Louisiana Geological Survey

NewsInsights

Fall 2006 • Volume 16, Number 2

Occurrences and impacts of Lignite within Aquifers of Louisiana

Douglas Carlson

Lignite is a sedimentary rock composed of consolidated and chemically altered plant remains (Haque, 2000). Lignite is soft, porous and carbonaceous and is the intermediate stage between peat and subbituminous coal containing a calorific value under 8,300 British Thermal Units (BTUs) per pound (Roland et al., 1976). It ranges in color from black to reddish brown, but is usually brown (Meagher and Aycock, 1942). Lignite is a fairly light weight form of coal with a density that is approximately 1.4 times that of water (Roland et al., 1976), and less dense than typical sands and clays which have density approximately 2 and 2.2 times that of water respectively (Telford, et al. 1976).

The occurrence of lignite in northwestern Louisiana was first noted in 1812. It is present throughout most of northwestern Louisiana, and mineable quantities are present in seven parishes: Bienville, Bossier, Caddo, De Soto, Natchitoches, Red River, and Sabine. For the next 170 years lignite was mined in small amounts from outcrops for local use as fuel for heating, black smithing, brick firing, and in manufacturing of sugar and tiles. Large scale mining of lignite did not begin until the mid 1980s. At this time lignite is being used as a fuel for electric power production (Haque, 2000). Typically yearly production between 1987 and 2005 is approximately three to four million tons (Haque, 2000; and Energy Information Administration, 1999, 2000, 2001, 2002, 2003, 2004, and 2005). This lignite comes from two major mines: Dolet Hills and Oxbow that are located in De Soto and Red River parishes respectively. Between 1990 and 2005 approximately 78% of the production came from the Dolet Hills mine and 22% of production from the Oxbow mine (Figure 1).

The lignite found in Louisiana was deposited during the Paleocene and Eocene epochs approximately 36 to 66 million years ago (Haque, 2000). Lignite surface outcrops are usually within the Midway and Wilcox Groups as indicated by the fact that 38 of 48 outcrops examined by Meagher and Aycock (1942) were within these units.

Lignite's source sediment is peat. Peat deposits were a part of a series of fluvial and deltaic sediments (Roland et al., 1976; and Coates, 1979) that were deposited in usually freshwater environments, but sometimes in brackish water environments. These environments of deposition are thought to be similar to the current Louisiana coastal environments (Meagher and Aycock, 1942; Coates, 1979).

The peat formed during the Eocene or Paleocene and was later buried and heated, thus converted into lignite. The processes of compression and heating of the peat reduces volatile and water content of the original peat as it was metamorphosed into lignite (Meagher and Aycock, 1942).

Lignite is composed mainly of volatile organ carbon compounds that include: carbon, hydrogen, nitrogen and oxygen. Impurities within the lignite include moisture, sulfur and ash. On average lignite is approximately 1/3 moisture, 1/4 each of fixed carbon and volatile material, and 1/6 ash (Figure 2). The ash is composed mainly of compounds of silicon, aluminum, calcium, and iron (Meagher and Aycock, 1942).

The fixed carbon and volatile material portion is composed mainly of carbon, approximately 75% with smaller amounts of: oxygen approximately 20%, hydrogen approximately 5%, nitrogen approximately 1.5%, and sulfur approximately 1% (Figure 3).

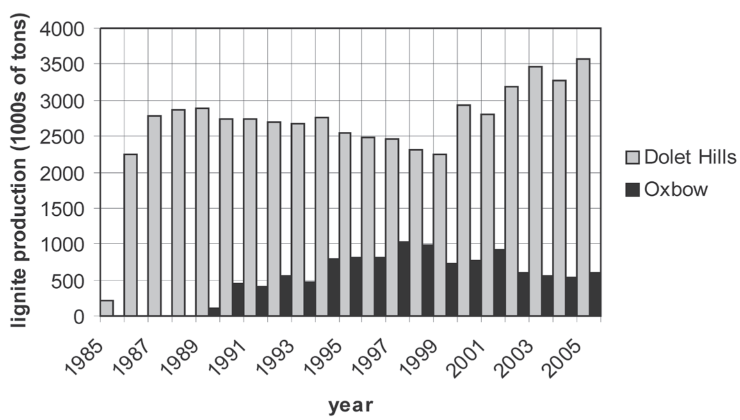

Figure 1. Louisiana lignite production 1985 to 2005 (Department of Natural Resources, 1999; and Energy Information Administration 1999, 2000, 2001, 2002, 2003, 2004, and 2005).

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.

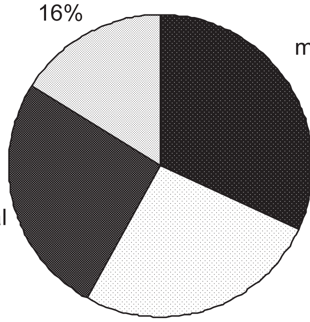

Figure 2. Average composition of lignite (Roland et al., (1976).

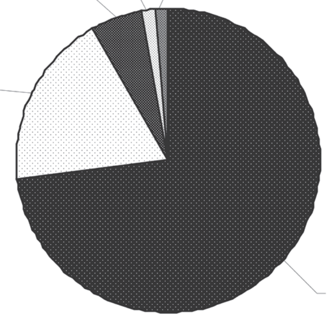

Figure 3. The average elemental composition of lignite's volatile compounds, (Roland et al., 1976).

Lignite's Impact on Groundwater

Beginning in the 1980s a number of studies (Snider, 1982; and Snider and Covay, 1987) have considered the impact of lignite and/or lignite mining on groundwater resources. The impact of lignite mining on groundwater availability was considered for areas in northwestern Louisiana (Snider, 1982; Snider and Covay, 1987; and Breyer, 2001). Badji (1990) studied the change of hydraulic properties between natural soils and mine reclaimed soils in northwestern Louisiana. However, beyond the mining of coal/lignite's impact of water level these mining activities can also impact the quality of groundwater in a variety of ways (Jacobs Engineering Group, 1994; Finkelman, et al., 2002; Chatziapostolou et al., 2006). These studies note that post-combustion ash is a source of groundwater pollution. In addition, it appears that groundwater flowing through lignite or coal seams leaches organic compounds that are injurious to human health (Finkelman et al., 2002; and Finkelman et al, 2006). This phenomena has been studied at a variety of sites throughout the world: Bulgaria, Bosnia, Croatia, Romania, and Serbia (Orem, et al., 2004); Portugal (Finkelman et al., 2006); Wyoming (Orem et al., 2004) and Louisiana (Bunnell et al, 2003; Orem, et al., 2004; and Finkelman et al., 2006). The impact on health appears to be irreversible kidney disease (Finkelman et al., 2002), which later was noted as including renal and pelvic cancers (Orem, et al. 2004; Finkelman et al., 2006). There are a number of agents that have been studied that could be causes of irreversible kidney disease. It appears that kidney disease and urinary tract cancers are associated with compounds in drinking water that have leached from the Pliocene lignites of the Balkans (Finkelman et al., 2006). They include bacteria and viruses, chromosomal aberrations, heavy metals, industrial pollution, mycotoxins, plant toxins, radioactive compounds, and trace element imbalances within soil (Finkelman et al., 2006). Finkelman et al's (2006) study appears to indicate that a series of organic compounds could be the disease agents. They are present consistently in larger concentrations in areas where kidney disease rates exceed normal rates than areas where kidney disease rates are typical.

It was observed that among the factors that impacted the occurrence of kidney disease was the consumption of untreated water, which is typical in rural areas of the Balkans (Finkelman et al., 2006). This may also explain why death rates from urothelial cancer are highest in the USA for North and South Dakota, two rural states with extensive lignite deposits (Bunnel et al., 2003; and Finkelman et al., 2006). With this in mind Bunnell et al. (2003) studied groundwater in northwestern Louisiana, a largely rural area with lignite deposits. Bunnell et al.'s (2003) study is of limited scope and showed the concentration of possible carcinogens in five parishes in northwestern Louisiana (15 wells, 4 surface waters). However, the occurrence lignite is far more extensive and it is found in, 16 parishes throughout northwestern and north central Louisiana. The objective of this investigation is to determine the area and the number of wells that could be impacted by lignite.

Focus of This Study

This study includes a review of geologic log reports for domestic wells with the Louisiana Department of Transportation and Development (2005) database for the presence of lignite. Water from these wells is usually not treated in any manner and hence are vulnerable to contamination from lignite. Treated water (i.e. filtered and chlorinated) appears to remove the kidney disease causing agents from water produced by a typical public water well (Finkelman et al., 2006).

Louisiana is divided into the: northwest, northcentral, northeast and southern regions for this study with the northwest region being the focus of the study, while the others are used for comparisons (Figure 4). For northern parishes all geologic logs associated with domestic well completion reports were examined for reports of lignite seams or mixtures of lignite with other sediments. For parishes in southern Louisiana if there are less than 500 domestic wells, all geologic reports were examined for reports of lignite. However, if there are more than 500 domestic wells within a southern parish then only a select fraction of every one, three or up to twenty five in the case of St. Tammany Parish were selected as a statistical sample of approximately 400 wells to determine approximate rate of occurrence of lignite in a parishes domestic water wells of the parish.

Thickness of Lignite seams

On occasions a seam of lignite is thick enough for the driller to note its thickness as a separate lithologic unit on the well log report. Most, approximately 83%, of the seams noted in water well logs are five feet thick or thinner (Figure 5). This result is similar to results for wells owned by the United States Geological Survey (USGS) at the time the well was drilled as listed on the well construction report and as noted within industrial and public supply wells. Approximately 79% of the 81 lignite seams noted within USGS wells are 5 feet thick or less, which is almost the same as 78% of the 167 lignite seams noted within industrial and public supply wells. Within domestic wells the most common thickness in 29% of the 1,105 seams is 2 ft., which is also the case for industrial and public supply wells. These results are similar to the results for Roland et al.'s (1976) study of lignite seams in De Soto and Sabine Parishes.

Both of the studies have a large majority of lignite seams that are five feet thick or less in 83% for this study compared to a smaller share of seams of 70% for Roland et al.'s (1976) study. Another difference is that Roland et al's (1976) study identifies a secondary peak of seam frequency at a seam thickness of six feet, while in this investigation the second peak is at seam thickness of 10 feet, this secondary peak of occurrence is smaller than Roland et al.'s (1976) secondary peak (Figure 5). This is probably the result of limiting examination of lignite outcrops to Sabine and De Soto Parishes on the southern side of the Sabine Uplift by Roland et al's (1976), versus this study which used mainly domestic water wells in Caddo and Bossier Parishes on the north side of the Sabine uplift.

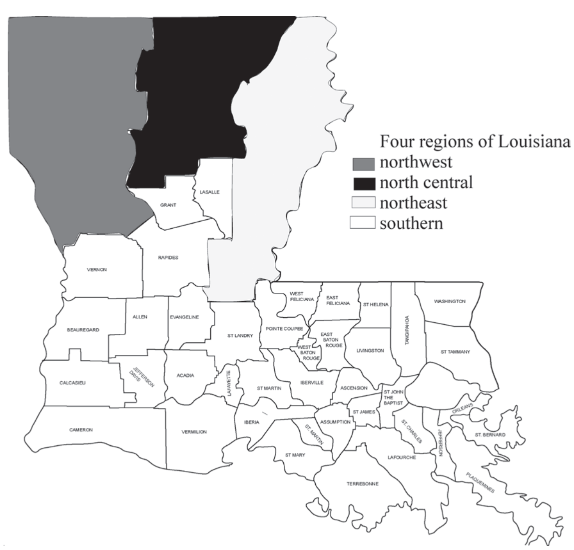

Figure 4. Division of Louisiana into four regions for the occurrence of lignite.

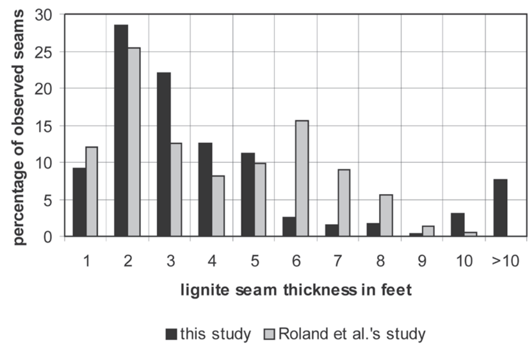

Figure 5. The percentage of lignite seams noted within domestic wells for values of thickness over 1 foot thick from a set of 1,105 seams noted within boring log records. Roland et al's (1976) study includes a set of 242 seams.

The variation of lignite seam thickness is not only dependent on position but also the stratigraphic unit considered. Among the 81 lignite seams within the USGS wells, lignite seam thickness has been measured for the Wilcox Group, Sparta and Cockfield Formations. The average thickness of seams in the Sparta Formation is 5.9 feet, in the Wilcox Group it is 3 feet, and the Cockfield Formation value is 3.6 feet.

Occurrence by lithology

Lignite seams are usually reported as being mixed within a sand, clay, or clay and sand within an interval of depth (Figure 6). This result is consistent with observations by Roland et al. (1976) which state that lignite seam lie between sands and clays.

Approximately 26% of reported occurrences of lignite are a seam of only lignite and state the observed seam thickness (Figure 6). Lignite more often occurs interbeded with clay or shale approximately 44% than with sand or sandstone approximately 21% (Figure 6). These results are similar to those within industrial and public supply wells were 46% of lignite occurrences are with clay or shale, and 18% are with sand or sandstone. The remaining set of lignite occurrences

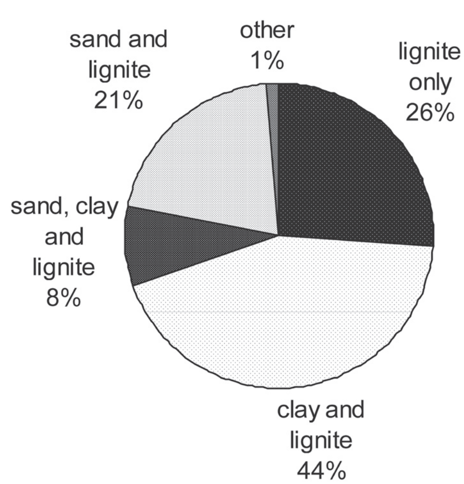

Figure 6. Share of occurrences where lignite is reported within domestic water well borings as determined from 4,213 occurrences of lignite recorded.

are usually mixtures of sand, clay and lignite, approximately 8% and approximately 1% of lignite occurrences are with mixtures of gravel, shell, or rock.

Occurrence by Stratigraphic Unit

Although lignite is reported to exist within most units within Louisiana, it is more common in the Eocene Age units of Cockfield, Sparta Formations and Wilcox and Midway Groups, than other units. Lignite occurs mainly in Wilcox and Midway Groups of Eocene Age, while the other Eocene Age units (Sparta and Cockfield Formations) have sparse amounts of lignite (Meagher and Aycock, 1942). However, Johnston and Mulcahy (1981) noted from their examination of approximately 2,200 shallow density logs that significant lignite seams lie not only within the Wilcox Group, but also in Jackson and Claiborne Groups (Claiborne Group includes Cockfield and Sparta Aquifers). Domestic wells screened within the Wilcox Group have the largest share of wells with lignite within the screened interval, approximately 7% (Figure 7), that is 449 wells within a set of 6,181 wells with screens open to Wilcox Group (Louisiana DOTD, 2005). However, there maybe thousands of additional domestic

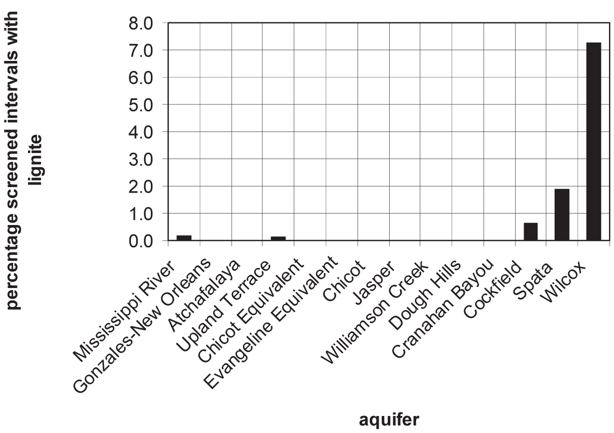

Figure 7. Occurrence of lignite within the screen interval of an aquifer, this includes both absolutely for sure occurrences and maybes from descriptions of domestic water well boring logs. Results are limited to aquifers that have over 200 observations. Note Jasper includes Williamson Creek, Dough Hills and Carnahan Bayou.

wells with lignite across their screened intervals since the Louisiana DOTD (2005) files only include the domestic wells registered in the last twenty-two years. Any small domestic wells completed before 1984 were largely drilled without any record of their presence being sent to the Louisiana DOTD. Smaller fractions of wells screened in the Sparta Formation (approximately 2%) and in the Cockfield Formation (approximately 1%) have screened intervals with lignite present. As with the Wilcox the full number of domestic wells with lignite within their screened interval is probably considerably larger due the requirements of reporting presence of domestic wells only since 1984. The presence of lignite in the Sparta Formation has been noted by Wang (1952) in his description of the Sparta Formation in Ouachita Parish, as a poorly sorted fine to medium grained non-calcareous sandstone which is interbedded with silty and sandy clay with occasional seams of lignite. Lastly there are few reports of lignite being present in the screened intervals of wells open to the Upland Terrace, Red River, Ouachita River and Mississippi River aquifers. This indicates that these Pleistocene Age units received sediments that contain a source of lignite.

Occurrence by Parish

Lignite seams are noted often within domestic wells of northwestern Louisiana. Forty-four of 48 lignite outcrops examined by Meagher and Aycock (1942) lie in nine northwestern parishes of Louisiana. Lignite seams are also reported within domestic wells in north central Louisiana, but with far less frequently than in the northwestern parishes (Figure 8). For northwest parishes 2,775 of the 8,745 domestic wells include lignite within the boring log (approximately 32%). By comparison in north central Louisiana only 34 of 913 domestic wells include lignite (approximately 3.7%). In northeastern Louisiana all 994 domestic wells have boring logs which show no indication of lignite. In southern Louisiana only 5 domestic logs show lignite within them out a total of 13,085 domestic wells that have boring logs examined in this study.

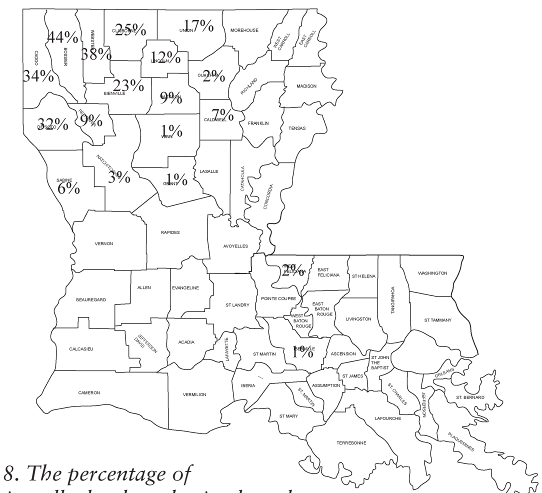

Figure 8. The percentage of domestic wells that have boring logs that include at least one interval with lignite within it. A percentage is only noted if it is at least 1% of the domestic wells within the parish.

Summary

The lignite seams of northwestern Louisiana have been an energy source for almost 200 years and a significant source of energy in the past twenty years. On the other hand studies in Europe and North America, including Louisiana, indicate that these seams may be a source of pollutants within groundwater that could cause various kidney diseases.

This study researched how many vulnerable domestic wells may exist in northwestern Louisiana. The lignite of northwestern Louisiana is present in the Eocene units of Cockfield, Sparta and Wilcox Aquifers. Lignite is usually noted as being mixed with sands and clays in approximately 75% of the occurrences of lignite that are reported, within the geologic logs submitted as part of well completion reports sent to the Louisiana Department of Transportation and Development. Only 25% of lignite occurrences note lignite as a seam rather than a mixture of lignite with sand, clay or other sediment. Usually these seams are less than 5 ft thick; approximately 80% of reported seams are 5 feet or under in thickness.

This study of approximately 8,750 domestic wells of northwestern Louisiana indicates approximately 32% of these wells contain lignite within the boring and approximately 7% include lignite within the screened interval. This would indicate that possibly a large share of residents on private water supply in northwestern Louisiana may be exposed to disease causing agents derived from groundwater flowing through lignite. In addition it should be noted that the data set only includes wells largely completed in the last twenty-two years and registered with Louisiana Department of Transportation and Development, therefore missing possibly many hundreds of wells drilled earlier before the reporting of domestic wells in Louisiana.

Acknowledgements

I thank Zahir "Bo" Bolourchi and Brad Hanson for their assistance and the access to the vast data set of well completion reports of the Water Resources Division of the Department of Transportation and Development.

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Assessment of the impact of hurricane Katrina's and Rita's storm surges on the Southern Hills Aquifer System in southern St. Tammany and Tangipahoa Parishes: An Update.

In September and October, 2005, Thomas Van Biersel, Douglas Carlson and L. Riley Milner of LGS collected samples from private and public water supply wells affected by the storm surges of hurricanes Katrina and Rita, in collaboration with the Louisiana Department of Environmental Quality and the U.S. Geological Survey (Van Biersel et al, 2006). Since then, these LGS researchers (Figure 1) have been sampling water supply wells in St. Tammany Parish. This on-going study is funded by the Louisiana Water Resources Research Institute at LSU, and seeks to assess whether potential long-term impact were caused by the flooding onto the regional groundwater resources.

Figure 1: LGS' Riley Milner testing water near Slidell, Louisiana

The LGS researchers have been conducting monthly monitoring of 14 private water supply wells and two (back-up) public water supply wells at Fontainebleau State Park. In addition, several other wells have been sampled as a courtesy to some of the monitored well owner's neighbors. The sampling program is on-going and will terminate during the spring of 2007. Samples collected in the field include inorganic and bacteriological samples. In addition, values for water depth, pH, specific conductivity and temperature are also recorded. Analyses of the water well samples are being performed at LGS Water and Environmental lab (for alkalinity, chloride, fluoride, calcium and magnesium hardness, nitrate, orthophosphate, sulfate, and total dissolved solids), and LSU's Wetland Biochemistry lab (for aluminum, arsenic, boron, calcium, cadmium, chromium, copper, iron, lead, magnesium, manganese, potassium, nickel, phosphorus, silica, sodium, and zinc).

The preliminary results have shown so far that there appear to be no long-term impacts to the aquifer, and impacts may have been limited to the casings, plumbing or the areas directly adjacent to the borehole of the wells. Concentrations of chloride and specific conductance have decreased, and have returned to what can be considered as "pre-Katrina" concentrations (Figure 3).

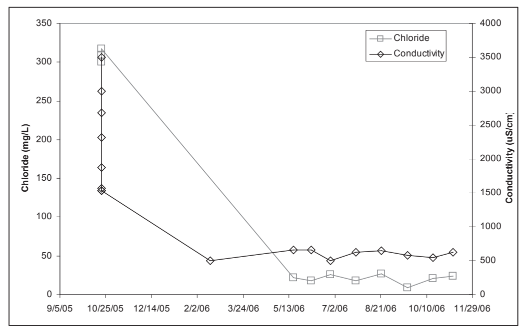

Figure 3: Monitoring results for chloride and specific conductance at well #14.

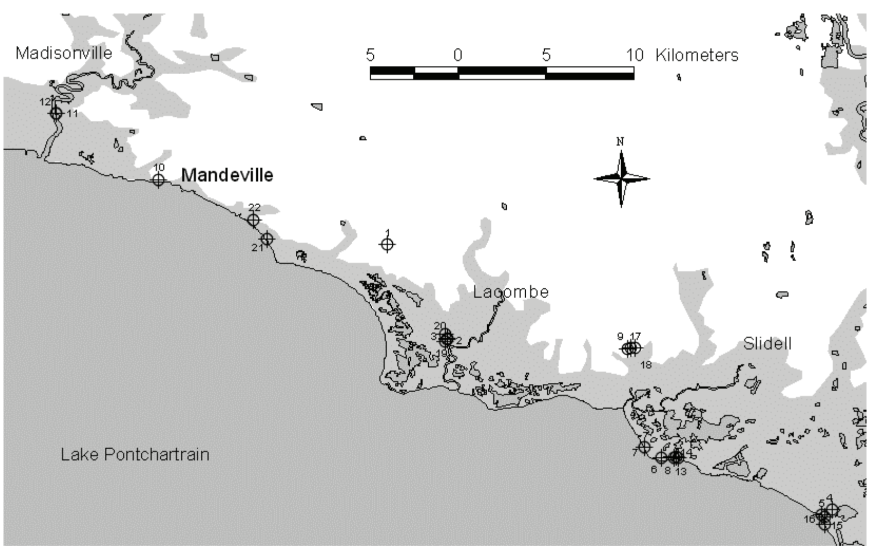

Figure 2: Location of the monitored wells along the north shore of Lake Pontchartrain. The shaded area represents the storm surge of Hurricane Katrina (modified from Anderson and Brakenridge, 2005).

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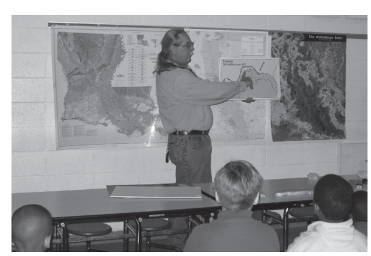
LGS Outreach Program

On October 19, 2006, Research Associate Riley Milner made a presentation on The Physical and Historical Geology of Louisiana to the third grade classes and one second grade class at Westminster Elementary School as part of the LGS Outreach Program. Teachers were provided maps and Earth Science Week 2006 activity kits to use in their earth science class work. The big hit with the children in attendance was the specimen of coprolite shown to them and allowed to hold.



Conferences

The Gulf Coast Association of Geological Societies Annual Conference was held at Lafayette, Louisiana (September 25-27) in conjunction with the Annual Louisiana Independent Oil and Gas Association Prospect Expo. LGS had an exhibit booth at this conference where LGS publications and maps were displayed along with information on ongoing LGS projects. Riley Milner staffed the booth and was assisted by other LGS Faculty and Staff who attended the meeting. LGS researchers who attended the meeting and made presentations were Douglas Carlson, Thomas Van Biersel, Clayton Breland, Chacko John, Brian Harder, Riley Milner and Byron Miller. The titles of the presentations are listed separately in this issue.

Louisiana Groundwater Resources Commission

The 8th meeting of the Louisiana Ground Water Resources Commission was held on October 16, 2006 at the Louisiana Department of Natural Resources LaSalle Building to discuss the activities of the Groundwater Resources Division. LGS hydrogeologists attended this meeting and after a brief introduction by LGS Director Chacko John, two ongoing research projects titled ***"Southern Hills Aquifer System groundwater flow model development"*** and ***"Updated Chicot aquifer system groundwater flow model and ongoing modeling for the Sparta and Mississippi alluvial aquifer system"*** were presented by Dr. Thomas van Biersel and Dr. Douglas Carlson, respectively. The presentations were very well received as evidenced by the number of questions from the attendees. LGS Director and State Geologist Dr. Chacko John is a member of the Ground Water Management Advisory Task Force which was established by the former Louisiana Governor Mike J. Foster in 2003.

New Publications

The Louisiana Geological Survey has published the second volume in its ongoing series, ***"Atlas of Oil and Gas Fields in Offshore State Waters of Louisiana,"*** which covers the Chandeleur Sound area. The first issue covered the Breton Sound vicinity.

This edition contains the latest available information on the region's geology, with cross-sections; production information by fields, type logs, field discovery information and structure maps of producing horizons; as well as a CD. It offers a single source for critical information needed by independent oil and gas companies and other business that may be planning to acquire Chandeleur Sound leases for further exploration and for those already operating in the area. The atlas is the only one of its kind currently available.

Browse through current offerings at www.lgs.lsu.edu or contact Patrick O'Neill at 225-578-8590 or poneil2@lsu.edu for more information.

Papers Published

Barnaby, R., 2006, Modeling the burial and thermal history, organic maturation, and oil expulsion of the north Louisiana petroleum system: Gulf Coast Association of Geological Societies Transactions, v. 56, p. 23-25.

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Personnel News

Reed Bourgeois (Computer Analyst) and Hampton Peele (Research Associate) completed 10 years and 15 years of service with LGS/LSU, respectively, and they were presented with LSU service award certificates by LGS Director Chacko John.

Roger Barnaby, Assistant Professor-Research resigned from LGS at the end of August to take up a position in the oil and gas industry in Houston.

M. Byron Miller, Research Associate, resigned from LGS in October to join the Office of Conservation, Louisiana Department of Natural Resources.

Chacko John, Professor-Research, attended the mid-year meeting of the Association of American State Geologists (AASG) in Philadelphia, PA (September 22-26) which is held in conjunction with the Geological Societies of America (GSA) Annual meeting. He is the President-elect of AASG and presented his mid-year report at the meeting and also assisted with staffing of the AASG exhibit booth at the GSA meeting.

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Louisiana State University
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LGS pipeline mapping projects subject of Houston Chronicle report

A front page article in the Sunday edition of the Houston Chronicle of November 12 featured the pipeline mapping projects of LGS cartographers John Snead and Robert Paulsell. The article, written by Chronicle environmental reporter Dina Capiello, addresed the problem that oil and gas states face in locating the vast network of pipelines that transport products from sources to users.

The article featured Snead's current project to map the pipeline crossings of the ten navigational channels crossing the Louisiana Coastal Zone which was funded by the Louisiana Oil Spill Research and Development Program (OSRADP). The article noted that company source maps and the federal mapping system are inadequate for the task of locating these pipelines, inhibiting the efforts of state and local oil spill responders to quickly locate and assess spills and pipeline-related accidents.

The Louisiana OSRADP is addressing this problem in Louisiana by contracting LGS mappers to conduct research and field investigations to begin gathering the accurate data needed. Currently Snead is conducting the navigation canal pipeline crossing study while Paulsell is conducting a study of pipelines in the industrial corridor between New Orleans and Baton Rouge. Paulsell's mapping has revealed a number of positional errors in the federal pipeline system.

An online version of the article can be viewed at http://www.chron.com/CDA/archives/archive.mpl?id=2006_4228023

Earth Science Week

Governor Kathleen Blanco issued a proclamation dated September 21, 2006, declaring October 8-14, 2006 as Earth Science Week, on request of the Louisiana Geological Survey. The Earth Science Week celebration is sponsored and coordinated by the American Geological Institute and its member societies and other organization on behalf of the Geoscience Community.

The LGS distributed over 100 complimentary Earth Science kits received courtesy of AGI to Louisiana School teachers. The kit contains geoscience related posters and information booklets designed to assist earthscience teachers in schools.

This document was published at a total cost of $483.51. Five hundred copies of this document were published in this printing at a cost of $483.51. The total cost of all printings of this document including reprints is $483.51. This document was published by the Louisiana Geological Survey, Louisiana State University, Baton Rouge, Louisiana 70803, to transfer information regarding applied geologic research to companies, organizations, state and federal agencies and the citizens of the state. This material was printed in accordance with standards for printing by state agencies established pursuant to R.S. 43:31.