June 2001

LAND INFORMATION Bulletin

from the National Consortium for Rural Geospatial InnovationS
Mid–South, University of Arkansas

Protecting Our Drinking Water

Geospatial Technologies Enhance Source Water Protection Plans: A Project Overview

”Source water" refers to the water taken from rivers, reservoirs, or wells for use as public drinking water. Assessments of source water help provide a basis for developing, implementing, and improving source-water protection plans. Such a plan delineates protection areas for drinking water intakes, identifies and inventories significant contaminants found within the protection areas, and determines the susceptibility of the public water supply to those contaminants. Geospatial technologies such as GIS (geographic information systems) have streamlined the assessment process making this statewide project in Arkansas a success.

A glimpse into many household kitchens today would likely reveal a relatively new phenomenon: add-on water purification systems. With a growing awareness of groundwater pollution and other source water contamination, many people increasingly are looking for ways to safeguard their drinking water.

To address the problem nation-wide, the Safe Drinking Water Act amendments to the Safe Drinking Water Act of 1996 required source-water assessment programs (SWAP) for all U.S. public drinking water supplies. These source water assessments determine a drinking water system’s potential susceptibility to contaminants.

In Arkansas, the Department of Health (ADH) was charged with developing the state’s source water assessment. The ADH identified the appropriate methodology for the assessment, and the RGIS Mid-South Regional Office provided GIS (geographic information system) assistance for the first two years of the project. This state-wide effort marked the first time a potential contamination assessment of these resources had ever been completed within Arkansas. And it would not have been possible without the use of geospatial technologies.

New Mexico Environment Department
Drinking Water Bureau

Collecting Appropriate GIS Data

One of the challenges of assessing source water is determining and collecting appropriate GIS data for the study. Potential sources of contamination (PSOC) must be mapped

and reliable sources for these data must be documented. (Anumber of well-known contaminates may be found on the Environmental Protection Agency (EPA) Website: http://www.epa.gov/OGWDW/swp/vcontam3.html. Local communities typically refine the EPA's list of contaminants to fit the conditions found within their region.

Besides the contaminants themselves, a number of other factors come into play when assessing source water. GIS data pertinent to a drinking-water susceptibility study might include such environmental and cultural factors as:

- Land use/Land cover
- Soils
- Elevation
- Population
- Precipitation
- Slope
- Geology / Land form type
- Roads
- Streams
- Lakes
- Public Water System intakes (PWS)
- All potential point and non-point sources of contamination

After the data are collected and reformatted into seamless GIS themes, a "health-risk" category may be added to the attribute record of each PSOC. These health-risk ratings provide a statistical "yardstick" for assessing conditions within each water-intake assessment area. A GIS can also compute the on-the-ground distances from each source water intake to all PSOC locations. By harnessing the capabilities of a GIS, the varied cultural and environmental factors and their attributes can be measured and summarized with ease.

Delineating Source Water Assessment Areas

The source water assessment area typically determines the boundary for GIS data collection and assessment calculations for each water source. Determining an assessment area is usually dependent upon the type of water system being evaluated. For instance, a water system that uses wells as the source for water is often referred to as a groundwater system. A groundwater assessment area may consist of a radius distance measured from the well. This distance may vary per intake depending upon site conditions and/or the professional recommendations of water system specialists. A surface water source, such as a spring, lake or river intake, may require an assessment area comprised of the watershed basin feeding the intake.

Although this wellhead in an urbanized area looks protected, it is still susceptible to potential sources of contamination adjacent to the intake.

GIS Tools of the Trade

After the assessment areas are delineated, the GIS can perform a variety of spatial operations. Assessment areas can be studied and summarized by overlying and comparing maps of different themes. Here are some sample GIS capabilities:

Geocoding

Mapping locations that may contain, use or store potentially harmful materials is very beneficial for a source water assessment. But collecting "non-regulated" PSOC locations (e.g., dry cleaners, hardware stores, golf courses, etc) is often the biggest challenge to an assessment team. However, a number of private sector companies (infobase database products: www.acxiom.com) specialize in maintaining and selling such non-regulated information. Typically, these business records contain a name, address and business type classification such as the North American Industrial Classification System (U.S. Census Bureau), which can be cross-referenced with a health-risk category for rapid updates of the health risks associated with each location.

Geocoding is the process of identifying the coordinates of a location given its address. Geocoding software, such as MapMarker3.3 (MapInfo Corp.), may be used to "tag" postal service addresses with a geographic coordinate (latitude, longitude). A GIS analyst may then map and compare those potentially threatening locations in relationship to public water sources.

Proximity Analysis

Distance buffering or proximity operations are considered a basic spatial analysis and the distance of each PSOC to a public water intake is of great concern to health officials. A GIS can calculate these distances for every PSOC within an assessment area. When distance and relative health risk are taken into account for each PSOC, a weighting factor may be associated with the PSOC for calculation of an overall health-risk summary for a water system.

Area calculations

The area and percent coverage for various map themes, such as land use, slope, geology type, and soil characteristics may also be calculated for assessment areas. These GIS operations perform much like a "cookie-cutter" by using the assessment areas as the "cutter" and other map layers as the "dough." These area and percent coverage calculations for each map theme are effective for quantitatively assessing the surface conditions found within multiple assessment areas.

Point-in-Polygon analysis

Whether extracting the elevation of each intake from a Digital Elevation Model (DEM) or adding additional attributes to a database of source water intakes, a GIS allows "spatial correlation" with other features. Within a GIS environment fluctuating database attributes may be updated by overlaying one theme, such as county population or annual precipitation, or elevation with map theme layers representing other features. This aspect of the GIS is very useful for “value-adding” an existing data layer.

Efficiency and Speed

The GIS also enables source water assessment teams to automate many repetitive processes such as map and report production. By automating this process, the Arkansas GIS team was able to produce 1500 (8.5-inch x 11-inch) maps with PSOC reports for

About RGIS

The National Consortium for Rural Geospatial Innovations–Mid South (RGIS) is located on the campus of the University of Arkansas in Fayetteville. It is a USDA program designed to promote the use of geospatial information and technologies by communities in rural America. RGIS is dedicated to helping communities understand the concepts and benefits of using geospatial data as well as assisting them in all aspects of GIS development.

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verification by the water system managers. Approximately 70% of more than 800,000 PSOCs were evaluated for errors and corrected—before the final summary reports and statistics were calculated for Arkansas. The entire process of map-report production, mail-out, field-verification, and map return took slightly over four months, which assured the source water team that their assessment data had been "verified" by the individuals at the public water systems.

The Department of Health and the USGS-Little Rock coordinated the Arkansas assessment but received assistance from the Arkansas Water Resources Research Center (AWRC) and the University of Arkansas Department of GeoSciences in Fayetteville.

For more information about this project, visit (http://www.cast.uark.edu/local/swap) or contact R. Brian Culpepper or Dr. Fred Limp, RGIS–Mid-South, University of Arkansas, 12 Ozark Hall, Fayetteville, AR 72701; 501-575-6159(phone) or e-mail: brian@cast.uark.edu, fred@cast.uark.edu. For additional information about RGIS, contact Tom Graff, University of Arkansas, 12 Ozark Hall, Fayetteville, AR 72701; (501) 575-3159, or email: tgraff@comp.uark.edu.

This bulletin was prepared by the National Consortium for Rural Geospatial Innovations–Mid-South at the University of Arkansas. Additional support provided by the USDACooperative State Research Education and Extension Service (CSREES).

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