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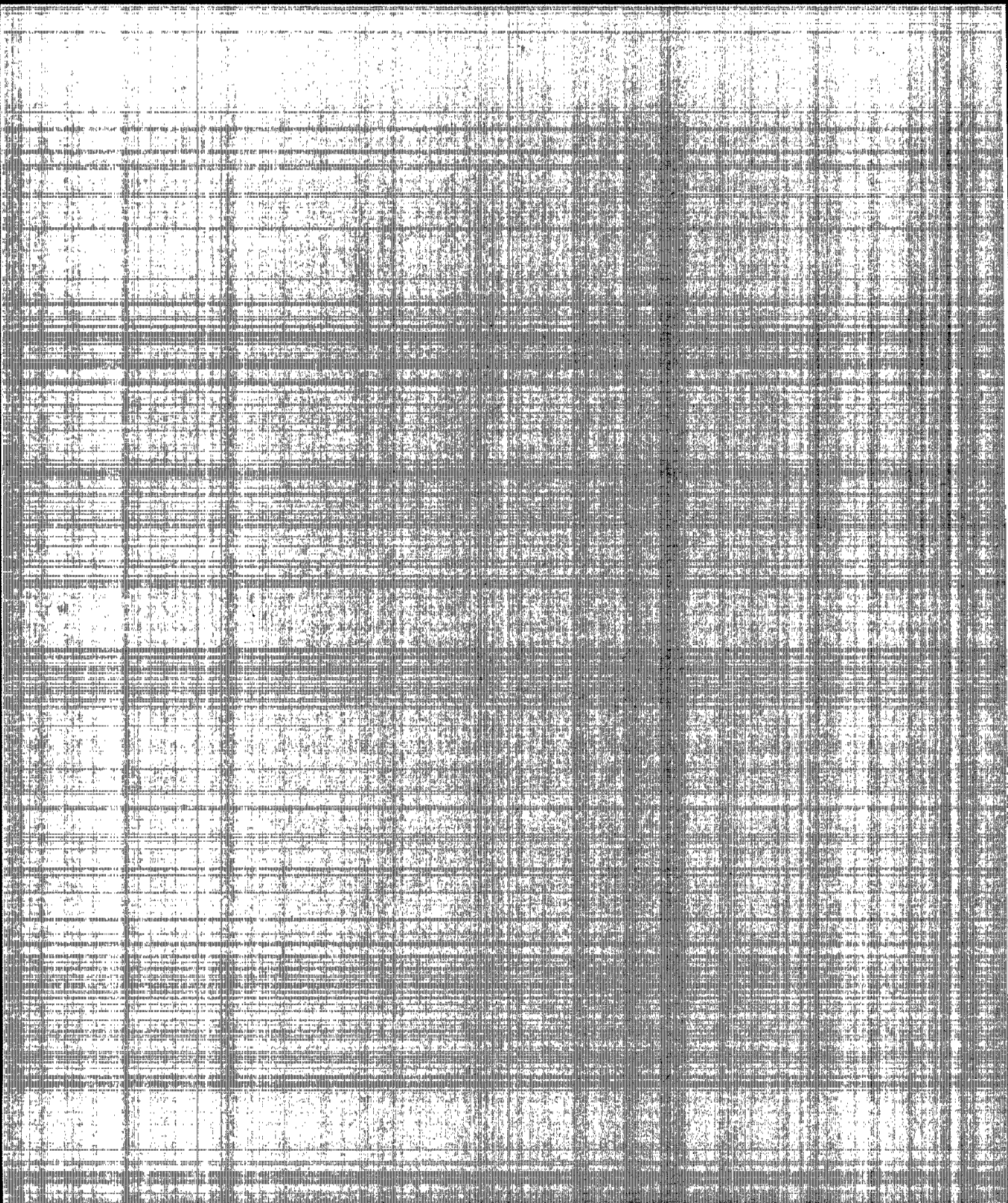
NATO/CCMS Pilot Study

Evaluation of Demonstrated and
Emerging Technologies for the
Treatment and Clean Up of Contaminated
Land and Groundwater (Phase III)

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OVERVIEW REPORT**

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NORTH ATLANTIC TREATY ORGANIZATION



**2002
Overview Report
NATO/CCMS Pilot Study**

**Evaluation of Demonstrated and Emerging
Technologies for the Treatment
of Contaminated Land and Groundwater
(Phase III)**

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NOTICE

This Overview Report was prepared under the auspices of the North Atlantic Treaty Organization's Committee on the Challenges of Modern Society (NATO/CCMS) as a service to the technical community by the United States Environmental Protection Agency (U.S. EPA). The report was produced by Environmental Management Support, Inc., of Silver Spring, Maryland, under U.S. EPA contract 68-W-00-084. Mention of trade names or specific applications does not imply endorsement or acceptance by U.S. EPA.

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INTRODUCTION

This report provides an overview of the Phase III Pilot Study on the Evaluation of Demonstrated and Emerging Technologies for Treatment and Clean Up of Contaminated Land and Groundwater. It also contains the key conclusions of the Pilot Study and recommendations for further action. Detailed information on the pilot study can be found in the annual reports located on the NATO/CCMS web site.

The Phase III Pilot Study was proposed to NATO by the United States Environmental Protection Agency (U.S. EPA) at the Committee on the Challenges of Modern Society's (CCMS) plenary session in 1997. Member countries voted on and accepted the proposal at the same meeting. Participating countries were:

- NATO: Belgium, Canada, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Norway, Portugal, Netherlands, Spain, Turkey, United Kingdom, United States.
- EPAC: Armenia, Austria, Finland, Latvia, Lithuania, Romania, Slovenia, Sweden, and Switzerland.
- Others: Australia, Japan.

The study was conducted under the joint leadership of the United States, the Federal Republic of Germany, and the Netherlands. It was co-chaired by Mr. Stephen James and Dr. Walter Kovalick, Jr., of U.S. EPA. Dr. Deniz Beten, Director of CCMS Programs, provided liaison with the NATO/CCMS secretariat. Additional information on CCMS and the Pilot Studies may be obtained from the Country Representatives listed at the end of this document.

The Pilot Study Group held a total of five meetings during the course of the study. During these meetings, countries submitted candidate projects that were discussed and voted on for inclusion in the study based on criteria agreed upon by the participating countries. In-depth interim and final report presentations on the implementation and results of these projects were made during the international meetings and summarized in meeting proceedings.

Each project was planned and executed by the responsible organization, with project funding from the various government and non-government organizations involved. The costs of participating in international meetings and preparing project reports were generally met by these organizations concerned, which in many cases were private companies.

Each international conference included host country presentations and a *tour de table*, during which member countries discussed developments in national legislation, regulations, and research and development programs. In addition, recognized experts in diverse technical fields gave invited papers related to the challenges of soil and groundwater remediation, and CCMS Fellows provided presentations and written reports on their work. These reports from Fellows were published as part of the proceedings of the international meetings.

In addition, the Pilot Study hosted a special seminar at each meeting on a technical topic chosen by consensus of the countries. Each seminar was an in-depth treatment of a newly emerging subject related to remediation with presentations by experts from industry, government, and academia. The seminars lasted one and one-half days each and, after the first year, were co-chaired by a North American and European expert. A report of the proceedings was published for each special seminar.

The Pilot Study chose to publish two documents and one CD each year to enhance the real-time nature of information transfer. The Annual Report summarized the results of interim and final project presentation reports and the *tour de table* presentation by each country. The second document was the proceedings of the special seminar. A CD was also published annually with all other meeting presentations from each year (including the Fellows) and all reports from the preceding year(s). Multiple copies of all of these documents and CD's were distributed to country representatives and NATO headquarters to insure the

widest possible distribution of the results of the Pilot Study. A final CD will be produced that documents all pilot study reporting. These reports will also be available on the NATO/CCMS web site.

The various Pilot Study activities resulted in extensive transfer of study findings to potential users of new remediation technologies and to a wider technical and administrative audience. They also increased the exchange of ideas on technology needs and fostered greater contact between experts and decision-makers within both member and nonmember countries.

1. BACKGROUND AND PURPOSE

The problem of land and groundwater contamination from improper handling and disposal of hazardous materials and wastes is faced by all countries. Many countries have committed resources to developing advanced, innovative remediation technologies and to evaluating them under field conditions. The ongoing challenge is how to maximize the value of these technology demonstrations and effectively transfer the technologies both within and between countries. In addition, there has been an increasing recognition of the need for approaches not dependent on advanced technologies and for technologies that can be cost-effectively employed in the socioeconomic circumstances of Eastern and Central Europe and developing countries, especially Central Asia.

The purpose of this NATO/CCMS pilot study was to identify, discuss, and review innovative, emerging, and alternative technologies, and to transfer technical performance and economic information to potential users of these technologies. A specific objective of the study was to identify "lessons learned" from the technology demonstrations—both the successes and those that illustrated technology failures or limitations. The latter type of information is rarely presented in conferences or discussed in the technical literature, but is very important for making informed decisions involving critical time and monetary requirements. It is also useful for defining priorities in research and development programs.

2. RELATIONSHIP WITH OTHER CCMS PROGRAMS

2.1 The CCMS Fellowship Program

The CCMS Fellowship Program made an important contribution to the success of the Phase III Pilot Study, as it did to the two earlier Pilot Studies on the remediation of contaminated soil and groundwater. It facilitated participation of several experts, including experts from countries that would otherwise not have had a presence in the Pilot Study. The participation of these experts enabled a wider range of topics to be covered.

Twelve NATO Fellowships were awarded under this Pilot Study. All of the Fellows attended one or more meetings of the Pilot Study Group and played an active part in the discussions.

The Fellows came from private, university, and governmental organizations. The following countries were represented by fellows: Belgium, the Federal Republic of Germany, Greece, the Netherlands, Portugal, Spain, Turkey, and the United States. Their activities covered a range of topics related to the Pilot Study, including an examination of the national approach to such problems as legal issues, costs and economics, innovative approaches to large-scale remediation projects, and assessment of the performance of treatment methods via modeling.

2.2 CCMS Study Visit Program

Participation by a number of individuals, including expert speakers, was made possible by the provision of travel funds through the CCMS Study Visit Program.

3. ACCOMPLISHMENTS

The Pilot Study Group examined 33 different remediation technology projects from 12 countries during the five-year program. The projects encompassed *in situ* and *ex situ* biological, physical-chemical, and thermal treatment technologies. Many of the projects involved two or more technologies, either in integrated treatment systems or in parallel treatment. The reports on these projects revealed an ongoing evolution of innovative and advanced technologies. The Pilot Study is believed to have been instrumental in facilitating this development.

Nonmember countries, including members of the Euro-Atlantic Partnership Council (EPAC) and Japan took increasing interest in and participated in the Phase III Pilot Study.

The Pilot Study was designed to provide participants with a broader view of the remediation technology development and deployment strategies of other countries to help them focus their own approaches. Technology transfer from the Pilot Study was promoted by distribution of meeting reports and CD's by the country representatives in their countries, involving members in conferences and symposia, and publishing papers in professional journals. Some examples of these activities include the following:

- Annual Reports of the Pilot Study meetings, Special Seminar reports, and CD's containing all documents on a cumulative basis were provided annually to country representatives (nominated by their respective countries for participation in the meetings) to duplicate and distribute within their countries, as needed.
- The German Federal Ministry of Environment, Nature Protection, and Reactor Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit-BMU) commissioned one CCMS Fellow to prepare a report of the meeting held in 2000 in Wiesbaden and a review of research needs. This report was circulated to national country representatives in Germany.
- During the Pilot Study meetings, participants visited waste treatment and disposal facilities, ongoing site cleanup, and research institutions. These activities stimulated the participation of private companies in the Pilot Study and enlarged the network of international experts and increased their interactions.
- The Pilot Study Director and Co-Directors developed and provided annual meeting reports and special session reports to NATO/CCMS for distribution to member and other countries.
- The Co-Directors and other members of the Pilot Study presented invited papers and special sessions at national and international technology conferences and symposia including: the 4th International Symposium on Environmental Contamination in Central and Eastern Europe (Warsaw - 1998) and the International Conference on Contaminated Soil (ConSoil) held in Edinburgh in 1998 and Leipzig in 2000.

Close liaison was maintained throughout the study with other international groups dealing with the problems of contaminated land including:

- The CCMS Pilot Study on the Environmental Aspects of Reusing Military Lands at its meetings in Warsaw and Tallinn (1998) and the CCMS/EPAC Workshop on Military Activities and the Environment in Warsaw (1998);
- NICOLE (the Network for Industrially Contaminated Land in Europe), an industry supported consortium interested in contaminated land research and remediation issues;
- The German-United States Bilateral Working Group on Sustainable Land Management, which is a joint R. & D effort of the German Federal Ministry for Education and Research (Bundesministerium

fur Bildung und Forschung-BMBF) and the U.S. EPA. The working group focuses on joint performance testing of technologies and joint development of strategies and tools for site redevelopment

Presentations and informal discussions at Pilot Study meetings by representatives of:

- CLARINET (the European Union's Contaminated Land Rehabilitation Network for Environmental Technologies in Europe)
- United Nations Economic Commission for Europe, Chemical Industry Program dealing with remediation issues
- EU Research Directorate
- UNIDO, International Centre for Science and High Technology (ICS)

Finally, the Pilot Study was instrumental in facilitating discussions and networking that contributed to the creation of the following international and national forums:

- The "Ad hoc International Working Group" on Contaminated Land, which grew out of discussions among country representatives attending the NATO/CCMS meetings. The Working Group exists to provide a forum—open to any country—in which the issues and problems of contaminated land and groundwater can be discussed at a national level and information can be freely exchanged to the benefit of all participants;
- The Common Forum on Contaminated Land in the European Union, RUBIN (Reactive Wall and Barrier Projects Cooperating in a Network) sponsored by the German Federal Ministry for Education and Research (Bundesministerium fur Bildung und Forschung-BMBF)
- The newly created EU-project, European Sustainable Land and Groundwater Management Information System (EUGRIS), which will begin in 2002.

4. TECHNICAL OVERVIEW

4.1 Introduction

There were 33 active projects in the Pilot Study. Summary information on each project is provided in the Annual Reports. The project summaries provide a technical abstract, which summarizes the project's progress and results, but is not a critical review of the project. The summaries also provide the name of a technical contact for further information.

While the objective of the Pilot Study was to evaluate applications of particular technologies, many of the projects involved more than one technology. Some involved the use of integrated treatment systems combining more than one technology, and others involved the application of more than one technology to deal with separate aspects of site contamination. Some projects involved monitoring technologies. One of the special sessions also addressed monitoring approaches and technologies.

Because the projects are classified below in a variety of ways, they may be counted two or three times, and not all projects may be included in each analysis. Furthermore, the categorization of projects is a matter of judgment, and alternative categorizations may be possible. The projects are classified as follows:

- By the development status (laboratory, field, actual cleanup);
- Whether they are *in situ* or *ex situ* technologies, or a combination of both;
- By the type used (biological, chemical, physical);
- By the contaminants treated (VOCs, PAHs, etc.); and
- By media: soil or groundwater.

4.2 Development Status

All of the 33 projects were technology-based. The Pilot Study accepted technical projects in two areas of development: "emerging" and "demonstration." For the purposes of the Pilot Study, an emerging technology is defined as bench-scale, while a demonstrated technology is one implemented at field- or full-scale. Demonstrated technologies are usually at or near to commercial application. Eight of the projects were emerging technologies.

4.3 *In Situ* and *Ex Situ* Technologies

There were 19 projects using *in situ* technologies. The remaining were ex-situ or monitoring technologies.

4.4 Technology Types

For the purposes of the Pilot Study, the technologies described in each technical project were broadly classified as one of five types: biological, chemical, physical-chemical, stabilization/solidification, or thermal.

The classification of projects was as follows (some projects were counted twice):

Technology Type	Number of Projects	Examples of Technologies
Biological	17	monitored natural attenuation, bio-reactors, phyto-remediation, composting, white rot fungi
Physical-Chemical	17	reactive barriers, soil washing, solvent extraction, surfactant removal
Chemical	2	chemical oxidation, pyrolysis/oxidation
Thermal	3	thermal desorption, in-situ thermal
Stabilization/Solidification	3	chemical fixation
Other	2	monitoring, excavation

4.5 Contaminants Treated

The projects were concerned with the treatment of the following contaminants polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and BTEX compounds (benzene, toluene, ethylbenzene, and xylenes), heavy metals (such as mercury lead, cadmium, zinc), petroleum hydrocarbons, pesticides, cyanides, coal tars, tanning wastes, TNT, and organic solvents.

5. SPECIAL SEMINARS

As discussed above, the Pilot Study hosted a special technical seminar at each annual meeting. The subjects for each special seminar and the name and countries of each of the co-chairpersons are listed below:

1998	Treatment Walls and Permeable Reactive Barriers	Harald Burmeier	Germany
1999	Monitored Natural Attenuation	Fran Kremer Anja Sinke	United States Netherlands
2000	Decision Support Tools	Paul Bardos Terry Sullivan	United Kingdom United States
2001	Performance Verification of In Situ Remediation Technologies	Robert Siegrist Bert Satijn	United States Netherlands
2002	Cost-Effective Tools for Site Characterization and Long-Term Monitoring	Eric Koglin Georg Teutsch	United States Germany

6. FOLLOW-ON PILOT STUDY

The country representatives and other participants in the Pilot Study agreed on the merit of a follow-on Pilot Study—both for those countries having established programs to address contaminated land and for those who have more recently begun to address contamination problems, such as countries in Central and Eastern Europe. Recognizing the broader issues of both preventing and remediating contaminated soil and groundwater, the country representatives also wanted to focus the policy and technical information on specific industrial sectors, rather than on technologies for remediation only. This would allow the results of the future Pilot Study to be of direct assistance to countries with affected industrial sectors.

Thus, a new CCMS Pilot Study entitled **Prevention and Remediation Issues in Selected Industrial Sectors** is proposed. The purpose of the proposed pilot study would be to define and explore best practices for reducing the health and environmental impact on soil and groundwater from industrial sectors of interest (e.g., metals mining, organic chemical production, gasworks, and fertilizer manufacturing) as well as other unique site “types” (e.g., old landfills, privatization sites [i.e., facilities transitioning from former state ownership in certain categories], mega sites [i.e., large scale former industrial and mining facilities], and shoreline sediment sites). In reviewing case studies as well as experience from the current pilot study on contaminated land and other sources, the proposed pilot study may be able to assess or benchmark “what is easy to clean,” “what is difficult to clean,” and “what is impossible, at reasonable cost, to clean.”

7. CONCLUSIONS

This Phase III Pilot Study again demonstrated the benefits of exchanging technical and economic information on contaminated land and groundwater remediation technologies. The conclusions are based on the deliberations of the Pilot Study Group, case studies, expert speaker presentations, and special studies carried out by Fellows of the Pilot Study. The conclusions are of two types and are listed below:

— non-technical and technical conclusions related to remediation—

7.1 Non-Technical Conclusions

1. Countries are recognizing soil as a resource and an important part of the living environment.

2. Soil protection is being recognized as an important policy area because of the high cost of clean up after contamination.
3. Clean up approaches driven by acceptable residual risk are becoming much more common than uniform, country-wide or region-wide strategies.
4. Policy flexibility by regulators creates the best opportunities for innovative solutions to soil and groundwater contamination problems.
5. The Pilot Study served as an incubator for several important new soil contamination organizations and networks (principally European) as well as an important new network for many NATO Partner countries.

7.2 Technical Conclusions

1. Remediation strategies in a number of countries are moving from technology focused treatment processes to increasing use of land use management and diverse approaches such as natural attenuation.
2. Approaches like phytoremediation or monitored natural attenuation may frequently require longer periods of time to clean up sites. Therefore, future remedial activities need to balance the time factor with other site clean up needs.
3. These longer time frames highlight new needs for extended project management, long-term monitoring, documentation, and financing for such long-term projects.
4. Public outreach for long-term clean up actions poses special challenges in risk communication and the ability to engage stakeholders over long periods of time.
5. Technical approaches for clean up are focusing more on in-situ, area-wide approaches vs. ex-situ, site specific approaches.
6. Integrated treatment systems are still necessary in order to provide lower cost and more effective site remediation solutions for complex sites.
7. Site clean up management strategies are moving from stepwise thinking (i.e., characterize, remediate, monitor) to more integrated approaches involving systematic planning and monitoring throughout the clean up.
8. Independent evaluation and verification of technologies and approaches and uniform data collection approaches are being developed and are a valuable resource for increasing acceptance of new technologies and approaches.
9. Remediation costs have been significantly reduced due to a better understanding of the problem and technological improvements; however, further application experience should help in lowering costs further.

8. RECOMMENDATIONS

- 1) *The CCMS is invited by the Pilot Study Directors to commend this Phase III Pilot Study Summary Report to the NATO Council for approval.*

All the participants in this phase of the study are commended for their professionalism, technical expertise, and cooperation. The Pilot Study Directors particularly thank the two co-pilot countries, Germany and The Netherlands, for their assistance. The CCMS Fellows are complimented on their

technical quality and personal input to the Pilot Study. The Special Seminars were a major success in stimulating discussion between participants, and the Directors thank those that chaired these sessions. Over and above the technical successes of the Pilot Study, camaraderie was established between participants leading to extensive exchanges of information outside of the Pilot Study. The progress of the Study was reported via annual meeting reports and special session reports. These reports were distributed via printed copies, CDs, and through Internet availability. Reports were distributed by NATO/CCMS, participating countries and at conferences in North America and Europe. Consequently, the CCMS is invited to commend the Summary Report to member governments and to the governments of the EPAC and other countries drawing their attention to the technical information, conclusions, and recommendations it contains.

- 2) *The CCMS is requested to encourage participation of NATO and non-NATO countries in a proposed follow on Pilot Study – Prevention and Remediation Issues in Selected Industrial Sectors.*

The participation of EPAC and other non-NATO countries has been a feature of the Phase III Pilot Study with mutual benefit to all involved. The Pilot Study co-pilot countries will continue to elicit formal participation in the follow on Pilot Study by additional countries known to have contaminated land and groundwater programs.

CCMS is requested to draw the attention of member countries to the way in which formal participation can open doors for researchers, regulators, and others from within and outside government to high quality technology and information exchange activities and to an extensive network of professional contacts. The CCMS is asked to encourage member countries to adopt formal observer status, even if the countries wish to have only minimal active participation at an official level.

- 3) *The follow on Pilot Study should maintain liaison with related international activities on industrial sectors and contaminated land.*

The benefits to all participants have been enhanced by the parallel activities in policy-oriented and technical areas. Opportunities for joint meetings and information sharing should be explored to expand the network for sharing results on prevention and remediation for industrial sectors.

- 4) *The follow on Pilot Study should continue the practice of publishing results annually and utilizing other electronic media for rapid information dissemination.*

The remediation of contaminated soil and groundwater is a rapidly evolving field, so that there is a risk that much of the information provided during the Pilot Study will be out of date rapidly. Continuing the current practice of annual reports of meetings with CD's that contain all reports cumulatively are a very effective way to make printed copies widely available. This approach coupled with Internet availability of reports is a very effective way to conduct outreach regarding future project results. The follow on Pilot Study should also continue the practice of seeking venues at international conferences to summarize and update Study findings.

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