EPA/DOD GIS PILOT FOR THE IDENTIFICATION, CHARACTERIZATION, EVALUATION, AND PRIORITIZATION OF SITES CONTAMINATED WITH RADIOACTIVE/MIXED WASTE

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ABSTRACT

The Environmental Protection Agency, Office of Radiation and Indoor Air, in cooperation with the Department of Defense, Office of Deputy Assistant Secretary of Defense for the Environment, developed an integrated data management and environmental analysis system to provide site-specific tools for decision-making at a Department of Defense installation contaminated or potentially contaminated with radioactive materials. The Radiation Assessment Data System (RADS) includes information management tools that facilitate the analysis and control of radiological and mixed waste sites. RADS has two functional levels. The first, the RADS core, consists of a geographic information system (GIS) and associated analytical tools that can be used to define and characterize a radiological or mixed waste site. The RADS core contains an advanced integration of software that includes: GIS, computer aided design (CAD), architectural and engineering and construction (AEC), scientific data management, geologic and geophysical interpretation, imaging, statistics, groundwater flow and solute transport models, radiation dose models, and relational database management. The second, or executive level, provides easy access to information generated in the RADS core and can serve as a stand-alone environmental information source.

INTRODUCTION

Remediating contaminated areas, preventing pollution of new areas, and planning future land uses is an inter-agency concern. Environmental information from a wide variety of sources that is integrated and effectively conveyed is a valuable and long-lasting tool for decision-making.

An environmental management system should provide project continuity throughout its lifetime, from sampling data to providing remedial alternatives and land use options. The flow of information within an organization must be efficient and accessible. Data must move between applications and systems, through workflows, and across disciplines, while at the same time integrating the diverse representations of environmental information: vector, raster, topological, grid, attribute, terrain, etc. Above all, the integrity and quality of data must be maintained.

To be truly effective, an environmental management system must be capable of growing as an organization's needs grow. As new requirements evolve, the environmental management system must have the flexibility to expand and accommodate new applications. An effective environmental management system must be readily adaptable by addition of simple analysis modules to provide answers to questions as they arise.

The best information management system is useless unless the right personnel in an organization have ready access to the system and the information it contains. A vital system must consist of powerful application tools needed to perform scientific data analysis for site management, and, at the same time, provide the headquarters manager a means to quickly answer questions for comprehensive decision-making.

The RADS Solution

RADS combines an analysis system with an easy to use management system. RADS provides scientists and engineers the power of GIS, CAD, and AEC technology through a relational data base interface system, and access to environmental pathway or dose assessment models.

At the same time RADS, through an executive level interface, provides:

- The ability to accurately co-register a variety of datasets in three dimensions,
- The ability to post attribute data against graphic entities on both maps and profiles,
- The ability to query the database through graphic entities (map features),
- Statistical tools for analysis and data verification,
- Custom report generation,
- An expandable database schema.

The core system is constructed to support rapid data extraction and display from complex, distributed databases. The core system also supports the generation of database reports, and the validation of data prior to input into application modules.

Applications Software

Application tools are added as modules to the RADS core and include tools for:

- Spatial analysis
- Subsurface geologic interpretation and modeling
- Terrain modeling
- Image display and analysis
- Numerical groundwater flow and contaminant transport modeling
- Site engineering
- Three-dimensional solid modeling

Integration of these application modules is achieved by adhering to a single graphics format, sharing an integrated database(s), and employing a common user interface. These features, as well as the capability of the core software to accurately compile and co-register graphics data in 3-dimensions, enables data to be moved readily between different

applications modules without lengthy reformatting or reconfiguration.

GIS and Spatial Analysis

RADS has the ability to interactively query both the relational database information and the associated graphics for information concerning a site's characteristics. The queries are simple to issue without having to know sophisticated database instruction commands, or without having to know what drawings are associated with the particular data of interest. These queries are made through a common-sense forms interface that requires no mysterious syntax, using an easy-to-follow menu that leads the user through a push-button process.

If the user decides to review another type of information in RADS, he or she simply activates another type of data and requests the specific criteria of interest. For example, only those sample values that exceeded a regulatory constraint may be of interest. The software maintains all the necessary information concerning where to find the database information and which files contain the associated graphics information so that the requested query is displayed both graphically and in tabular form. As a result, the operator is able to efficiently review any type of information pertinent to his responsibilities.

After reviewing several user-specified types of database information within RADS, the user may perform a variety of analyses either on individual data types or on a complex combination of data types. For example, the user could display the location of the ground penetrating radar survey lines and generate a buffer zone around only those portions of the line where a clay reflector was identified. The operator may then extend the query to indicate areas of contaminants that are not bounded by underlying clays and, as a result, represent a potential hazard to deeper aquifers. RADS capability of performing spatial queries enable users to evaluate several different scenarios very quickly and efficiently. Any number of data types can be utilized in the what-if scenarios, depending upon the type of data that was either collected on the site or generated by a predictive model.

Environmental projects also involve the assessment of risks and the delineation of hazards to personal property or public health and safety. RADS provides numerous analytical modules to query complex relationships contained in the database, including geographic, descriptive, and statistical data. For example, if a contaminant plume is delineated in the site assessment phase, it may be critical to notify all owners of water wells extracting from the same aquifer within a specified buffer around the plume. RADS provides topological analysis using multiple spatial operators, network routing and trace analysis, and grid cell analysis including overlay, proximity, and optimal path analyses.

Hydrogeologic Analysis

Interpretation of hydrogeological conditions is an important part of site characterization. The hydrogeological characterization process involves collecting both surface and subsurface reconnaissance information and capturing the data digitally. With RADS, subsurface data can be manipulated to produce an interpretive model. The software clearly and accurately represents subsurface interpretations in the form of stratigraphic cross sections, correlation panels, thickness maps, structure maps, and distribution maps. In all phases of the characterization, the user is provided with data at its correct 3-dimensional locations and is able to concentrate his efforts on displays of all available data including geophysical log curves, sample analysis results, descriptive information from the driller's logs, etc. Interpretations performed on cross sections are closely linked with the mapping environment to ensure consistent representation of subsurface conditions.

The hydrogeologist is able to use RADS software to generate a series of drawings representing the subsurface conditions. These displays delineate the geological units, the water-bearing units, and the various physical and chemical constituents of these units. Since the subsurface is constantly undergoing changes in response to the environment, the software provides enough flexibility to reflect changes in interpretations and updates to previous models as new information becomes available.

Modeling

The RADS environment provides mechanisms for analyzing point data and generating interpretive models that can be linked to the relational database or incorporated into more complex spatial queries. The results of graphical models can also be used an input into a numerical simulation model.

RADS includes interfaces to groundwater flow and modeling and contaminant transport software. This software interface is integrated into the RADS environment so that input of data to the model and display of results are simplified for the users. Where appropriate, required data from the database or from graphic displays are input automatically. These models allow the hydrogeolist to perform evaluations of various remedial scenarios and predict the movement of contaminants within the groundwater system. RADS facilitates comparison between measured and predicted results to allow the hydrogeologist to evaluate the validity of his models and to refine the model, if necessary.

The process of design and evaluation often involves multiple iterations of the above processes to compare several different scenarios and also to keep data current as additional information is collected on the site. An ongoing effort of comparison between predictive models and measured results will refine the models and ensure the validity of complex, multi-disciplinary analyses. RADS provides a basic environment that provides for data integration and efficient data flow into the appropriate application modules.

RADS EXECUTIVE LEVEL

While designed as a facility level solution, RADS also meets the data sharing and global availability requirements of upper management by providing a functional module called the Environmental Manager (EM). EM is a PC or workstation based module that serves as an executive level connection to radiation-related activities within the universe of sites. EM can exist as a direct interface to the RADS core or as a stand-alone module. In the stand-alone version, the EM database would be updated periodically from inputs from remote installations. Data as varied as available remedial technologies to individual facility maps with plume and contaminated site locations can be included in the EM database.

For the most part the EM database will be developed at the facility level so that each facility can use RADS to solve their individual environmental problems. For example, the facility information could be downloaded to a central

processing unit that would update the EM database and distribute it to all EM users via CD-ROM disk. There would also be an on-line feature called "CAD-Conference" that allows a senior manager running EM to access, in a read-only mode, a facility RADS database over a standard telephone line. In this way maps, model results, and specific technical information could be shared in a real-time graphic environment as decisions are made. The EM concept is meant to facilitate a network of scientists, engineers and managers working in concert to solve environmental problems at a variety of sites nationwide.

RADS APPLIED TO SPECIFIC MILITARY BASES

DOD installations were selected jointly by EPA and DOD, in cooperation with the military services, based on the criteria of being on the BRAC and National Priorities List (NPL) and having suspected radioactive contamination. Information obtained from these bases was imported into RADS, and this information was used in a series of RADS demonstrations provided to senior military service and DOD environmentalists and senior EPA officials.

These managers could use RADS, with the EM interface, to perform database queries, create maps, or generate reports. Figures 1 and 2 show a typical set of EM computer screen displays that a manager would see if he were to query the relational data base to provide a list and a map of all Air Force bases on the NPL, scheduled to close under the Base Realignment and Closing Acts, and containing potential Ra-226 contamination. All of the query functions are completed by use of pulldown menus and push button operations. Knowledge of complex computer code or commands is not required. Finally, the information is immediately available in an easy to interpret display.

More complex analysis can be performed by accessing the RADS core. For example, a waste landfill potentially contaminated with radiation was identified at George AFB. This site had been in use until the 1960s and radioactive electron tubes and radium painted aircraft gauges were thought to have been buried there, encased in one or more steel containers. The size of the containers is known, but the exact location in the landfill is not. Air Force plans to excavate the two acre site to be sure that all radioactive material is removed before George AFB is converted to civilian use. Geophysical surveys were used in an attempt to locate the steel containers. Use of GIS technology, particularly the modeling capability provided in the RADS core was used to extract additional information from

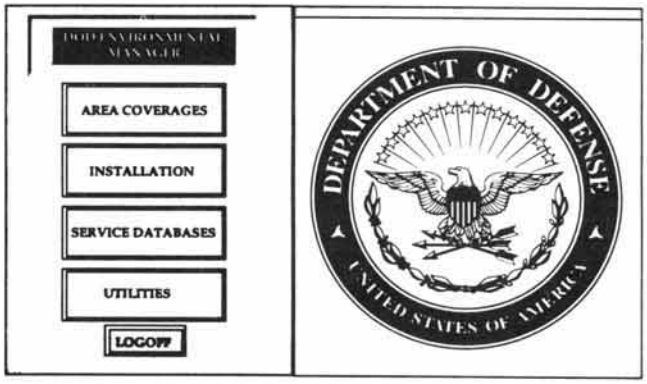

Fig. 1. The starting point of Environmental Manager provides easy to use and understand choices for the environmental manager.

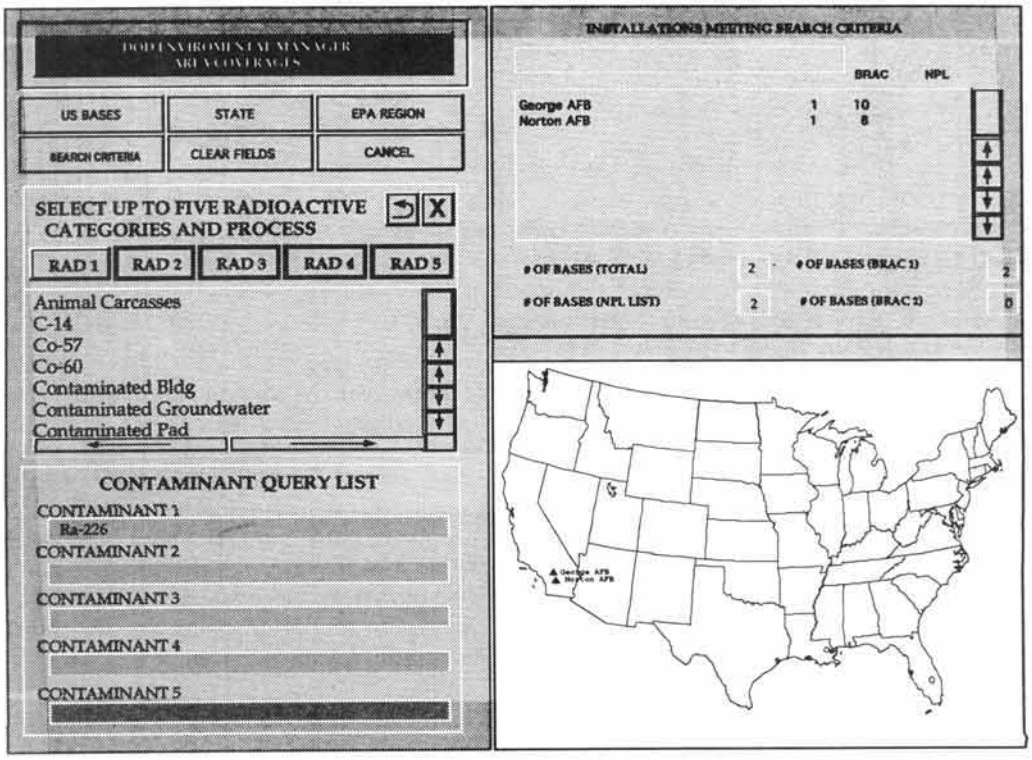

Fig. 2. Environmental Manager used to query the relational database to list Air Force bases on the NPL, scheduled to close and containing potential Ra-226 contamination.

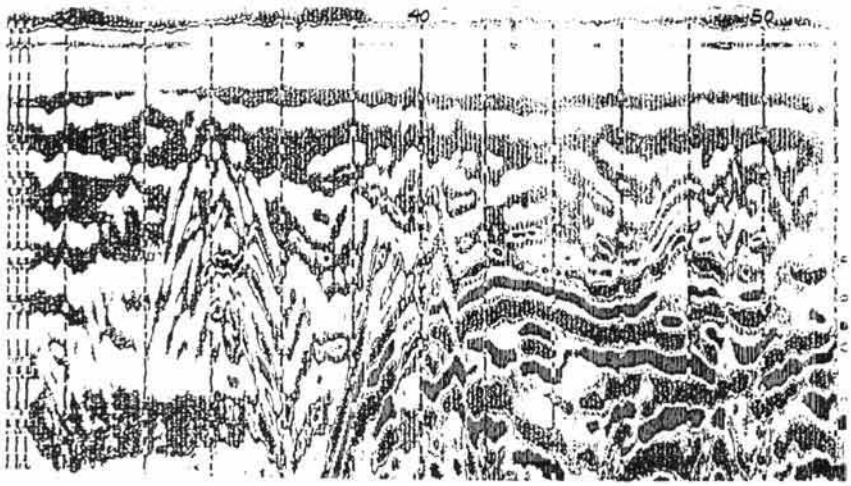

Figure 3. Typical data from a ground penetrating radar survey.

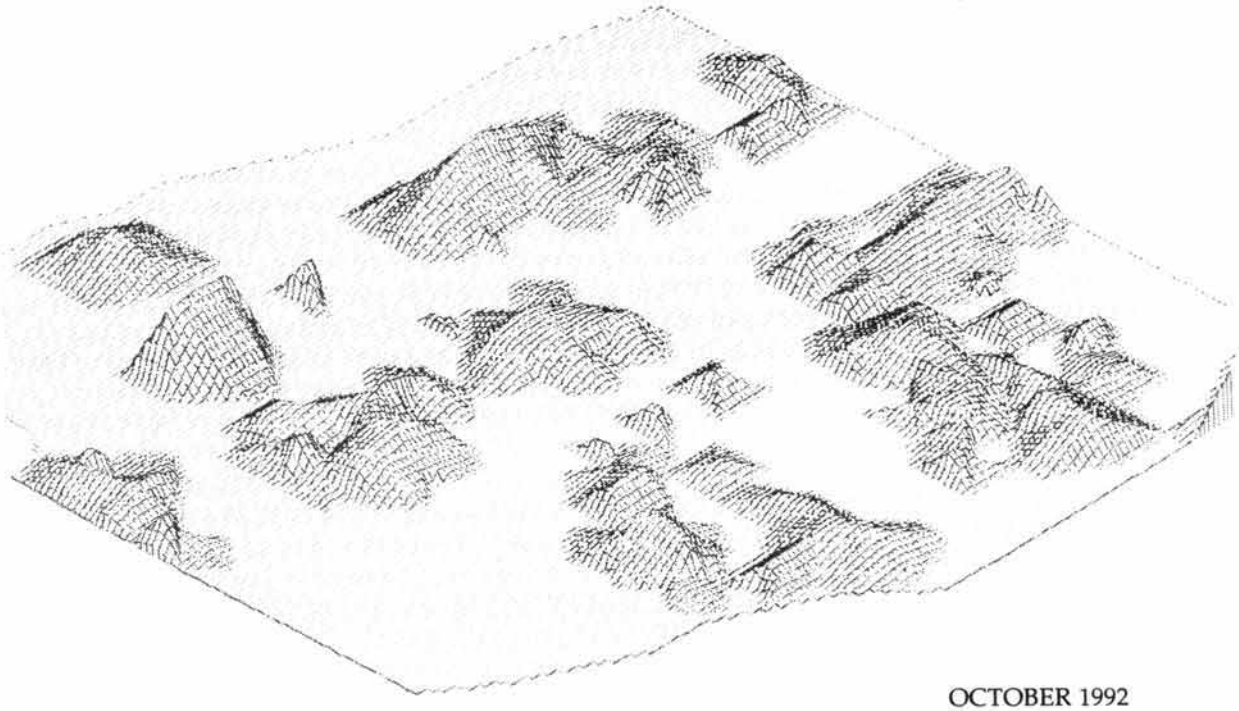

Fig. 4. GPR data from George AFB modeled in the RADS core to show subsurface volumes in a radioactive waste burial site.

the data obtained during the geophysical surveys. The results of this modeling effort of George AFB data are shown in Figs. 3 and 4. Note that the model outputs can be displayed in the EM interface. Figure 3 modeling data means little to those managers who are not familiar with this type of survey. In Fig. 4, the GPR data has been modeled using a standard RADS geophysical modeling application software program to convert the relatively unintelligible data to any easy to understand and visualize format. This particular application can help reduce the costs of excavation by showing the subsurface volumes. Knowing the size of the buried containers, Air Force personnel may be able to eliminate many of the possible volumes as too small to hold the containers.

CONCLUSION

RADS was intended to demonstrate the utility of GIS technology in assisting the DOD with remediation of military bases contaminated with radiation/mixed waste. It also has proven its capabilities for including chemical contamination, and can be applied to a variety of sites nationally and internationally. By constructing easy to use and understand user interfaces, EPA and DOD have brought the power of GIS to the desk of the senior environmental manager. RADS can be used directly by these managers to perform simple or complex queries, to support decision-making and to communicate information in a manner that enhances understanding.