A GIS APPROACH TO POTABLE WATER PROTECTION ON THE LOWER MISSISSIPPI RIVER

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ABSTRACT: The application of a geographic information system (GIS) for protection of drinking water supplies drawn from the lower Mississippi River is described in this paper. Potential sources of contamination of public water supplies resulting from pollutant spills or releases on the Mississippi River are identified by a GIS developed specifically for the Mississippi River Industrial corridor in Louisiana. The GIS includes a relational database, which is geo-referenced through a digitized map of the River. In addition to location, the database includes information on discharger outfalls and drinking water intakes. This paper discusses the development of the digital graphics model and geo-referenced database, and work in progress that will interface the existing graphics and database with a numerical model that estimates the time-of-travel on the River at various flows. Application of the GIS and time-of-travel model programs in surveillance of an actual chemical spill in the River is described.
KEY TERMS: GIS; Mississippi River; Water Quality Monitoring; Time-of-Travel Model, Spill Detection; Early Warning System.

INTRODUCTION

The GIS for the lower Mississippi River was designed primarily to assist the Louisiana Department of Environmental Quality (LDEQ), Office of Water Resources (OWR) in its mission to manage and maintain water quality. The project was carried out through an interagency agreement between the OWR and the Center for Louisiana Inland Waters, Department of Civil Engineering, University of Southwestern Louisiana.

Physical Attributes of the River

Hydrodynamically, the Mississippi River is unique. Even though the River has been contained by the levee system and is regulated by the Old River Control Structures, the volume of water, the meanders, and the deep channel create mixing and flow characteristics which are different from those found in smaller North American rivers.

The lower Mississippi River is utilized for multiple, and often conflicting purposes. As a drinking water source for over a million people, the quality of the water must be maintained. However, the River is also used for the transportation of raw materials by cargo ships, and the transportation of finished or intermediate products by barges Additionally, the River is a source of cooling water for industrial facilities, and a discharge medium for municipal and industrial wastewater.

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The basin drained by the Mississippi River stretches as far east as New York and Pennsylvania, as far north as Minnesota and as far west as Montana. The area of focus for discussion in this paper represents only one 300 mile segment of the basin. However, flows originating in this enormous upper drainage area are literally funneled through this lower 300 mile River segment. This 300 mile segment is therefore at risk not only from the extensive transportation, industrial, and municipal users within the segment, but also from pollutant sources throughout this diverse and expansive watershed.

Water Quality Management and GIS

The application of GIS to the Lower Mississippi River provides a spacial perspective to the narrative and numerical information needed to adequately manage water quality within the 300 mile segment. Beyond the digital mapping aspect, the GIS provides a mechanism for retrieval of relevant information through either a graphical user interface, through the application of more traditional non-graphical database query methods, or through a combination of these techniques. A user might, for example, select all industries that report discharging a specific chemical (non-graphical query) within a user-specified region of the River (graphically selected). Data may be reported graphically, or through the generation of a printed report.

The first step in the project was to create the digitized geographic files. U.S. Geological Survey (USGS) 7.5 minute quadrangle maps (scale 1:24,000) were digitized to create the necessary geographic files. These files form the geo-referenced background to which specific information in relational database form can be graphically referenced, according to the assessment, surveillance, or enforcement needs of LDEQ. Relevant information from other River maps and charts was also integrated into the digital map.

Locations on the River are often specified by rivermile and stream bank. The convention on the Mississippi River is to measure rivermiles upstream from Head of Passes. The GIS digital map and databases incorporate this spacial reference in addition to geographic coordinates in a state-plane projection.

The information database was designed to include all water quality monitoring sites, water intakes, industrial and municipal dischargers to the river, docking facilities, barge fleeting operations, and other potential spill sites. To expedite data entry and to ensure quality control, electronic transfer of data was been carried out whenever feasible. A partial listing of data sources which were used in the building of the GIS informational databases are listed in Table 1.

TABLE 1. Sources of relevant Mississippi River data.

Source	*Data*
Office of Water Resources, La. Dept. of Env. Quality	Municipal and Industrial Dischargers; Sites of Water Quality Monitoring Stations
La. Dept. of Health & Hospitals	Public Drinking Water Intake Locations
U.S. Coast Guard	Docking Facilities
U.S. Env. Protection Agency	Toxics Release Inventory

In the planning phase of this project it was recognized that several of the LDEQ requirements could be well served by a geographical approach to management of data which had already been collected within the State. The next development step was to identify sources of information and to evaluate the feasibility of electronic data transfer from the existing database to the GIS database. Database file transfer and translation required considerable effort and, at times, ingenuity. The GIS application which was developed incorporated selected parts of the various informational databases, and added a geo-reference through relational database links.

Some of the databases used in the GIS project are described in the following paragraphs as a way to illustrate the adaptability that is available to the GIS designer. With increasing file transfer capability, there is increasing opportunity to access even more varied database information than what was used for the Lower Mississippi River GIS. The GIS is an on-going project. Future directions for the project are also described within the context of the description of each of the accessed databases.

Municipal and Industrial Dischargers

OWR maintains an informational database which contains those parameters of interest to the Permits Section. Beyond identifying information for each facility, the permit limits and flow capacity are included. This database was used to develop the list of dischargers to the Lower Mississippi River for the GIS. Address information was translated to geographic coordinates for reference to the digitized map.

Toxics Release Inventory

In 1987, the US Environmental Protection Agency (US EPA), under the provisions of SARA 313, developed a computerized database of all dischargers to the water, air, and land. Toxics Release Inventory (TRI) data have been updated each year and the number of dischargers obligated to report to the EPA has increased each year. TRI data, pertinent to the Lower Mississippi River GIS, were the geographic coordinates for each discharger. the receiving stream for the discharge. the chemical constituents of the discharge at each site, and the amount of chemical discharged. All TRI data selected for use in the GIS were electronically transferred to avoid data entry error. In the future, for spill investigations, the user will have the capability of highlighting on the computer monitor those sites discharging a specific chemical, or printing a report of such selected dischargers.

US Coast Guard Data

The US Coast Guard maintains an informational database of all docking facilities located on the Lower Mississippi. The database is called RIMS and is accessible on Macintosh computers through a graphical database management software package, called File Vision. In the future, docking locations will be accessed and added to the Lower Mississippi River GIS as potential source sites for spill events in the river.

Water Quality Data

Water quality assessment is based on analytical chemical results from water sampling. Since 1966 ambient water samples have been collected as part of the Water Quality Monitoring Fixed Station Network (WQN) operated by LDEQ. Samples are collected monthly from the ferry slips located along the Lower Mississippi River. The samples are collected at 1 ft depths. Parameters which are measured include twenty six conventional and inorganic chemical water quality parameters. Human health criteria have been developed for arsenic, chromium, and lead which are on the WQN parameters list. In 1990, the WQN was revised to include volatile organic chemical sampling. The parameter list now includes 22 volatile organic chemicals, identified by the US EPA, as priority pollutants. At the present time, the WQN monitoring sites are in the GIS. In the future, for assessment purposes, the monitored concentrations for various water quality parameters may be incorporated.

The Early Warning Organic Compound Detection System (EWOCDS) was established in 1986. The primary mission of EWOCDS is to provide water providers with a timely warning of the approach to their intakes of high levels of priority pollutants. This warning should allow water providers to avoid intake of excessively contaminated river water.

There are EWOCDS monitoring locations at both municipal and industrial water intakes. At first, sampling was carried out on a daily basis. Manual sampling was increased to 2 times per day at most of the sites in August, 1989. In May, 1990, an automatic sampler was installed at the St. James site and sampling was increased to seven times per day at that site. Data generated at each EWOCDS site are transferred to a large water quality database maintained at LDEQ.

Originally designed solely as an early warning system, the EWOCDS data have been found to be useful in water quality assessment and management. All EWOCDS sampling sites are located in the GIS. In the future, for surveillance and enforcement purposes, instream concentrations for various volatile organic compounds may be incorporated into the database for each EWOCDS site.

EWOCDS data have shown that episodic and frequently unreported spill events account for at least 50% of the priority pollutant load found in the Lower Mississippi River. Thus, spill tracking has been one important use which can be made of the EWOCDS data. This was put into practice during a carbon tetrachloride spill which occurred in December, 1990. In conjunction with locations determined from the GIS digital map, a time-of-travel model was used to estimate the arrival of the leading edge, peak, and trailing edge of the spill to the downstream water providers. Estimating that the spill had taken place at approximately 14:00 on December 11, 1990, near Rivermile 216.5, at a River discharge of 378,000 cfs, the model reliably predicted peak travel times (with an accuracy of over 95 percent) over more than 100 miles. Taking the observed peak passage time at the rivermile 209.6 station as zero, travel times to downstream stations were calculated and are shown in Table 2.

TABLE 2. Peak Travel Time for Carbon Tetrachloride Spill.

Site Location (Rivermile)	Observed	Calculated
209.6	0.0	
175.5	<19.0	18.2
152.2	>27.8	30.7
120.0	51.0	48.8
104.7	56.5	57.7

Based on the predicted arrival of the leading edge at the rivermile 120 EWOCDS site, additional sampling was carried out. The concentration profile provided enough information to estimate the mass discharged at 700 pounds. The profile is shown in Figure 1.

A future goal for the GIS is to integrate the time-of-travel model output with the geo-referenced background and databases of the GIS. Then, during a spill event, the progress of the spill can be geographically followed. For early warning purposes, potential upstream dischargers of the contaminant can be immediately identified and located for surveillance purposes.

A view of a section the of the GIS digital map as it is currently configured is shown in Figure 2. Figure 2 illustrates the river segment at Baton Rouge, and includes industrial and municipal dischargers. Rivermile markers shown on the map are important for spill response and enforcement purposes. The center line drawn in the River has tick marks each 0.1 mile, and is used for distance measurements. Linear distances between points can also be calculated by the GIS. The GIS capabilities have been applied in the determination of water surface areas for estimation of gas exchange between the River and the atmosphere.

CONCLUSIONS

A GIS application has been designed to assist LDEQ in its mission to maintain and manage water quality throughout the 300 mile segment of the Lower Mississippi River. The geo-referencing of water intakes, dischargers, and sampling sites, has assisted LDEQ in carrying out permitting, enforcement, surveillance, and assessment duties.

There is much work that must be carried out to fully characterize and assess the chemical contaminants and the reason for their presence in the Mississippi River. It has been a co-operative effort among government, industry, and academia to reach the current level of knowledge about the attributes of the Mississippi River. Above all, the quality of the water must be maintained to meet water quality standards applicable to waterbodies which provide a source of drinking water. The co-operative effort to maintain and improve that water quality must be continued. The Lower Mississippi River GIS is a contribution to that effort.

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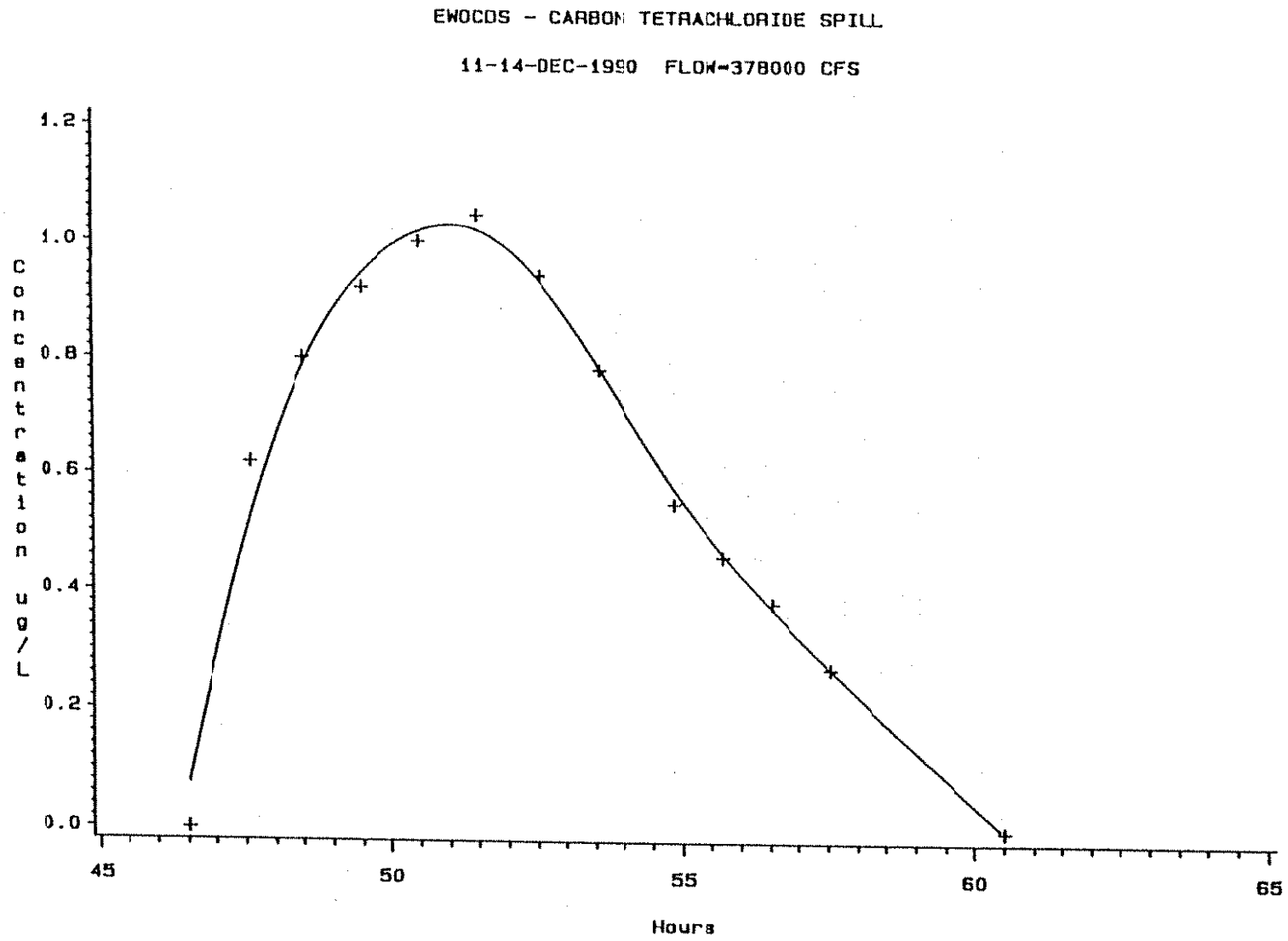

Figure 1. Carbon Tetrachloride Concentration Profile.

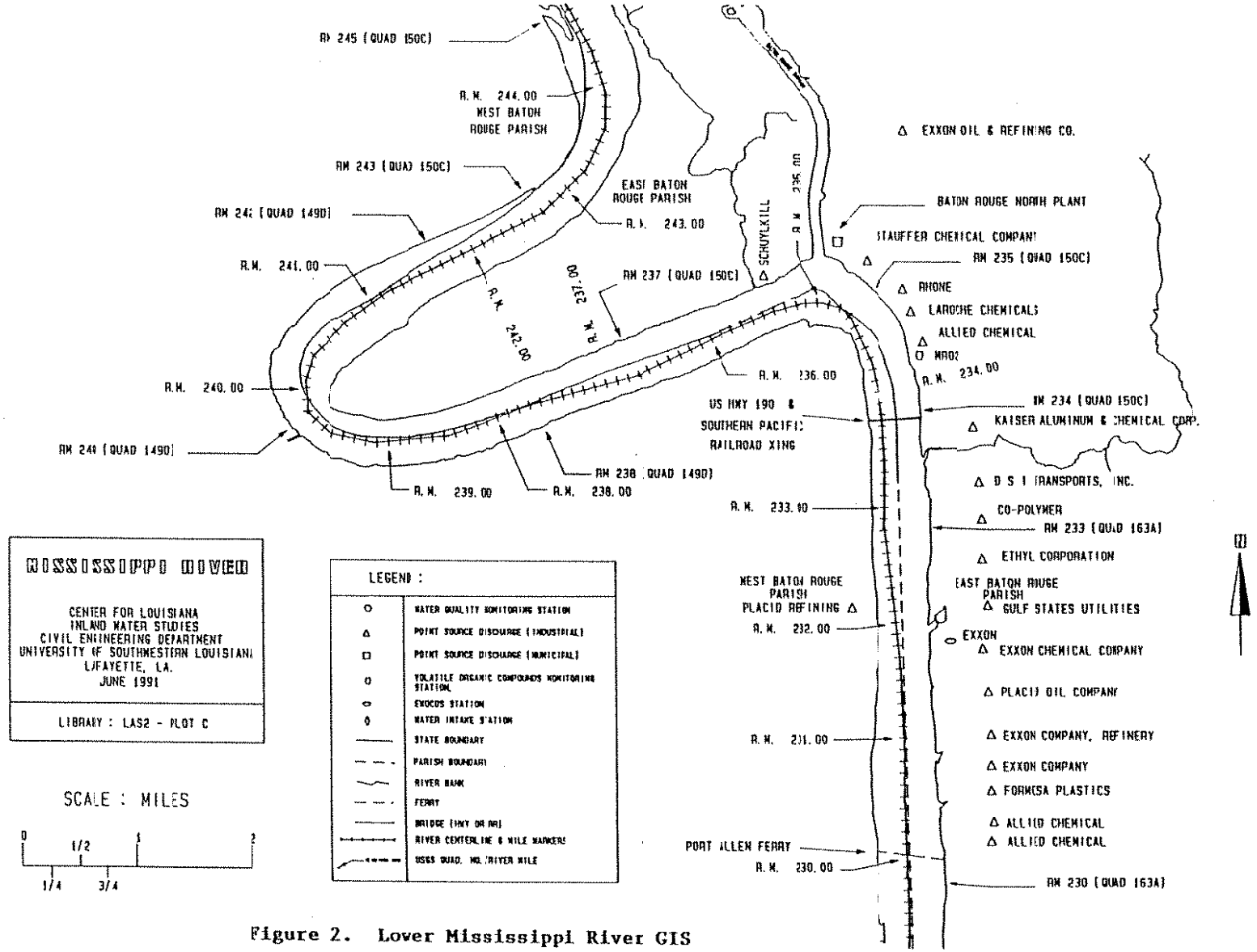

Figure 2. Lover Mississippi River GIS Baton Rouge segment