SWAP
Technical Assistance Document

The Application of GIS Technology and Data Management in States' Source Water Assessment Programs

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New England Interstate Water Pollution Control Commission

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Introduction

An assessment is only as good as the data on which it is based. As states move into the implementation phase of their Source Water Assessment Programs (SWAP), it is becoming evident that data quality, coordination, management, and distribution are key to the success of these programs. The completion of source water assessments requires the input of numerous datasets, including locations of potential contaminant sources, water supplies and physical source characteristics such as hydrogeologic setting. Much of this data already exists but must be compiled and organized for integration with state SWAPs.

In the early phases of SWAP implementation, states are focusing their efforts on stabilizing and building their datasets and management structures. These datasets consist of primarily locational data more commonly known as Geographic Information System (GIS) data, which refers to the software, hardware, and data that together allow for the management, manipulation, analysis and spatial presentation of data. Locational data represents information which is tied to geographic locations and is vital to states' SWAPs since assessments are partially an analysis of water supplies based on locational parameters.

Pennsylvania, Washington, Ohio, Iowa, and Nevada have provided their approaches to utilizing GIS in their Source Water Assessment Programs with the intent that this document will spark ideas and potential solutions for other states with similar issues. Each state section focuses on a specific aspect of data management, coordination or distribution as outlined below.

- **Iowa -** Collection and storage of datasets, and use of GIS technology to develop SWAP assessments and reports.
- **Nevada -** Coordination with the Ground Water Protection Council to develop their SWAP database.
- **Ohio -** Use and development of an interactive database.
- **Pennsylvania** - Application of GIS based analysis to complete assessments on small groundwater systems.
- **Washington** - Use of Internet based GIS applications to distribute assessment results.

Information in this document was provided by state SWAP plans and directly from state SWAP program coordinators and GIS/data management system coordinators. This document was researched and produced through a grant from the U.S. Environmental Protection Agency (EPA). The grant is a joint effort between the New England Interstate Water Pollution Control Commission (NEIWPCC), the Ground Water Protection Council (GWPC), and the Association of State Drinking Water Administrators (ASDWA).

IOWA

Using Iowa's Natural Resources Geographic Information System Library for Source Water Assessment and Protection

The Iowa Department of Natural Resources (IDNR) is implementing the Source Water Assessment and Protection (SWAP) program for approximately 2,000 public water supplies in the state of Iowa. As part of its commitment, IDNR will prepare Phase I assessments for all public water supplies that rely on groundwater and a small number of the surface water-based systems. Most of the surface water assessments will be prepared by private contractors.

Phase I assessments for source water protection rely primarily on existing data and have three components:

- Delineation of the source water protection (SWP) area using time-of-travel criteria if hydrogeologic data is available. A fixed radius of 2,500 ft. (one mile in karst areas) is used where data is inadequate
- Inventory of contaminant sources within the source water protection area
- Analysis of the susceptibility of the water supply to contamination based on the SWP delineation using risk factors associated with capture zones, susceptibility of the aquifer, and land-use category assigned to each contaminant source

IDNR and the contractors are relying extensively on geographic information system technology for all aspects of developing SWP assessments and communicating the results to the water suppliers. The extensive data resources available from the IDNR Natural Resources Geographic Information System (NRGIS) Library has made it an invaluable tool for source water protection.

The NRGIS Library

The IDNR Geological Survey Bureau began development of the Natural Resources Geographic Information System (NRGIS) Library in 1992. As the name suggests, the focus has primarily been on development of GIS data related to the state's natural resources. Its purpose was to make natural resource data widely available to IDNR staff and the public to aid study and management of the state's natural resources. Among the early goals for the NRGIS library was the creation of statewide or countywide data rather than detailed datasets covering small geographic areas. Widespread availability of the library data within IDNR has been another major goal of the NRGIS library. Access within IDNR is provided by mirrored disk drive arrays on a wide-area network. More recently the NRGIS Library data has been made available for download on the Geological Survey Bureau's worldwide web site:

http://www.igsb.uiowa.edu/nrgis/gishome.htm

The NRGIS library is currently comprised of over 4,000 datasets. The water well and contaminant source data sets, summarized below, are directly applicable to the source water protection program, but all other data categories provide data for developing delineations, preparing maps for reports, etc.

- Water wells: municipal water supplies, private well permits, plugged wells, abandoned wells, agricultural drainage wells, and water use permits
- Contaminant sources: underground storage tanks, hazardous waste generators, landfills, waste water treatment plants and permitted animal waste control facilities, mines and quarries
- Natural features: bedrock topography, bedrock geology, groundwater vulnerability regions, sinkholes, digital soil survey maps for about 97 (of 99) counties, landforms, drainage basins, and rivers, topographic contours, and National Wetlands Inventory for each county in the state
- Features related to human activity: land use, land cover, county and township boundaries, incorporated boundaries, place names, zip code boundaries and legislative districts, designated rivers, protected streams, fish kills, threatened and endangered species, levees and gauging stations and roads, section lines and census data for each county in the state
- Scanned 24k, 100k and 250k topographic maps
- Digital orthophoto quadrangles for about 30 counties

Using GIS for Source Water Protection

Delineations

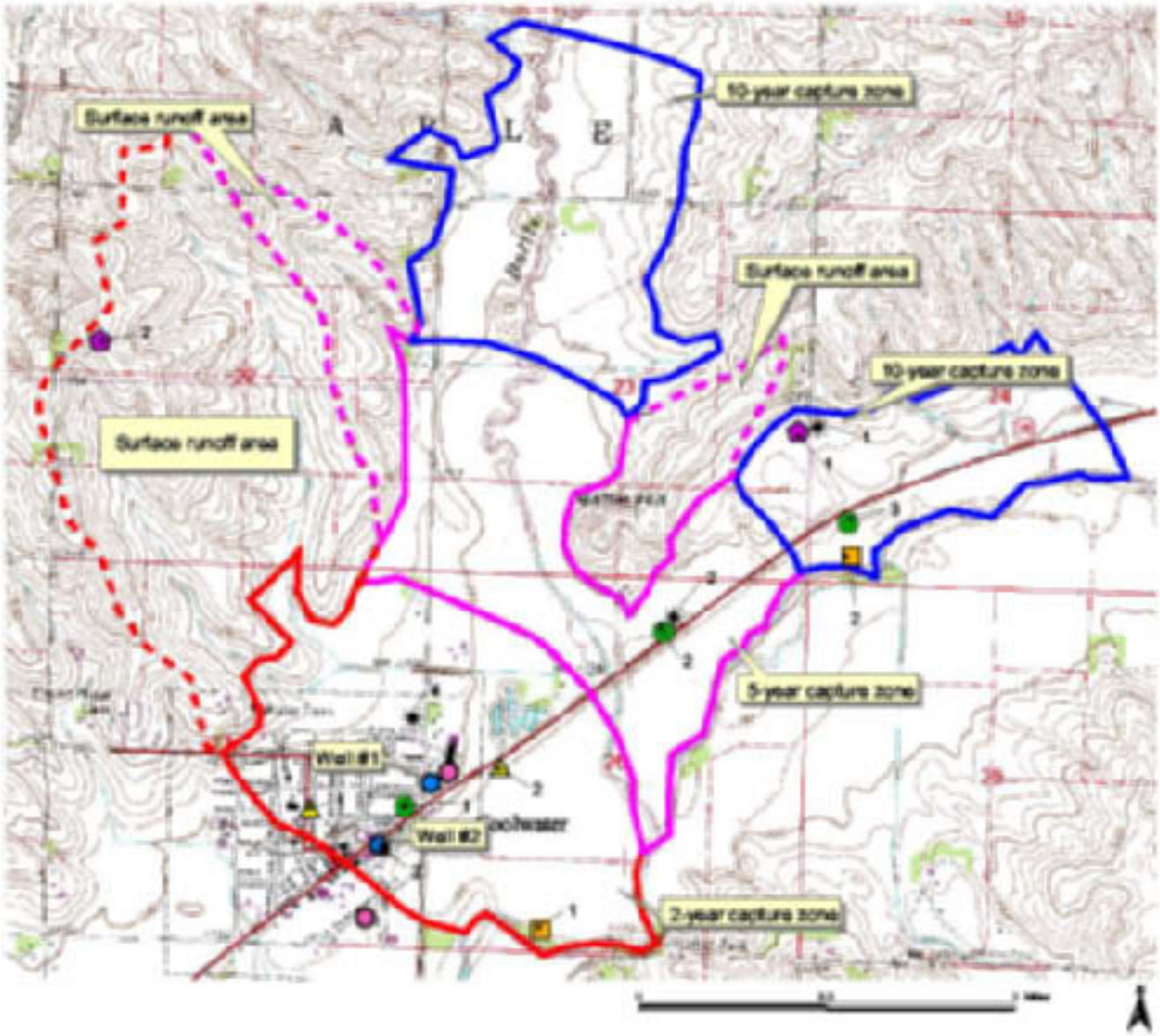
Source water protection areas are defined using the best method permitted by the data available for the wells and aquifer. For groundwater systems, other than karst areas, the preferred criterion for the delineation is time of travel using intervals of 2-, 5-, and 10-years. Delineations based on time of travel in alluvial aquifers are further refined by hydrologic boundaries and watershed areas that contribute runoff and surface water to 2- and 5-year capture zones. The following figure shows a SWP delineation in an alluvial aquifer. For systems with insufficient data, a default delineation using a 2,500-ft. radius is used. In karst areas, one-mile radii are used.

An ArcView® application was developed to aid in creating delineations by allowing the user to locate the public water supply system. Fixed-radii delineations are created directly in ArcView by buffering selected points from one of the public well datasets. Where time-of-travel criteria are to be used the use defines boundaries for a groundwater-flow model and exports the coordinates of the wells to an input file to be used in the model. A simple, shareware, finite-element model, WHPA, was used for most delineations. Visual Modflow® was used for a few systems when adequate hydrogeologic data was available.

The user adds additional parameters required by the WHPA or Modflow models. The results of the model are returned to the ArcView application so that the user can digitize capture zones. Thus, while the model isn't run "inside" ArcView or as an extension, the result plots in the correct location.

Delineations are being developed individually for each aquifer used for public water supply. After review, the delineations are compiled into a single shape file and attributes are added to identify the public water supply, well field, aquifer, and capture zone. Ultimately, all individual system delineations will be combined into a single, statewide shape file. Updated delineations will be added as new hydrogeologic data is obtained, and as more detailed, Phase II delineations are submitted and approved by IDNR.

Coolwater - Source Water Protection Area
Alluvial Wells



Source Water Protection Area

Coolwater municipal water supply wells

- Alluvial wells used in delineation
- not used

Source water protection area delineation zones

- 2-Year capture zone
- 5-Year capture zone
- 10-Year capture zone
- 2-Year watershed
- 5-Year watershed

Potential Contaminant Sources

- Other wells not used in delineation
- Underground storage tank sites
- Hazardous waste generators (RCRA permits)
- Wastewater treatment facilities
- Permitted confinement livestock operations

The previous figure portrays a typical map for a small municipal water supply with two active wells in a shallow alluvial aquifer. Capture zones were delineated for 2-, 5-, and 10- year travel times and the watersheds contributing to the 2- and 5-year capture zones were added. The capture zones were further refined by adding the hydrogeologic boundaries, here the river and the limits of the alluvial deposits. Contaminant sources from NRGIS library and other coverages are plotted on the map. These sources will be included in the susceptibility assessment of the aquifer. The background is a scanned 7.5' topographic map (DRG). This map is included in the SWAP report to the public water supply. The report will also include a table listing the contaminant sources and susceptibility analysis.

Contaminant Source Inventories and Susceptibility Analyses

The completed delineations are used by an ArcView application that selects the contaminant sources that occur within the SWP area and assigns risks to each associated with the capture zone they occur in, the overall susceptibility of the aquifer, and a land-use risk associated with the source type. The locations are plotted on a map with identifying numbers. A risk factor is calculated for each source and the result is formatted for inclusion in a report. Wells, particularly those in the same aquifer as the public water supply, are viewed as potential pathways to the aquifer. Although wells are not inherently contaminant sources, well data will be reported to the water supply as part of the contaminant source inventory.

GIS Data Used for SWP Assessments

The contaminant source data that will be used for Phase I SWP assessments are listed in Table 1. All coverages listed were developed by IDNR or underwent substantial reformatting from the original data source. Source data was provided by EPA for EPA-permitted sites. Other data was provided by IDNR or Iowa Department of Agriculture (IDALS) programs. Metadata is available with data sets maintained by the NRGIS Library that describes the source, accuracy, and attributes of the data set. Other data sets generally lack metadata, but in many cases individual records include attributes that describe the accuracy of the associated entity.

Table 1. GIS datasets recommended for Phase I contaminant source inventories by IDNR.

Comprehensive Environmental Response Compensation Liability Act sites
Underground Storage Tanks
Resource Conservation and Recovery Act sites (treatment, storage, disposal)
Wastewater Treatment Plants
State Permitted Agricultural Facilities (livestock confinement feeding facilities)
Solid Waste Disposal Facilities (landfill, transfer, land application)
Airports
Sinkholes
Mine, Quarries, Gravel Pits (coal and non-coal)
Wells (public and private)
Agricultural Drainage Wells
Highways
Railroads
Land cover
Standard County Soil Surveys
Pesticide/Herbicide/Fertilizer Dealerships
Pipelines
Toxic Release Inventory sites (TRI)

Phase II Source Water Assessment and Protection Plans

If a public water supply chooses, it may develop Phase II SWAP plans. Phase II plans are the responsibility of the public water supply. The Phase II plan should provide a more detailed and accurate delineation of the source water protection area, particularly where a default delineation was used. Currently available data are insufficient to evaluate likelihood of contamination from sites listed on the contaminant source inventory developed during Phase I. So adequate Phase II inventories will incorporate some evaluation of a contaminant source's construction and management practices. Documents are being developed to aid public water supplies in developing Phase II inventories and assessments that include forms and tables to help guide the process. The state's SWAP program guidelines describe Phase II plans and direct IDNR to incorporate data developed by public water supplies for Phase II plans into the SWAP database and revise the susceptibility assessment based on the new data.

Summary

Geographic information system technology has enabled IDNR to develop Phase I SWAP reports quickly and with consistent results. Revised reports can be prepared easily to reflect new or updated information provided by Phase II plans, other IDNR programs, contractors, etc.

The NRGIS Library and other data maintained by IDNR are a vital resource for the state SWAP program both within IDNR and for contractors involved in SWAP. It is anticipated that the data in the Library will also be used by public water suppliers as well for Phase II plans. When it is completed, the statewide source water protection area coverage is likely to be widely used for environmental planning programs. Preliminary data has already been used for the Conservation Reserve Program (CRP) and for siting confinement-feeding operations.

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NEVADA
Development of a SWAP Data Management System

The State of Nevada's Source Water Assessment Program is patterned after Nevada's successful Groundwater Vulnerability Assessment Program that was approved by EPA in 1995. During the period between 1995 and 1998 over 500 community and non-transient, non-community wells and contaminant sources that lie within the 10-year capture zone of wells were identified and located with the Global Positioning System (GPS). Information regarding the well (i.e., well construction, water quality, aquifer characteristics) and information regarding potential sources of contamination were input into a Fox Pro database.

In January 2000, the Nevada State Health Division, Bureau of Health Protection Services (BHPS) entered into a contract with the Ground Water Protection Council (GWPC) to develop a database for housing Nevada's source water assessment data. It is expected the new database will be fully operational by October 1, 2000. Existing vulnerability assessment information from the Fox Pro database will be migrated to the newly created Microsoft Access database. Water systems that have not yet had source water assessments will be entered into the new database.

SWAP Data Entry and Report Development

Using entry forms, BHPS staff will be able to enter data directly into the database. GWPC will convert a number of existing paper forms into electronic forms for use in adding, editing, selecting, and viewing PWS records in the database. These forms will include a Groundwater Vulnerability Assessment Survey form, WHPA computer Model-RESSOC Model data Summary, Potential Contaminant Information and Sources, Surface Vulnerability Assessment Form, Risk Ranking Vulnerability Assessment Sheet, Public Water Supply Sanitary survey and the volumetric flow equation. Another feature of the database will allow for storage and tracking of water quality monitoring results. Water quality monitoring schedules prepared for all sources (wells/springs/surface water) through the year 2010 will be entered and tracked for compliance by the new database. GWPC will also develop a field assessment module of the database. This will allow for field staff to complete assessments and enter data when they are at a field site using laptop computers, then upload it to the main database in the office.

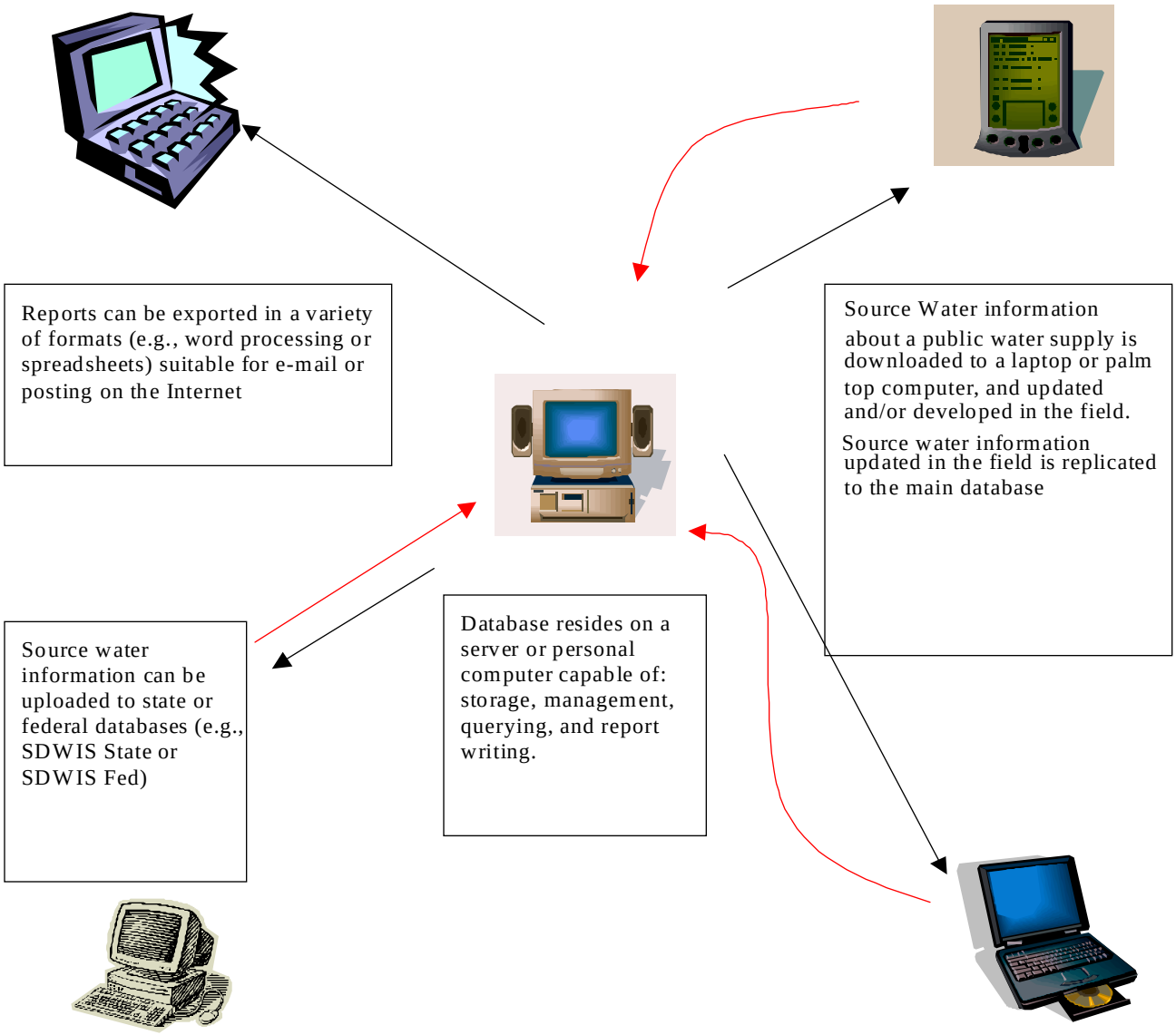
Using the SWAP database, BHPS staff will be able to create various reports, including Vulnerability Determination, Monitoring Waivers Granted, Waiver Renewals, a prototype CCR and monitoring sample reports. BHPS will utilize MapGuide to make its source water assessment information available over the Internet. GIS information will be exchanged between local, state, and federal agencies. GIS coverage's will depict potential contaminant sources within 2-,5-, and 10- year capture zones of wells on scanned 1:24000 scale topographic maps. USGS watershed delineations will be utilized for surface water. Potential contaminant sources in buffer zones adjacent to surface water bodies providing drink-

ing water will be mapped. Overland time of travel modeling of contaminants to surface water will be utilized (where practical) to determine the source water protection areas. ESRI ARC-View 3.2 and Auto Desk MapGuide are software currently used by BHPS.

Environmental Information Management Suite (EIMS) Source Water Module

GWPC's EIMS Source Water Module, a PC-based tool that programmatically integrates GIS and environmental database technologies, is a 32-bit Visual Basic program that uses a GIS ActiveX control to link mapping features to an environmental data management system (Figure 1). EIMS is fully functional with either Windows or UNIX based operating systems and can be customized for any type of environmental analysis.

Figure 1: How EIMS Source Water Will Work



The development of the Source Water Assessment Data Source for Nevada will complete GWPC's EIMS Source Water Module. A generic format of the Source Water Module will then be made available for use in most state and local governments. GWPC expects the completion of the EIMS Source Water module to allow water resource managers to shift their energies from activity-based measures of performance (e.g., counting the number of permits issued) to outcome-based measures of progress (e.g., determining qualitatively whether water quality is improving, degrading, or staying the same).

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Nevada's SWAP Website – http://www.state.nv.us/health/bhps/sdwp.htm
GWPC's EIMS Project Contact:
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GWPC's EIMS Website - http://gwpc.site.net/eims2/

OHIO
Creating a Living SWAP Database

The Ohio Environmental Protection Agency (Ohio EPA) is developing a "living" SWAP GIS database that is continually being improved, rather than a static paper file that becomes outdated in a relatively short period of time. The database is continually updated, using integrating software to add and edit information as a user works with the data. This keeps information up-to-date and accurate as compared to more antiquated data structures that do not allow for centralized storage of data that is easily accessible for use and editing. Another advantage of this new database is that paper records may be reduced or eliminated.

Ohio EPA is developing several databases, which constitute the "living" SWAP GIS database, for use in completing SWAP assessments. A SWAP delineation database is made up of two data layers, one for groundwater and one for surface water sources. For groundwater delineations a Resource Characterization (RC) database, housing hydrogeologic parameters, such as hydraulic conductivity and aquifer thickness, was developed. For surface waters, various databases will be used to analyze watershed characteristics to determine the sensitivity of watershed protection areas. A Potential Contaminant Source Inventory database has also been developed.

Delineation Databases

Separate groundwater and surface water protection area delineation layers will be created and stored in a single database, which will reside on a central server located at the agency's Central Office in Columbus. GIS data, maintained on the server, may then be accessed from the agency's five district offices using Environmental Systems Research Institute's Spatial Data Engine (SDE) technology. SDE enables spatial data to be stored, managed, and quickly retrieved, which in turn allows several state users to view and edit information in the database at the same time. Changes that have been made are tracked as separate versions of the database. GIS Specialists in the agency's Central Office will examine all modifications and update the delineation data layers after a thorough QA/QC process. There are several firms that provide these data management tools. Ohio EPA is using ESRI. For more information on ESRI's Spatial Data Engine, visit their website at: http://www.esri.com/software/sde/index.html .

GIS specialists have also created an ArcView customization for conducting delineations for small (pumping less than 10,000 gallons/day) public water supplies. The customization is based on the volumetric equation and allows SWAP staff to delineate circle, half-circle, or quarter-circle delineations depending on the confidence in the ground water flow direction. The customization determines an appropriate down-gradient protection area for the half-circle and quarter-circle methods based on an equation derived through Monte-Carlo probability analysis. The customization assists SWAP staff in efficiently and consistently delineating protection areas for Ohio's small public water systems with

limited hydrogeologic data.

Resource Characterization

The Resource Characterization (RC) database is critical for the delineation of the groundwater source protection areas, since it contains important hydrogeologic information. The RC database is being assembled from many different hard-copy reports that have been produced through the years by Ohio EPA, Ohio Department of Natural Resources (ODNR), and the US Geologic Survey (USGS). Information on hydrogeologic parameters such as aquifer thickness, conductivity, and porosity, along with locational coordinates (latitude/longitude values), is collected from the various reports and entered into a FoxPro database. Using the coordinate information the RC is converted into a GIS point coverage for use in ArcView.

To model a groundwater SWAP area for a public water system various hydrogeologic parameters are required. In many cases, Ohio EPA will not have all of the information necessary to complete the delineation for a particular public water system. Using ArcView, the Ohio EPA will be able to query the RC database to extract the necessary parameters from other wells located in a similar hydrogeologic setting and apply that data to delineating the GW SWAP area.

For surface water systems, Ohio EPA will utilize existing USGS watershed delineations (based on 8-, 11- and 14-digit hydrogeologic units) and refine the watershed boundaries when necessary. After a delineation has been completed, information in various existing databases and coverages will be used to describe characteristics of the watershed using GIS analytical tools. These watershed characteristics include watershed shape and size, slope characteristics, soil information, water quality monitoring data, number of bridge crossings, number of road miles within 100 feet of streams, etc. The purpose of this analysis is to evaluate the potential for overland transport of contaminants to surface water and to document biological and chemical quality of the water resource. The results of this analysis will be saved in a collection of geographically referenced data sets.

Potential Contaminant Source Inventory Database

Another database that has been created for SWAP is the Potential Contaminant Source Inventory layer (PCSI). This is a point coverage of sites throughout Ohio that could potentially impact public drinking water supplies. Many separate GIS point coverages are included in this data layer:

- Federal EPA ENVIROFACTS database - A listing of all facilities currently regulated under one of the many US-EPA programs. Some of these include CERCLIS (potentially hazardous waste sites), RCRIS (hazardous waste handlers regulated by US-EPA), TRI (Toxic Release Inventory), and SSTS (pesticide-producing companies).
- Ohio EPA GIS layer of all active and inactive Landfills, Underground Injection Wells, Confined

Animal Feedlots, Surface Inpoundments, Town Gas Sites, and Ohio's Master Sites List.

- Cemeteries, Hospitals, and Military Bases (from USGS Geonames database)
- Underground Storage Tanks (UST) and Leaking Underground Storage Tanks (LUST) - UST/LUST databases are maintained by the State of Ohio Fire Marshall. Since this data did not include addresses, Ohio EPA used geo-coding (address-matching) software to attach locational information to each of the sites for inclusion into the PCSI.
- Ohio DNR's Abandoned Mines and Oil and Gas Well GIS coverage

The point layer contains over 100,000 potential contaminant sources. The PCSI layer will reside on the agency's central SDE server in Columbus. Ohio's SWAP effort for groundwater and surface water delineations will include a field visit to inventory potentially significant contaminant sources. During the inventory, staff will verify the location of PCSI sources in relation to the actual delineated SWAP area and locate additional sources not identified in the statewide databases. After the site visit, Ohio EPA district personnel will edit the PCSI GIS layer using the SDE, adding new sites and moving mislocated points. As with the delineation layer, Ohio EPA Central Office GIS professionals will be responsible for updating this coverage following a QA/QC of the modifications.

Key Benefits of Ohio's "Living" SWAP Database and Use of GIS Technology

There are several benefits to the Ohio EPA GIS approach for accomplishing SWAP objectives. Maintaining a few large GIS layers in a central location allows a more consistent approach to QA/QC of the data. It will also be easier to determine the progress of the overall SWAP program in the context of rigid completion deadlines. SDE technology provides the ability for several different individuals, located in five separate Ohio EPA offices, to edit the same GIS database via remote access. Once the individual SWAP areas have been delineated and inventoried for potential contaminant sources, the information can be displayed to the public over the Internet in a timely and consistent manner using the SDE structure and ESRI's Internet Map Server. A very important side benefit to the overall SWAP program will be on-the-job training of several employees in the use of ArcView. This experience should prove to be extremely valuable to many future Ohio EPA program initiatives.

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PENNSYLVANIA
Use of GIS Analysis to Reduce SWAP Resource Needs

Due to the large number of public water supply sources in Pennsylvania and the limited amount of resources available to the Department of Environmental Protection (DEP), a variety of methodologies will be utilized in the implementation of the state's SWAP. To overcome these limitations Pennsylvania is relying heavily on the use of existing data and the capabilities of GIS analysis in completing and managing their SWAP efforts.

State/Federal Agency Data Coordination

Pennsylvania's SWAP assessments for most sources will be conducted almost exclusively using existing GIS coverages and other databases already in existence or in the process of development. The PA DEP has worked with a number of state and federal agencies to collect GIS coverages. These agencies include the US Geological Survey (USGS), US Fish and Wildlife Service (US FWS), US EPA, US Department of Agriculture (USDA), PA Department of Transportation (DOT), PA Department of Labor and Industry (DLI), the PA Department of Conservation and Natural Resources (DCNR) and others. PA DEP has developed a wide range of GIS coverages for a variety of programs through the Environmental Resource Research Institute (ERRI) at the Pennsylvania State University, and these are being applied to SWAP assessments. The Pennsylvania Spatial Data Access center at The Pennsylvania State University is a clearinghouse for PA DEP data and is a source for many other coverages from both public and private sources that may be used in the SWAP assessments. The DEP is also using its own coverages generated from databases developed for regulatory purposes. This coordination between agencies has allowed the DEP to compile a sizable list of coverages (see next page), both currently available and under development, for use in conducting assessments.

GIS Data for Assessments

PWS – Groundwater Sources	PWS - Surface Water Sources
PWS - Treatment Facilities	PWS - Entry Points
PWS - Storage Facilities	PWS - Service Areas
PWS - WHPA	PWS – Watershed from PWS Intakes
Agricultural DRASTIC	7.5 Quadrangle Boundaries
Streams (corrected w/ attributes)	Streams
Roads	Railroads
Small Watersheds	Land Use
Soils (state)	Soils (county)
Surface Geology	Physiographic Provinces
Terrabyte (LandSat derived land cover)	Minor Civil Divisions
State & County Boundaries	Voting Districts
Census Tract	Census Bloc
PA Digital Elevation Model	PA Digital Raster Graphics
PA Orthophotos	Sinkholes
Surface Water Gaging Stations	Floodplains
Dams	State Parks
State Forests	PCS – NPDES Points
Toxic Release Inventory (TRI)	STORET – GW& SW WQ Monitoring Points
Agr. Census Data by Zip Code	Septic Systems by Zip Code
Depth to Groundwater	National Wetland Inventory
Act 2 Sites	Storage Tanks with Releases
Hazardous Waste Sites	Watershed Act 537 Municipal Sewage Planning
Abandoned Mines	Acid Mine Drainage Sites
Anthracite Mines	Areas Unsuitable for Mining
Bituminious Mining	Deep Mines
Oil & Natural Gas Wells	Cemeteries
Golf Courses	Nuclear Power Plants

*** List compiled from PA DEP, ERRI, USGS, US FWS, and PA DCNR GIS data layers.**

Application of a GIS Based Methodology for Small System Assessment

PA DEP will use GIS analysis to conduct initial assessments for all of the state's Public Water Supply (PWS) sources. Initial assessments will apply criteria in the SWAP program to prioritize systems for further assessment. These assessments will identify critical watershed areas for analysis based on land-uses, discharge locations, available monitoring data and stream impairments. The analysis will also identify drainage basins that are primarily agricultural or moderately developed with permitted discharges for contracted assessments and identify critical areas within the assessment area that have impaired streams and/or high potential for non-point source contamination.

Assessments for PWSs with groundwater sources serving fewer than 3,300 customers will be completed using GIS analysis. GIS analysis will reduce costs and expend less staff resources than regular methods for assessments. The first step in the analysis is the delineation of the source water assessment area. Improvements on Pennsylvania's default half-mile wellhead protection area (WHPA) Zone II will be made based on available GIS data. Data on well production, construction and water quality will be used with data on topography, geology, soils, streams, etc., through a conceptual groundwater flow model developed for each physiographic section of Pennsylvania. Existing databases and those enhanced through other delineations will be applied for the inventory of potential sources of contamination and susceptibility analysis. More rigorous delineations and assessments will be completed for this size and type of PWS as staff time permits after completion of the statutory requirements for the state's assessments.

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WASHINGTON
Distribution of Digital SWAP Data to the Public

What is to be expected of the state that has been heralded by Vice President Al Gore as "the most digital" state in the nation? The answer: a SWAP program focused on the development, integration and dissemination of digital data. Washington state's SWAP efforts are centered on "using data from existing programs; converting it into a GIS data system; utilizing the GIS system for the initial inventory efforts; upgrading the inventory over time by integrating data from inventories conducted by water systems and local governments; and providing the data to interested entities via primarily an Internet access mechanism." This approach allows for SWAP data to be distributed and used for source protection planning and decision making, which is the ultimate goal of any state's SWAP.

Although the development and integration of GIS data coverages are key to the success of SWAP programs, Washington state considers the distribution and use of the data to be a better measure of success. Having informed water systems and citizens will almost certainly ensure that source water protection efforts are undertaken in the state. Washington has made data distribution a priority for its program and has allocated substantial SWAP State Revolving Fund (SRF) resources to this effort. Data distribution will be accomplished through two mechanisms: 1) a simple Internet application for public access to data on individual water systems, and 2) data transmission to entities that have sophisticated GIS capabilities, such as public interest groups, local governments, consultants and the private sector.

The Washington State Department of Health (DOH) is developing two complementary Internet access strategies to accomplish these two objectives. Mapping applications will be developed using various software packages, including Map Objects, Arc/IMS and Map Objects IMS from Environmental Systems Research Institute (ESRI). (See http://www.esri.com/software/index.html for more detailed product information.) The main programming language will be Microsoft Visual Basic 6.0 and will utilize the Active X controls from ESRI.

Distribution of SWAP Data to the General Public

To supply the public with the completed assessment information is a critical part of a states' SWAP efforts. In Washington assessment information will be visually presented through a basic display and query Internet application (see Figure 1 and Figure 2) that is simple to use. Individuals with little GIS knowledge, a web browser and access to the Internet can query the website to select a subset of the state, down to the sub-county or large water system level. Individual water system service areas will be displayed, along with wellhead protection area boundaries, watershed control boundaries, inventory results and susceptibility ratings. The public will be able to download maps and data from the site. To assist in the understanding of the assessment results, a general "fact sheet" with explanatory informa-

tion and an interpretive guide will also be provided on the website.

In addition to the SWAP results, metadata about the information and the databases supporting the results will also be posted so that interested users can better use the assessment findings for their purposes.

Distribution of SWAP Data to Organizations with GIS Capabilities

The second strategy is to transmit data to entities with sophisticated GIS capabilities, such as public interest groups, local governments, consultants and the private sector. GIS coverages of wellhead protection areas and surface water protection areas will be posted at a Department of Health FTP Internet server accompanied by the appropriate metadata to allow for proper processing and interpretation of the data. Metadata are data about the content, quality, condition, and other characteristics of data. A high level GIS application will also be deployed over the Internet, using ESRI's ArcIMS technology. This application will target high-end users with GIS knowledge and will allow them to incorporate and analyze relevant GIS data that they may have on their own machines or to network with the state SWAP data being served (see Figure 3). This would all happen within the browser environment, so software licenses would not be a requirement. The functionality this application will deploy via a web browser includes display and query, overlay and buffer capabilities, downloading specific data queried from various datasets, and combining SWAP data with the user's local data in a browser environment.

Hardware and Software Requirements for Internet Applications

The following is a list of hardware and software Washington will use to run their display and query Internet application:

Map Server Computer hardware:

Compaq SP750 Workstation
Dual 733MHz Xeon Processors
2 Gigabytes of RAM
100+ Gigabytes of hard disk space
Raid disk controller
AGP slot with an Open GL card and 32 MB of VRAM
Rack mount kit
Lockable case
CDROM/Floppy

Map Server Computer software:

Microsoft Internet Information Server v4.0
ESRI's Map Objects IMS v2.0
ESRI's ArcIMS
NT Server

Product names are provided for information purposes only and should not be construed as an endorsement by the state of Washington.

Please visit http://www.doh.wa.gov/ehp/dw/swap.htm to see Washington's website once it is in full production. The following screen shots (Figures: 1–3) portray the type of information that will be presented to the general public as well as to entities with more sophisticated GIS capabilities through Washington State's Source Water Protection Web.

Washington DOH Source Water Protection Project contacts:

David Jennings, Project Lead - david.jennings@doh.wa.gov
Washington's SWAP Website – http://www.doh.wa.gov/ehp/dw/swap.htm

Figure 1: Opening Screen - Simple HTML Viewer: any browser capability.

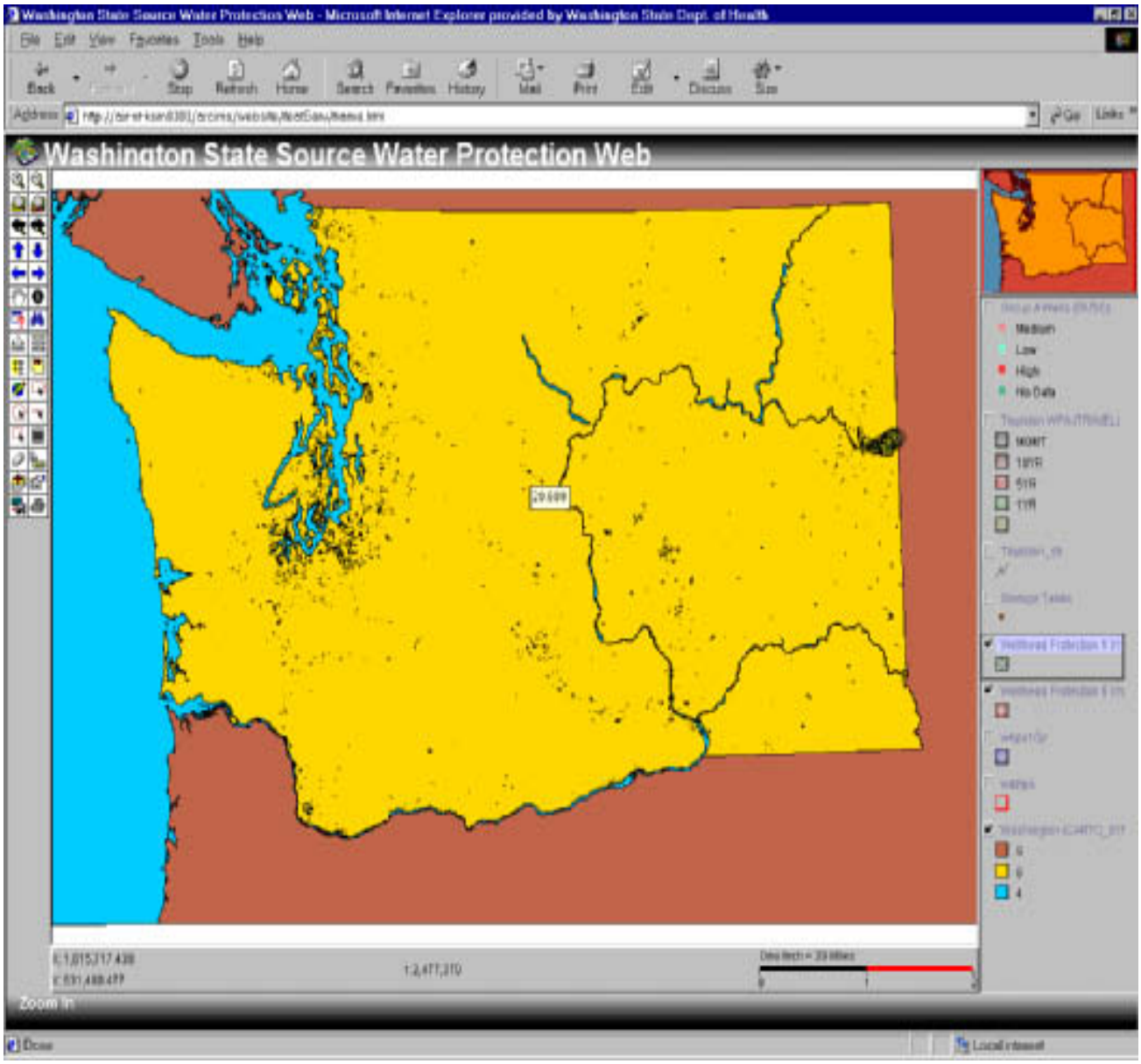

Figure 2: Query by Attribute - Simple HTML Viewer: any browser capability.

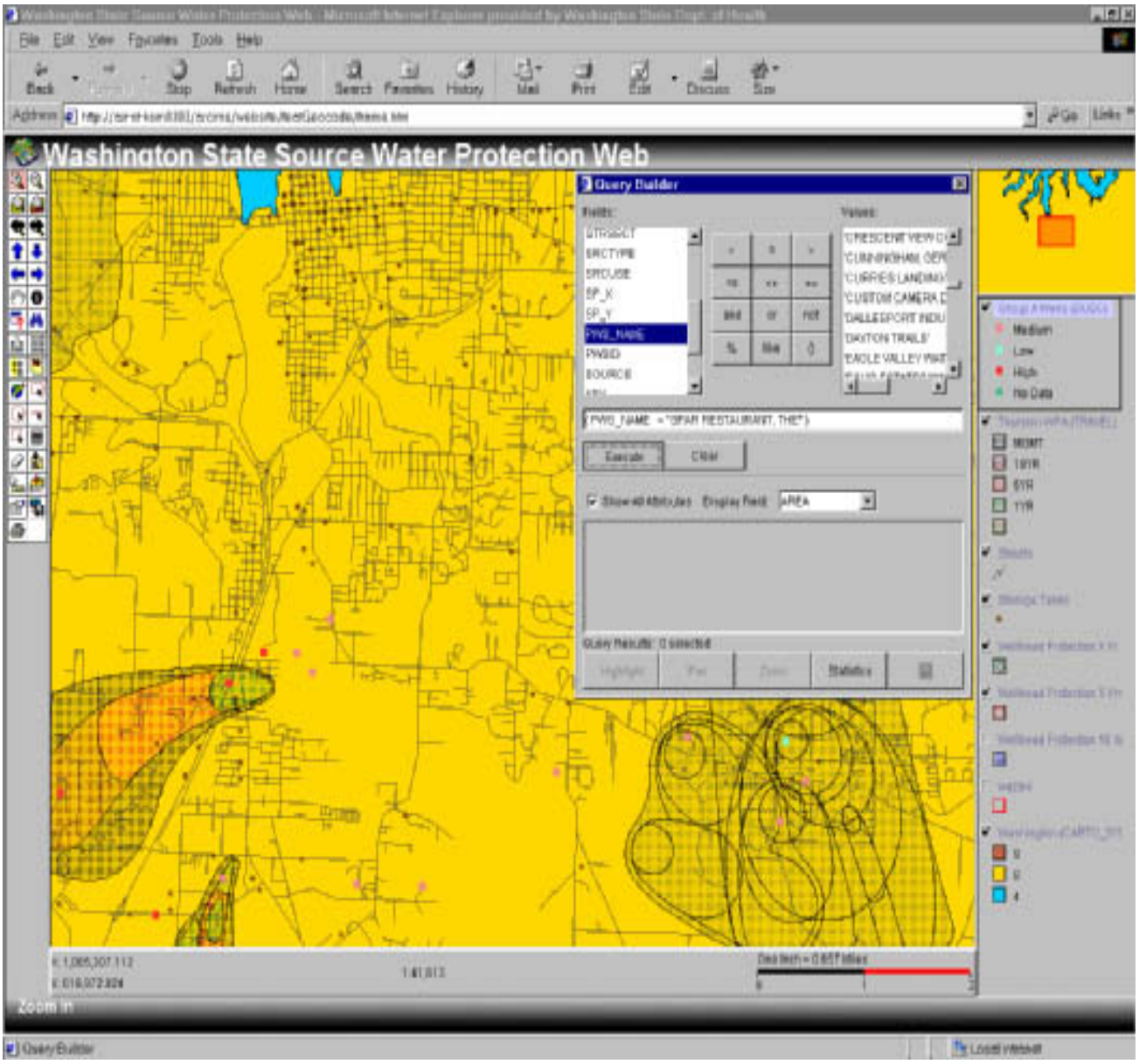

Figure 3: Advanced Browser Application Using Java - Allows users to add their own data to State data being served.