Using NHD in the Incident Command Information Tool

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Abstract

The purpose of this project is to develop an Incident Command Information Tool (ICIT) that enables decision makers to evaluate and take actions against terrorism attacks on public drinking water sources in real time. This tool will integrate multiple sources of information to give decision makers concise summaries of current conditions and forecasts of future consequences of terrorist acts on public water supply safety. The system will be GIS-based and the output will be compatible with the Defense Threat Reduction Agency's (DTRA) Consequences Assessment Tool Set (CATS), the Federal Emergency Management Agency's HAZUS system, the Environmental Protection Agency's Situation Room, and the TSWG sponsored Chemical Biological Response Aid (CoBRA). The core element of the ICIT will be the RiverSpill time-of-travel model. RiverSpill will be modified to operate at the 1:100,000-scale stream network available through the EPA and USGS National Hydrography Dataset (NHD).

Background

The United States Department of Agriculture (USDA) Forest Service, Environmental Protection Agency (EPA), Federal Emergency Management Agency (FEMA), Technical Support Working Group (TSWG), and Defense Threat Reduction Agency (DTRA) have identified as a high priority, the need for protecting drinking water sources from terrorist attacks. Making key information rapidly available to incident commanders will better enable them to evaluate the risks posed to the public and to direct the actions of first responders to effectively reduce those risks.

The United States has approximately 180,000 water systems, serving over 250 million persons (Rycus and Snyder, 2001). An estimated 16 trillion gallons of water is processed annually in the United States by these water utilities. All levels of government recognize that protecting the health and safety of all Americans requires safe drinking water and have invested heavily in public drinking water systems to achieve this goal. Despite strenuous efforts to protect public drinking water systems, however, they can still sometimes fail with tragic consequences. For example, in 1993, Milwaukee's drinking water was accidentally contaminated with the pathogen, *Cryptosporidium,* resulting in over 100 deaths. Recent acts of terrorism, including the attacks on the World Trade Center and Pentagon and the dispersal of *Anthrax* in the mails, illustrate the need to upgrade protection of drinking water to include defenses against deliberate terrorist acts as well as inadvertent water contamination.

The nation has two important ways to protect drinking water safety: (1) upgrade infrastructure to physically protect water supplies and (2) upgrade preparedness to take timely and effective action to minimize the consequences to the public should an attack occur. Physical protection will be expensive, may take years to accomplish, and at best provides only partial protection. Strengthening emergency response to attacks on drinking water can offer substantial and rapid gains in protection of public safety and civil order and can bolster security while infrastructure is being improved. Emergency response can be strengthened by (1) improving the speed and accuracy of detecting an attack and (2) providing personnel who direct the emergency response ("Incident Commanders") with critical information to decide: who is at risk and what actions will most effectively reduce the risk. ICWater focuses on providing Incident Commanders with critical information they need to protect the public during contamination attacks on drinking water sources.

System Requirements

The requirements for ICIT (now known as ICWater) are provided in the system requirements specification document (SAIC 2004a). In summary, these requirements are:

- Design, develop, and test a prototype ICWater (formerly known as "ICIT") for all 50 states of the United States
- Ensure the application meets the user requirements for an incident command tool.
- Develop the application to operate on the COBRA platform developed by Defense Group Inc. under a TSWG sponsored project and be compatible with the Defense Threat Reduction Agency's CATS, Environmental Protection Agency's Emergency Response Analyzer, and Federal Emergency Management Agency's HAZUS system.
- The contractor shall include the Real Time RiverSpill watershed and river-reach model as an integral part of ICWater.
- Ensure the RiverSpill tool is capable of operating at the highest resolution available through the United States Geological Survey (USGS) National Hydrology Dataset (NHD) and will at a minimum be at a 1:100,000 scale.

Technology Description

This project involves the development an information tool that will give Incident Commanders the critical information that they need to make informed decisions regarding the consequences of threats to public water supplies. The tool will be designed to meet the specific needs of Incident Commanders with respect to its content, timing and spatial coverage and resolution. ICWater, being a multi-disciplinary application, will meet the following requirements:

- Integrate critical data needed to evaluate and respond to an incident into a GIS-referenced system.
- Predict dispersion of waterborne contaminants by integrating the EPA and TSWG
- RiverSpill system with the National Hydrography Dataset (NHD)
- Incorporate interfaces between field sensors and RiverSpill
- Develop an interface for input of field reports by first responders and mobile units.
- Incorporate an interface for inclusion of hospital admissions data
- Contain GIS layers and databases to display water threats in relation to: surface water contamination sensor locations; sensor outputs; the location of oil and gas pipelines, dams, reservoirs, and locks; the location of surface water bodies; all public drinking water intakes; roads and other terrestrial transportation networks; topography; and population
- Provide secure web-based access to local incident commanders, and to a centralized, regional or national command center.
- Provide the capability of tracking human pathogens, toxic chemicals, and radioactive substances that pose significant threat to public safety in case they were used to attack water sources.

ICWater's core component, RiverSpill, is a GIS-based system used to track and model the flow and concentration of contaminants in source water supplies. With RiverSpill, personnel can calculate, locate, and map the population that could be at risk from the contamination of a public water supply, by providing data through a variety of modules. In addition, the model calculates the travel time of a contaminant based upon stream flow, decay, and dispersion of the constituent introduced in surface waters.

The technical approach to develop an operational incident command system (as shown in Figure 1) is:

(1) Integrate existing components to interact seamlessly,
(2) Upgrade the supporting data bases to give the tool national coverage at the appropriate level of detail,

(3) Enable the tool to run on the web, and
(4) Maintain the tool ready to be available quickly in an emergency and for training.

As shown in figure 1, ICWater will integrate real-time flow data from USGS gages as well as contaminant detections from field sensors and reports with geographic information (NHD, GIS layers) and the RiverSpill model to provide up-to-date maps, reports and tables that enable emergency response personnel to make timely decisions about people at risk and what actions will most effectively reduce that risk. The ICWATER is based on three-tier system architecture. Each tier is described below:

- Tier 1: End user machine with an Internet browser, such as Netscape or Internet Explorer. The graphical user interface will allow the user to execute all ICWater functions as well as export maps, tables and reports to CATS, HAZUS, the EPA Emergency Response Analyzer and CoBRA.
- Tier 2: Web and Map Server, which houses the ICWater business logic including the RiverSpill model and the Internet Map Server
- Tier 3: Database Server, which houses the National Hydrography Dataset, and GIS layers

The system will also access external data from the USGS real-time stream gauging stations and contaminant detections from field sensors and reports

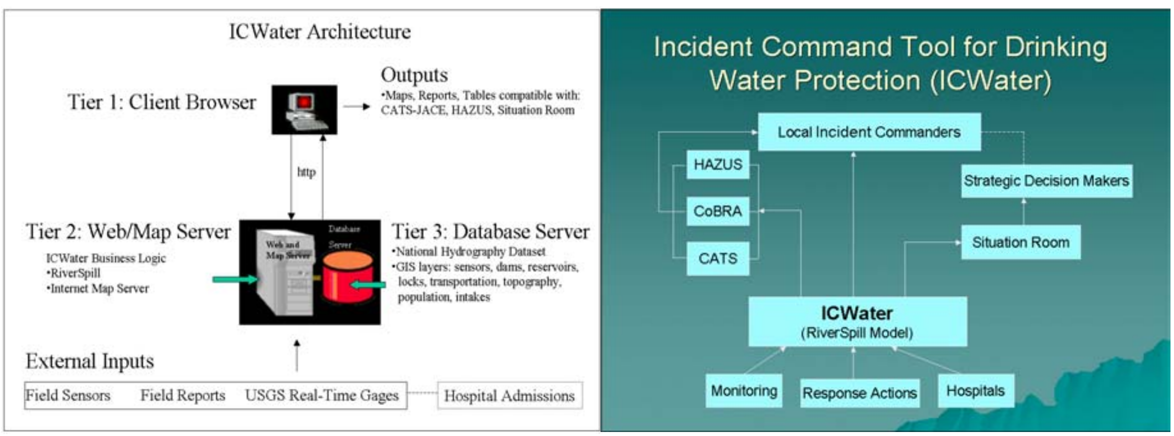

Figure 1. ICWater System Architecture Diagram.

System Packages

ICWater will be composed of several specialized service packages, performing processes for the benefit of the whole system (SAIC, 2004b). Figure 2 shows the layout of the major packages within the ICWater system. Several of these packages are described in more detail in the paragraphs that follow.

NHD Manager

The National Hydrography Dataset manager (see figure 3) maintains the interfaces dependent components will call in order to query the network topology provided by the river network. It is expected that in some instances at the EPA, this may be housed in the Reach Address

Databases (RAD), while other sites may be using a system maintained by the USGS, and others may have a small set of hydrologic unit codes (HUCs) on their local system.

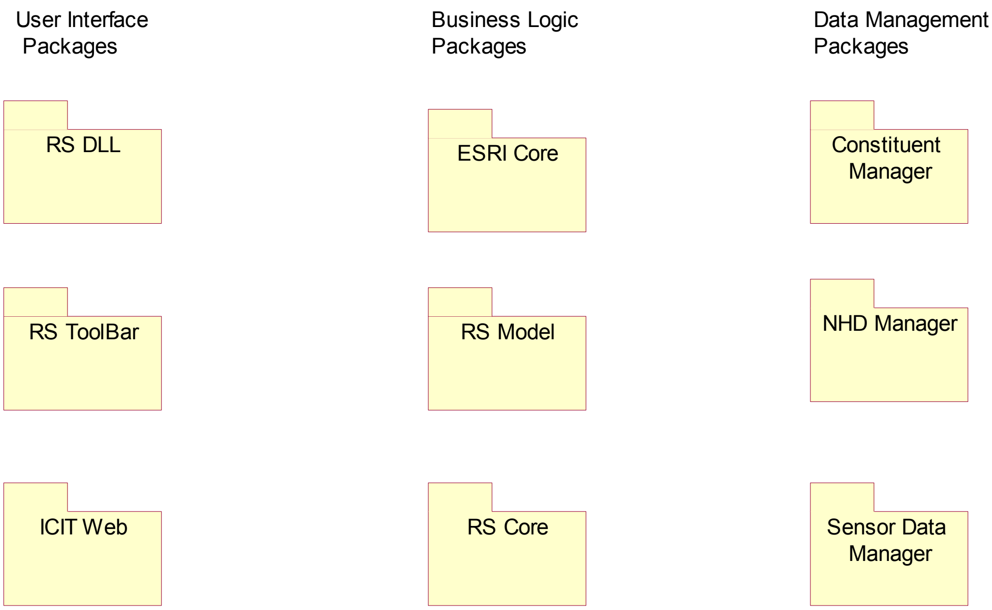

Figure 2. ICWater System packages (RS = RiverSpill, NHD = National Hydrography Dataset)

This component will be responsible at the application level, to provide interfaces into the NHD for use in network tools, to identify features, and to enable (limited) editing of features. Attribute mappings to the network will be handled as part of this tool, such that, for example, a generic call to "Reach Length" is mapped to the correct attribute and converted to system units if necessary. The ability to register new data sets or selection subsets from larger sets will be provided as an interface.

It is important to note that this component does not simply manage reaches, but also, manages nodes along the reaches. Nodes along the reaches include flow control dams, stream gages, public water intakes and any other nodes at which time versus concentration estimates may wish to be predicted, or flow modified in some form or fashion.

In general, any hydrologic network should be maintainable through this system, not necessarily the NHD. For this project however, NHD is the focus Network.

RiverSpill Model

The RiverSpill component (see figure 4) is the core computational component within the ICWater, responsible for taking an incident description and computing the contaminant transport throughout the network.

This component will receive from a client (either the web or ArcGIS system primarily, or any web service client such as COBRA or EPA Emergency Analyzer), a definition of an Incident Object as well as necessary execution parameters, and respond with a Result object defining the upstream, downstream network nodes and links.

It is important to note that the RiverSpill model in ICWater should not be thought of as the entirety of the RiverSpill system written in Avenue from previous systems. It should be thought of as the portion of that system which was responsible for computing the up and downstream transport results.

RiverSpill Core

The RiverSpill Core (see figure 5) package contains the objects and interfaces that define the core functionality of the systems. Objects here are used throughout the system in various ways. One may think of the core package as containing objects whose scope does not clearly fall within any of the other major packages.

The definition of an incident itself will be contained within the RiverSpill Core package. At this time, incident objects contain source terms, release times, materials and documentation (metadata, ancillary information) provided by the client.

ESRI Core

ESRI Core (see figure 6) objects are the objects provided by the ArcGIS libraries. Detailed information on those objects is maintained by ESRI at http://arcobjectsonline.esri.com/.

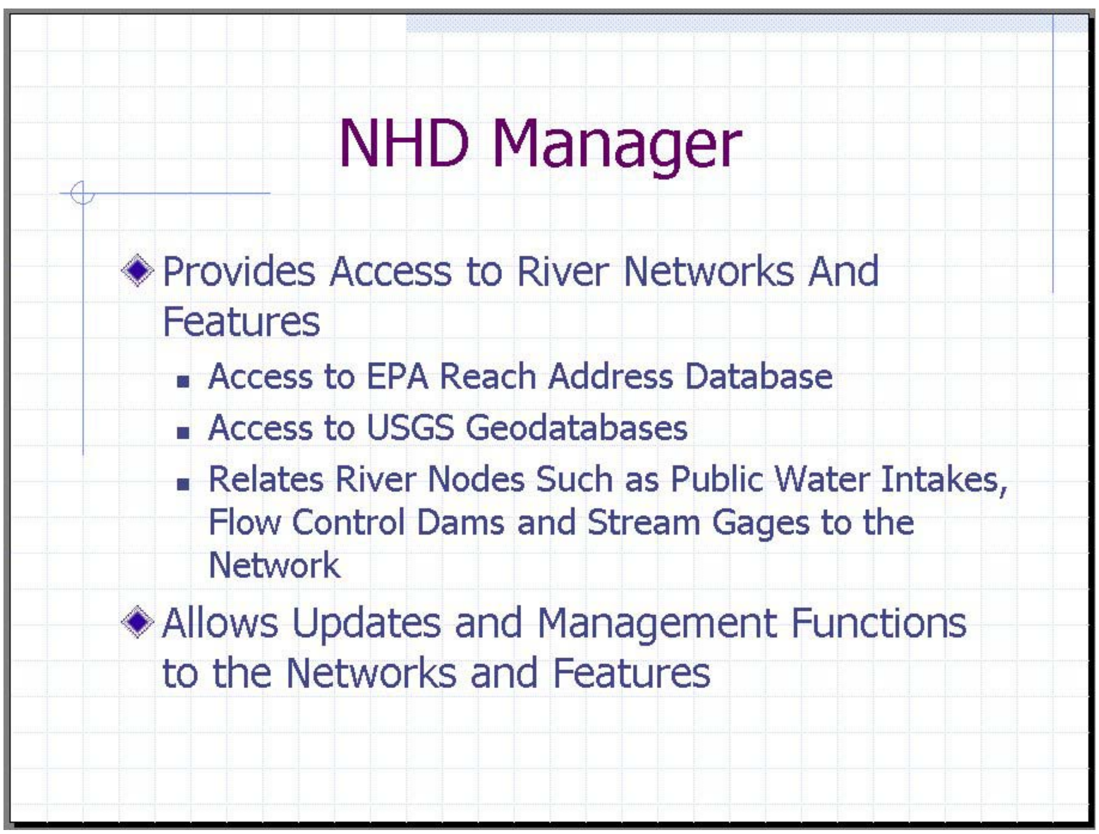

Figure 3. Summary of NHD Manager functions.

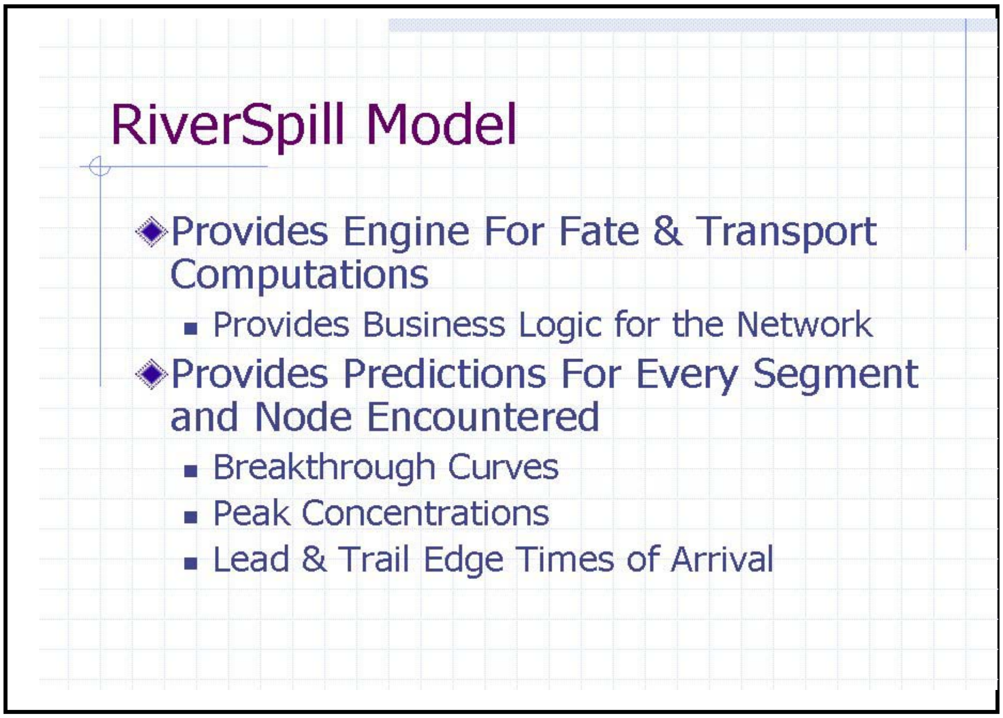

Figure 4. Summary of RiverSpill Model components.

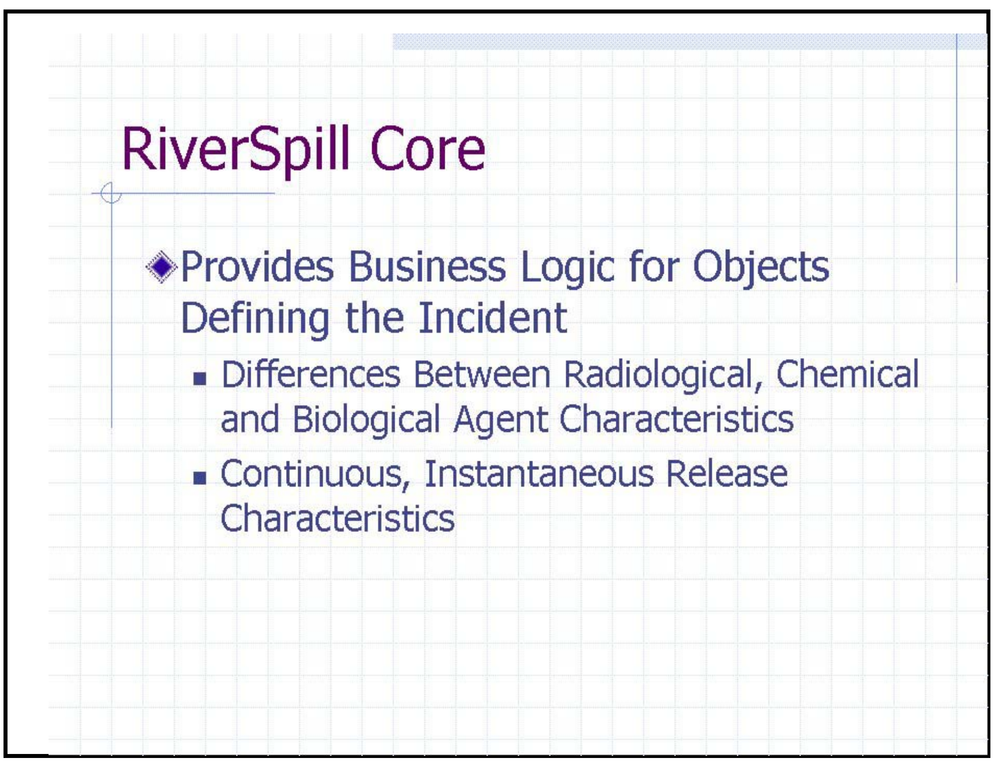

Figure 5. Summary of RiverSpill Core functions.

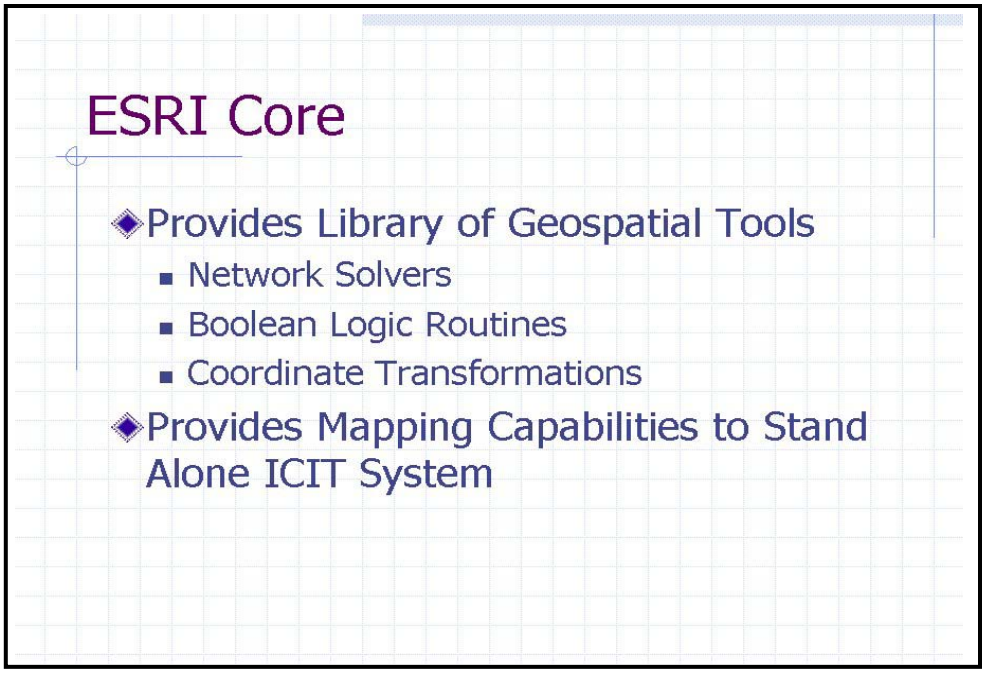

Figure 6. Summary of ESRI Core components.

RiverSpill DLL

The RiverSpill DLL package is the package containing classes covering the user interfaces necessary for the stand-alone application. The stand-alone application may be run alone from windows, but primarily is expected to be launched from the ArcGIS toolbar. The components will allow for the setting of a coordinate from the toolbar, to set the initial release location, though once in the application, it is possible to edit the location.

RiverSpill ToolBar

The RiverSpill Toolbar package contains classes providing the ESRI snap-in extension capabilities. Communications with mapping framework will also occur in these classes.

Buttons to initiate analysis, to identify network features, as well as tools to manipulate, analyze, and produce reports from analysis will be provided on the toolbar. Interaction with the toolbar allows the user to perform downstream (figure 7) and upstream (figure 8) tracing.

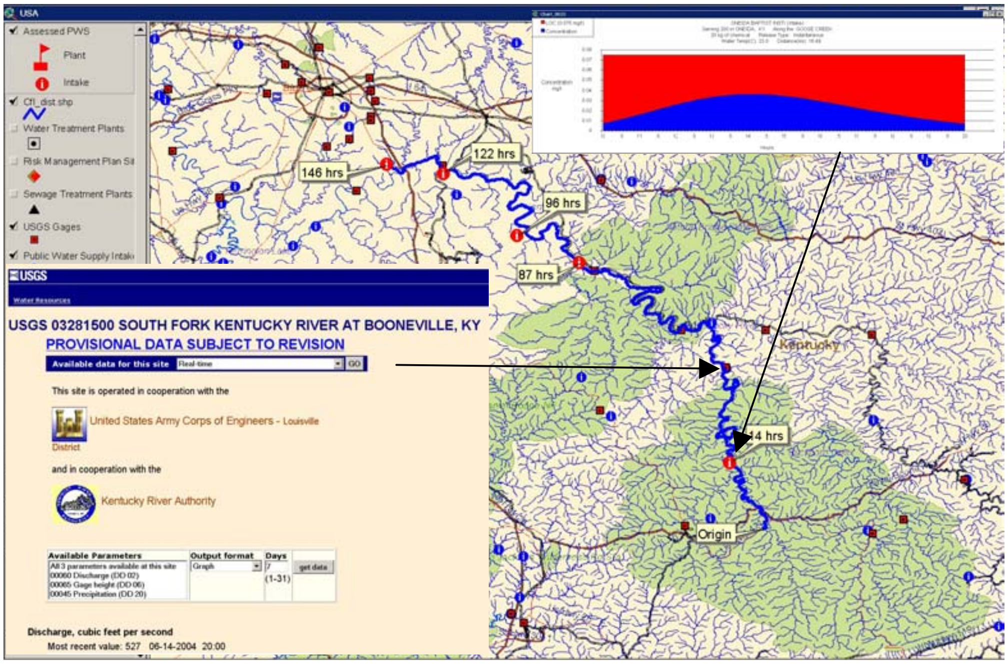

Figure 7. Example downstream tracing capability showing travel times (based on real-time stream flow) to water supply intakes.

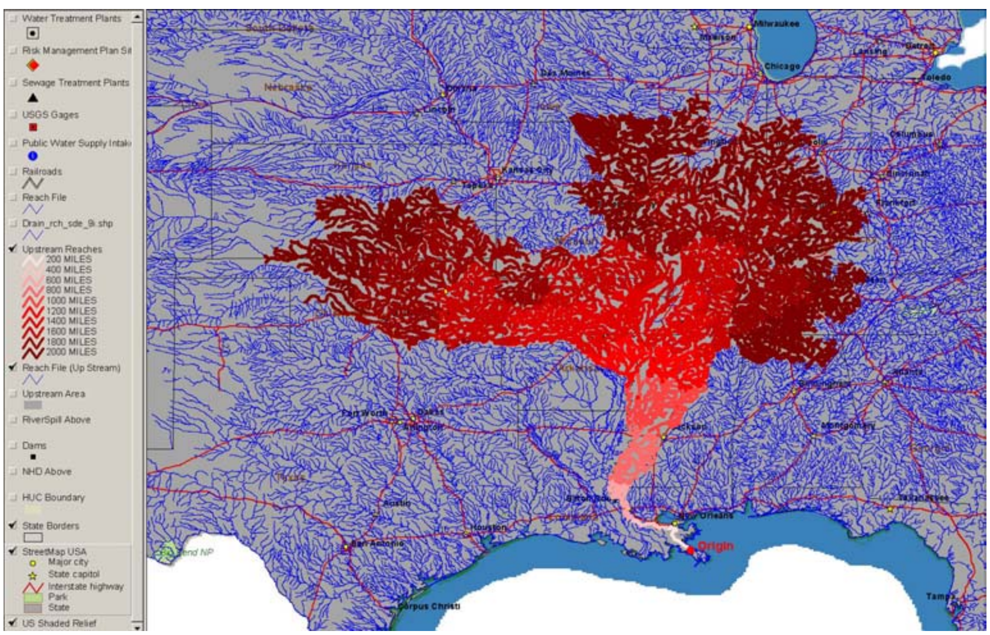

Figure 8. Example upstream tracing capability showing travel distance zones.

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