Enhanced Louisiana Groundwater Monitoring for Sustainability and Energy Management

prepared for the

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by

Patrick Courreges
Louisiana Department of Natural Resources
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Summary:

The Louisiana Department of Natural Resources (DNR) is proposing the use of Petroleum Violation Escrow (PVE) funding for a collaborative effort to enhance the understanding and management of state groundwater resources through the addition of monitoring wells, expansion of aquifer mapping capability and more frequent assessment and public dissemination of groundwater data. Ongoing issues of groundwater depletion and accompanying threats to both supply and quality have a direct impact on the energy costs of stakeholders statewide – including domestic wells for households, supply wells for commercial and industrial operations, supply wells for public water supply systems and irrigation wells for agriculture. Enhancing the breadth and accuracy of groundwater data will greatly improve the state's ability to make sound decisions and plans in managing use of groundwater to minimize depletion and threats to water quality, thus minimizing the need to expend greater energy to reach critical water supplies.

Introduction

The management of Louisiana's ground water resources is one of state government's most vital efforts in terms of ensuring the basic need for a clean and sustainable supply of fresh water for its people, farms and businesses throughout the state – but also in conserving energy and containing the energy costs associated with drawing on and delivering that water supply. In several papers and presentations in recent years, Dr. Allan Hoffman, senior policy analyst with the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, has established that a nexus exists between energy and water supply – frequently noting that a central issue of water security is having the energy to extract water from aquifers, as well as transporting it and treating it. In a recent article, he wrote, "The inseparable linkage between energy and water is clear, but it hasn't always been recognized."(1)

(1) "The Water-Energy Conundrum: Can We Satisfy the Need for Both?" Journal of Energy Security Sept. 29, 2010

In addition, the 2003 U.S. Geological Survey report "Groundwater Depletion Across the Nation" on the impact of existing and potential groundwater decline, noted that "as the depth to water increases, the water must be lifted higher to reach the land surface. As the lift distance increases, so does the energy required to drive the pump. Thus, power costs increase as groundwater levels decline. Depending on the use of the water and the energy costs, it may no longer be economically feasible to use water for a given purpose." The USGS report further noted that the nation's "reliance on groundwater necessitates long-term monitoring of groundwater levels to track groundwater depletion."

While many other states utilize surface water as the primary source for drinking water and other fresh water needs, more than half of the water used by public water systems and rural homes in Louisiana is taken from groundwater sources. In addition, more than 70 percent of the water used in agricultural activities, such as irrigation, is drawn from groundwater sources, as well as nearly 10 percent of water used by industry.

Supplying the daily ground water needs of those homes, farms and businesses requires an enormous amount of energy due to the need to pump water up from fresh water aquifers. An effective statewide ground water management program is essential in ensuring both the sustainability of the supply and the minimizing of energy use and costs associated with drawing on and delivering that supply – a role served by the Louisiana Ground Water Resources Program within the DNR's Office of Conservation. The state Ground Water Resources Program is responsible for using available data to make determinations on the potential impact of proposed water wells on the various aquifers and on neighboring water users.

Critical to the effort of that management program is maximizing the capability of the program to effectively and accurately track ground water levels and trends over time. Increasing the ability of the ground water management program to effectively track ground water levels and predict potential trends in different areas of the various aquifers serving the state offers greater capability to regulate and advise best practices for use of ground water in the state – offering twofold opportunities for energy savings for domestic well owners, agricultural users and public water suppliers.

First, more accurate and detailed data on the upper reaches of a fresh water aquifer and its usage trends in a localized area can provide the owners of ground water wells with better data to draw from in determining the appropriate depth for their wells. As they get deeper, wells require more energy in order to pump water up from an aquifer, and the less accurate the information the state and well owners have on aquifer levels and trends, the deeper wells must be drilled to ensure they reach an area that can sustain the supply that is needed over time.

More accurate information can mean more water wells drilled to the minimum depth necessary to provide supply, providing energy savings opportunities to all ground water users. Secondly, greater access to data on aquifer levels and trends provides state regulators with the opportunity to predict potential ground water supply problems before they become crises, and take advisory or direct action to manage such situations. This minimizes the likelihood of areas of fresh water aquifers being drawn down to a point where users must either drill deeper wells in the same area, which will require more energy to operate, or where users have to resort to wells further away from where supplies are needed, adding new energy costs due to increased distance of transport. The opportunity for ongoing reduction of energy costs for well operators, and reduction to the direct and indirect costs to water users in homes, farms and businesses across the state, taken in its totality, offers great potential for a significant impact to the state's overall energy conservation efforts.

In 2011, recommendations for continued development of the state's groundwater management plan were developed by Ecology and Environment, Inc. for DNR's Office of Conservation. Among the recommendations in the report is the need for timely, continuous, and comprehensive water-level measurements, water-well production data, and water-quality data.

Although some of these data currently are being collected, the report finds that additional data are needed for the State to develop and implement a successful groundwater management strategy. The data are needed to assess spatial and temporal water-level declines, water-use trends, saltwater encroachment, and impacts of new activity on water levels and quality in aquifers throughout Louisiana. There is a need to assess new demand on state aquifers not only from development and growth in communities and traditional industries, but entirely new demands such as the volumes of water used in the practice of hydraulic fracturing in energy exploration of shale formations and other dense hydrocarbon-bearing layers. Louisiana is currently the site of exploration of one established producing shale formation, the Haynesville of Northwest Louisiana, and two prospective shale plays that are currently in the early stages of exploration – the Tuscaloosa Marine Shale, covering most of Central Louisiana from Texas to Mississippi, and the Lower Smackover/Brown Dense limestone formation currently believed to underlie most of the parishes on Louisiana's northern border.

The USGS Louisiana Water Science Center currently maintains statewide water-level and chloride concentration (an indicator of saltwater encroachment) networks, publishes period potentiometric maps of aquifers, and compiles and publishes water-use data on a 5-year basis. Most of the work has been performed in cooperation with the Louisiana Department of Transportation and Development or the Capital Area Ground Water Conservation Commission.

The LaDNR proposes to enhance the current water-level and chloride-concentration networks, update potentiometric maps of all aquifers and aquifer systems in the state (table 1) on a more frequent and regular basis, establish water-quality networks and estimate water use in Louisiana on an annual basis. The resulting data will provide the State with comprehensive information that can be used to assess groundwater conditions and manage the resource.

The work consists of five major elements that are briefly described below. A more detailed and comprehensive work plan will be developed during the first three months of the project.

Element 1 - Water-level network

Need – Existing water-level networks in Louisiana consist of about 220 wells that are measured quarterly. The resulting data provide information about regional trends in most major aquifers or aquifer systems, but there are many areas and aquifers that are not monitored. Quarterly measurements also often miss the high and low points of the annual hydrograph, especially in areas where water levels fluctuate due to seasonal withdrawals. Furthermore, ongoing shale play oil and gas well development requires high volumes of water (approximately 5 million gallons per well) used in short time spans (approximately 2 – 3 weeks per well) for hydraulic fracture stimulation operations. It is expected that future statewide shale development will continue to rely upon similar water use demands. Therefore, additional water-level data are needed to assess the impacts of ground-water withdrawals and monitor short-term and long-term water-level trends.

Approach - Water levels will be measured in about 200 additional wells to enhance existing water-level networks and close data gaps discussed in the statewide groundwater management plan recommendations report. Additional water-level data needs will be determined based on assessment of data and information from existing water-level networks, historical potentiometric maps, water-use data, well-registration data, and maps of major oil and gas shale plays. Frequency of measurements, which could be quarterly, semiannually, annual, hourly, or hourly with real-time satellite transmission, will be determined based on various factors including assessment of existing fluctuations and trends indicated by existing water-level data, water-use trends, proximity to areas of rapid development or growth, and public awareness needs. For instance, hourly data recorders could be used in areas with rapid or large fluctuations. Real-time hourly data could be considered for high-profile areas of interest or concern or highly-representative wells. In addition, a rapid-deployment system of recorders or real-time monitors could be used to respond to short-term or emergency events.

During the first year, potential new wells will be selected based on aquifer, location, use, and other factors. Selected wells will be visited to determine whether water-level measurements can be measured on a routine basis. Alternate wells will be investigated as needed until a sufficient number and distribution of wells have been added to the network. Water levels will be measured using steel or electric tapes marked with 1/100-ft gradations using USGS protocols. Hourly water-level data, when needed, will be collected using pressure transducers programmed to measure and record water levels at 1-hour intervals. Collected data will be quality controlled by comparison with previous data and/or data from nearby wells screened at similar depths. The data will be entered and stored in database.

Product - All water-level data will be published and made available to the public on an internet site.

Element 2 - Potentiometric maps

Needed - Potentiometric maps are needed to spatially visualize water levels and the impacts of pumping; delineate cones of depression, water-level gradients, and flow paths; and determine the spatial extent of water-level changes. Exiting potentiometric maps for many aquifers in the state are more than 15 or more years old. To create potentiometric maps, water levels are collected at many more wells than are usually included in water-level monitor networks. The additional data are needed to define the potentiometric surface, but also help identify changes that may not be apparent from network well data, e.g., rural or remote expansion.

Approach - Potentiometric maps of each aquifer or aquifer system in the state will be updated on a 10-year basis. Each year, data for 2 or 3 potentiometric maps will be collected and used to create potentiometric maps. Maps of water-level changes also will be created by comparing the new data to previously collected data. A 10-year schedule to update potentiometric maps for each aquifer or aquifer system will be developed during the first 3 months of the project. Previous potentiometric maps will be inventoried and LaDNR staff will be consulted to develop and prioritize a schedule.

Water levels will be measured at a sufficient number of wells to reasonably map the potentiometric surface of an aquifer. Water levels will be measured using steel or electric tapes marked with 1/100-ft gradations using USGS protocols. Collected data will be quality controlled by comparison with previous data and/or data from nearby wells screened at similar depths. All data will be entered and stored in a database and made available to the public on an internet site. Water levels will be mapped and contoured to produce a potentiometric surface. Water level changes at previously measured wells also will be mapped. Collected data will be quality controlled by comparison with previous data and/or data from nearby wells screened at similar depths. The data will be entered and stored in a database.

Product – Potentiometric maps and water-level measurements will be published. Two or three potentiometric maps will be produced and published each year. In addition, collected data will be available to the public on an internet site

Element 3 - Chloride-monitoring network

Need – Saline water is present in basal sands and/or down-dip areas of most freshwater aquifers in Louisiana. In some areas, saltwater is also present in isolated bodies at shallower depths. Heavy withdrawals from some aquifers have created conditions favorable for saltwater encroachment to occur as lateral movement or upconing into freshwater areas. Chloride is a stable, nonreactive component of saltwater and is commonly used as an indicator of saltwater encroachment. Monitoring at additional wells is needed to enhance existing chloride-monitoring networks and close gaps identified in the statewide groundwater management plan recommendations report.

Approach – During the first year, about 50 potential new wells will be selected based on aquifer, location, use, and other factors. The wells will be selected after an assessment of existing chloride-monitoring networks, reports and maps that discuss saltwater encroachment or the base of freshwater, historical specific conductance and chloride concentration data, historical potentiometric maps, and well-registration data. Selected wells will be visited to determine whether samples can be easily obtained. Alternate wells will be investigated as needed until a sufficient number and distribution of wells have been added to the network.

Water samples will be collected semiannually from selected wells. The samples will be analyzed in the field for specific conductance and in a laboratory for specific conductance and chloride concentration. Analytical results will be quality controlled by comparison with previous data and/or data from nearby wells screened at similar depths. All data will be entered and stored in a database.

Product – All collected data will be published and made available to the public on an internet site.

Element 4 - Water-quality network

Need – Extensive development of shales in north, central, and southeastern Louisiana for natural gas and oil using hydrofracturing techniques could adversely impact water quality in aquifers used for public and domestic supplies. A groundwater-quality monitoring network is needed in these areas to determine whether water quality is changing over time due to hydrofracturing activities. Although water quality has been previously documented for many wells in shale development areas, there is no ongoing effort to determine whether water quality could be changing.

Approach – Water samples will be collected annually from about 100 selected domestic wells in areas of current or future hydrofracturing activity. Potential wells will be selected based on aquifer, use, proximity to hydrofracturing sites, and other factors. During the first year, each well will be visited to determine whether samples can be obtained. Alternate wells will be investigated as needed until a sufficient number and distribution of wells have been added to the network. Samples will be analyzed at a laboratory for selected physical properties, such as pH and specific conductance, major inorganic ions, and trace metals using an analytical schedule developed specifically for detecting the impacts of hydrofracturing. Analytical results will be compared to previous data to determine whether changes have occurred. All data will be entered and stored in a database

Products – All analytical results will be published and made available to the public on an internet site.

Element 5 - Water use in Louisiana

Need – An understanding of water needs and use is necessary for managing water resources. Water-use data also provide an understanding of water-level changes observed at network wells and on potentiometric maps. Currently (2011), groundwater and surface water withdrawals in Louisiana for various uses currently are estimated on a 5-year basis. Substantial changes in water use can occur between the 5-year estimates due to a variety of situations including climate fluctuations, industrial plant openings or closures, crop changes, population changes and other factors such as oil and gas shale development and production. An annual estimate of water use is needed to better understand the impacts of withdrawals on water resources and identify water-use trends.

Approach – The methods currently used by the USGS Louisiana Water Science Center to collect and compile water-use data in Louisiana will be used to produce an annual estimate groundwater and surface-water withdrawals for various categories of use including public supply, industrial, power generation, irrigation, rural domestic, livestock, and aquaculture. Withdrawals will be estimated for each parish, major aquifer or aquifer system, and surface-water basin.

Product – Annual estimates of water use will be published on-line in tables. The tables will include total groundwater and surface water withdrawn for each category of use in each parish, major aquifer or aquifer system, and major surface-water basin.

BUDGET BY STATE FISCAL YEAR

	State Fiscal Year		
	2013	2014	2015
Water-level network	$260,000	$250,000	$260,000
Potentiometric maps	230,000	240,000	250,000
Chloride-monitoring network	65,000	57,000	60,000
Water-quality network	85,000	68,000	70,000
Water use in Louisiana	230,000	240,000	250,000
TOTAL	$870,000	$855,000	$890,000

Table 1. Major aquifers, aquifer systems, and aquifer subunits in Louisiana.

- Mississippi River alluvial and Atchafalaya aquifers
- Red River alluvial aquifer
- Upland Terrace aquifer
- Chicot aquifer system
  - Undifferentiated sand
  - Upper sand
  - Lower sand
  - 200-foot sand of the Lake Charles area
  - 500-foot sand of the Lake Charles area
  - 700-foot sand of the Lake Charles area
- Chicot Equivalent aquifer system
  - 400-foot sand of the Baton Rouge area
  - 600-foot sand of the Baton Rouge area
  - upland terrace aquifer
  - Ponchatoula aquifer upper sand
- New Orleans area aquifers
  - Gramercy aquifer
  - Norco aquifer
  - Gonzales-New Orleans aquifer
  - 1,200-foot sand of the New Orleans area
- Evangeline aquifer

- Evangeline equivalent aquifer system
  - 800-foot sand of the Baton Rouge area
  - 1,000-foot sand of the Baton Rouge area
  - 1,200-foot sand of the Baton Rouge area
  - 1,500-foot sand of the Baton Rouge area
  - 1,700-foot sand of the Baton Rouge area
  - Ponchatoula aquifer lower sand
  - Big Branch aquifer
  - Kentwood aquifer
  - Abita aquifer
  - Covington aquifer
  - Slidell aquifer
- Jasper aquifer system
  - Jasper aquifer
  - Williamson Creek aquifer
  - Carnahan Bayou aquifer
- Jasper equivalent aquifer system
  - 2,000-foot sand of the Baton Rouge area
  - 2,400-foot sand of the Baton Rouge area
  - 2,800-foot sand of the Baton Rouge area
  - Tchefunte aquifer
  - Hammond aquifer
  - Amite aquifer
  - Ramsey aquifer
- Catahoula aquifer
- Franklinton aquifer
  - Cockfield aquifer
  - Sparta aquifer
  - Carrizo-Wilcox aquifer