INFORMATION MANAGEMENT SYSTEMS FOR INTEGRATING THE TECHNICAL DATA AND REGULATORY REQUIREMENTS OF ENVIRONMENTAL RESTORATION ACTIVITIES

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ABSTRACT

Current environmental regulations require that comprehensive planning be conducted before remediating a hazardous waste site to characterize the nature and extent of site contamination, calculate the risk to the public, and assess the effectiveness of various remediation technologies. Remediation of Department of Energy (DOE) sites contaminated with hazardous or mixed (containing hazardous and radioactive constituents) wastes will require the effective integration of scientific and engineering data with regulatory and institutional requirements.

The information management challenge presented by waste site cleanup activities goes beyond merely dealing with the large quantity of data that will be generated. The information must be stored, managed, and presented in a way that provides some consistency in approach across sites, avoids duplication of effort, and facilitates responses to requests for information from the regulators and the public.

This paper provides background information on the regulatory requirements for data gathering and analysis for environmental restoration activities, and outlines the data and information management requirements for completing the pre-remediation phases of an environmental restoration project. Information management systems for integrating the regulatory and institutional requirements of the environmental restoration process with the technical data and analysis requirements are also described.

INTRODUCTION

When the Federal hazardous waste program was initiated, the amount of paperwork was sufficiently small to allow the program managers to keep track of the enforcement activities. As the program has grown, however, so have the concerns about information and data management and the need for standardization. Currently, data and information management has become an overriding concern in the Superfund program. Recent Environmental Protection Agency (EPA) panels have recommended that more emphasis should be placed on data collection efforts and on making the most effective use of the data that are collected.

The management of the vast amount of information to be gathered and utilized in the DOE environmental restoration program is a major challenge for the agency. Some data bases, analytical tools, and communication networks have been developed which address various pieces of the information management problem. No system yet exists to integrate these individual components into a comprehensive system that is capable of supporting both the technical and management information requirements of the DOE Program. This paper describes the information management challenge for the DOE environmental restoration program and some of the technical approaches available or under development for meeting this challenge.

REGULATORY REQUIREMENTS FOR ENVIRONMENTAL RESTORATION ACTIVITIES

The Comprehensive Environmental Response, Compensation, and Liability Act(1) (CERCLA, otherwise known as Superfund) and the Resource Conservation and Recovery Act(2) (RCRA) are the principal federal statutes prescribing how the nation's hazardous waste problem will be addressed. CERCLA focuses on remediation of old, usually abandoned, hazardous waste sites. The primary goals of RCRA are to ensure the safe disposal of currently generated hazardous waste and the environmentally sound operation of waste treatment, storage, and disposal facilities. Amendments to RCRA in 1984 also authorized an extensive corrective action program for RCRA-regulated facilities. This corrective action program closely resembles the CERCLA remediation program in intent and function.

Federal agencies generally are subject to the requirements of CERCLA, RCRA, and relevant state laws on hazardous waste cleanup and operation of facilities handling hazardous waste. The CERCLA program is administered by EPA at the regional level. This means that to clean up a hazardous waste site under CERCLA, DOE must get approval on its process and its documentation from the EPA. Under RCRA, the process is somewhat more complicated, because RCRA allows EPA to authorize individual states to administer the RCRA program. Because few states have yet been authorized to administer the full program,

DOE must often get approval on cleanup activities under RCRA provisions from both EPA and state agencies.

There exists substantial overlap between the requirements of the RCRA corrective action program and the CERCLA program, particularly when remediating a contaminated area next to an operating facility. Sites associated with currently operating facilities normally will be subject to RCRA corrective requirements. "Abandoned" sites or spill sites not associated with a currently operating facility usually will be addressed under CERCLA. Because decisions on compliance strategies for various sites are still evolving, those involved in the technical assessment of the sites and the data gathering for support to compliance documents often need to meet the requirements of both laws. Early attention to the requirements of both laws early in the engineering process can save time and money later in the remediation process since it is unclear for many DOE sites which law they will be subjected to for a particular release site.

The CERCLA and RCRA processes require an extensive planning, characterization, and assessment activity before actual site cleanup can begin. This process is referred to as the remedial investigation/feasibility study (RI/FS) process under CERCLA. Under RCRA, the analogous process is called the remedial feasibility investigation/corrective measures study (RFI/CMS). The objectives of the activities conducted within these processes are to assess the nature and extent of the environmental problem at a site, identify the regulations and requirements that will be used to guide cleanup, and evaluate the technology alternatives and costs proposed for cleanup. An important part of the process is the involvement of regulators and the public in determining the problems at a site and in developing a reasonable solution for cleanup. The appropriate regulatory agencies and public parties must agree with decisions at specific points in the RI/FS process before work can proceed.

INFORMATION REQUIREMENTS FOR ENVIRONMENTAL RESTORATION

A diverse set of technical and regulatory data must be collected and analyzed to complete the requirements of the remediation process. To reach a cleanup decision, site characterization and assessment must be conducted to determine the nature and extent of site contamination, calculate the risk to the public, and assess the effectiveness of various remediation technologies. To be effective, an information system must be capable of dealing with the magnitude of the data that must be collected while at the same time meeting both technical and management needs.

The Nature and Magnitude of the Information

The type of data required includes scientific information gathered from the site, such as the results of physical sampling tests (e.g., geologic core sample data, chemical analyses of water and soil samples, etc.); institutional data, such as community issues and relevant regulations for setting cleanup targets; engineering information (technical characteristics, feasibility, costs, etc.) on potential remediation technologies; and data on the potential chemicals/constituents of concern at a site (chemical forms, health effects, potential pathways, etc.). These data are gathered throughout the preremediation process, which may stretch up to seven years for complex sites, and is continually being updated as new information is obtained. In addition to the data gathered throughout the process, a number of technical models and tools, such as risk assessment models, are utilized to obtain the input required for decisionmaking.

The information used in these analyses and to support decisionmaking must be of a high quality, to withstand the technical questioning of outside parties, and must be presented in a number of forms, to communicate with the technical reviewers, the regulatory agencies and the publics involved in the decisions about site cleanup. Technical data collected at a site must be provided to the EPA, the state and the public at various stages of the remediation process.

The information requirements to complete the planning, characterization, and assessment activities for a hazardous waste site can be immense. For each remedial investigation report, there are an estimated 2500 data records, for each of 15 to 150 variables. For a feasibility study report, this number is expected to double. The average RI/FS report is 1500 pages long, with supporting information housed in rooms of file cabinets. The average administrative record for a site going through the RI/FS process consists of more than 170 linear feet of boxes of paper. This amount of documentation is required to complete the activities for the planning process; supporting data and documentation during actual remediation will likely be much larger(3).

The gathering, use, and storage of data are even more important for DOE given the visibility of its sites and the problems it faces in convincing the public that the program is being conducted in a responsible manner. Between major documents required for the process, and the backup data and analyses required to support the administrative records, DOE could face the handling and storage of up to 2.5 million pages of information each year(3). This figure is based on the number of DOE sites and on previous experience at Department of Defense (DOD) sites thought to be representative of the complex federal sites DOE will be

addressing. Of particular concern will be providing for the quality assurance of data that is to be used to support regulatory documents, and providing the traceability to decisions that may have been made years previous in the process and to the data supporting those decisions. Current schedules for completion of The RI/FS or RFI/CMS activities for most DOE sites span from 2 to 7 years(4).

Technical Information Needs

In conducting the remedial investigation and feasibility study, field personnel need the ability to store and retrieve large volumes of site data, the ability to maintain a traceable work record, and access to data bases and tools that allow them to screen and analyze appropriate remediation alternatives based on the characteristics of the site and the relevant regulations. These needs lead to the following specific information system requirements.

Data Quality. The public needs the confidence that cleanup decisions are being made on the basis of the best data available, and data of a certain quality. The quality assurance and control issue arises from the fact that DOE waste sites will be addressed by a number of individuals residing in different organizations and that sources of data may range from laboratory tests to engineering judgment based on data for similar situations. In collecting and entering data as part of the information base for a site, DOE will need to be able to attach a quality level to the data along with an identifier that indicates the data source.

Access to Data and Analysis Tools. There will be a need to efficiently access and link information from diverse data sets in the analysis process. These data sets might include commercial data bases providing information on applicable statutes and regulations, technical information generated at other sites, or technical information produced by different contractors within the same site. The data are also required input to a number of analytical tools and predictive models, and must be in a form to facilitate such use. Many of the data bases to support the environmental restoration program are under development or exist across the DOE complex.

Linking Decisions With Data. At each stage in the RI/FS process, decisions must be made and documented. Because the data set associated with site characterization and cleanup is continually evolving, it is important to be able to track each decision to the data set that was available at the time when the decision was made. Given the scrutiny that each decision is likely to receive by both EPA and by the public, and possibly the courts, it is important to have the documentation readily available to support the decisions that are made.

Management Information Needs

To support the management needs of DOE, the information system should support both vertical and horizontal information management. Vertical information management refers to the ability to access, aggregate, and communicate information between levels in the management hierarchy. Horizontal information management refers to the ability to access, aggregate, and communicate information among users at the same level within the management hierarchy (e.g., between operable units).

Vertical Information Management. Planning and tracking is typically coordinated at the site level, with individual release site plans abstracted and integrated for reporting to headquarters (HQ). There is currently no standard format for collecting or transmitting this information. The ability of DOE to effectively integrate these reports and provide documentation on the program at a national level is thereby limited. Standardization will be needed among sites with respect to how information is stored, what information sources are used, and how information is used to make key decisions such as identifying relevant regulations and cleanup criteria and screening remediation technologies. In addition, standardization of reporting information, at least for the documents required by the RI/FS process would be useful. If DOE receives the same types of reports from each of the sites in the same format, DOE and EPA/state staff will be able to conduct their reviews more quickly, thus streamlining both the review schedule and the cost.

Horizontal Information Management. Each DOE site will be required to complete the same regulatory process. As remediation decisions and actions are undertaken at individual sites, the opportunity exists to share knowledge gained at one site with other sites and thereby avoid costly duplication of effort. Currently, information sharing among sites occurs somewhat serendipitously and depends upon individual relationships. Information on new technologies is typically disseminated in technical reports and presentations and may not reach the appropriate audiences or have the complete content or documentation needed to make a decision to consider the technology as a remediation option. The transfer of technology and information across sites can increase the effectiveness of the DOE environmental restoration program and reduce costs.

CURRENT APPROACHES TO INFORMATION MANAGEMENT

The current state of information management for environmental restoration is a result of the efforts of government agencies and their contractors to manage the enormous amount of information with existing technology and scarce

funding. Many information management systems and databases exist at many different levels of complexity and quality assurance. The major components currently in existence or under development for site waste management or environmental restoration include sitewide databases of site characterization data, data management systems, and centralized databases. These components tend to address one aspect of information management, but no system yet exists which integrates the individual components into a single system capable of supporting both technical and management requirements.

The site specific data required for characterization and restoration of DOE hazardous waste sites are being collected and stored on many different computer systems throughout the DOE complex. Each system is uniquely defined by the type of computer hardware/software used and the type and quality of the data stored. This variability makes data access difficult and time consuming and the quality of the data is sometimes difficult to determine. Because of the difficulty inherent in accessing or retrieving data from many different systems some of the sites are working toward sitewide centralized databases. These databases will contain site characterization data which previously existed on several different computer storage systems and are brought together in a relational database for greater control of data quality and validation and to facilitate access to all data relevant to remediation activities. These sitewide databases such as those being constructed at Hanford (Hanford Environmental Information System) and Idaho National Engineering Laboratory (Environmental Restoration Information System), are designed to aid researchers and engineers working at the operable unit level as well as provide access to scientific data to those responsible for oversight and to regulatory agencies.

Many of the large environmental contractors have developed data management systems which access available government and commercial databases, such as EPA's Integrated Risk Information System (IRIS), and store, retrieve, and analyze site specific data. These systems tend to be unique to the contractor and proprietary.

The need for storage and access to environmental data of value to all hazardous waste sites and the need for quick access to information by overseers and regulators prompted the development of large centralized data bases such as EPAs' Alternative Treatment Technology Information Center (ATTIC) and the DOE Hazardous Waste Remedial Actions Programs' Waste Information Network (WIN).

The ATTIC system is designed to provide a single searchable source for information used to identify alternative treatment technologies for hazardous waste. The primary component of the PC based system is the ATTIC database which contains technical abstracts and report summaries obtained from the EPA SITE program, state alternative treatment programs, treatability studies, private industry and the Department of Defense. Other resident data bases address treatability, soil transport and fate, hazardous waste collection, and remedial action costs. The ATTIC system also provides access to the Record of Decision (ROD) Database at Research Triangle Park, the Technical Information Exchange (TIX), the Office of Solid Waste and Emergency Response (OSWER) Bulletin Board, and several commercial databases(5).

The DOE Waste Information Network consists of a centralized database and electronic mail and bulletin board functions. WIN is used to provide tracking and planning information to DOE HQ, operations offices, and the DOE Ad Hoc Waste Operators Committee. The information contained in the databases pertains to hazardous and mixed waste management and hazardous waste site remedial action activities. The primary focus of the WIN system has been information management for DOE waste management activities; however, a remedial action database is currently being developed. The Environmental Restoration Remedial Action Data Base, developed under HAZWRAP (Hazardous Waste Remedial Action Program) and the Environmental Restoration Remedial Action Program (ERRA), will provide information to support DOE-HQ in tracking funding, tasks and milestones associated with DOE site restoration activities. A Technology Data Base is being developed to provide a compilation and technical description of available technologies for processing wastes from active generation or from remedial activities and provide some technology screening capability(6).

INTEGRATED INFORMATION MANAGEMENT

The information supporting the DOE environmental restoration program must be stored and managed in a way that provides some consistency in approach across sites, avoids duplication of effort, and facilitates responses to requests for information from the regulators and the public. The design of the information system to support this activity can be a critical part of achieving a cost-effective system to support engineering activities and compliance. Because of the number of contractors and different technical approaches that are being used to manage the data and information at DOE sites, there is the potential for experiencing the same program implementation problems that have plagued EPA. The Superfund program has long been criticized for inconsistency in the approaches used to select cleanup standards and final remediation technologies. Failure to build off the experience of other contractors and the

lack of effective technology transfer has increased EPA program costs.

Implications for Information Management

A number of difficult technical questions will need to be addressed in order to effectively utilize existing site databases, central databases, and analytical tools within an integrated information system developed to support the achieving the goals of the environmental restoration program. These include the following: 1) the portability of information across multiple software and hardware platforms; 2) the physical distribution of information systems; and 3) the need to provide for visualization of scientific and textual information.

Portability. The problem of dealing with the portability of information across the multiple software and hardware platforms currently in use and being developed across the complex must be resolved in order to integrate systems (e.g., the Oak Ridge Waste Information Network) that are already in existence, with new systems developed for use by DOE. Portability is also an important consideration in the design and evolution of new technologies (both software and hardware).

Centralized versus Decentralized. Another issue is how to deal with the physical distribution of the information systems and the databases associated with these systems. Under the DOE environmental restoration program more than 3600 release sites will need to be characterized and assessed to determine the appropriate remediation action. These release sites are aggregated into approximately 330 operable units, managed by a variety of Management and Operations (M&O) contractors at 19 facilities distributed throughout the United States. The M&O contractors report to eight different DOE field offices, which in turn report to DOE headquarters.

EPA's experience reveals clearly the need for coordination of site planning, characterization, and assessment activities at the national level(7). While there is a need for centralized coordination, the issue of how much of the information management function should be centralized continues to be discussed. The cost effectiveness of a fully centralized approach is also questionable given that each site would still need to maintain its own data base in addition to the one centrally maintained. The dual systems would exacerbate the data quality issue, particularly if the site systems and the central system contain differing information as a result of data entry errors or differences in the timing of system updates. Decentralized systems reinforce a tendency for each site to "reinvent the wheel," which can be costly, and present barriers for sharing information among sites.

Visualization. Given the diverse needs of the users of information and their varying experience levels, scientific and textual information will need to be visually displayed in different ways and at different levels of aggregation.

Information Management System Architecture

The Environmental Restoration Information System (ERIS), proposed for development by Pacific Northwest Laboratory and Argonne National Laboratory, would integrate and enhance ongoing information management activities across the DOE complex. By coupling technical data with regulatory compliance and administrative data within the context of a generic system architecture, ERIS can provide an effective solution to many of the information management issues discussed earlier. ERIS will build upon the local national site specific databases such as HEIS and interface with the centralized, databases such as WIN and ATTIC. A new concept in system architecture will be required to support such a system.

Within ERIS, technical workstations would be networked with management workstations throughout the DOE complex to address the information needs of DOE managers and site characterization, assessment and remediation contractors. Technical workstations at the operable unit level would provide:

- entry to data bases of information collected by the end users within the context of standard formats and with built-in quality assurance checks;
- decision support and decision documentation;
- a consistent user interface to existing data bases (e.g., WIN and ATTIC) and verified analysis tools;
- rapid aggregation, analysis, and presentation of data;
- incorporation of existing and future application programs.

Management workstations at the field offices and headquarters would enable aggregating information from the technical workstations for the purpose of planning, tracking and reporting and for disseminating guidance and standards throughout the complex. Both the technical and management workstations would be heavily based in interactive graphics utilizing advanced computer visualization technology (such as geographic information systems) so that users can more readily and accurately manipulate, interpret, and communicate environmental restoration information.

The generic system architecture that is independent of, but adaptable to, a variety of application codes (e.g., groundwater models, risk assessment models, etc.) is a vehicle for dealing with the portability issue associated with the physical distribution of existing components. Within

ERIS, each site could maintain its own site-specific information in a standardized format that would facilitate retrieval and integration with data from other sites. Central data bases would contain information relevant to all sites (regulations, cleanup criteria, technology data).

CONCLUSION

Environmental restoration requires collection, storage, and retrieval of many types of environmental data as well as information generated for management of the restoration work, documentation of analyses and decisions, and reporting. Site specific environmental data and technology assessment information is required by scientists and engineers working at the operable unit level. Aggregated site data and scheduling and tracking information is required for oversight at the field offices and at headquarters.

The information management challenge presented by waste site cleanup activities is not simply a matter of dealing with the large volume of the data that will be generated. The diversity of these data, and the need to utilize them in a long-term, interactive decision-making process, present challenges for the handling and control of the information. As the volume of information continues to grow, the lack of standardization and compatibility of current systems used to manage the information will become more and more apparent.

ERIS would complement existing systems, such as WIN, by providing network access and gateways to these data bases and information systems without requiring wholesale restructuring of systems that are already in place. The ERIS architecture will also provide a mechanism for incorporating new application programs as the environmental restoration program evolves, allowing the output of these tools to be managed in a consistent manner and minimizing training required to learn new tools.

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