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APPLICATION OF EnviroTRADE INFORMATION SYSTEM FOR THE CLEANUP OF THE FORMER SOVIET UNION (FSU) SITE AT KOMAROM BASE, HUNGARY*

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Abstract

During a NATO Advanced Research Workshop (ARW) held in Visegrad, Hungary, June 21-23, 1994, portions of contamination data from the Former Soviet Union (FSU) site at Komarom, Hungary were used to demonstrate the international EnviroTRADE Information System as a tool to assist with the identification of alternative cleanup measures for contaminated sites. The NATO ARW was organized and conducted by the joint Florida State University and the Technical University of Budapest, Center for Hungarian-American Environmental Research, Studies, and Exchanges (CHAERSE). The purpose of the workshop was to develop a strategy for the identification and selection of appropriate low-cost and innovative site remediation technologies and approaches for a typical abandoned FSU site. The EnviroTRADE information system is a graphical, photographical, and textual environmental management tool under development by the U.S. Department of Energy (USDOE) at Sandia National Laboratories (SNL) as a part of the cleanup program of the nuclear weapons complex. EnviroTRADE provides a single, powerful, multi-purpose, multi-user, multi-media, and interactive computer information system for worldwide environmental restoration and waste management (ER/WM). Graphical, photographic, and textual data from the Komarom FSU site were entered into EnviroTRADE. These data were used to make comparative evaluations of site characterization and remediation technologies that might be used to clean up primarily hydrocarbon contamination in the groundwater and soil. Available Hydrogeological and geological features, contaminated soil profiles, and topographical maps were included in the information profiles. Although EnviroTRADE is currently only partially populated (approximately 350 technologies for cleanup are included in the database), the utility of the information system to evaluate possible options for cleanup of the Komarom site has been demonstrated.

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Introduction

Purpose: This paper highlights some of the applications of the EnviroTRADE Information System for potential site cleanup requirements and describes how the tool can be used to clean up a contaminated site near Komarom, Hungary. It describes the capabilities of EnviroTRADE as a tool for environmental scientists, engineers, and planners in developing a typical remediation effort.

Background: The U.S. Department of Energy (USDOE) is committed to remediation of waste sites throughout its complex by the year 2019. Examples of remediation problems are volatile organic compounds (VOCs) in soils and groundwater, soils contaminated with radionuclides and heavy metals, and mixed waste sites containing both hazardous and radioactive waste. Waste management problems include characterization, monitoring, treatment, and disposal of wastes. Environmental technologies must be identified and developed that will facilitate the remediation of these existing problems and minimize future waste streams.

DOE's Office of Technology Development (OTD) recognizes that it can accelerate the technology development efforts and enhance the expenditure of available funds through international cooperation among government entities, private industry, and educational institutions. Promising foreign technologies are being considered for application in the United States, and the USDOE hopes to involve the private sector in the application of U.S. technologies abroad. Consequently, OTD is sponsoring the development of EnviroTRADE - an international information system that facilitates the exchange of environmental restoration (ER) and waste management (WM) problems and technologies worldwide [1], [2].

NATO Advanced Research Workshop: A NATO Advanced Research Workshop was held in Hungary to prepare a technical report that recommends a procedure for cleaning up typical abandoned sites in the Former Soviet Union (FSU) [3]. This workshop was supported by USDOE's Office of Environmental Restoration and Waste Management (EM), Office of Technology Development (OTD), under the International Technology Coordination Program (USDOE/EM-52.1), for cooperative activities on NATO site restoration and relevant technologies. The Center for Hungarian-American Environmental Research, Studies, and Exchanges (CHAERSE), established jointly by Florida State University and the Technical University of Budapest, was responsible for planning and organizing this NATO workshop.

The EnviroTRADE Information System was presented and described at the NATO workshop using data from an FSU military installation at Komarom, located about 40 kilometers from Budapest, Hungary [3]. A temporary EnviroTRADE workstation was also installed by SNL at the Technical University of Budapest (TUB) for demonstration during the NATO workshop. The system was populated with the Komarom Base site data, and the attending participants were able to obtain first-hand experience operating the system for data retrieval and applying characterization and remediation technologies. The Komarom Base site was visited by the workshop participants and used as a model for evaluating ER/WM problems and applying technological solutions. More than 40 technical experts representing numerous NATO (including the United States) and Central and Eastern European countries made presentations, had discussions, and jointly developed generic procedures for ER/WM applications at some potential 170 FSU abandoned sites in the region.

EnviroTRADE Information System

System Description: The EnviroTRADE Information System contains profiles of domestic and

foreign ER/WM problems and technologies [1]. It offers an alternative to searching manually through masses of written documents. The system's unique architecture and the easy-to-use interface allow the user to locate specific site descriptions or technology profiles by searches based on attributes such as waste type, soil conditions, and location of contaminants. Users are able to identify matches between worldwide problems and available or emerging technologies. For example, a user may browse through the information on "Available and Applied Technologies," select a particular technology for viewing, and then request that the system locate environmental problems that might have use for the technology. Conversely, the user may browse the information on "Environmental EM Problems," select a particular problem for viewing, and request that the system provide information and contacts for applicable technologies. Each technology profile includes performance information, cost and availability, technical contacts, and drawings and photographs. The system is able to compare candidate technologies from the point of view of effectiveness, availability, safety, public acceptance, and cost by the operator manually reading profiles and information. Where matches between problems and existing technologies cannot be found, the system identifies the potential for development of new and innovative technologies to address environmental problems. EnviroTRADE also provides general information on international energy and environmental organizations, sites, activities, and contacts.

EnviroTRADE is being developed on a Reduced Instruction Set Computing (RISC)-based UNIX workstation platform [2]. A relational database management system (RDBMS) is being used to store, manage, and retrieve information. A graphical user interface (GUI) communicates with the RDBMS to provide user-friendly "point and click" menus in a standard windowing environment. The system is easy to use and provides visually oriented information such as maps and photographs or diagrams of environmental sites and technologies, as well as text profiles of the problems and technologies. The prototype runs on a SUN workstation under the Open Look window manager as a stand-alone system. The system design is based on a client/server model that can be maintained and delivered over a network when the information base is large enough to require that architecture.

Capacity and Capability as an Environmental Tool: The EnviroTRADE Information System utilizes the capabilities of a geographical information system (GIS) viewer to manage and display any spatial data that might be associated with an entry in the database. When GIS views are available, a button appears in the GUI that allows the user access to the spatial information. This information might be in the form of a map that displays and describes environmental contamination at sites, in rivers, and over large land areas. Because the USDOE is funding the identification and restoration or management of sites within its complex, many of the national laboratories and other sites are capturing this spatial information using GIS software. These views, or appropriate subsets of views, can easily be embedded in the EnviroTRADE information base.

System Status and Potential Commercialization: The transfer of appropriate USDOE technologies that have the potential to benefit the private sector is a priority of the USDOE, and EnviroTRADE is one of the technologies being considered for transfer to industry. Commercialization involves identifying potential private investment partners, determining their level and nature of interest, and eliciting their guidance on the requirements that such a system must accommodate. If the current commercialization negotiations are successful, a private partner(s) would help develop and manage a commercial version of the EnviroTRADE system. Cooperative Research and Development Agreements (CRADAs) or other mechanisms would be used to formalize the relationships among the participants.

Future Plans and Programs: The USDOE recognizes the great need to have easy access to large volumes of accurate, current, affordable, and integrated information on environmental

waste problems, technological solutions, and development efforts within the weapons complex. A long-term effort is needed to share and integrate environmental information and resources across the entire complex [2]. Information on waste sites must be organized and made accessible, and technologies within the USDOE and private sector matched to these problems. Regulations must be considered, and management tools made available.

An integrated system of data and decision support tools will also provide knowledge beyond matching of technologies to waste sites. It will allow for successes beyond the use of the raw data alone. Patterns in data may be discovered and intelligence can be applied to the information. Redundancy of cleanup efforts can be minimized and government funding used as effectively as possible. The USDOE/EM decision makers require methods for analyzing existing problems and technology development efforts to determine if their environmental needs are being addressed in the most efficient manner. Waste site managers, technology developers, and the private sector, including universities and other laboratories, need access to information about environmental research projects and performance of existing remediation technologies. In addition to these customers, the potential exists for use and expansion of the environmental information system by U. S. Department of Defense site managers and regulators such as the U. S. Environmental Protection Agency.

Komarom Site Database

Site Description and Former Use: In Central and Eastern Europe, abandoned FSU military sites constitute a serious and widespread environmental problem. In Hungary alone, there are more than 100 of these sites. This environmental problem is aggravated by the economic difficulties of the countries in the region, which allows the application of only the most cost-effective remediation technologies. The proposed demonstration project would involve the comprehensive cleanup of one of these sites in order to demonstrate an effective and affordable approach to such activities [4]. The Hungarian Environmental Authority has recommended that the Komarom site be used as a target site for a regional demonstration project.

The city of Komarom, near the northern border of Hungary, is the site of two abandoned former Soviet military bases, both of which show extensive contamination of soil and groundwater by various hydrocarbons associated with motor fuels. The Komarom site consists of two subareas: the Monostori Fort and the Arpad Army Post. Following the withdrawal of Soviet troops from Hungary, these military complexes were evaluated and found to be extensively contaminated and in poor states of repair [4].

The Monostori Fort was built during the last century by Italian army engineers. It is one of a number of military installations in a chain of forts built every 6-10 km along the Danube River to defend the Austro-Hungarian monarchy from possible attacks from the river. The Monostori Fort is one of the largest of the fortifications (58 hectares) associated with this defensive chain of military establishments. It is located approximately 150 m from the Danube and is considered a valuable military-historical monument.

From the early 1950s until 1990, twelve (12) hectares of this facility were used by the FSU military as one of the largest ammunition storage areas in the region. Military activities associated with the use and subsequent abandonment of this site led to a large amount of hydrocarbon contamination. This has adversely affected groundwater resources and threatens the quality of the Danube River, which serves as the source of drinking water for cities along its course.

The Arpad Army Post was a garrison of approximately 28 hectares in the heart of the city of Komarom. The adjacent lands are densely populated residential areas. At this site, the FSU military repaired vehicles, fueled them, and stored fuel and oil. As a result of these activities, the soil and groundwater throughout the site are highly contaminated, and the contaminants are known to have reached the drinking water wells of nearby residences. This discovery resulted in the intervention of the Hungarian Ministry for Environment and Regional Policy (MERP).

Preliminary Site Evaluation: The MERP conducted preliminary site characterizations in 1991 to define and assess the extent of contamination of groundwater and soil at both sites. Soil and groundwater samples were taken as part of the initial site investigation. All samples were analyzed for total hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), phenol, and benzopyrene. Selected samples were also analyzed for Cr, Ni, Cu, Zn, Cd, Hg, Pb, and As. The results of this investigation identified several specific areas within these two sites as needing further study.

At the Arpad Army Post, 45,700 m^3 (representing a surface area of 25,500 m^2, to an average depth of 2 m) of hydrocarbon-contaminated soil are associated with three main pollutant sources. Hydrocarbon concentrations range from l,000 to 8,000 mg/kg. The total mass of hydrocarbons contained in the soils is estimated to be 82,250 kg. An estimated 350 kg of free product are floating on top of the aquifer.

At the Monostori Fort, 29,400 m^3 (representing a surface area of 10,700 m^2, to an average depth of 2.8 m) of hydrocarbon-contaminated soil are associated with two pollutant sources. Hydrocarbon concentrations are similar to those found at the Arpad Army Post and the total mass of hydrocarbons contained in the soils is estimated to be 53,000 kg. The dissolved hydrocarbon concentration in the groundwater ranges from 1 to 10 mg/l. An estimated 10,900 kg of free product are floating on top of the aquifer. The human health hazards associated with these contaminated sites include the migration of contaminants off-site and the resultant contamination of drinking water wells, the Danube River, and its associated drinking water function.

Komarom Base Site Information in EnviroTRADE: The Komarom base site information has been incorporated into EnviroTRADE. There is a general overview of the site, as well as detailed descriptions of both Monostori Fort and the Arpad Army Post included in the information system. Site maps, drawings of cross-section hydrogeology, and photographs are also included with the text descriptions. Technical contacts are listed, and important elements have been extracted and coded with the profiles.

The Environmental Research Laboratory (ERL) at the TUB has been involved in environmental research and development, and two technologies under development were added to EnviroTRADE. The first characterizes in situ hydrocarbon contamination in soils, and the second characterizes and monitors air pollution. Both technologies are organized under a general description by the TUB, and technical contacts are provided in all of the profiles. The TUB technologies are among several worldwide technologies identified by EnviroTRADE for potential application at the Komarom Base site.

Additional information from the Komarom base site will be added to the EnviroTRADE system. These include the relative ranking of subareas with regard to cleanup priority and the various approaches selected for cleanup. A critical next step will be the development and input of a quantitative evaluation of the potential risks posed by these sites. This will include estimates of exposure concentrations for potential receptors (human and nonhuman) in all relevant media, as well as the selection of exposure scenarios. Upon completion, the Komarom base site

profiles in the EnviroTRADE system will contain a comprehensive collection of site-specific text information, maps, photographs, drawings, and possibly video pictures.

TUB Workstation and Current Database: The EnviroTRADE demonstration system was on loan from SUN Micro-Systems. A permanent system installation is currently subject to USDOE evaluation and approval, and will depend also on the availability of alternative funding sources. Proposed plans include the installation of a central region node at the TUB with subnodes at other institutes within the countries of the Central and Eastern European region, depending on expressed needs and interests. Although considerable interest was expressed at the NATO workshop in using EnviroTRADE to assist with the cleanup of Former Soviet Union military sites in the region, further review of the requirements and funding actions are pending.

Evaluation of Remediation Requirements

Cleanup Requirements: The Monostori Fort is owned by the Hungarian government. The site is intended for use as an historical monument, museum, hotel, and meeting facility to be operated by the City of Komarom. The Arpad Army Post is jointly owned by the local government of Komarom, an association of private property owners, and a number of private companies. The future uses of this site are under discussion.

During 1992 and 1993, some remedial measures were taken at the sites. The last leaking underground storage tanks were removed. At two areas, where the hydrocarbon contamination was the most significant, 5 pumping wells were established. During almost a two month period, 7,500 m^3 of groundwater were treated using a phase separation technique. Some 1.7 m^3 of free product (oil) were removed. The first phase of the contamination isolation effort was finished in mid-December 1992. In 1993, the second phase of the work was implemented when another 2.24 m^3 of groundwater were pumped out of 10 wells in the Monostori Fort. Some 7.4 m^3 of oily emulsion were removed.

The planned actions following the preliminary assessment include: (1) conducting a full assessment, including sampling, analytical evaluation, risk assessment and prioritization, and cost evaluation; (2) performing groundwater decontamination activities; (3) cleaning up contaminated soil; and (4) evaluating results. Unfortunately, a lack of financial resources has prevented further remedial activities, despite the extent and nature of the contamination.

For the phases described above, in addition to funds, technologies are needed which allow the appropriate degree of characterization and remediation at minimal cost. Therefore, following the assessment phase, a detailed analysis of traditional and innovative technologies will be carried out. Different areas of the Komarom Base site will be addressed (for demonstration purposes) using different technologies in order to evaluate and compare their effectiveness. In situ technologies will be preferred (e.g., groundwater pumping and treatment, bioremediation, and vapor extraction technologies). The evaluation of results to be conducted during the last phase will include both the effectiveness of the methods used and a cost and risk evaluation.

As an integrated demonstration project, the Komarom Base site will illustrate full remedial activity for a very common and acute environmental problem of the region. The site could be used as a field laboratory for testing and evaluating low-cost technologies which could then be transferred throughout the region for further application. In selecting these candidate technologies, the EnviroTRADE system can be used as a clearing house for the worldwide exchange of environmental restoration information, helping to match technologies with site problems and criteria.

Conclusions

There are some 170 FSU sites similar to Komarom in the Central and Eastern Europe region that might require cleanup in the near future, depending on the needs of the land and the longer term interests of the country involved. The successful demonstration of EnviroTRADE's capability and the documentation of its advantages and utility in the NATO report may have a significant impact on its potential application throughout NATO, in the Central and Eastern European region, and elsewhere in the future.

The modular architecture of the system allows additional decision support tools to be implemented in the future. Such tools could include the ability to: (1) rank appropriate technologies at a site based on user-specified criteria; (2) analyze and view flow and transport processes at sites; and (3) calculate the health effects of potential exposures to pollutants at the sites.

EnviroTRADE's ability to match the needs of a site with a technology will make it an invaluable tool in remediation efforts worldwide. Using the system, waste site managers with similar environmental problems will be able to identify each other and share successes and failures in applying different technological solutions. In addition, technology developers will be able to identify areas needing new technologies as well as areas in which existing technologies need to be improved.

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