Implementing and Maintaining
The Digital Geospatial Database of Louisiana
for Topographic Mapping

A Report to the House and Senate
Committees on Transportation, Highways, and Public Works

prepared by

Louisiana Department of Transportation and Development

December 2012

Background

This report is submitted to the House and Senate Committees on Transportation, Highways, and Public Works, as required by Act 409 of the 2012 Legislative Session.

Act 409 amended and reenacted R. S. 48:36 to read as follows:

> §36. Topographic mapping
>
> > A. The department shall develop and maintain a statewide digital geospatial database for topographic mapping with the assistance of other state agencies or departments. The department shall act as authority for geographic names, set standards for the mapping of topographic features, and plan and manage data collection for incorporation into a statewide database for topographic mapping. Rules and regulations shall be promulgated by the department in accordance with the Administrative Procedure Act as are necessary for the planning and managing of the geospatial data associated with topographic mapping.
> >
> > B. The department shall submit a written report to the House and Senate committees on transportation, highways, and public works providing for a program and plan of implementation for the development and maintenance of a statewide digital geospatial database for topographic mapping as required by Subsection A of this Section no later than December 31, 2012.

Since Act 159 of 1928, the Department of Transportation and Development (DOTD), through its predecessor agencies, has had the responsibility for topographic mapping of the State of Louisiana. Until 2007, this responsibility was exercised by contracting with the US Geological Survey (USGS), and participating in their Cooperative Topographic Mapping Program. When the program ended, in 2002, DOTD was spending approximately $200,000, annually for USGS to update and produce paper topographic maps. Map-1., in Appendix I, shows the current age of each map in the USGS 7½-Minute Quadrangle Maps Series, in Louisiana.

Since 1969, geographic information systems (GIS) have matured and developed digital mapping technology and data management techniques that are now the common accepted practice for cartography and map production. GIS has transformed mapping from a process of fieldwork and cartographic design to a continuum of digital data collection, processing, and cartographic presentation. Digital maps transcend the limitations of a fixed presentation on paper map by providing the opportunity to access the data and redraw the map with different information. Digital maps can transform a map of Parishes to a map of population, revenue, crime, healthcare, or whatever data the Parish database contains.

Today, using GIS, maps are produced from geospatial data stored in a database, referred to as a geodatabase. This transition has decreased the time and cost to make maps, as well as, providing an efficient way to share and distribute the information contained in the data behind the map.

The most significant contribution that GIS and geospatial data have made to today's society, especially to providing better government, is the ability to perform geospatial analysis and geoprocessing tasks that use "location intelligence" to investigate existing data and spatially combine them to create new information. For example, create a dataset of all the schools within a quarter mile of an Interstate highway, railroad, or pipeline. In recent years, consumer mapping products on the Internet, "in-car navigation" devices, and cell phone-based mobile applications have brought geoprocessing into nearly everyone's life. Tasks like, "find an address," "find a business," or "navigate from one address to another;" are every-day examples of geoprocessing. These applications all require geospatial data and technology. These applications rely on accurate, up to date geospatial data, but are often built upon old and aging data. Topographic maps are no different.

Topographic maps and the data layered on them form the foundation for most of the planning, analysis, and decision making done in transportation, economic development, local and regional planning, and virtually all other aspects of government.

These data layers comprise the digital geodatabase of Louisiana and form the "base map" and "common operational picture" used in most agencies' activities, including disaster and emergency planning, mitigation, and response.

The geodatabase of Louisiana is comprised of the typical features (layers) found on topographic maps and listed in Table-1, below.

Table-1
Topographic Map Features

Map Layer	Geospatial Feature
Transportation	Roads, highways, railroads
Hydrography	Rivers, streams, bayous, lakes, bays
Hypsography	Elevation contours and points
Boundaries	State, federal, and municipal borders
Land Use/Land Cover	Forest, urban, rangeland
Manmade Structures	Significant buildings and other features
Public Land Survey	Township, range, and section boundaries
Geodetic Control	National Geodetic Survey Benchmarks

Note: These features appear on almost every standard USGS topographic map. However, there are other features that have appeared, as standards have changed.

These features, or "layers," form the content of all USGS topographic maps. Other layers may also appear, depending on the age, and other factors, at the time the map was produced.

In the 1970s, the features on paper USGS maps were "digitized" (digitally encoded into GIS-compatible formats). Many of those maps were out of date at that time. To further compound the problem of out of date maps, the digital data were never updated by the USGS. Forty years ago, maps made the data. Today, the data make the maps.

In 2007, the Public Works Section at DOTD selected a contractor with the ability to perform digital geodatabase development, to support the production of topographic maps. Initially, funding for this effort was provided by the state through the Public Works budget in the amount of $200,000. This was approximately what was being spent to pay on the USGS Cooperative Topographic Mapping Program.

To date, using competitive grants and cooperative agreements, an additional $2.5 million has been obtained from other state and federal agencies. Of that, $2.1 million was dedicated to completing the statewide updating of the National Hydrography Dataset (NHD). The NHD represents all of the nation's water features on topographic maps and for other official mapping purposes.

To maximize data compatibility and interoperability, federal geospatial data standards (like the NHD) have been utilized in the data collection and database development of all the features in the geodatabase of Louisiana. Over the first five years of the DOTD Topographic Mapping Program, preliminary data development of the hydrography and transportation layers has been fully funded. The DOTD Planning Section completed an initial statewide roads dataset, which is now in update and maintenance mode. Initial updating of hydrography is scheduled for completion by early 2013 (see Map-2., in Appendix II, for an overview). Production of individual topographic maps has not been funded since 2009.

Today, "mapping" is an exercise in geodatabase development. DOTD has embraced the paradigm shift created by GIS and digital mapping. Map-3, in Appendix II, compares a USGS map with a new Louisiana digital map. This has moved the state of the art from traditional cartography; where the maps make the data, to modern digital mapping; where the data makes the maps. It does not "reinvent the wheel," but builds on existing information technology to collate existing geospatial data and build an integrated digital geodatabase for the state. This database will become the source for all data on topographic maps and will create a common base map and common operational picture for all levels of government in Louisiana. To accomplish this, these data will be available via Internet services for use by anyone.

Current Status and Accomplishments to Date

Cost-savings Realized Through Digital Geodatabase and Map Production

Since its inception, the DOTD Mapping Program has significantly reduced the cost of topographic map production. Under the USGS Cooperative Topographic Mapping Program, maps cost from $11,000 to nearly $17,000, per map. Costs ranged due to the nature of the revisions. Additionally, USGS never revised all of the map elements (layers). Often, partially revised maps depicted conflicts between layers. For example, USGS produced paper maps showing elevation contour lines crossing waterbodies. Under the DOTD Topographic Mapping

Program, 138 maps have been produced, at an average cost of $5,942. This cost includes the updating and development of all the data layers that are represented on the maps.

Prior to the DOTD Mapping Program, USGS was the only source of topographic maps and only produced paper map products. The DOTD, "data make the maps" approach is creating the valuable digital geospatial data that comprise the geodatabase of Louisiana, along with the digital maps. Digital maps are distributed in Adobe® PDF format. This makes them available to virtually anyone with a computer and allows them to print them at any size they wish. This avoids the costly process of producing paper maps, *a priori,* and warehousing the bulky paper maps that often sit for decades in large file cabinets. A number of these new, "Louisiana Topographic Maps" have been used by DOTD and other state agencies to perform their work.

Louisiana's Investment to Date

Most of the cost of the DOTD Topographic Mapping Program has been funded through federal grants. State funds that were previously spent on the USGS Cooperative Topographic Mapping Program were used to develop some data and all of the finished topographic maps. Some staff time is also dedicated to this program with positions funded through both state and federal sources.

At the present time, DOTD has eight (8) full-time GIS positions, on staff. All of these have been providing some level of technical support or data development related to geospatial data layers in the geodatabase of Louisiana. Five (5) of these positions are located in the DOTD Data Collection and Management Systems Section, GIS and Cartographic Mapping Unit. The primary responsibility of this unit is to develop and maintain DOTD's geospatial data. Of these, four (4) provide approximately ten percent (10%) of their time to maintaining DOTD's road base map (the transportation layer in the geodatabase of Louisiana). One position is dedicated, solely, to the update and maintenance of those data. This amounts to 1.4 full-time equivalent (FTE) positions directly responsible for maintaining data in the geospatial database of Louisiana. Of that, $17,166 per year is state funds and $89, 253 per year are federal funds. The federally-funded position is supported through USDOT, State Planning and Research (SPR) funds. Three positions in the GIS staff of the Information Technology Section also provide support, with about 10% of their overall duties dedicated to the geodatabase of Louisiana. The three IT positions, at this level of effort, amount to about $22,233, per year. Therefore, the total annual staff commitment (TO) to maintaining the geodatabase of Louisiana is about 1.7 FTE positions, and $128,752.

The majority of database development projects have been funded from federal sources. Including imagery acquisition, through a US Department of Homeland Security (DHS) grant to the Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP), this amounts to a total of $10,839,150. This investment accomplished three very important milestones. First, the state obtained a statewide updated imagery with 6-inch and 1-foot resolution. Second, initial development was completed on a statewide database of all roads, state-maintained and otherwise. Third, is the completion of statewide hydrography revision, using the National Hydrography Dataset (NHD) standard of USGS and USEPA. These two features represent the first complete layers for the geodatabase of Louisiana and can be kept up to date at a much lower cost. Furthermore, transportation and water are two of the most

important layers for Louisiana and represent a significant accomplishment. These data are immediately available to support modeling and analysis applications for economic development, local and regional planning, hazard mitigation, emergency response, and many other important activities of government. Table-2, below, summarizes the current investment in data development for the digital geodatabase of Louisiana. These accomplishments have placed Louisiana at the forefront of statewide geospatial data development in the US.

Additional statewide geospatial data layers remain to be completed and over 750 Louisiana Quadrangle Maps remain to be produced. Because Louisiana is situated in the Mississippi River Delta, the landscape is inherently dynamic. Factors such as subsidence and tropical storms are constantly changing map features. In 2013, 27 percent of these maps are 30 years or older, 38 percent are 25 years or older, 62 percent are 20 years or older, 81 percent are 15 years or older, 98 percent are 10 years or older. Based on these numbers, the average USGS paper map is nearly 24 years old. In terms of the natural processes that shape Louisiana's landscape, 20 years represents six (6) major hurricanes and a great deal of subsidence and coastal land loss. To effectively use government's significant investment in GIS technology, Louisiana must keep its geospatial data up to date.

The most significant accomplishments are the full funding and near completion of initial, statewide updates of the hydrography and transportation features. Because these layers are done, this will further drive down the cost of map production. In addition, they provide valuable, up to date geospatial data for government to use to perform its work.

These two layers comprise a large majority of the features in the geodatabase of Louisiana. Roads and water are everywhere in Louisiana and are very important base map features. They form the backbone of many geospatial analyses across all functions and levels of government. These features are never, "complete," and will always require updating and maintenance. Most importantly, the cost to maintain them is much less than the initial investment. In addition, the tools available to keep these features up to date are already in use and greatly simplify the maintenance process. Table-A.1, in Appendix I, summarizes work remaining on this project.

Infrastructure Required to Build and Maintain the Geodatabase of Louisiana

Geospatial Technology

Over the past decade, DOTD has developed an enterprise approach to GIS. "Enterprise GIS" is the term used to describe an environment where geospatial data and resources are available for everyone to use. The enterprise GIS implemented at DOTD provides a foundation for the geographic information systems technology required to support a statewide effort to collect, process, manage, maintain, and distribute data from the geodatabase of Louisiana. However, this will require the upgrading of current hardware and software within the agency. These are dated and current technologies will provide the necessary improvements in performance to support this endeavor. DOTD has access to sufficient technology, but needs to implement the necessary upgrades. A recent GIS Strategic Plan indicates, "Some amount of staff augmentation can be expected," to configure and implement the technology to properly and efficiently meet the requirements of statewide production mapping and data distribution obligations.

Table-2
Investment in the Geodatabase of Louisiana and Topographic Map Production

Start Date	Project	Deliverables	State Funds	Federal Funds
September 2007	Task Order 1 S. P. 701-65-0900	22 Louisiana Quadrangle Maps produced from the database	$189,035	
June 2008	Road Base Map S. P. 736-99-1509	Statewide Road Base Map and Linear Referencing System	$174,937	$699,748
June 2008	LADEQ - NHD Update Grant	NHD Revision of East Central Louisiana Coastal Basin		$50,000
August 2008	Task Order 2 S. P. 701-65-1117	25 Louisiana Quadrangle Maps produced from the database	$193,800	
May 2009	Task Order 3 S. P. 701-65-1249	17 Louisiana Quadrangle Maps produced from the database	$198,000	
December 2009	Task Order 4 S. P 701-65-1413	24 Louisiana Quadrangle Maps produced from the database	$240,057	
December 2010	USEPA Exchange Grant S. P. H2000002018	NHD Update of MS and TX "Border" Basins		$349,402
December 2009	GOHSEP-DHS Hazard Mitigation Grant	Statewide Imagery		$7,500,000
June 2010	USGS NHD Grant S. P. 701-65-1437	NHD Update and Coastal Wetlands Workflow Protocol		$90,000
June 2010	Task Order 5 S. P. 701-65-1516	50 Louisiana Quadrangle Maps produced from the database	$300,000	
June 2011	Statewide NHD update funded by GOHSEP via IAG	Complete Statewide NHD Update and Revision		$2,000,000
September 2011	USGS NHD Mississippi River Delta Revisions	Mississippi River Delta NHD Update and Revision		$100,000
December 2012	USGS NHD/Geographic Names Project	Synchronize Geographic Names of Louisiana Waterbodies		$50,000
		Total	$1,295,829	$10,839,150

Production mapping provides the tools to produce new geospatial data and differs from enterprise GIS, which is primarily focused on the distribution of those data.

A statewide topographic mapping program will require DOTD to implement and sustain a production mapping environment. This involves a major new GIS database commitment at DOTD. Production mapping requires maintaining a large, versioned editing environment that supports multiple simultaneous editors, collaborating on the same database. Specifically, it eliminates the problem of the work of one editor interfering with the edits of others. The ESRI *Production Mapping*® suite of products provides this capability and is already part of the DOTD software inventory. This also requires the implementation of an additional *ArcSDE*® enterprise geodatabases, using Microsoft *SQL Server*®. DOTD already owns or has access to these technologies. Since these are not yet in use, further technical analysis will be necessary to determine the nature and configuration of this environment.

Although, DOTD already has access to the requisite software and hardware resources to develop these new systems, their implementation will require expertise not currently available at DOTD. Web services will also play an important role in data collaboration and sharing to support a production mapping environment. Again, DOTD already has sufficient GIS software licensing to accomplish this. However, configuration of the Web servers (hardware) and GIS Web services (software) is beyond the skills and experience of DOTD staff and will have to be included in a comprehensive IT GIS architecture analysis.

Base Information Technology

The information technology infrastructure at DOTD is sufficient to support this program. The server, network, and other supporting services available through the DOTD IT Section are well developed, maintained, and supported. They are capable of assimilating a program of this scope, with the addition of a minimal amount of infrastructure (hardware/software).

Training Required to Implement Production Mapping

A production mapping environment must be implemented to fully support this program. Production mapping is a comprehensive system, comprised of a suite of advanced GIS tools designed to support a multi-editor environment, in a versioned geodatabase. It includes tools to assist with the application of standard workflows for specific editing tasks, as well as, workflow scheduling and management. In addition, production mapping includes a set of data reviewing tools to direct editors through an approved editing protocol and facilitate specified, standard QA/QC procedures. These are essential capabilities to ensure data quality and accuracy.

A typical state-agency enterprise GIS supports the sharing and distribution of data across the agency. DOTD has done this for over a decade. Most agencies are not responsible for large-scale geospatial data production and do not require these advanced editing tools or a versioned database environment. Because this is new to DOTD, it is not within the experiences of DOTD GIS data editors. In addition to how users operate production mapping, the management of this new system is an IT GIS function. This is outside of the skills and experience of DOTD GIS support staff. A well-trained editing and support staff is a key to successfully implement the

geodatabase of Louisiana. It will be necessary to provide training to both users and support staff who will be involved in this system. It will also be important to include in any training key external, non-DOTD collaborators and contractors who will contribute data and use this system.

Required Staffing

Almost all of the staff necessary to implement this program are already in place at DOTD. The collaborative editing environment will involve individuals from three different groups. First, the Data Collection and Management Systems Section house a GIS and Cartographic Mapping Unit, whose staff already performs DOTD's in-house geospatial data development. Second, the DOTD IT Section currently has a small staff for GIS technology support (a GIS Manager and two GIS Technical Specialists). Third, to date, virtually all of the topographic mapping database development has been completed through contractors. Once adequately trained, these three groups will be the primary users of the production mapping system.

The operation and management of this new system represents a new IT function at DOTD. Proper staffing is essential for successful implementation of production mapping and the management and dissemination of data from the geodatabase of Louisiana. Two new resources (potentially contractors) will be necessary to fulfill these tasks. One will require an individual with spatial database development and management expertise. The other will require an individual with spatial data analysis and application development expertise. Although these are specialized sets of skills, individuals with these skills are available for employment.

Funding to Support On-going Database Development and Maintenance

As outlined in Table-2, substantial efforts have already been undertaken to develop the geodatabase of Louisiana. To date, the hydrography and transportation features in the statewide geodatabase have been supported, primarily, through external funding. These sources include a combination of US Geological Survey, US Environmental Protection Agency, and US Department of Homeland Security (through the Governor's Office or Homeland Security and Emergency Preparedness). There are several federal programs that fund such geospatial data development efforts. These include:

USGS - National Hydrography Dataset
USGS - National Elevation Dataset
USGS - Geographic Names Information System (US Board of Geographic Names)
USGS - National Land Cover Database
USGS - National Structures Database
US Bureau of Land Management - Public Land Survey System
US Bureau of the Census - Political Boundaries
USDHS-FEMA - Hazard Mitigation Program
USDHS-FEMA - National Flood Insurance Program
USDHS-FEMA - Homeland Infrastructure Foundation-Level Data

These on-going federal programs regularly offer grant support for geospatial data development and related projects. In addition, the US Department of Transportation has several programs and initiatives that emphasize geospatial data collection and use. The Highway Performance Monitoring System (HPMS), State Planning and Research (SPR), and Everyday Counts are current examples of USDOT programs, with special provisions for a geospatial data emphasis. In September, 2012, USDOT released a memorandum announcing that SPR funds would be available, without state matching requirements, for states to develop and maintain geospatial road data. These provisions will be in effect for the next three fiscal years.

IMPLEMENTATION STRATEGY

DOTD has been building the digital geodatabase of Louisiana, since 2007 and will continue the momentum of that work and focus on the complete development of all of the geospatial data required for topographic mapping. Building on current accomplishments, the following approaches are being undertaken to implement the geospatial database of Louisiana:

1. The Department has assigned the IT GIS Manager to be responsible for the Department's full compliance with the provisions of R. S. 48:36. (Act 409).

2. The Department continues to collaborate and coordinate with other agencies and departments within state government to actively assist the Department with the development and maintenance of the statewide geospatial database.

3. The Department is implementing a GIS Strategic Plan, with a priority implementation team responsible to provide the geographic information systems technology required to support a statewide effort to collect, process, manage, maintain, and distribute data from the geodatabase of Louisiana. This includes:

   The information technology infrastructure sufficient to support the implementation of R. S. 48:36.

   Staff experienced in managing and providing support for geospatial data, geospatial applications, and performing geospatial analysis.

4. The Department will continue its efforts to secure funding for the implementation and maintenance of the geospatial database, from whatever sources are available. Contingent on funding, the remaining topographic mapping layers represent approximately two (2) years of work to complete

5. As topographic mapping features are completed and incorporated into the statewide geodatabase of Louisiana, they will be placed into a maintenance status. This will ensure the data are kept up to date through periodic review and revision.

APPENDIX I
STATUS AND WORK REMAINING

Table-A.1
Work Remaining to Complete Topographic Map Features

Map Feature	Responsible Agencies*	Status and Work Remaining†	Required‡ Resources
Transportation	DOTD, in cooperation with the Federal Highway Administration, US Dept. of Transportation	Last complete update, 2008 Requires update to current photography	$2,500,000
Hydrography	DOTD and DEQ, in cooperation with the US Geological Survey, US Dept. of the Interior	Initial compete revision scheduled for April, 2013	$ 0
Hypsography (elevation)	DOTD, in cooperation with the US Geological Survey, US Department of the Interior; Federal Emergency Management Agency, US Department of Homeland Security; and US Army Corps of Engineers	Last complete update, 2002 Requires update to current conditions	$ 400,000
Boundaries	DOTD, in cooperation with the Bureau of the Census, US Department of Commerce	SCR-11 of 2012 recognizes numerous errors in the US Census boundaries that require updating	$ 350,000
Land Use and Land Cover	DOTD and CPRA, in cooperation with the US Geological Survey, US Department of the Interior; Natural Resources Conservation Service and US Forest Service, US Department of Agriculture	Statewide generalized land use was last updated in 2006. More detailed data dates back to 1992. Requires updating to current conditions	$ 985,000

Table-A.1
Work Remaining to Complete Topographic Map Features

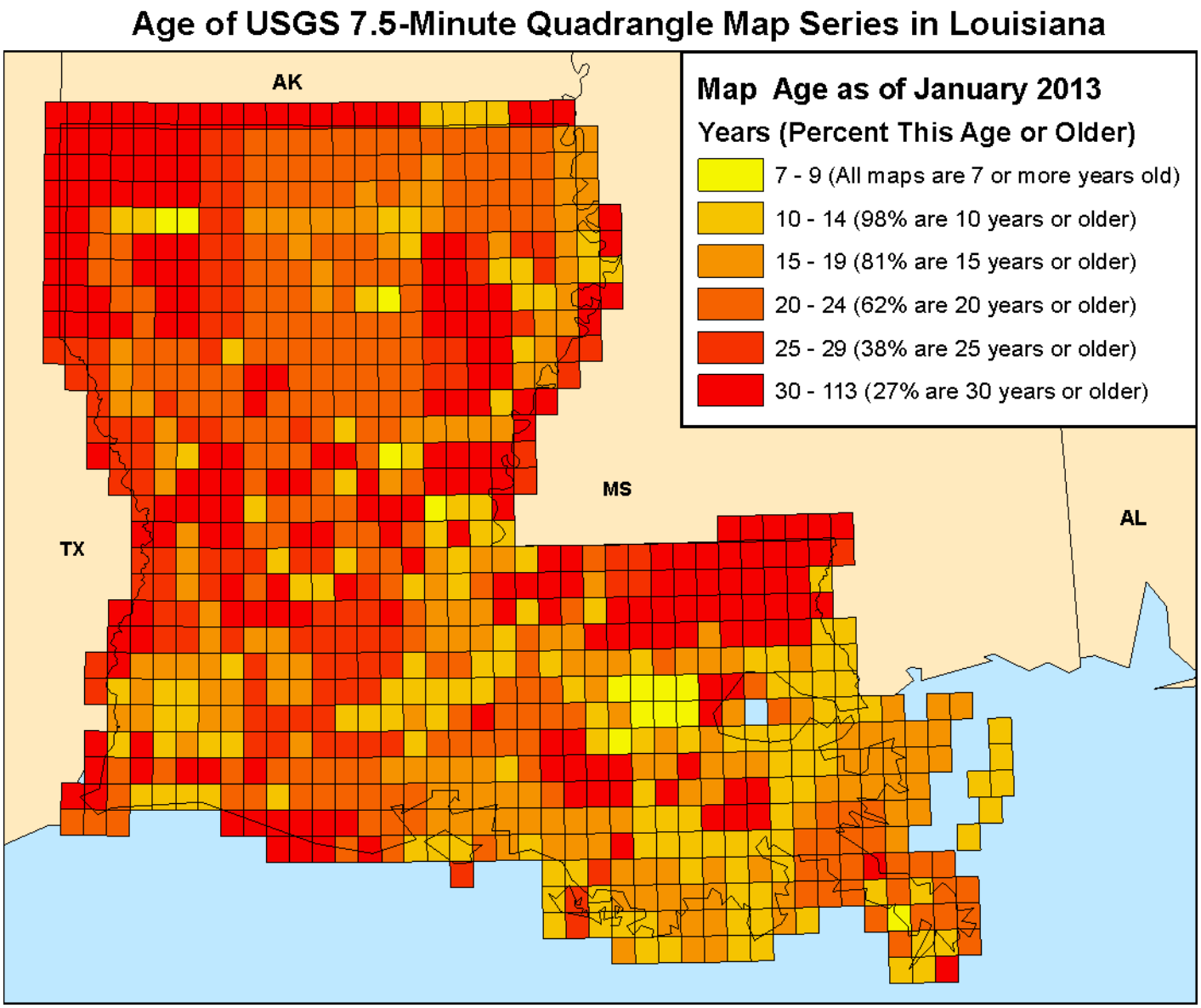
Map Feature	Responsible Agencies*	Status and Work Remaining†	Required‡ Resources
Manmade Structures	DOTD and GOHSEP, in cooperation with the US Geological Survey, US Department of the Interior and the US Department of Homeland Security	No complete update exists at present Requires update to current conditions	$ 1,550,000
Public Land Survey	DOTD, in cooperation with the US Bureau of Land Management, US Department of the Interior	Currently under revision by the US Bureau of Land Management	$ 200,000
Geodetic Control	DOTD, in cooperation with the National Geodetic Survey, US Department of Commerce	This layer is static and out of date, due to issues related to subsidence. It is no longer being maintained by the National Oceanic and Atmospheric Administration and appears solely for historical reference	$ 0
		Total	$5,985,000

*__NOTE__: For Louisiana, Acts 782 of 2010 and 409 of 2012 stipulate DOTD as the state agency responsible for topographic mapping layers and creation of a digital geodatabase of Louisiana. Federally, White House Circular A-16 defines federal agency lead-roles for specific geospatial data activities.

†__NOTE__: The figures in this table reflect the current status of developing an up to date geodatabase for topographic mapping in Louisiana.

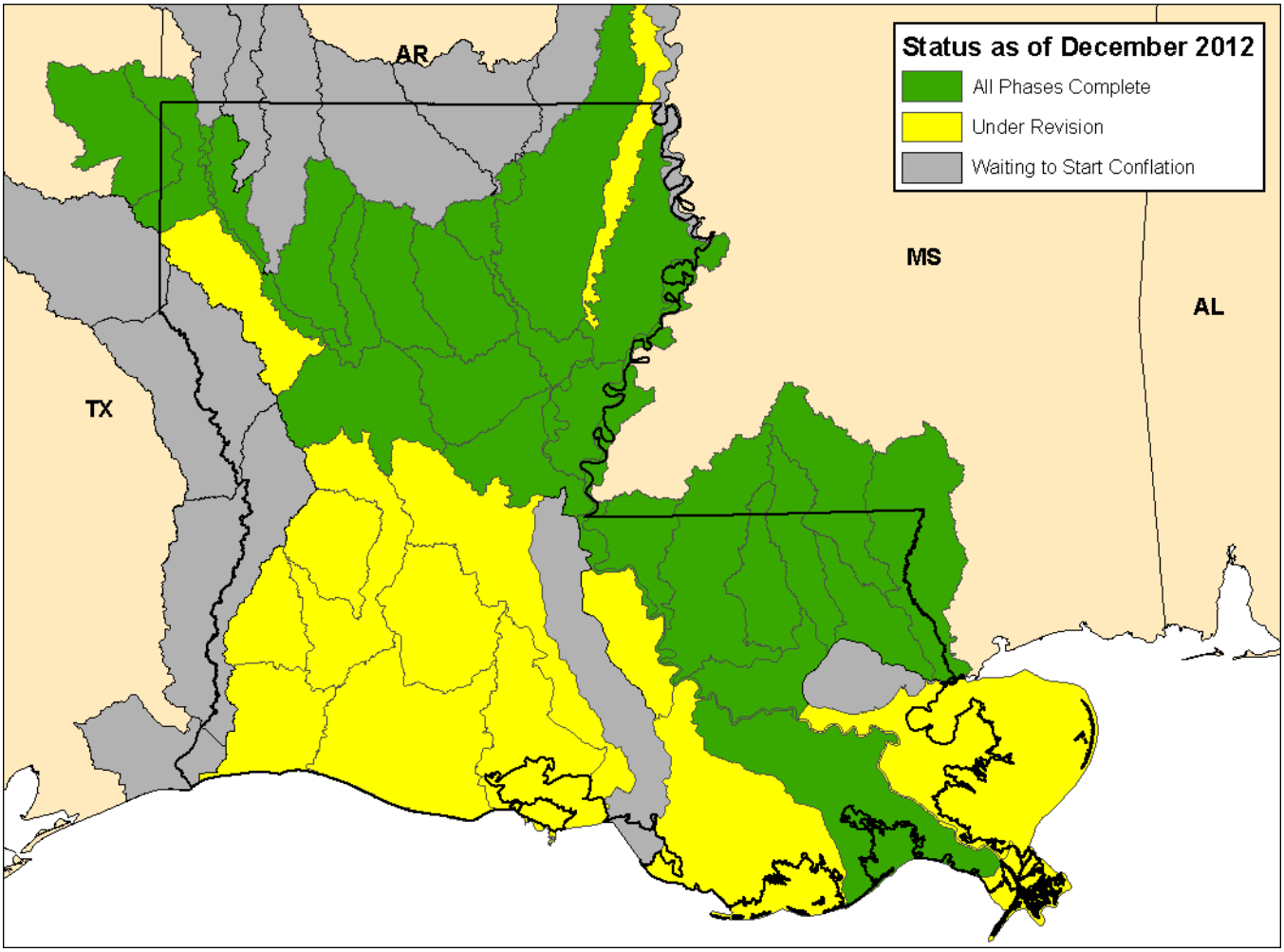
‡__NOTE__: Cost estimates are based on the production of map features from existing data and do not include new data acquisition.

APPENDIX II
SUPPORTING MAPS

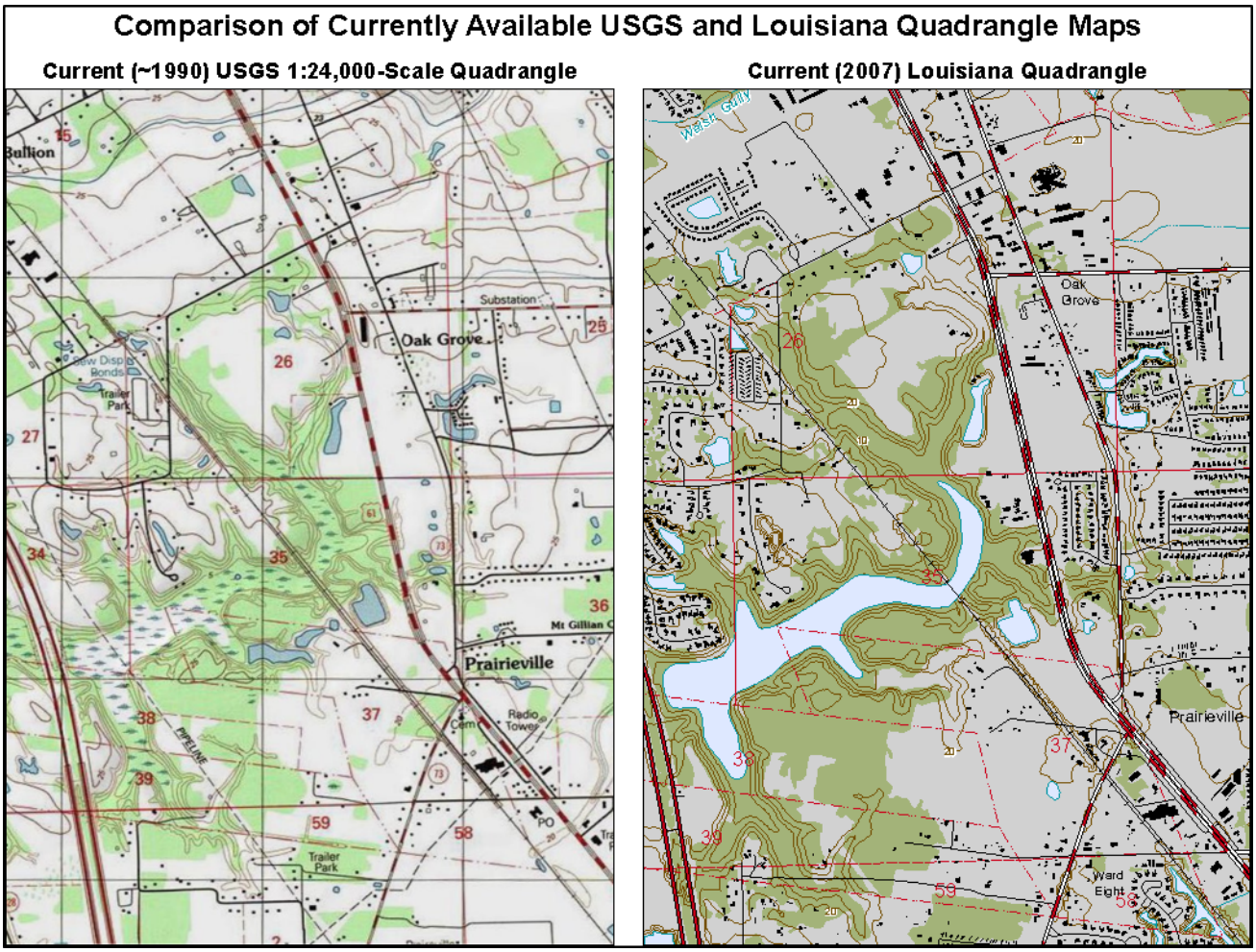


Map-1. This map depicts the age of USGS 7½-Minute Series Quadrangle maps in Louisiana, as of 2013. Each year, the existing USGS paper maps become more out of date and this map gets redder. These maps form the basis of almost all of the base map features used in GIS and remain in common use.

Revision Status of the National Hydrography Dataset in Louisiana



Map-2. Revision status of the National Hydrography Dataset (NHD), in Louisiana. The NHD was created by the US Geological Survey and the US Environmental Protection Agency to represent the water resources of the United States. The initial version was created by existing, out of date USGS Quadrangle Maps. The entire national database must be revised to correct map edge errors and out of date features. As of December, 2012, of the 54 NHD basins depicted on the map, 27 are complete and in the USGS Database (39.2%, by area), 14 are in revision (31.6%, by area), and 13 are waiting for conflation processing (29.1%, by area).



Map-3. Landscapes change over time and maps must be kept up to date. This diagram depicts a portion of the Prairieville quadrangle map. On the left is the current USGS Quadrangle map, dated 1990. On the right is the Louisiana Quadrangle map of the same area, produced by the DOTD Topographic Mapping Program, in 2007. Digital mapping technology provides a means for faster, more cost effective updating of maps. This streamlines the editing of geospatial database features that comprise those maps, keeping them in sync with current conditions. In addition, by keeping historical data, it is possible to measure and study change over time, as well as, model future conditions to support better regional planning.