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AN INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEMS AS APPLIED TO A GROUNDWATER REMEDIATION PROGRAM

by

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ABSTRACT

While the attention to environmental issues has grown over the past several years, so has the focus on groundwater protection. Addressing the task of groundwater remediation often involves a large-scale program with numerous wells and enormous amounts of data. This data must be manipulated and analyzed in an efficient manner for the remediation program to be truly effective. Geographic Information System's (GIS) have proven to be an extremely effective tool in handling and interpreting this type of groundwater information. The purpose of this paper is to introduce the audience to GIS technology, describe how it is being used at the Savannah River Site (SRS) to handle groundwater data and demonstrate how it may be used in the corporate Westinghouse environment.

INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEMS

A geographic information system (GIS) is a computer based system for the capture, storage, retrieval, analysis and display of diverse types of spatial data. A GIS makes possible storing hundreds of different kinds of data and viewing all or some of them in a clear, integrated display. GIS is one of the fastest growing branches in the computer field, with continually expanding applications. GIS uses range from monitoring groundwater contamination to finding the most direct police routes during emergencies to planning new housing subdivisions.

The needs of the user dictate how the system will be developed. The system consists of four basic components: software, hardware, data, and people. All of these components are closely integrated with each contributing to the overall performance of the system.

Software

The software is the set of instructions which allow the user to manipulate the map and data files. Of the GIS software packages currently available, Environmental Systems Research Institute's (ESRI) ARC/INFO is the leader in the market. ARC/INFO's powerful functions coupled with it's flexibility have made it the standard in GIS technology. For these reasons, SRS has chosen ARC/INFO as their primary geographic information system, and will be the GIS referred to in this paper.

Hardware

Recent developments in the hardware used in geographic information systems have also made GIS more readily available to users. Geographic information systems can be run on a complete range of hardware platforms, from personal computers to the largest mainframes. Faster and less expensive workstations with excellent graphics are also emerging as one of the more popular GIS alternatives.

Data

The data in a GIS can be viewed in two categories: the cartographic data which describes the location of the map features and the attribute data which describes the characteristics of these features.

Cartographic data consists of coordinates and the relationships among various features, or topology. The cartographic x,y coordinate data are used to identify geographic feature locations, and the topological data are used to identify arc, node, and polygon relationships. The cartographic data is then linked by way of common feature numbers to the attribute data. Figure 1 illustrates this basic relationship of data, which makes GIS unique. The user can graphically display a map and then retrieve information about the selected features.

ARC/INFO makes the process of digitizing maps easier with many advanced features. The software can automatically edit the digitized maps, add topological data to the various features, and calculate areas and perimeters. The system also automatically flags digitizing errors.

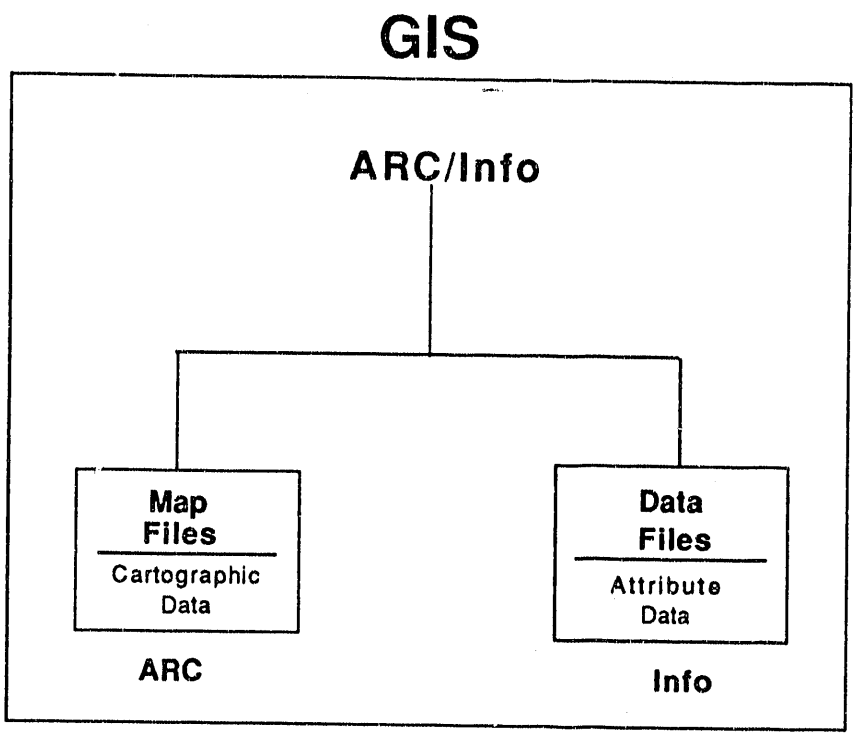

Figure 1

Data Relationship

Some existing digitized geographical data can be purchased from various sources. The U.S. Geological Survey and the U.S. Census Bureau provide such maps, as does many private companies. Information from aerial and satellite imagery is also available. The U.S. Landsat and French SPOT satellites are two such sources. ARC/INFO can accept and automatically convert data from a variety of formats, including non-topological graphic data from scanners and satellites.

Map data are organized into various layers, each representing a specific type of spatial information. A map could be separated into hydrography, transportation, man-made features, and topography. The separation of these data allows the user to selectively choose the layers they wish to view. Analysis can then be performed on these combined layers. Figure 2 shows the layering concept.

Once the map database has been completed, maps can easily be kept current. Maps can be edited, by adding, moving, and deleting features interactively or by using batch programs.

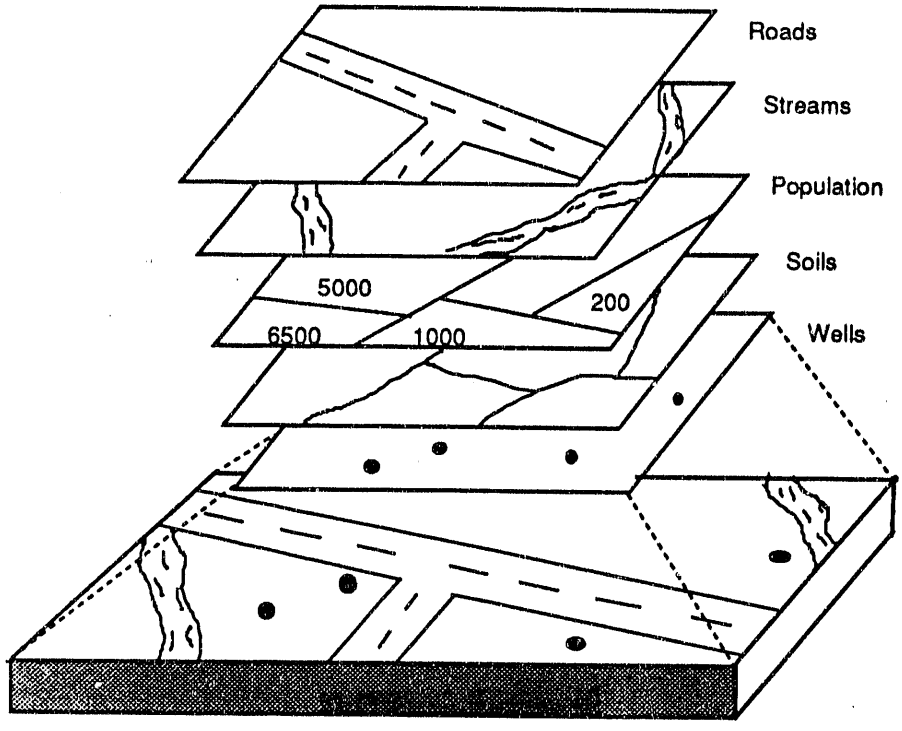

Figure 2
GIS Data Layers

One method for keeping maps current is to use an Erdas system with ARC/Info, which allows users to superimpose satellite images on a digitized map of the same area. The user can then update the map by entering the new features.

INFO is the relational database integrated into the ARC/INFO system which manages the data. Users can enter attribute data through conventional database methods or with the aid of user defined screen formats. Attribute data files can also be loaded into INFO from existing database management systems in a variety of file formats with ARC/INFO automatically making the conversions. ESRI has also developed interfaces between ARC/INFO and other database management systems. ARC/INFO interfaces are currently available for ORACLE and INGRES database systems.

People

For a geographic information system to be effective, you must have the personnel who are trained in its use. These are the experts that will customize the GIS to the organization's specific needs. They can create a user-friendly system that can be used by the inexperienced user on a daily basis to perform routine operations.

GIS APPLICATIONS AT THE SAVANNAH RIVER SITE

Introduction

The Savannah River Site (SRS), which has been in operation since 1952, is a 320-square mile reservation that produces plutonium and tritium for the national defense program. As a result of past waste handling practices the groundwater at several locations on the Site has become contaminated with solvents, metals and radionuclides. In 1981 the groundwater located under the Site's fuel and target rod fabrications area (M-Area), was found to be contaminated with degreasing solvents, specifically trichloroethylene and tetrachloroethylene. Since this contamination was detected over 270 monitoring wells have been installed in this area to assess the vertical and horizontal extent of the plume. In September of 1985 an air stripping column, designed to treat 400 gpm of water, was placed into operation. Since the beginning of the clean up program over 700 million gallons of groundwater has been treated removing approximately 180,000 pounds of degreasing solvents. The groundwater clean-up program in this area is expected to continue for 30 years.

Current Uses

SRS is required, by law, to prepare quarterly and annual groundwater corrective action reports. These reports, which contain the field, hydrologic and analytical data collected from groundwater monitoring wells, are due to the South Carolina Department of Health and Environmental Control (SCDHEC) for review thirty days after the close of the quarter. Also required as part of the report are analytical data posting maps, piezometric maps for each water bearing unit and statistical data analysis designed to determine trends. The purpose of the report is to determine the effectiveness of the remedial action program.

The large amount of data involved in this program and time constraints dictate the need for managing and analyzing the data in an efficient and timely manner. SRS implemented the ARC/INFO geographic information system into its groundwater data management program. One of the primary uses of GIS is to produce the large scale maps for these reports.

Analytical data posting maps are created for trichloroethylene and tetrachloroethylene, two of the major chemical contaminants. In the past the data were hand written on copies of the base map. Now ARC/INFO automatically updates the posting maps with the current data. This reflects a substantial savings in time and greatly increased the quality of the maps.

A contouring software package named SURFER is currently integrated into the existing system to contour the groundwater elevations. This contouring was previously performed by hand. The contours are created in SURFER using a Kriging algorithm, which allows for consistent interpretation of the data, allowing the human biases to be eliminated. A BASIC program is then used to convert this contour data from the SURFER format to the ARC/INFO format. This contour data file is then loaded into ARC/INFO and used to create water elevation contour coverages. These coverages are overlaid on the base maps for the M-Area.

Another use being developed is a GIS project for emergency response. This system, which is tied into the National Weather Service data bank, would allow tracking of toxic gas releases and be able to direct emergency vehicles to the site and surrounding areas in the most efficient manner.

Future Uses

The need for good quality environmental data that is consistent site wide and accessible to all users, was recently identified. As a result of this need a Sitewide Environmental Data Management Committee was formed. The mission of this group is to identify all environmental data bases at SRS and transfer them to a central computing facility. The relational database ORACAL was selected as the data manager.

The amount of environmental data has greatly increased in recent years and a more efficient method to handle these data is needed. Therefore, a site-wide GIS system plan has been initiated at SRS and will be interfaced with the ORACAL environmental database system. This system will be connected with the site wide Local Area Network (LAN), allowing a wider range of users to use this technology. Initially the system will be used for environmental issues, but can be expanded to a variety of applications.

As part of this effort, USGS has been contracted to digitize the sixteen 7.5 minute quadrangle sheets that comprise the site. These maps will provide an accurate and consistent set of base maps. Potential applications for this site wide system will include optimizing well sampling schedules and routes, and groundwater contamination modeling.

GIS is a very powerful tool for manipulating and analyzing spatial data. With the increasing demands to process and interpret data quickly and accurately, organizations need every tool they can use to achieve this goal; and geographic information systems have proven to be such a device.

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