Open Water Data Initiative

Spill Response Use Case

Background

The United States has over 250,000 rivers totaling about 3,500,000 miles. Rivers provide drinking water, irrigation water, transportation, electrical power, drainage, food, and recreation. There are approximately 155,000 public water systems in the United States. Sixty five percent of these systems use rivers and streams as their water supply. In the lower 48 states, 357,404 total miles of streams provide water for public drinking water systems. Toxic spills can disrupt the drinking water supply as evidenced by the January 2014 chemical spill in the Elk River, West Virginia that contaminated the city of Charleston's water supply which services nearly 200,000 residents. The Elk River flows into the Kanawha River which confluences with the Ohio River, a major water supply for cities such as Huntington, WV and Cincinnati, OH. In August 2015, a breach of the Gold King mine in Colorado resulted in the release of approximately 3,000,000 gallons of metal-rich mine waste water into Cement Creek, a tributary of the Animas River which flows into the San Juan River and ultimately into the Colorado River.

Modeling the fate and transport of toxic spills in rivers is critical in forecasting the time-of-travel and concentration of contaminants that may impact water supplies. This information, in turn, can be used by decision-makers regarding when and how long to shut down a water intake to avoid contamination coming downstream. Spill response models have been developed which answer the following questions: (1) where is the contaminant going, (2) is there a drinking water intake in the path, (3) when will it reach drinking water and (4) is the level high enough to be a human threat. A prioritized list and overview of the data sets and three case studies are presented below to illustrate the data needs and recent experience in contaminant spill response.

Spill Modeling Data Sets

1. National Hydrography Dataset Plus (NHDPlus)

NHDPlus[1] is a comprehensive set of digital geospatial data that contains information for over 3 million surface water features such as streams, rivers and lakes. NHDPlus extends the capabilities of the National Hydrography Dataset (NHD) by integrating it with the National Elevation Dataset (NED) and National Watershed Boundary Dataset (WBD). It contains mean annual stream flow volume and velocity for each stream segment in the NHD network to enable time-of-travel and contaminant transport modelling. The NHDPlus is the hydrologic framework that can be used for downstream and upstream tracing of contaminants in rivers. The NHDPlus is organized by hydrologic regions and further subdivided into four-digit subregions. It is also available as a single national dataset. It is packaged as Geographic Information System (GIS) databases to facilitate loading into GIS-based applications. One-dimensional, longitudinal dispersion models, (where rivers and streams are represented by flow lines can perform contaminant transport calculations using the NHDPlus. In wide rivers and in-line lakes, (represented by shorelines) artificial flow lines (river center lines, connections from lake inflows and outflows) allow for network navigation. The NHDPlus stream network can be navigated in the upstream direction using either distance or time. This approach differs from the traditional one in that, instead of following the water in a segment or volume element downstream, the system tracks back upstream to find the source

[1] http://www.horizon-systems.com/nhdplus/

location and strength of the contaminants. Backtracking starts from the reach with the detection point and finds all the upstream sources of contaminants that flow into that reach.

2. Stream Flow – Measured and Forecasted

Long-term average values of velocity and flow (discharge) are attributes of the NHDPlus reported for each reach. Real-time gauges[2] report stream and river flow from approximately 7,000 sites located throughout the United States. Relationships between river velocity and river flow can be used to determine the real-time velocity from the measured (gauged) real-time flow. Real-time gauges can be used to update the average reach flow to the current conditions. Gauges are selected based on their proximity to the contaminant release location. The National Weather Service (NWS) uses river forecast models[3] to estimate the amount/level of water flowing through the US Rivers. These models estimate the amount of runoff a precipitation event generates, computes how the water will move downstream, and then predicts the flow of water at a given location (AHPS forecast point) throughout the forecast period (every six hours, out 3 to 5 days in many locations).

3. Drinking Water Intakes

The Safe Drinking Water Information System (SDWIS)[4] contains information about public water systems and their violations of EPA's drinking water regulations, as reported to EPA by the states. These regulations establish maximum contaminant levels, treatment techniques, and monitoring and reporting requirements to ensure that water systems provide safe water to their customers. Access and display of drinking water facilities data, fall under EPA's policy[5,6] on sensitive drinking water information. This policy involves restrictions that apply to displaying the precise locations of drinking water entities to a wide non-EPA audience. Sharing information products related to sensitive drinking water information with a wide public audience must be approached carefully.

4. Municipal/Industrial Dischargers, HAZMAT Sites

The Facility Registry Services (FRS)[7] is a centrally managed database that identifies facilities, sites or places subject to environmental regulations or of environmental interest. These include municipal and industrial dischargers as well as HAZMAT sites. The FRS provides Internet access to a single integrated source of comprehensive (air, water, and waste) environmental information about those facilities, sites, or places.

5. Contaminant Databases

The Water Contaminant Information Tool (WCIT)[8] is a secure on-line database with comprehensive information about chemical, biological, and radiochemical contaminants of concern for the water sector. WCIT includes more than 200 analytical methods tied to more than 800 potential contaminants. The enhanced method table contains the method number, title, matrices analyzed, instrumentation required, the organization that developed the method, and three additional fields that rate rapidity, specificity, and how thoroughly the method has been tested.

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[2] http://waterdata.usgs.gov/nwis/rt
[3] http://water.weather.gov/ahps/forecasts.php
[4] http://www3.epa.gov/enviro/facts/sdwis/search.html
[5] U.S. GAO. 2006. Information Sharing: The Federal Government Needs to Establish Policies and Processes for Sharing Terrorism-Related and sensitive but Unclassified Information. GAO-06-385. U.S. Government Accountability Office, Washington, DC.
[6] U.S. EPA. 2005. Policy to Manage Access to Sensitive Drinking Water-Related Information. Office of Water, Michael Shapiro, Deputy Assistant Administrator, April 5, 2005, Washington, DC.
[7] http://iaspub.epa.gov/sor_internet/registry/facilreg/home/overview/home.do
[8] http://www.epa.gov/waterlabnetwork/water-contaminant-information-tool-wcit

6. *Databases for Surface Runoff*

Surface runoff is a potential source of contamination in rivers. This includes chemical, biological, and radiological contamination resulting from atmospheric deposition or direct application to the watershed. Datasets for surface runoff modeling include the NHDPlus catchment layer, National Elevation Dataset (NED), land use/land cover, hydrologic soil groups, precipitation and a rainfall-runoff algorithm to simulate overland flow of contaminants from atmospheric deposition.

7. *Homeland Security Infrastructure Protection (HSIP) Datasets*

HSIP Gold

The HSIP Gold database[9] is assembled by the National Geospatial-Intelligence Agency (NGA) in partnership with the Homeland Infrastructure Foundation-Level Data (HIFLD) Working Group for use by Homeland Defense (HD), Homeland Security (HLS), National Preparedness – Prevention, Protection, Mitigation, Response and Recovery (NP-PPMR&R) communities. It is a compilation of 560 of the best available, geospatially enabled baseline infrastructure datasets for all National & Defense Critical Infrastructure Sectors. HSIP Gold data is assembled from federal, state, local government and private sector mission partners. HSIP Freedom, led by the Department of Homeland Security (DHS), is a license free subset of HSIP Gold. These datasets assist HD, HLS, and NP-PPMR&R mission partners with planning, situational awareness, threat and impact analysis (natural or man-made), modeling emergencies, protection of borders, and decision making during response and recovery operations. The Geospatial Management Office (GMO) in coordination with the Homeland Infrastructure Foundation-Level Data (HIFLD) Subcommittee has created HSIP Gold 2015 Web Services and HSIP Freedom 2015 data are now available via the DHS Geospatial Information Infrastructure (GII) located at https://gii.dhs.gov.

HSIP Freedom

The HSIP Freedom 2015 data product is a license-free subset of 356 HSIP Gold layers downloadable from the GII located at https://gii.dhs.gov/HSIPFreedom.aspx. A Homeland Security Information Network (HSIN) account is required to access the GII. To meet the HSIP goals, NGA's focus is to acquire data for national critical infrastructure sectors as identified by the DHS. This data provides a common frame of reference for decision makers and operational planners for critical infrastructure vulnerability analysis and for domestic crisis response and consequence management. While much of the data in HSIP comes from government (Federal, State, local) sources, some is acquired from commercial sources that were not designed to directly support HLS/HD missions. Examples of the varied types of information contained within the HSIP Freedom product include transportation data, energy data, emergency services data, public venues, basemap boundary data, and LandScan population data. HSIP Freedom in its entirety is unclassified; it is subject to the handling and distribution rules for "Unclassified For Official Use Only" due to licensing and sharing restrictions. Individual datasets contained in HSIP Freedom 2013 have varied data access and use constraints, which are documented in each individual dataset's metadata.

Category or layer example data from HSIP GOLD is shown below:

[9] http://www.dhs.gov/infrastructure-information-partnerships

Agriculture	State Fairgrounds, Crop Farms
Borders	Canada, Mexico
Boundaries	Urbanized Areas, Federal Lands
Chemicals	HazMat Routes
Commercial	Grocery Stores
Communications	Cell Towers
Education	Public Schools
Emergency Services	Communications Centers
Energy	Electric Generation Plants
Finance	Banks
Food Industry	Ice Manufacturing
Government	State Gov't Buildings
Inventory Asset List (IAL)	Dams, Bridges
Law Enforcement	Police/Sherriff Stations
Mail/Shipping	USPS Processing Facilities
Manufacturing	Wood Products
Mining	Sand & Gravel
National Food Hazard	Flood Hazard Areas by Risk
National Levee	Crossing Points
National Symbols	Historic Sites
Natural Hazards	Landslides, Fault Lines
Population	LandScan: Day & night time
Public Health	Hospitals
Public Venues	Campgrounds, Churches
Transportation – Air	Airports
Transportation – Ground	Railroads
Transportation – NAVTEQ	Interstates, Highways, Major Roads, Streets, Exits
Transportation – Water	Lake Area, Ferries
Water Supply	NHD, Inland Waterways

Case Studies

Three case studies are described below which illustrate spill response modeling to actual spill events as well as interactive mapping for environmental emergency response.

West Virginia Chemical Spill

The first event is the chemical spill that occurred in the Elk River, West Virginia in January 2014. On January 9, 2014, an estimated 10,000 gallons of 4-methylcyclohexane methanol (MCHM) a solvent used in coal processing leaked from a ruptured container into the Elk River. The spill, just 1 mile upstream from the Charleston, WV water-treatment plant, forced officials to ban residents and businesses in nine West Virginia counties from using the water for anything other than flushing toilets or fighting fires. Downstream tracing was initiated at the spill site to forecast the location of the leading edge, peak concentration, and trailing edge of the plume for drinking-water intakes as far downstream as 250 miles. The NHDPlus national river network coupled with real-time streamflow data and river forecast data allowed for the simulation of the leading edge, peak concentration, and trailing edge of the spill from its origin on the Elk River to intakes hundreds of miles downstream. Model runs were updated based on

MCHM measurements at downstream locations on the Ohio River to provide accurate forecasts to nearby water intakes.

Gold King Mine Spill

The second event is the Gold King mine spill that occurred in Colorado. On August 5, 2015, EPA was conducting an investigation of the Gold King Mine. The intent of the investigation was to create access to the mine, assess on-going water releases from the mine to treat mine water, and assess the feasibility of further mine remediation. The plan was to excavate the loose material that had collapsed into the cave entry back to the timbering. During the excavation, the loose material gave way, opening the adit (mine tunnel) and spilling the water stored behind the collapsed material. Approximately, three million gallons of acidic, metal-rich mine wastewater from the Gold King Mine spilled into Cement Creek, a tributary of the Animas River. The large pulse of water dissipated in about an hour. Downstream tracing was used to compute initial time-of-travel from the spill site to the New Mexico border (about 48 hours). This was followed up with concentration calculations as sampling results became available.

Western Lake Erie Area Committee (WLEAC)-Ohio Mapping Project

The Western Lake Erie Area Committee (WLEAC)-Ohio Mapping Project is a geographical information system (GIS) environmental emergency response tool which bring public (local, state, federal) and private sector responders together working in one GIS forum for spill response and emergency pre-planning. The layers of the GIS are collected from various Federal, State and Local Agencies, but are all environmental emergency response specific. During an emergency response, responders can view vulnerable downwind/downstream populations (schools, day care centers, hospitals, nursing homes, etc.) and incorporate data or shape files from other response tools (ALOHA, IMAAC, ICWater, etc.) for situational awareness at the incident command post. For contingency planning, we can introduce facilities to the communities which they may impact during a hazardous materials/petroleum release, and develop watershed containment data sheets or Geographic Response Plans which provide specific response information during a release. The program can also be used during exercises of Facility Response Plans by all participants through web access using the programs response tools such as plume modeling, and the draw tool widget with import/export features.

The development of the spill containment point layer consists of the environmental emergency responders determining which locations will provide the best containment/product collection sites, staging areas, and monitoring sites. By bringing the GIS layers in the Project to view Inland Sensitivity data (such as water intakes, wetland areas, endangered/protected species/habitats, vulnerable population, etc.), the data sheets can then be developed for those sites downstream of a potential pollution sources (pipelines, rail lines, fixed facilities, regulated facilities, etc.) based on environmental risk. The information is best collected by the facilities which are associated upstream from the specific watershed containment locations, and the collected information is confirmed by environmental emergency responders who may need to use the containment information during a response. Once the information is collected and the data sheet is made, it is verified and loaded in to the Project linked to its GPS coordinates.

Summary and Conclusions

GIS-based tools using the NHDPlus, a hydrologically connected river network that contains over 3 million reach segments in the US, allows for both downstream and upstream network navigation. Mean flow and velocity has been calculated by the USGS and EPA for each reach. Coupled with real-time stream flow data, assessments of the travel and dispersion of contaminants in streams and rivers can be accomplished. Stream and river flows can be derived from web accessible real-time gauging stations maintained throughout the country by the USGS. Additional databases pertinent to spill modeling include: dams, reservoirs, public drinking water intakes, municipal and industrial dischargers, bridge crossings, pipeline crossings, and transportation networks. A contaminant database is also of interest to identify biological, chemical and radiological constituents of concern.