Journal of Environmental Sciences Vol. 11, No. 4, pp. 432—442, 1999

ISSN 1001—0742
CN11—2725/X

Article ID: 1001-0742(1999)04-0432-11

Managing international collaboration for the development and application of environmental technologies: opportunities for China & other Asia Pacific countries

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Abstract: Increased international cooperation in the field of contaminated site management has resulted in the formation of numerous networks and fora. The key benefits of increased co-operation are perceived to be in the reduction of duplication in efforts, particularly related to industry, in the co-ordination of contaminated site research, policy development and information dissemination. The paper introduces and briefly discusses key networks and collaborative projects currently in operation throughout the world relating to contaminated site management. The experience shared within these groups should prove useful to the application of such environmental problems in China and the Asia-Pacific region.

Key words: contaminated sites; technology transfer; soil remediation; contaminated soil; risk assessment

CLC number: X-1 **Document code:** A

Introduction

As a result of an increased awareness of pollution and subsequent environmental contamination, the level of cooperation between countries and organizations in the field of contaminated land management has increased immensely. The benefits from collective and shared expertise in this technology- and science-dependent field are clear. This increased cooperation is evident at the country, regulatory, industry and research levels. One of the major outcomes of this is the emergence of networks to enhance the exchange and collaboration between organizations working in the field of soil contamination and impinging areas (Kasamas, 1998a).

This paper introduces and briefly discusses key networks and collaborative projects currently in operation throughout the world relating to contaminated site management. These have contaminated land assessment, risk assessment, and remediation as their major focal areas. Indeed there are numerous networks, in many varied forms and media, in contaminated site management and related fields including conferences on contaminated soil and water, remediation technologies and risk assessment. These mechanisms for international cooperation, which have an emphasis on technology transfer at the level of individuals, have not all been discussed here.

The networks and collaborative projects have been detailed on a geographic basis, in particular those originating and predominantly active in Europe, the United Kingdom, and the United States. It should be recognized that these boundaries do not limit the scope and coverage of the networks and many cut across continents and interest areas. This increased collaboration will enhance the extent of successful transfer of environmental technologies into China and the Asia Pacific region, an area which currently is seeking much attention(Guerin, 1998).

1 The European Union

There are numerous networks operating throughout the European Union. The key focus of the European Union-based networks is the emphasis on contaminated site and risk assessment (Kasamas, 1998b). The diversity of networks and action groups reflect the many aspects of soil contamination being faced and addressed in the European Union. This wide diversity of networks has arisen as a result of heightened environmental awareness and concomitant financial contribution by the European Commission.

1.1 CESER

The CESER (countermeasures: environmental and socio-economic responses) program was established to deal specifically with the safety and environmental health effects relating to the operation of nuclear reactors and contaminated land resulting from their operation (or malfunction). CESER is currently developing countermeasures that can be used in the event of a nuclear accident, to reduce the entry of radionuclides into the human foodchain (Salt, 1998). CESER recognizes that long-term contamination of agricultural land may require measures such as deep ploughing, application of special fertilizers, changes in the feeding of livestock, or changes in land use. CESER is assessing the potential environmental and socio-economic impacts of such countermeasures. The major anticipated outcome of the program will be a computer-based decision support system for the management of radioactively contaminated land.

The overall objective of this program is to pursue an approach to nuclear safety, which encompasses all its facets, ranging from the utilization of nuclear energy to medical applications and other uses of radioactive materials. Research and technology development activities currently underway relate to the following five topics : (i) "Exploring new concepts" in order to address the three main concerns: reactor safety, the management and disposal of long-lived radionuclides, and the risk of diversion of fissile materials; (ii) "reactor safety" the aim being to acquire a better understanding of the mechanisms of severe accidents, in order to improve safety measures and prevention; (iii) "radioactive waste management and disposal" the objective of which is to address issues relating to the disposal of long-lived radioactive waste (safety aspects of geological disposal, retrieval of waste, and the safeguarding of spent fuel) and the decommissioning of nuclear plants in order to close the nuclear fuel cycle; (iv) "radiological impact on humans and the environment" in order to improve our understanding of the mechanisms of radiation action (such as in-utero effects and impacts on DNA) in order to eliminate, or at least reduce, induced effects on health and establish safety standards for the protection of the public (especially in industry, medicine and energy production); and (v) "historical liabilities" given that the situation in Central and Eastern Europe remains a source of concern where nuclear safety is concerned. In view of the historical context and its geographical proximity, the European Union aims to establish collaborative projects with the Central and Eastern European countries, with the emphasis on radiation protection, waste management and site restoration.

1.2 CONCAWE

CONCAWE (or conservation and clean air and water in Europe) is the oil companies' European organization for environment, health and safety (Crawford, 1998). CONCAWE was established in 1963. Most oil companies that refine crude oil in Western (OECD) Europe have chosen to be CONCAWE members, several of them continuously so since 1963. Furthermore, the possibility of associate membership for Eastern European oil companies has recently been opened up. It is all of these companies that contribute the essential resources to keep CONCAWE viable. The annual costs of CONCAWE and the people who contribute management and technical expertise to CONCAWE on a part-time basis are major commitments. What member companies also gain by working cooperatively through CONCAWE is elimination of the replication of many tasks which each company would otherwise have to do for itself such as responding to industry or government position papers, changes to legislation, and introduction of codes of practice. In the field of environment, health and safety, the involvement of a wide range of scarce specialists is necessary. Both the quality and the quantity of what is done are enhanced by fielding the companies' experts together in teams which are well managed to obtain timely results.

In the past, some countries have set fixed numerical criteria to decide on whether remedial actions are necessary. These limits are based on generic assumptions on site conditions such as: soil type, depth to groundwater, geology and hydrogeology, and proximity to potential receptors (e.g.

water well, basement, and surface water body). Such an approach ignores the fact that contaminated oil industry sites vary widely in terms of complexity, and the potential risk they may pose to either human health or the environment. As fixed numerical criteria are nearly always set at very low levels to ensure safety, their use has led to the clean up of more land than may be necessary. The result is wastage of industry resources (and ultimately added expense to the consumer) conducting clean up with no incremental reduction in risk to human health and the environment.

In recent years, the principles of risk-based corrective action (RBCA) have been applied in a number of countries in Europe and in North America where it has been developed by the American Society for Testing Materials (ASTM). This follows a flexible approach to decision making whereby corrective action is appropriately tailored to site-specific conditions and hazards(ASTM, 1995; 1998). This leads to more cost-effective solutions, and allows the greatest effort to be applied where it is most beneficial. In its broadest sense, risk assessment in relation to contaminated land can be defined as "an evaluation of whether there is a potential for adverse effects to occur, based on factual knowledge about a site, scientific theories concerning the environmental behavior and toxicity of the chemicals present, assumptions which have to be made where there is a lack of site-specific data, and predetermined acceptability criteria".

Many CONCAWE member companies have been involved with this US-based ASTM activity but realized that there are a number of differences between the two continents and even within them (Crawford, 1998). CONCAWE has aimed to develop similar techniques for Europe and they have therefore established a task force to carry out this work and produce a guideline setting out the approach, which could be adapted to the situations prevailing in the various European countries. This guideline describes a 3-tiered approach to corrective action decision making. The CONCAWE guideline is built on the premise that one begins with relatively little site data (using conservative generic assumptions) and, through additional investigation and analysis, progresses towards more site-specific knowledge and less conservatism. The result is an equal level of protection of human health and the environment throughout Tiers 1, 2 and 3 (Crawford, 1998). The 3-tiered approach in the guideline starts with an initial assessment of the site, which involves gathering general data including potential sources of contaminants, obvious evidence of contamination, landuse, and presence of potable groundwater. The pathways by which contaminants could reach populations and environmental compartments at risk are also identified. In Tier 1, chemical data on the degree of contamination of the site is collected and compared with risk-based screening levels (RBSL) and other relevant criteria follow this initial assessment. The RBSLs comprise of a set of trigger concentrations for contaminated soil and groundwater. These figures are not intended to be soil standards or clean up targets. If exceeded, they are simply an indication that further study is required. RBSLs are derived using conservative assumptions and contaminant migration models and, as such, are based on a generalized risk assessment. If the observed values are below these levels, then the risk will be insignificant. In Tiers 2 and 3, the assessment involves refinements of the study to take into account more site-specific considerations, with the possible collection of additional data. The actual environmental compartments and populations at risk are identified, along with the possible pathways. These pathways are modeled to prepare quantitative risk estimates, which can be compared with acceptability criteria. There is an option at the end of each of these tiers to develop a corrective action program based on remediation to the newly derived Site Specific Target Levels (SSTL). Corrective actions can include taking no action or instituting a long term monitoring program, akin to natural attenuation.

1.3 NICOLE

NICOLE (or the network for industrially contaminated land in Europe) is an industry-driven network, which has as one of its aims as identifying the research needs from an industry

perspective, particularly in the European Union. NICOLE organizes and conducts technical meetings where key contaminated land issues are debated. Many questions about the tools for risk assessment of industrially contaminated land were raised and discussed by 80 participants at the 1st workshop of NICOLE Working Group 2-Contaminant behavior and risk assessment. The workshop took place in France in November 1996, and was jointly held with the CARACAS network (introduced and discussed later in this paper). First, CARACAS members described the contaminated land policy of different countries and the associated risk assessment methods. The approaches of site owners to different aspects of risk assessment and their experience from administrative, industrial and research points of view were also considered. Linking the 2 networks during this first workshop was an ideal opportunity for both NICOLE and CARACAS to promote technical and scientific exchanges between policy makers, scientists and industrialists. The NICOLE interest areas have been divided into 4 groups to work on the following specific themes: toxicology and ecotoxicology; fate and transport; exposure evaluation; risk communication.

The main objective was to agree what is needed to reach a consensus on risk assessment of industrially contaminated land in Europe. The ten top priorities for each theme and an overall top ten was selected by the industrial members and the Scientific Advisory Group and finally discussed in a plenary session. The top ten research priorities identified were: study of natural attenuation; validation of available risk assessment models; development of toxicological and ecotoxicological tools for risk assessment; data collection for exposure assessment; study of environmental significance of leaching tests; development of sensitivity analysis for pathways and contaminants; merging of networks for contaminated land issues; fundamental study of fate and transport processes for exposure assessment; development of adapted in situ monitoring techniques for the fate and transport of pollutants in the environment; environmental significance of treatment residuals.

1.4 CARACAS

CARACAS (or the concerted action for contaminated sites in the European Union) is an initiative within the environment and climate program of the European Commission Directorate General (DG) XII. There are 16 European countries participating in the CARACAS project with scientists from national environmental authorities and research organizations. CARACAS co-ordinates current research initiatives on contaminated land risk assessment in Europe and identify priority research tasks for future research and development programs. CARACAS is funded by the European Commission DG XII within the environment and climate program (1994—1998) and supported by the participating countries. The key areas addressed in the CARACAS program are as follows: the nature of contaminated land site characterization; bioavailability of contaminants in soil and groundwater for estimating bioavailable fractions in the environment; fitness for use/human health risks; ecological risk assessment; risk perception and communication; remediation technologies and monitoring remediation.

NICOLE's focus is primarily on industrial sites still in use or owned by industry, whereas CARACAS has the broader perspective of governments who have to make decisions within a national contaminated land policy and planning framework. Together the 2 concerted action networks identified very similar areas, which would benefit from further research and development initiatives(Kasamas, 1998).

The scientific cooperation in Europe successfully established through the CARACAS project has led to the development of another concerted action: CLARINET, the Contaminated Land Rehabilitation Network for Environmental Technologies, which was launched in 1998. The primary objective of CLARINET is to develop technical recommendations for sound decision making for the rehabilitation of contaminated sites based on current scientific knowledge. CLARINET aims to bring together the combined knowledge of academics, government experts,

consultants, industrial landowners and technology developers. Three particular aspects of contaminated land rehabilitation will be examined within this project: risk assessment; remedial technologies; and decision support issues, including economic, societal and political dimensions. CLARINET aims to elaborate the scientific basis underlying the rational management of contaminated sites(Kasamas, 1998).

The action programs, NICOLE, CARACAS and CLARINET, are networks established under the European Commission's DG XI and XII. The DG XI mission is to ensure: a high level of environmental protection, improvement of the quality of life, increased environmental efficiency, and preservation of the rights of future generations to a viable environment and ensuring equitable use of our common environmental resources. The DG XII develops the European Union's policy on research and technological development. It supplements national research efforts, strengthens the scientific and technological bases of European industry, and supports the policies followed by the European Union in its major fields of jurisdiction (including environment, health, education, and energy).

1.5 The Common Forum

The Common Forum for Contaminated Sites in the EU is an informal group formed for cooperation between the EU ember states, the European Commission and the European Environment Agency on contaminated land issues (Kasamas, 1998). The inception and first meeting was held in Bonn in December 1994, by the German "Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit" (Anonymous, 1994). All EU member states and the representatives of the European Commission (DG XI, DG XII) were invited to attend this international workshop titled "Contaminated Sites in the European Union: Policies and Strategies". The main objectives of the Common Forum were identified in this workshop as follows: to facilitate the understanding of each member state's approach to tackling the problem of contaminated land; to identify with the European Commission thematic areas of transnational interest where an EU-wide cooperation would be beneficial; to establish a common forum with delegates from EU member states to discuss the results of the DG XI study "Survey of European Union member states: contaminated land" and to develop recommendations to identify an EU-wide co-operation in the area of contaminated sites.

In this forum, member countries are able to raise issues pertinent to contaminated land management. This is commonly done at the Common Forum meetings. In the Bonn meeting final document, the delegates agreed that this cooperation should continue with regular meetings as a Common Forum. The Environment Ministries of the Netherlands, Germany and Austria jointly organized the second meeting in Maastricht, the Netherlands, in October 1995. The topics reflected the main concerns in contaminated site management and these were identified as follows: financing of remediation activities; lessons learned from the management of remediation projects; monitoring, control and after care of contaminated and remediated sites.

Many of the member countries have difficulties in financing remedial work. The Netherlands presented their concept, which is to make different industrial sectors take responsibility for their own problems. They started with the oil industry, which made an agreement, the SUBAT, on the remediation of gas (petrol/filling) stations. This has been followed by other sectors including the state railways, gasworks sites, and laundries. So far this solution has worked well and has demonstrated a substantial reduction of effort put into administration. Limitations and constraints in the execution of remediation projects is also of particular concern. Such constraints include legal, financial, organizational, educational, technical and acceptance problems. Some of the main tasks are clear assignment of responsibilities within an organization and for the particular project and include: establishment of a powerful quality assurance staff, which focus on avoidance of errors instead of "repair" or toleration; readiness to carry higher cost for quality to reduce risk of failure;

documentation that allows thorough reviewing in all project phases; keeping and ensuring flexibility but eradicating unfocused work; strengthening the "positive" human factor (innovation, creativity, care); combating the "negative" human factor (carelessness); refinement of planning goals and solution of goal-conflicts, preparation and realization of public information and participation.

2 United Kingdom

The fora based in the United Kingdom have a major focus on contaminated land research and public involvement. These networks and groups have arisen out of a need to minimize the cost of activities related to contaminated soil management. It is also apparent that these networks emphasize the encouragement of industry involvement at the levels of fundamental contaminated site issues, including research, through to full scale implementation. The following section introduces some of these fora.

2.1 CEST

CEST is the Center for Exploitation of Science and Technology. It is a non-profit organization, registered as a charity, operating for the benefit of its members and for the public good. CEST has around 30 members, drawn from: industrial manufacturing and service sector corporates; research and academic institutions; government bodies and agencies.

The CEST mission is to identify new business opportunities for science and technology and to assist their realization by linking key decision makers in industry, research and government, helping them to identify the best options and to profit through collaborative action. CEST has been operating successfully under this collaborative advantage banner for over 10 years, based in London. CEST instigate collaborative programs, independent research sponsored by our CEST members and other initiatives, in areas where science and technology has the capacity to make substantial impacts on the economy and in society(CEST, 1998).

CEST are currently involved in developing CONSEPT, now called CLAIRE (contaminated land applications in real environments). CEST have found that the options available for contaminated land remediation were limited by the lack of proven alternative treatment technologies. Where new technologies were developed, their progress (and subsequent adoption by contaminated landowners) was often constrained by the absence of an appropriate framework for testing and validation.

The ultimate goal of CLAIRE is to assist in bringing contaminated land back into beneficial use through the development of both technical solutions and a better understanding of the problems. CLAIRE aims to establish and co-ordinate a national network of field test sites for the testing of remediation technologies to clean up contaminated land. It will provide a brokerage service between those seeking solutions to contaminated land problems, the research community and providers of treatment technologies. It is being designed to complement existing public and private sector collaborative programs in contaminated land remediation and management. Industry has involvement either as a provider of test areas (contaminated sites) or through research into, or demonstration of, remediation technology. CLAIRE is envisaged as providing an umbrella across a number of collaborative initiatives, providing consistency and cohesiveness, which should greatly improve the prospects for, and perception of the work. A consortium of UK statutory agencies and major industrial companies is supporting CLAIRE.

2.2 ISO TC 190/WG 7

This working group of ISO, TC 190/WG 7, is addressing the questions of "what is soil quality and how can it be measured?" The problem with monitoring the quality of soil is that unlike water and air there are often no immediate signs that the quality is declining. One cannot taste or smell poor quality soil as can be done with water and air respectively, and indeed there are generally

no immediately obvious health hazards as the soil quality declines as there frequently are with declining water and air quality. The answer to "what is soil quality?" lies in the domain of the politicians and legislators, and will often have different interpretations by country or region. In some cases there will be definitions of soil quality which are all encompassing such as the notion of "multifunctionality" which was widely promoted in environmental legislation in the Netherlands, where it identified the need for land to have properties so that it may be used for all purposes. In other circumstances the concern is with soil quality for a particular use or purpose, as with the "fit for purpose" approach which is widely adopted in the legislative and environmental control framework in the United Kingdom. In the United Kingdom, the concept is that different land uses may be undertaken with soil of varying quality, and therefore a soil to be used as an industrial site would generally not be required to meet the same standards as a soil at a site to be used for housing.

The International Standardization Organization established in 1985 a Technical Committee, ISO/TC 190, to consider standardization in the field of soil quality (Nortcliff, 1997). The Technical Committee is organized under six subcommittees. These subcommittees (SC) are : SC1 Terminology and Codification; SC2 Sampling; SC3 Chemical Methods; SC4 Biological Methods; SC5 Physical Methods; and SC7 Soil and Site Assessment. SC6 Radiological Methods was established during the first 10 years of the Technical Committee but was disbanded through insufficient interest in these methods(Nortcliff, 1997). The work of the Technical Committee is concerned with the standardization of methods following testing with inter-laboratory trials where appropriate. There are 3 broad themes, which guide much of the work. These themes can be broadly summarized as: presence of soil contaminants which may pose a threat to human health; presence of soil conditions which damage the potential or actual functions of the soil as components of ecosystems; the spread of contaminants from one part of the soil to another, or from one environmental component to another. The transfer may result in the situation identified in bullets 1 and 2 above.

The Technical Committee has meetings at which the progress of work in each of the sub-committee programs is reviewed and the suggestions for future work considered. The decision making progress is a complex as there are various stages in the development of a standard. Initially the proposal to work on a particular topic must be approved by all the national standardization organizations participating in the program of the Technical Committee (there are currently 45 national standardization organizations involved to varying degrees in the activities of the Technical Committee). This approval is normally sought through reference to interested persons or organizations at a national level.

2.3 SNIFFER

SNIFFER (or Scotland and Northern Ireland Forum for Environmental Research) was established in 1989 as a consortium to direct and manage research funded by contractual subscription. The consortium proved successful in establishing a business-orientated program of joint research and in building collaborative links with other organizations. In 1994, SNIFFER was reformed as a company limited by guarantee with charitable status. SNIFFER's objectives are to further: the protection, conservation and amelioration for the public benefit of the natural environment; the promotion of scientific research in areas of water, waste, air and the environment and the subsequent dissemination of the results of such results undertaken; the advancement of education for the public benefit and in particular the advancement of education in ecological and environmental studies.

SNIFFER recognizes the value of effective collaboration, in terms of a funding perspective, extension of the skills base and also staff development. SNIFFER therefore seeks to collaborate with other research-commissioning organizations, in particular: The Environment Agency, Scottish Office, DoE, MAFF, UK Research Councils, Scottish Natural Heritage and other

Conservation Bodies, and European Groups.

3 The United States

Diversity and amount of information transferred, and a drive to pursue the potential of new technologies, characterize networks and collaborative groups that have arisen in the United States. In the United States, there has been a large demand for new technologies in particular for the remediation of contaminated sites. Further, there is evidence of substantial government funding in their development. These groups are discussed in the following sections.

3.1 USEPA

The USEPA provides a key locus for numerous co-operative groups. US legislation requiring the remediation of contaminated soil and groundwater at private party sites and clean up programs on Federal government lands has been a major driver for remediation technology development in the US since the early 1980s. The USEPA's Office of Solid Waste and Emergency Response created the Technology Innovation Office (TIO) in 1990 to act as an advocate for new technologies. TIO's mission is to increase the applications of innovative treatment and field analytical characterization technologies to contaminated sites, soils and groundwater. TIO has worked with partners in other US agencies and in the private sector to improve the collective understanding of remediation and technology development and reduce the impediments to their widespread application (USEPA, 1998).

3.1.1 General overview

Within the USEPA, TIO works with other offices to: effect policy changes, assist technology demonstrations, analyze trends in technology development and use, identify the supply of technologies and vendors to the marketplace, chart the future demand for technologies, chart the cost and performance parameters, and improve the diffusion of technology-related information. Outside the USEPA, TIO works with states, other agencies, professional associations and private companies to create a marketplace with a rich diversity of cost effective solutions. The goal of these partnerships is to create an information-rich and practical network for all public and private decision-makers that affect the applications of clean up technologies(USEPA, 1998). The web site (http://clu-in.com) is intended as a forum for all stakeholders in waste remediation and contains information on policies, programs, organizations, publications and databases useful to regulators, consultants, technology developers, researchers, and remediation companies.

3.1.2 Reviewing supply and demand for technologies

TIO has recently published reports that analyze the future demand for remediation services for all major US clean up programs. These reports focus on the national perspective, as well as market opportunities in the Mid-Atlantic and Southeast regions of the US. TIO has produced 2 PC-based systems that identify technologies and vendors for remediation and field analytical screening technologies. The Vendor Information System for Innovative Treatment Technologies (VISITT 5.0) provides data on 346 innovative treatment technologies (75% of which are commercially available) provided by 210 vendors. The Vendor Field Analytical and Characterization Technologies System (Vendor FACTS 2.0) provides vendor supplied information on 129 field portable technologies supplied by 85 vendors for measuring and monitoring contaminated soil and groundwater.

3.1.3 Development of partnerships and consortia

TIO has worked with many partners to develop new technologies, demonstrate and evaluate technology performance and verify vendor performance claims. Under the USEPA public-private partnership program, TIO is working with Fortune 500 technology users, other federal agencies, and regulators to demonstrate and evaluate full scale technologies on problems of mutual concern at federally operated sites. The purpose of this effort is to allow potential technology users to help

define the parameters of the demonstration to produce information the companies need to evaluate technology for their own sites and problems.

3.1.4 Benchmarking the development of technology and its application

On a regular basis, TIO produces reports and data systems that track the development of emerging technologies and application of full scale technologies at sites. These reports are accessible through the web site. One such report is the "innovative treatment technologies: annual status report", which tracks the application of new remediation technologies at over 300 sites and details information on planned, ongoing or completed applications of innovative treatment technologies. The database contains site-specific information on approximately 400 innovative projects at sites across the United States(USEPA, 1998).

Despite the progress in using new technologies, 2 areas stand out where new methods are needed. The first is treatment of metals in soil and the other is the in situ remediation of groundwater. TIO has 2 reports that identify emerging technologies for metals treatment and groundwater remediation. "Emerging abiotic in-situ remediation technologies for groundwater and soil" describes 96 field demonstrations or full scale applications of technologies for non-aqueous phase liquids and groundwater treatment. Six technology specific reports are available on surfactant enhancements, treatment walls, co-solvents, electrokinetics, thermal enhancements, and hydraulic/pneumatic enhancements. "Recent developments for in situ treatment of metal contaminated soils" provides hazardous waste professionals with information on four emerging technologies: electrokinetics, phytoremediation, soil flushing, and solidification/stabilization (USEPA).

3.2 CRESP

The consortium for risk evaluation with stakeholder participation (CRESP) is a university-based national organization created specifically to develop a credible strategy for providing the information needed for risk-based clean-up of complex contaminated environments, especially those for which the US Department of Energy is responsible. The consortium specifically responded to the call in early 1994 by both the US Department of Energy and the National Research Council that there be created an independent institutional mechanism should be established capable of integrating such risk evaluation work. As the result of a national competition, the US Department of Energy awarded a 5-year cooperative agreement to CRESP in March of 1995. This forum is being funded to provide the US Department of Energy with an increased understanding of risk-related issues that concern waste cleanup. CRESP is to develop information and methods of analysis and prediction that will support the decision-makers involved in managing the decommissioning and clean up of American nuclear weapons production facilities.

CRESP, though not a decision maker at DOE sites, has 3 fundamental commitments: (i) to draw upon stakeholders throughout its work for the refinement of priorities and evaluation of technical data; (ii) to include consideration of social, cultural and economic values in conjunction with human health and ecosystem impacts in a risk-based decision process at each site; and (iii) to work actively with other organizations whose skills and capabilities can contribute to the improved definition, understanding, and reduction of these risks.

CRESP recognizes that the management of radioactive, chemical and physical hazards and restoration of damage at US Department of Energy sites will require a considerable ongoing effort. Thus CRESP's work focuses on the current hazards, long term impacts and the importance of expeditious decision-making and good timing in implementing restorative action. CRESP also undertakes original research projects on various scientific, technical, occupational, and behavioral aspects of risk-based environmental management. The consortium reports annually to stakeholders on its progress in developing new methods for stakeholder participation, for technical assessments and for integration of diverse information, nationally, and at various sites.

3.3 RTDF

The Remediation Technologies Development Forum (RTDF) encourages collaboration among companies, states and federal agencies in defining, prioritizing and funding new, untried concepts for clean up technologies. By consulting at the earliest stages of technology development, the RTDF seeks to combine the financial and intellectual resources to promote research co-ordination on problems of mutual interest(Bell, 1998). The forum is composed of USEPA, the US Departments of Defense and Energy, other Federal agencies, state regulators, technology evaluation and verification entities, and potential end users of these technologies to facilitate independent and expert verification of site characterization technology performance. The forum was created to increase the use of new site characterization, monitoring, and measuring technologies at clean up sites(Bell, 1998). The purpose of the RTDF is to identify what government and industry can do together to develop and improve the environmental technologies needed to address their mutual clean up problems in the safest, most cost-effective manner. The RTDF fosters public and private sector partnerships to undertake the research, development, demonstration, and evaluation efforts needed to achieve common clean up goals.

There are several action teams within the RTDF. These action teams address specific interest areas identified by the RTDF: The Bioremediation of Chlorinated Solvents Consortium is one of seven action team; The Permeable Reactive Barriers Action Team; The In-Place Inactivation and Natural Ecological Restoration Technologies (IINERT) Soil-Metals Action Team; The Phytoremediation of Organics Action Team; The Sediments Remediation Action Team.

An outcome already emerging from the RTDF is the improved efficient leverage of resources for technology development and implementation in contaminated site management and elimination of duplication of efforts by the member companies.

4 The North Atlantic Treaty Organization (NATO)

The NATO Committee on the challenges of modern society (CCMS) was established in 1969 in order to give the NATO Alliance a new "social dimension". Its aim was to deal with practical problems already under study at the national level and, by combining the expertise and technology available in member countries, arrive rapidly at valid conclusions and to make recommendations for action to benefit all member countries. The CCMS has completed 2 phases on "pilot studies on the evaluation of demonstrated and emerging technologies for treatment of contaminated land and for ground water". More than 50 different technologies were demonstrated. In March 1992, the Workplan for Dialogue, Partnership and Cooperation issued at the meeting of the North Atlantic Cooperation Council (NACC) included enhancement of participation of Cooperation Partners' experts in CCMS activities.

4.1 Organization and activities of the CCMS

The Committee meets twice a year in plenary session and annually with EAPC countries. The Committee does not itself engage in any research activities; its work is carried out on a decentralized basis, through its pilot studies(Smith, 1998). Subjects for pilot studies cover a large spectrum dealing with many aspects of environmental protection and the quality of life, including defense-related environmental problems.

Each pilot country is responsible for developing, conducting, and disseminating the results of a pilot study. Co-pilot countries and other participating countries share the workload according to their interest. The participation of NATO members and of EAPC countries in the pilot studies is always on a voluntary basis. As a part of the activities of the pilot study, workshops, seminars or international conferences may be held. Pilot countries submit reports on the progress of studies to the committee at regular intervals. On completion of a study a summary report is submitted to the committee members and then forwarded to the North Atlantic Council. A technical report is usually

also published by the pilot group and made available on a worldwide basis to anyone expressing interest.

4.2 International conferences, seminars and roundtables

One of the most important advantages of the CCMS is that it is a unique forum for discussion of environmental problems relating to military activities, an aspect, which is being successfully illustrated by the defense-related pilot studies. The effects of peacetime defense-related activities on the environment are of particular interest to experts from cooperation partners. In this respect, to further enhance exchange of information and technology in this field, international conferences, seminars and roundtables have been organized and/or co-sponsored by CCMS.

4.3 Fellowships and study visits

The CCMS sponsors a fellowship program, which makes modest grants to a number of scholars each year to encourage research, linked to the CCMS ongoing pilot projects. The program allows fellows to contribute to the work of CCMS pilot studies by conducting research under the guidance of pilot study directors and/or working as members of the CCMS pilot study teams. Fellowship awards are made to citizens of NATO countries through open competition. The deadline for submitting applications is February 28th of each year. Another scheme also exists, the CCMS study visit program, which provides financial assistance (to cover travel and/or living expenses) to experts who have difficulty in obtaining the necessary funds to attend CCMS pilot study meetings. The CCMS study visit program is open to experts from both NATO and partner countries. Requests are made to the CCMS secretariat and should be endorsed by the appropriate pilot study director and by the national CCMS coordinator.

5 Conclusions and future directions

Formal networks that address issues relating to contaminated sites and their remediation are emerging globally. The experience shared within these groups should prove useful to the application of such environmental problems in China and the Asia-Pacific region. In addition to the formal networks described, which largely operate at the international, national or institution levels, there are many other mechanisms currently in operation to enhance international cooperation in contaminated site management. For example there are several such discussion groups in operation on the internet. In these groups (while not discussed here), individuals are able to exchange ideas and formulate solutions to environmental problems (GZA-GeoEnvironmental, 1998). These "informal" networks will assist countries not directly involved in the major global initiatives in the European Union, NATO, UK or the United States, to contribute to enhanced international cooperation.

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(Received for review October 5, 1998. Accepted June 8, 1999)