrated by area and during a few of 36 years considered.

POROSITY VALUES

Lastly for this year, porosity for the aquifers and aquitards of northern Louisiana has been determined from analysis of sonic logs; a combination of electrical logs and water conductivity data; moisture content data; and dry density data. All four of these techniques have allowed for the calculation of hundreds of porosity values.

The combination of electric logs and water conductivity data has been used to determine porosity values throughout northern Louisiana. This technique involves using Archie(s equation (Archie, 1942), sediment resistivities (U.S. Geological Survey, 2003a) after borehole corrections have been completed using Hallenburg (1984) correction factors and water conductivity data from a variety of sources (Newcombe et al., 1963; Page et al., 1963; Page and May, 1964; Winner et al., 1968; Dial, 1970; Hoseman et al., 1970; Sanford, 1972; Snider et al., 1972; Ryals, 1982; Snider, 1982; Snider and Covay, 1987; Rapp, 1996; U.S. Geological Survey, 2003b).

The determination of porosity for this technique was a three-step process. The first step was to read and record the observed resistivity (Ro) usually for the 64 inch normal log and sometimes the deep induction log for a well that has water quality data. The second step is to determine the resistivity value of water. The water resistivity (Rw) was determined by inverting the reported values of electrical conductivity, from the sources that are noted previously. With Ro and Rw values, the third and last step is to determine porosity by using Archie's equation (Archie, 1942). This technique has been used to determine 176 values of porosity for Wilcox and 153 values of porosity for Sparta Aquifer. Altogether 394 values of porosity have been determined using this technique. The average porosity for Sparta Aquifer is 22.31 + 10.13 %. This porosity is similar to the average porosity value for Wilcox Aquifer 20.56 + 5.52%.

The second technique used to determine porosity of northern Louisiana aquifers is to analyze sonic logs located in Bienville, DeSoto, Jackson, LaSalle, Morehouse, Ouachita and Richland Parishes. Of these logs 26 of the 40 lie in Ouachita Parish. A value of porosity has been determined every ten feet within the section of Eocene age. This process is a three-step process for determining porosity. One, read off the sonic log's recorded travel time noted as a value of microseconds per foot of travel distance at points a ten feet apart. Two, calculate the porosity using a standard equation for sonic logs assuming sandstone. Three, divide porosity by the necessary correction factor to adjust the previous equation for unconsolidated materials (Schlumberger, 1972). For this study the correction factor was set at 2.5. This yields results that are reasonable in light of porosity determined by other techniques discussed later. This technique has currently been used to determine 3668 values of porosity, of these 1565 values are for the Sparta Aquifer and 1348 are for the Carrizo-Wilcox Aquifer. The result is the porosities are slightly larger than from the previously discussed technique. The average porosity for Sparta Aquifer is 29.36 + 3.89 % (Figure 8). This porosity is similar to the average porosity value for Wilcox Aquifer 22.29 + 3.40%. This is not surprising given that this technique responds to all pores filled with water while the previous technique is only responding to interconnected pores, a subset of all pores. However both of these techniques yield as expected normally distributed values of porosity as expected for sands, Figure 8 shows results from analysis of sonic logs.

As expected in Bienville Parish which is up dip from Ouachita Parish the porosity is somewhat higher. The average porosity for 131 Sparta Aquifer porosity values is 34.13 + 7.02 %. This porosity is larger than average porosity value for 267 Wilcox Aquifer porosity values is 26.93 + 6.25%. Both of these values are larger than results for Ouachita Parish. The statistical confidence of this difference is over 99.5%.

Conversely as expected in LaSalle Parish which is down dip from Ouachita Parish the porosity is somewhat lower. The average porosity for 166 Sparta Aquifer porosity values is 24.71 + 4.42 %.

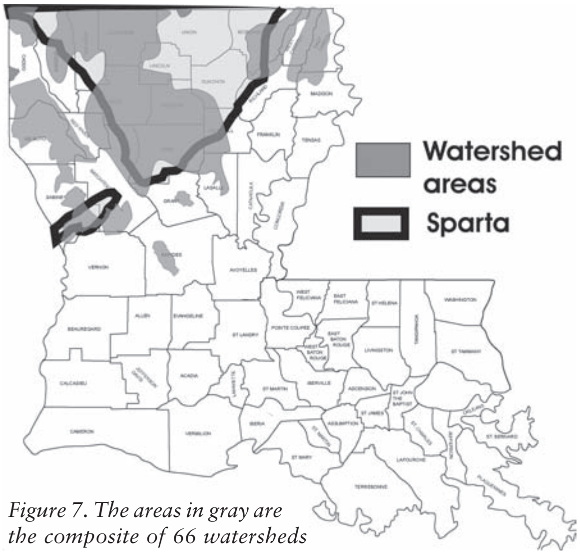

Figure 7. The areas in gray are the composite of 66 watersheds that are sources of recharge rates as determined from analysis of baseflow data from yearly USGS stream discharge reports from 1966 to 2001.

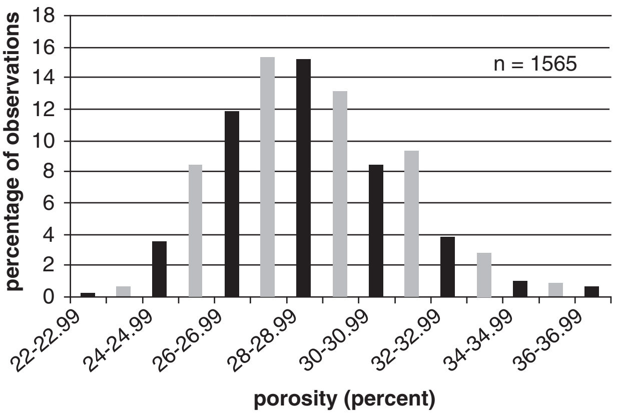

Figure 8. Porosity values determined from analysis of a combination of sonic logs for the Sparta Aquifer in Ouachita Parish.

This porosity is larger than the average porosity value for 529 Wilcox Aquifer porosity values is 17.36 + 4.67%. Both of these values are statistically significantly different from Ouachita Parish results with a confidence of over 99.5%.

The third and fourth techniques used to determine porosity were applied to moisture content and dry density data available from Magnolia Landfill in Ouachita Parish (Southwestern Laboratories, 1984). In this area the sands are parts of the Cook Mountain Formation. In general, the results are such that porosity for clays is higher than for silts and sands, which is expected (Fetter, 2001). Moisture content data was the more complete data set. Average clay porosity for the 439 values analyzed is 47.26 + 6.56%. Average silt porosity for the 32 values analyzed is 39.44 + 2.74%. Lastly the average sand porosity for 147 values analyzed is 37.41 + 4.66%. The sand value is very similar to the porosity value determined from analysis of sonic logs for the upper sands such as Sparta in Bienville Parish 34.13 + 7.02 %, Cook Mountain in 35.34 + 7.44 % Ouachita Parish, and Cockfield in 31.05 + 4.78 % LaSalle Parish.

Acknowledgements

I would like to thank Charlie Demas, Wendy Lovelace among others at the Baton Rouge office of the U.S. Geological Survey for their gracious help and access to their vast set of records. Without this information many of the data sets analyzed and presented in this report would be either impossible or far more difficult to access. I would also like to thank Bill Schramm of the Louisiana Department of Environmental Quality (DEQ) for his help accessing DEQ landfill permitting documents.

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Conferences/Exploration Present Data on Coal Seam Natural Gas (CSNG)

Clayton Breland

Exploration activity has continued since the Woods Oil and Gas #1 IPCo was drilling in early 2001 in Caldwell Parish, LA. The Woods well was the first well drilled in Louisiana to specifically test the production potential of coal seam natural gas (CSNG). Since that well was drilled, more than a dozen wells have been drilled in and around Caldwell Parish to further assess CSNG and interest in the play remains high. CSNG exploration players include companies with relatively long histories and experience in CSNG like Devon Energy and Geomet Operating. New to the play but experienced in oil and gas exploration in the area are King Drilling, Jonesboro, LA and Enervest Management Partners, Houston, TX. More recently Vintage Petroleum, Tulsa, OK and Harvest Gas Management, Houston, TX have entered the play by drilling the Colgrade CZ Fee A #114 in Winn Parish, LA and KFG #4 International Paper in Catahoula Parish, LA respectively. Both wells were drilled early this year and both wells used Baker Hughes Inteq's Coredrill Coring System and TerraTek Core Analysis Coalbed Methane Evaluation to core and evaluate the gas content and character of the coal.

USGS and LGS have actively pursued assessment of Louisiana's CSNG resources since forming a partnership in October 2001. As partners we have worked with Devon Energy, Enervest Gas Management and most recently Harvest Gas Management through an arrangement called a Cooperative Research and Development Agreement (CRADA). LGS and partner USGS would like to thank Deane Foss, Harvest Gas Management, for kindly sharing some of the core data from his well. Also, LGS/USGS would like to thank Kirk Ross, Vintage Petroleum, for contributing core and water data from their well with us.

In an effort to spread the word about CSNG in Louisiana and the Gulf Coast, Dr. F. Clayton Breland, Jr. collaborated with Dr. Peter D. Warwick (USGS) and members of the recently formed Gulf Coast Coal Seam Natural Gas Consortium; Ed Ratchford (Arkansas Geological Commission), Steve L. Ingram (Mississippi Minerals Resources Institute) and Jack C. Pashin (Alabama Geological Survey), to present a paper at the recent Geological Society of America Convention in Washington, D.C. entitled "Coal Gas Resource Potential of Cretaceous and Paleogene Coals of the Eastern Gulf of Mexico Coastal Plain." Dr. Peter D. Warwick, Alex Karlsen, Phil Hackley (all with USGS) and Dr. Breland (LGS) also presented a poster at the recent AAPG National Convention in Dallas entitled " Regional Correlation and Character of Coal-Bearing Zones, Wilcox Group, North-Central Louisiana: Implications for Coalbed Gas Exploration." In April, Dr. Breland was invited by the Department of Geology at the University of Louisiana at Lafayette to present a talk on CSNG entitled "An Introduction to Coalbed Methane and Its Occurrence in Louisiana." The presentation was well attended. Lafayette was also the venue for a recently held workshop entitled "Coalbed Methane Resources in the Southeast." The workshop was held on June 8, 2004 and took place at the Energy Institute in Abdalla Hall at ULL. Speakers included: Dr. Peter D. Warwick (USGS), Steven A. Tedesco (Atoka Geochemical Services Lab), Doug R. Wight (CDX, LLC), Derek Crowson (Halliburton), Terry D. Burns (GeoMet Operating Inc.) and Dr. F. Clayton Breland, Jr. (LGS). The morning presentations included topics such as: an introduction to CBM, regional CBM activity, drilling and completion techniques, wireline log evaluation and state regulatory issues. Following a lunch break, a panel discussion concluded the workshop. Members of the dais included the speakers, plus Kirk Ross (Vintage Petroleum), Deane C. Foss (Harvest Gas Management) and Diana Chance (Donner Minerals). The workshop was very well attended and deemed a success. For further information about CSNG in Louisiana, please contact Dr. F. Clayton Breland, Jr. at 225-578-8300 or clayton@lgs.bri.lsu.edu.

Geologic Review Defined

John Johnston

Geologic Review is a regulatory assistance program of the Louisiana Geological Survey (LGS) (http://www.lgs.lsu.edu). It is funded by the U.S Army Corps of Engineers and the Louisiana Coastal Management Division and provides the agencies with LGS assistance on proposed oil and gas operations in Louisiana and Texas which impact environmentally sensitive areas (wetlands, wildlife refuges, etc.). The purpose of Geologic Review is to ensure that only the least damaging feasible alternative is permitted while still allowing the operation in question to proceed.

Geologic Review consists of an examination of the permit applicant's geologic, engineering, and lease data. Economic data may be reviewed, and perhaps reviewed in depth if necessary. The review takes place in the presence of representatives of the permitting and the relevant commenting agencies of the federal, state, and local governments involved. The Geologic Review team retains no confidential data.

As oil and gas operators commonly optimize their operations for profit rather than for environmental protection, Geologic Review seeks to find ways to feasibly minimize the impact of oil and gas operations by looking at reducing the length and size of ring levees, board roads, canals, slips, and other means of access and operation. Possible outcomes include determining that there is no feasible alternative, or recommending that the length of a board road or canal can be reduced, that the areal extent of a slip or ring levee can be reduced, that an alternate access route should be employed, that a containerized (closed loop) mud system should be employed, that a well should be directionally drilled, that a location should be moved, or that an entirely different access method should be employed. Technically feasible methods of impact reduction which fail economic tests are not recommended.

Geologic Review has been in place in Louisiana since 1982, when the Louisiana Coastal Management Division asked the Louisiana Geological Survey to design and implement such a program for the Louisiana Coastal Zone. As a result of Geologic Review's immediate success, the New Orleans District of the U.S. Army Corps of Engineers joined the process in 1984, followed by two other districts of the USACE. Geologic Review reduces proposed impacts significantly; average annual impact reductions of over two-thirds are common. As for long-term effects, since the beginning of Geologic Review, the average length of board roads and canals in the Louisiana Coastal Zone has been reduced by three-fourths.

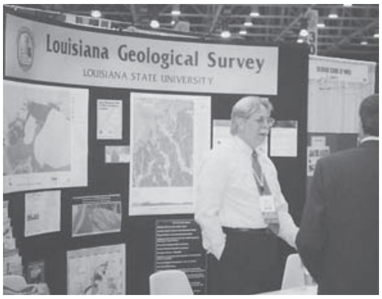
For further information about Geologic Review, please contact John Johnston III, either at hammer@lsu.edu or at 225-578-8657.

Personnel News

Bradford Hanson, Research Associate, left LGS to take a position at DOTD.

Chacko John, LGS Director, was elected to Fellowship in the Geological Society of America, by the GSA Council at its meeting on April 25, 2004

Conferences and Presentations



American Association of Petroleum Geologists (AAPG) Annual Convention, Dallas, Texas

April 18 - 21, 2004

LGS staff authored/co-authored the following presentations at this AAPG Conference:

- ***The University Oil and Gas Field: Hydrocarbons, Reservoirs, and Future Potential*** by Byron Miller, Chacko John, Brian Harder, and Reed Bourgeois.
- ***Preliminary Geologic Characterization of the Chicot Aquifer in Southwest Louisiana: Acadia, Allen, Beauregard, Calcasieu, Evangeline, and Jefferson Davis Parishes*** by Riley Milner (LGS) and Sean McLaughlin (DNR).
- ***Regional Correlation and Character of Coal-Bearing Zones, Wilcox Group, North Central Louisiana: Implications for Coalbed Gas Exploration*** by P.D. Warwick (USGS), F.C. Breland (LGS), A.W. Karlsen, and P.C. Hackley (USGS).

Exhibit Booth: LGS had an exhibit booth at this AAPG Convention displaying LGS publications and providing information on ongoing LGS research projects. Riley Milner manned the booth, and was assisted by Chacko John and Ron Zimmerman. A large number of attendees visited the LGS booth.

EVERY AMERICAN BORN WILL NEED

1390 pounds of copper • 20,226 pounds of clay • 29,336 pounds of salt • 772 pounds of zinc • 1.55 million pounds of stone, sand and gravel • 1279 Troy ounces of gold • 573,056 pounds od coal • 21,848 pounds of phosphate rock • 4864 pounds of bauxite (aluminum) • 849 pounds of lead • 32,810 pounds of iron ore • 5.78 million cubic feet of natural gas • +48,096 pounds of other minerals and metals • 65,543 pounds of cement • 81,518 gallons of petroleum

45,524 POUNDS OF NEWLY MINED MINERALS
FOR EVERY AMERICAN, EVERY YEAR

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AAPG Energy Minerals Division Luncheon and Awards Function

The President of the Energy Minerals Division of the American Association of Petroleum Geologists, Chacko J. John, (LGS Director) presided over and presented all of the Division Awards for Honorary Membership, Distinguished Service, and for Oral and Poster Papers presented at the 2003 Annual Convention in Salt Lake City. Patrick Leahy, USGS Associate Director of Geology was the luncheon speaker. His informative talk was titled *"The USGS Role in Preparing for the Energy Mix of the Future"*. Optimistic Oil Company (Frank Harrison - President), ChevronTexaco, and the National Mining Association were sponsors for this event.

2004 Digital Mapping Techniques Workshop

Robert Paulsell attended the 2004 Digital Mapping Techniques Workshop in Portland, Oregon in May. The DMT is sponsored by the US Geological Survey and was hosted this year by the Oregon Geological Survey. The Louisiana Geological Survey will be hosting the 2005 DMT in Baton Rouge next April or May. This annual meeting brings mapping professionals and geologists from state and federal government together to exchange technology and methods for digital geologic mapping.

Other presentations by the LGS staff include :

- ***Status of an Inventory of Petrochemical Pipelines in Louisiana*** by Robert Paulsell at the Louisiana Remote Sensing and GIS Workshop, Cajundome Conference Center, Lafayette, April 20-22.
- ***Pipeline Mapping in Louisiana: Homeland Security Issues*** by John Snead at the Louisiana Oil Spill Interagency Council Annual Meeting, Baton Rouge, April 29.
- ***Research and Development of a GIS of Petrochemical Transmission Pipelines in Lake Charles and Westlake, Lousiana*** by Robert Paulsell at the Louisiana Oil Spill Research and Development Symposium, Pennington Conference Center, Baton Rouge, May 12-13.
- ***Field Investigation and Digital Mapping of the Pipeline Crossing of the Ouachita/Black River System in Louisiana*** by John Snead at the Louisiana Oil Spill Research and Development Symposium, Pennington Conference Center, Baton Rouge, May 12-13.

New Publications

Paul V. Heinrich, Richard P. McCulloh, and John Snead, 2004, ***Gulfport 30 x 60 minute Geologic Quadrangle***, (1:100,000), Louisiana Geological Survey, $10.00.

John Snead, Lisa Pond, and Robert Paulsell, 2004, ***Map and Satellite Image of the Atchafalaya Basin***, 2nd Edition, (1:160,000)Louisiana Geological Survey/DNR Atchafalaya Basin Program, $12 rolled, $9 folded.

Note: a new updated LGS Publication List with revised prices is now available. The publication list will also be accessible on the LGS website, www.lgs.lsu.edu. Please direct all inquiries and orders to: Patrick O'Neill at (225)578-8590 or e-mail him at pat@lgs.bri.lsu.edu.

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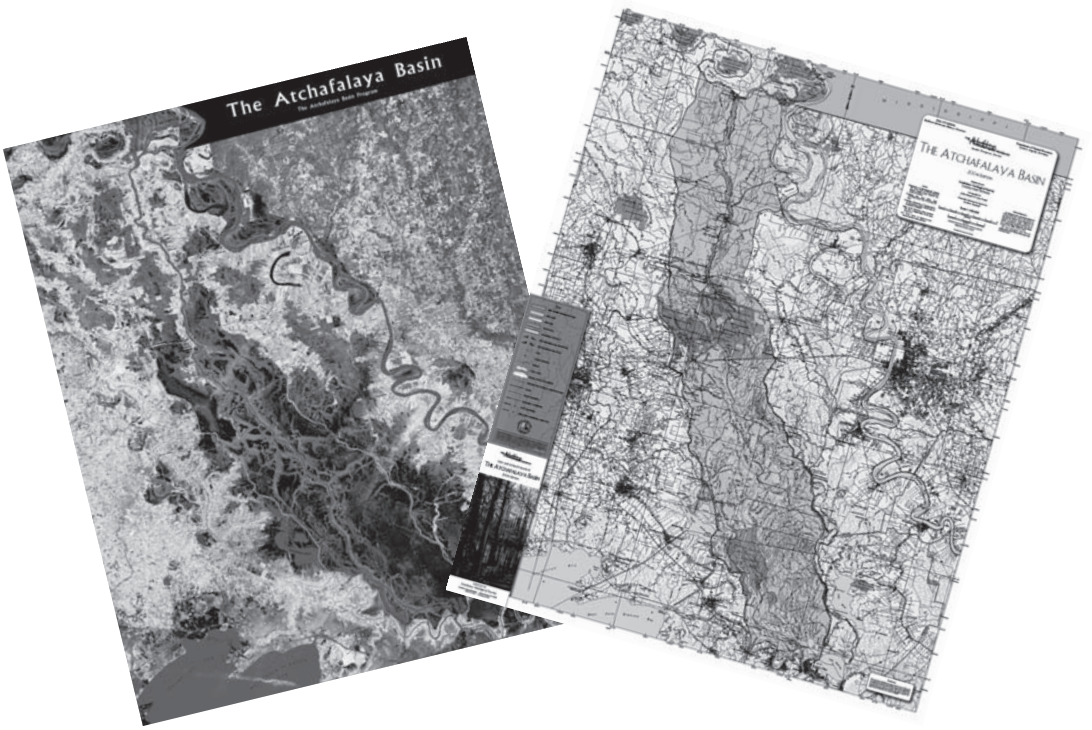

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