INTERSTATE TECHNOLOGY & REGULATORY COUNCIL

INTERSTATE TECHNOLOGY REGULATORY COOPERATION

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COLORADO CENTER FOR ENVIRONMENTAL MANAGEMENT

CCEM

CASE STUDIES OF

REGULATORY ACCEPTANCE

IN SITU

BIOREMEDIATION TECHNOLOGIES

Prepared for
the Federal Advisory Committee
To Develop On-site Innovative Technologies

Second Printing
of
-FINAL-
February 1996

Prepared by
the Case Studies and Task Group
of the Interstate Technology and Regulatory Cooperation
Work Group
and
the Colorado Center for Environmental Management

ABOUT THE ITRC

Established in 1995, the Interstate Technology and Regulatory Cooperation Work Group (ITRC) is a state-led, national coalition of personnel from the regulatory and technology programs of more than 25 states, three federal agencies and tribal, public and industry stakeholders. The organization is devoted to reducing barriers and speeding interstate deployment of better, more cost-effective, innovative environmental technologies.

Various tools have been developed and services provided by the ITRC to accomplish this goal. ITRC **Technical/Regulatory Guidance** documents, each of which deals with a specific type of technology, enable faster, more thorough reviews by state agencies of permit applications and site investigation and remediation plans for full-scale deployment of such technologies. Use of these documents by states in their regulatory reviews also fosters greater consistency in technical requirements among states and results in reduced fragmentation of markets for technologies caused by differing state requirements.

Those who conduct and oversee demonstrations and verifications of technologies covered by ITRC Technical/Regulatory Guidance documents will also benefit from use of the documents. By looking ahead to the typical technical requirements for permitting/ approving full-scale deployment of such technologies, they can collect and evaluate information to facilitate and smooth the permitting/regulatory approval process for deployment.

The ITRC also has developed products in the categories of **Case Studies** and **Technology Overviews**, (including regulatory information reports, state surveys, closure criteria documents, and formats for collection of cost and performance data); provided state input into other complementary efforts; and worked on approaches to enable state regulatory agencies to accept performance data gathered in another state as if the testing had been done in their own state.

More information about the ITRC and its available products and services can be found on the Internet at **http://www.westgov.org/itrc**.

DISCLAIMER

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Foreword

This report is one of a series prepared by the federal advisory committee to Develop On-site Innovative Technologies (DOIT). The DOIT Committee was created in 1992 to implement a Memorandum of Understanding between the Western Governor's Association (WGA) and the United States Departments of Defense, Energy, and Interior, and the Environmental Protection Agency. The goal of the DOIT Committee was to establish a more cooperative approach for developing technical solutions to environmental restoration on federal lands. WGA manages the efforts of DOIT.

Under the auspices of the DOIT Committee, a group of representatives from states around the country gathered in Denver, Colorado during February 1995 to initiate a cooperative effort that became known as the Interstate Technology and Regulatory Cooperation (ITRC) Work Group. The ITRC Work Group is one of five work groups supporting the efforts of the DOIT Committee. The mission of the ITRC Work Group is to facilitate cooperation among the states in the implementation of innovative technologies that will clean up contaminated sites safely, economically, effectively, and quickly.

Early on, the ITRC Work Group recognized that the field of in situ bioremediation was important to all stakeholders in environmental remediation. However, while in situ bioremediation offered the promise of affordable and effective cleanup, its demonstration and deployment was hampered by institutional and regulatory barriers. Not all of these barriers were attributable to state environmental agencies, and their rules and policies, but these certainly merited consideration by the ITRC Work Group.

The key objective of the Task Group was to document and report how state agencies had resolved institutional and regulatory barriers associated with in situ bioremediation. The Task Group developed a unique approach by conducting in-depth, face-to-face interviews of representatives from states with success stories. The purpose of this report is to share useful insights with stakeholders in other states, stakeholders who may influence the process of using innovative technologies in their respective states. Generally, these stakeholders will be the state policymakers and managers of regulatory processes.

The total cost for cleanup of waste sites nationally has been projected to be hundreds of billions of dollars. Small efficiencies can make an enormous difference in the total cost of environmental restoration. The effort of the Task Group to share lessons learned among state environmental agencies constitutes one of the first, if not the first, effort at producing an "institutional memory" regarding waste site cleanup among the states in the environmental arena. It is hoped through recording the experiences of various persons and programs contributing to this report, that the difficult process of change and learning undertaken by the states interviewed, can benefit stakeholders outside those states.

This report is a joint effort between the Case Studies Task Group (Task Group) of the ITRC Work Group and the Colorado Center for Environmental Management (CCEM).

Paul Hadley, Chair, Case Studies Task Group
Department of Toxic Substance Control, California Environmental Protection Agency

Gary Broetzman
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The Interstate Technology and Regulatory Cooperation (ITRC) Case Studies Task Group and the Colorado Center for Environmental Management (CCEM) wish to acknowledge the individuals and organizations that contributed to this report.

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We owe a debt of gratitude to the individuals who generously gave their time to tell about their experiences and insights. Their willingness to speak frankly was essential to being able to share with other states the barriers they overcame and the lessons they learned in bringing in situ bioremediation (ISB) and other innovative technologies to their respective states. These people include the following. Phone numbers are provided for individuals to contact for additional information.

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- Bur Filson, Manager, Upstate Unit, LUST Section, Division of Remediation Management, Bureau of Land, IEPA
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- Harry Chappel, CDS Environmental Services (former Manager, Permits Section, Division of Land Pollution Control, Bureau of Land)

Massachusetts

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- Brian Looney, Principal Investigator, Ground Water Group, Savannah River Technology Center, Savannah River Site (SRS)
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- Joette Sonnenberg, Manager, Ground Water Group, Savannah River Technology Center, SRS

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Nettie J. Rosenthal
Colorado Center for Environmental Management
Editor

Case Studies of In situ Bioremediation

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Appendix C- Acronyms

1.0 Summary

This section is an executive summary of the overall report. It includes (1) an introduction, (2) objectives for performance of the case studies, (3) approach to conducting the case studies, and (4) the conclusions.

1.1 Introduction

This report discusses case studies in six states where institutional and regulatory barriers to implementation of in situ bioremediation (ISB) were overcome. The concept for this project arose out of the Interstate Technology and Regulatory Coordination (ITRC) Work Group, whose mission is to facilitate cooperation among the states when dealing with implementation of innovative technologies. The ITRC Work Group is one of five work groups under the direction of the federal advisory committee to Develop On-site Innovative Technologies (DOIT) for cleanup of federal lands. The DOIT Committee was created, in part, at the request of the Western Governors' Association (WGA) to the federal Departments of Defense, Energy and Interior, and the Environmental Protection Agency (EPA). The overall project is managed by WGA.

1.2 Objectives

The objectives for the conduct of the case studies are two-fold.

- The primary objective is to document and report how state regulatory agencies encourage use of innovative technologies for environmental restoration.
- The secondary objective is to determine whether the case study approach adopted by the Task Group would yield information useful to the states.

1.3 Approach

This subsection addresses the rationale for selection of ISB as the example innovative technology and describes how the case study method was implemented.

1.3.1 Selection of In Situ Bioremediation

ISB was selected by the Case Studies Task Group (Task Group), of the ITRC Work Group, as the vehicle for the case studies, because many members of the ITRC believe that ISB can provide cost-effective, safe, and successful cleanup, yet the technology is not widely utilized. The Task Group perceived that the major impediments to implementation of ISB were institutional and regulatory -- not technical.

Institutional barriers to implementation of ISB tend to be typical of most innovative technologies. Use of an innovative technology creates uncertainties by virtue of the fact that a technology is innovative. Uncertainties create disincentives to approval, such as risk aversion, desire to expedite cleanup, and desire to maintain the remediation project budget and schedule.

Regulatory barriers to implementation of ISB tend to be unique to ISB. The Task Group further focused on the aspects of ISB that involve injection of additives to ground water, because of the tension commonly found between state agencies responsible for remediation versus agencies responsible for ground water quality. Ground water quality standards can inhibit or prohibit injection of additives that accelerate biodegradation of chemicals in ground water. In some states, the lengthy time required for obtaining a permit for a discharge to ground water discourages use of ISB for non-Superfund cleanups.

1.3.2 Case Study Methodology

Because the objective was to learn from states that successfully overcame institutional and regulatory barriers to ISB (rather than merely to identify the barriers), the Task Group selected a biased and limited sample of states for study. The sample was biased in favor of states with success stories to share, so that other states could gain useful insights. The sample consisted of six states known to the Task Group to have successfully implemented ISB. The states selected for evaluation included Massachusetts, Illinois, New York, South Carolina, Montana, and Oregon. Considered together, these states have had experience with the use of ISB technologies for remediation of petroleum fuel, chlorinated solvents, and wood preservative contaminants.

As the acronym suggests, the philosophy of the ITRC Work Group is premised on interstate cooperation. As a result, the Task Group sent state representatives to interview, face-to-face, colleagues in the selected states. A Colorado Center for Environmental Management (CCEM) representative accompanied the ITRC state representative to the interviews. The Task Group recognized that a focused interview process for such a limited sample of states would provide anecdotal data (rather than statistical data to be used for comparison of approaches adopted by many states).

1.4 Conclusions

This subsection addresses the conclusions of the Task Group and CCEM, and includes (1) the overall findings, (2) approaches that the studied states use to encourage the use of innovative technologies, (3) possible consequences of broad-based state actions on innovative technologies, and (4) approaches used by the studied states to change.

1.4.1 Overall Findings

- In most states, ground water quality standards and permitting procedures were the primary barriers to deployment of ISB. Application of ground water requirements to specific sites was highly variable among the states in which case study analyses were conducted. The degree to which a state maintained a flexible approach to implementation of ground water protection requirements (e.g., using risk-based cleanup levels, downgradient points of compliance, or temporary waivers or variances), was determinative of the degree of implementation and support of ISB in that state. A trend toward flexibility and a relaxation of ground water requirements was observed among the states.

- A potential barrier to use of ISB and other innovative technologies is the observed trend among the states to reduce or eliminate a preexisting statutory preference for treatment in favor of containment or institutional controls. However, in the case of ISB, containment is often utilized with ISB treatment of ground water to assure no migration of contamination or other additives occurs.

- Most states that have approved use of ISB technologies have resolved fundamental differences between the water quality and site cleanup programs regarding injection of additives into ground water. Because the Environmental Protection Agency (EPA) does not regulate ground water (except under the Underground Injection Control [UIC] program), each state independently has had to develop its own approach to resolving internal conflicts without any national guidance.

- State agency managers determined the degree to which ISB and other innovative technologies, in general, are demonstrated and deployed in their state. In a few of the states, managers initiated an innovative technologies program. In other states, managers were responsive to the regulated community and/or staff requests to do what was necessary to test ISB.

- Experience gained through use of ISB has allayed many of the concerns of water quality protection staffs. Also, proactive education of regulators by experts has helped gain more ready acceptance by regulators of innovative technologies.

1.4.2 Approaches that States Have Used to Encourage Use of Innovative Technologies

- Discrete innovative technology or technical support group formed within state environmental agency to support remedial programs.

- Interagency committee created to address specific innovative technology.

- Evaluation of dual remedies (conventional and innovative) concurrently during feasibility study phase of Superfund cleanup.

- Selection of dual remedies (innovative with backup of conventional remedy or enhancement).

- State financial guarantee to cover costs of replacement technology if innovative technology does not meet program goals.

- Waiver of permit requirement for injection of additives into ground water.

- Flexible permits that anticipate occasional amendments to incorporate demonstration and use of innovative technologies.

- Flexible regulations that allow for site-specific waiver or variance from ground water quality standards or points of compliance.

- Delayed action based on observing how technology works at other sites.

- Centralization of cleanup authority into one state agency.

1.4.3 Possible Consequences of Broad-based State Actions on Innovative Technologies

State legislation, rules, and administrative policies that are not specifically directed toward the use of ISB or innovative technologies can have an indirect or unintended effect on their use. The following broad-based state actions, noted during the interviews, could have an effect on the use of ISB and innovative technologies.

- Deletion of preference in state Superfund statute for treatment in favor of co-equal consideration of containment, institutional controls and treatment.

- Amendments in state cleanup statutes that make cleanup levels in soil and/or ground water health risk-based.

- Indirect state oversight through licensed professionals, who are not state employees, but are state certified.

1.4.4 Approaches to Change

A state that is considering how to enhance its support for ISB or other innovative technologies can obtain guidance from these case studies. The approaches to change include legislative, regulatory, organizational, and policy changes. Legislation is a powerful means of creating incentives or disincentives for the use of innovative technologies. But, change may be well within the administrative powers of the regulatory agencies, in the form of regulatory, organizational or policy reform, without the necessity of legislative amendment.

1.4.5 Usefulness of Case Study Methodology

Collection of anecdotal data, from a limited sample, through a case study approach, could have value beyond the primary objective of this report. Such an approach could be used to guide states regarding resolution of institutional/regulatory barriers not only in regards to ISB and other innovative technologies, but also with respect to other troublesome issues (e.g., incineration and containment of spiraling remediation costs).

The Task Group discovered that the approach of interviews by state representatives made for more candid dialogue than could otherwise be achieved. Face-to-face interviews between colleagues created an opportunity for trust. Also, the ITRC lent credibility to the process as being the sponsoring organization and provided the opportunity to showcase each state's success story.

2.0

Introduction

This section presents background information pertaining to the case studies project and the specific objectives identified by the Case Studies Task Group.

2.1 Background

This subsection provides an overview of the origin and goals of the Task Group.

2.1.1 Western Governors' Association

During autumn 1990, WGA approached federal agencies with the idea of developing a project to improve the overall process for cleaning up environmental contamination of federal lands located in western states. The result was a Memorandum of Understanding (MOU) to establish a more cooperative approach to developing technical solutions to environmental restoration signed by WGA, EPA, Department of Energy (DOE), the Department of Defense (DOD), and the Department of Interior (DOI). To implement the MOU, a federal advisory committee, the DOIT Committee, was created in 1992.

WGA held a commercialization roundtable during August 1993 and a regulatory roundtable in October 1993. The concept of the ITRC Work Group was conceived during the roundtables. The roundtables revealed that, in the view of environmental businesses and investors, the demonstration of innovative technologies is secondary to the development of markets for those technologies. One of the proposals for removing market uncertainty to innovative technologies included testing a process for interstate permitting cooperation. It was recommended that technology demonstrations involve a number of regulators from key states, as well as federal regulators, to explore opportunities for interstate permitting cooperation.

2.1.2 The DOIT Committee

The goals of the DOIT Committee are the following.

- Protect the environment and public health by speeding the safe cleanup of federal facilities in the West.
- Improve the process by which innovative technologies are tested, evaluated, permitted, deployed and commercialized.
- Reduce regional labor surpluses through education, retraining and development of opportunities in environmental markets.

To achieve these goals, the new approaches being tested by the DOIT Committee are the following.

- Enhanced stakeholder involvement
- Streamlined regulatory review
- Improved commercialization process

The DOIT Committee is composed of five work groups. These are the following.

- Mixed Waste
- Generic Technology (formerly Military Bases)
- Munitions
- Mine Waste
- Interstate Technology and Regulatory Cooperation

2.1.3 The ITRC Work Group

In February 1995, the ITRC Work Group was formed. Its mission is to facilitate cooperation among states in the common effort to test, demonstrate, evaluate, verify, and deploy innovative environmental technology, particularly technology related to waste management, site characterization and site cleanup. The ITRC Work Group is devoted to encouraging the development and demonstration of innovative environmental technologies through cooperative efforts among state members. A key operating principle of the ITRC Work Group is that barriers to interstate deployment and commercialization of innovative technologies can be reduced and often overcome through cooperative efforts that identify, describe and explain regulatory requirements, policies, procedures and preferences of states and their agencies regarding innovative technology.

The activities of the ITRC Work Group are distributed among three task groups. These are the following.

- Electronic Bulletin Board Development
- Case Studies
- Protocols and Regulatory Requirements

2.1.4 Case Studies Task Group

The Task Group was created to select and review case studies of projects employing ISB to clean up soil and ground water. The path to regulatory approval and the key components and issues associated with these case studies are evaluated and summarized in this report. The Task Group developed its objectives and scope of work in the same cooperative manner and spirit as guides the ITRC Work Group.

Members of the Task Group included seven state representatives, one EPA representative, one member of the private sector, and one WGA representative. A membership list is provided in Appendix A.

2.1.5 Colorado Center for Environmental Management

CCEM was approached by the ITRC Case Studies Task Group in May of 1995 to assist with conducting multiple case studies involving ISB. CCEM had been involved in a series of support tasks for the DOIT initiative and had extensive experience in case study development, governmental environmental management programs, identification of institutional/regulatory barriers, DOE technology development, and collaborative decision-making processes involving hazardous waste, mixed radioactive and hazardous waste, and mining waste. CCEM accepted this challenge and agreed to use its ongoing technology/regulatory integration grant from DOE (after obtaining DOE approval) to support its contribution to this portion of the DOIT effort.

2.2 Objectives

The primary objective of the Task Group was to document and report how state regulatory agencies encourage use of innovative technologies for environmental restoration. The intent was not to focus on barriers to implementing new environmental technologies, but to emphasize the approaches to resolving barriers that were identified.

ISB was selected as the example technology for purposes of the case study efforts. ISB, by its nature, reveals the issues and concerns endemic to virtually all regulatory reviews of innovative technologies for site cleanup. The approach of considering projects dealing with ISB, not so much from a technical point of view, but rather by looking at the institutional and regulatory issues, was a unique aspect of the work undertaken by the Case Studies Task Group.

The secondary objective of the Task Group was to determine whether the case study approach adopted by the group would have merit in achieving the primary objective. The adopted approach involved state-to-state interviews. Selection of the states for inclusion in the case study was biased in favor of states perceived to have success stories in support of successful deployment of ISB. Collection of anecdotal data from a limited sample, rather than a more comprehensive or statistical approach, was evaluated by the Task Group to determine its usefulness to other states.

3.0

In Situ Bioremediation

This section (1) describes ISB, (2) explains why ISB was selected as the subject of the case studies, and (3) describes the perceived institutional/regulatory barriers to ISB.

3.1 Description of In Situ Bioremediation

Generally stated, the phrase "in situ bioremediation" refers to a broad spectrum of bioremediation techniques and technologies that rely on the capabilities of indigenous or introduced micro-organisms to degrade, destroy or otherwise alter objectionable chemicals in soil and ground water. Three factors affect the success of ISB. These are (1) the type of organisms, (2) the type of contaminant, and (3) the geological or chemical conditions at the contaminated site. The text, *In Situ Bioremediation - When Does It Work?* by the Committee on In Situ Bioremediation, Water Science Technology Board, Commission of Engineering and Technical Systems, National Research Council (NRC 1993), provides the basis for this subsection.

The key players in ISB are bacteria. ISB is an extension of the natural function of existing micro-organisms to break down human, animal and plant wastes. Typically, ISB systems rely on micro-organisms indigenous to the contaminated site. An emergent technology involves injection of microbes to augment biodegradation at contaminated sites.

A critical factor in determining whether ISB is appropriate at a site is whether the contaminants are susceptible to biodegradation. ISB is well established for certain types of petroleum hydrocarbons and their derivatives, including gasoline, fuel oil, alcohols, ketones, and esters. For other types of organic contaminants, such as solvents, ISB has been successfully tested in the laboratory and at a limited number of field sites.

The amenability of the subsurface environment to ISB depends, in part, on whether the bioremediation will be intrinsic or engineered. Intrinsic bioremediation utilizes the innate capabilities of naturally-occurring microbes without any enhancements. Engineered bioremediation accelerates microbial activity by site-modification procedures, such as by introduction of microbes or the installation of wells to circulate fluids and nutrients that stimulate microbial growth. The case studies in this report focus only on engineered bioremediation.

Proponents of ISB say it is a less costly, faster, and safer method for the cleanup of contaminated soil and ground water than more conventional cleanup methods. They argue that the conventional pump-and-treat approach to ground water cleanup is costly yet does not restore the ground water to health-based levels within a reasonable period of time and merely brings contamination to the surface for treatment or disposal elsewhere. Likewise, they assert that conventional methods of soil cleanup involve excavation and treatment or disposal elsewhere with increased exposure to contaminants for both workers and neighbors.

3.2 Selection of In Situ Bioremediation

In situ bioremediation was selected by the Task Group as the innovative technology that would be the subject of the case studies. It was the general belief of the members of the ITRC that the field of ISB has the potential of providing cost-effective, safe, and successful cleanups for a variety of waste sites, but that the technology was not being widely implemented. The Task Group also recognized that much apprehension existed within the regulatory community over technological solutions that involved chemical additives for stimulating biological activities in ground water that served as a drinking water source. The Task Group believed that significant lessons could be learned, through ISB, regarding the resolution of institutional/regulatory disincentives to deployment of innovative technologies.

3.3 Institutional/Regulatory Barriers to In Situ Bioremediation

The barriers to deployment of innovative technologies can be technical, institutional, and/or regulatory. This report focuses on the institutional and regulatory barriers. This subsection addresses institutional and regulatory barriers to innovative technologies, generally, and to ISB, specifically.

3.3.1 Institutional/Regulatory Barriers to Innovative Technologies - Generally

The major incentives for use of innovative technologies for environmental restoration include their promise of faster, better, safer, and cheaper cleanups. Yet, institutional/regulatory barriers to the use of innovative technologies often arise by virtue of (1) the lack of cost and performance data and (2) an inflexible institutional/regulatory framework.

In a 1992 study prepared for CCEM, Stone and Webster Environmental Services identified several institutional/regulatory barriers to the implementation of innovative technologies by virtue of their lack of cost and performance data and to the lack of incentives in support of their demonstration and deployment (CCEM, *Methods for Assuring the Use of Innovative Technologies*, 1993). The risks associated with uncertain performance of innovative technologies included the following:

- Risk aversion. Regulators charged with assuring a safe and effective cleanup, may be unwilling to assume the risk of an innovative remedy that may not prove to be either safe or effective. Regulators must be accountable to both their management and the public when assuming these risks.

- Desire to expedite cleanup. Remedial site managers (i.e., regulators) must adhere to schedule milestones. Responsible parties benefit from getting the site out of the media, the public eye, and regulatory scrutiny. Public opinion generally favors immediate action. However, the initial delay associated with the study and testing of the innovative technology, coupled with the uncertainty of its performance and possible necessity for follow-up remediation, can give pause to those concerned with expeditious remediation.

- Desire to maintain a projected budget. Remedial site managers are under pressure to maintain projected budgets and responsible parties have a significant incentive to minimize cleanup costs. Yet the study of an innovative technology may drive up costs in the short-term. If the technology should not perform as expected, budgets may be overrun.

  Regulatory drivers also may impede the implementation of innovative technologies. Such regulatory concerns include the following:

- Regulatory standards. Frequently, regulatory standards can actually impede, rather than facilitate a cleanup. Examples include the land disposal restrictions that prohibit removal of contaminated media, treatment and land disposal, if the media contained listed hazardous wastes. Ground water quality standards can inhibit injection of additives that accelerate the biodegradation of chemicals in ground water.

- Permitting procedures. Permitting of innovative technologies is often a lengthy process and a process that is unfamiliar to many regulators (e.g., Research, Development and

Demonstration [RD&D] permits under the Resource Conservation and Recovery Act [RCRA]). Additionally, there is potential for interagency friction when one agency is ready to approve use of an innovative technology, but another agency feels compelled to adhere to its established permitting process.

3.3.2 Perceived Institutional/Regulatory Barriers to In Situ Bioremediation - Specifically

Barriers associated with ISB are typical of many innovative technologies. The following describes some of the barriers anticipated by the ITRC Task Group relevant to ISB.

Because of performance uncertainties associated with ISB, the Task Group anticipated that some regulators would not be willing to assume the risk of approving ISB. The biochemical mechanisms causing the degradation of hydrocarbons and solvents are complex and poorly understood by some practitioners and regulators. On a site-specific basis, subsurface conditions (such as the presence and activity of the organisms), generally, are also unknown.

ISB technologies crosscut multiple environmental programs and agencies. Consequently, the Task Group expected differing approaches to approval of the technology among states and between the state and federal jurisdictions. ISB may be used in a remedial action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a corrective action under RCRA hazardous waste or underground storage tank (UST) programs, or a state analog to these programs. Moreover states have their own unique programs to which ISB may be applicable, such as aboveground storage tank (AST) programs, ground water restoration programs, or voluntary cleanup programs. Each of these programs and their respective agencies have unique requirements, policies and approaches.

By selecting case studies for only those ISB projects that involved injection of nutrients or other additives into the ground water, the Task Group recognized that information could be gained regarding resolution of regulatory requirements pertaining to the injection. Regulatory constraints include ground water quality and permitting requirements. Injection can cause direct conflict with ground water quality standards and anti-degradation policies in the short-term. Thus, injection can be prohibited, even though in the long-term it may facilitate source removal and aquifer restoration. Injection also triggers a potential need for a variety of permits (or permit equivalents, in the case of a CERCLA-based cleanup). Possible permits include an underground injection control (UIC) permit, ground water discharge permit, or another type of permit unique to each state or local agency. Extensive permitting requirements can cause delays.

4.0

Case Studies

This section provides (1) the purpose of the case studies, (2) site selection criteria; (3) the case study methodology, and (4) the case study highlights for six states. More detailed case study descriptions are provided in Appendix B.

4.1 Focus of the Case Studies

These case studies examine the institutional and regulatory factors that allowed (or hindered) the demonstration and deployment of ISB remediation projects. The Task Group focused on the deliberations, decisions, and organization of the relevant regulatory agencies.

4.2 Site Selection Criteria

The Task Group relied on participating member states to identify candidate ISB projects for the case studies. States were initially screened to include only those that could potentially reveal how ISB was approved and/or implemented in that state. The criteria for selection of projects as case studies included:

- The project involved injection into the ground water of additives that were perceived to be of regulatory concern.
- At least one case study would be selected for each of the following categories.
- Petroleum fuel
- Chlorinated solvents
- Wood preservative
- Diversity in site conditions, geography, and regulatory framework.
- Local and state support to the interviewers in accessing relevant information and interviewing appropriate people.

4.3 Case Study Methodology Used

The approach of the Task Group was to review key documents and interview key people associated with each case study. Interviews of key people (e.g., regulatory, site owners, and technical professionals) were conducted by teams of two, consisting of a representative from a participating member state and a representative from CCEM. The approach taken was that of a neutral survey; no single hypothesis was being tested.

After the Task Group conducted the first round of interviews with representatives from Massachusetts, preliminary results were presented to the whole ITRC Work Group at its Summer 1995 meeting. At the invitation of the ITRC, Massachusetts showcased its successes in resolving institutional/regulatory barriers to implementation of ISB. The ITRC Work Group provided positive feedback regarding use of the case studies approach and encouraged the conduct of additional case studies.

4.4 Highlights of the Case Studies

Six case studies were performed. The highlights of each are provided below and are organized by type (e.g., petroleum, chlorinated solvents, and wood preservatives). Detailed descriptions of the case studies are contained in Appendix B.

4.4.1 Massachusetts -- Petroleum Fuel

Background -- The Massachusetts Department of Environmental Protection (MADEP) is responsible for managing environmental programs in Massachusetts. The Bureau of Waste Site Cleanup (BWSC), within MADEP, is the lead agency for cleanup of contaminated sites. MADEP supports use of innovative technologies through the use of Òinnovative technology coordinatorsÓ within the remediation and other environmental programs. During the past few years, the framework for conducting site remediation, the Massachusetts Contingency Plan (MCP), has been revised to include more flexibility for determining site-specific cleanup levels and reliance on private, state-licensed, site professionals for overseeing site cleanup activities.

Regulatory Framework -- Site remediation in Massachusetts must comply with the requirements of all applicable environmental regulations. For sites designated for cleanup under the State Superfund program, substantive requirements must be met, but permits from other agencies, such as Air Quality Control and Hazardous Waste divisions, can be waived. The one exception has been the ground water quality management program where permits issued by the Division of Water Pollution Control (WPC) have been required for any discharge into ground water. Conditions of such permits are typically based on protection of ground water quality for drinking water use. This procedural requirement has been a disincentive for new technologies, such as ISB, that involve a discharge to ground water, because a ground water quality permit can take upwards of one year to process.

MADEP management and technical staff formed a committee to address the ground water quality and permitting issues associated with ISB. That committee created the ISB Pilot Study, which administratively eliminated the need for ground water quality permits and centralized project approval and oversight within BWSC. WPC program staff were part of the committee and were integrally involved in the design of the ISB Pilot Study.

Current Status -- Nine sites utilizing ISB technologies are proceeding under the Pilot Study. Each is relatively small and not conducive to excavation and off-site disposal because of the close proximity of neighboring structures. The ISB technologies involve the addition of nutrients through dry wells or as surface applications. At eight of the nine sites, ground water quality standards were not violated by ISB efforts. The Pilot Study has generated evidence that reduces the original concerns of WPC regarding the impact of nutrient additives on ground water quality. Partially as a result of the Pilot Study, MADEP recently passed regulations that allow site cleanup occurring under the MCP to proceed without obtaining a WPC ground water discharge permit.

Findings -- The primary findings from this case study follow.

- The 1993 revisions to the MCP embodied two major themes:
- private Licensed Site ProfessionalsÕ oversight of site cleanup
- more flexible definition of site-specific cleanup levels, using a risk-based approach
- The ISB Pilot Study was established to address several vexing issues primarily related to ground water drinking water protection. Key points follow.
- Fundamentally important internal support for the Pilot Study came from top management and the WPC program staff. Other MADEP technical staff provided meaningful contribution and commitment to the study design.
- The regulated community, including private technical professionals, also provided major external support for the Pilot Study.
- Ground water monitoring and documentation were required.
- The point of compliance was moved downgradient of the injection point.
- Limiting approval authority to one agency streamlined the approval process.
- Results of the Pilot Study have helped achieve acceptance of ISB within MADEP.

- The Pilot Study was partially responsible for recent regulatory changes, including the following.
- A site cleanup, including any ground water discharge, approved by the BWSC can proceed without a WPC ground water discharge permit.
- The experimental changes from the Pilot Study in organizational roles and procedures for ISB review and approval, are codified in the new regulations.
- The point of compliance is moved downgradient of the contamination source.
- The MADEP emphasis on innovative technologies, as demonstrated by its innovation technology coordinators, helped create the Pilot Study and is responsible for greater use of other innovative technologies.

4.4.2 Illinois -- Petroleum Fuel

Background -- The Illinois case study involves a review of the Leaking Underground Storage Tank (LUST) program, which is managed by the Illinois Environmental Protection Agency (IEPA). The purpose of the LUST program is to regulate the design of new underground storage tanks (UST) and to help defray the cost of cleanup at sites where old tanks have been defective. An UST Fund, financed by a State gasoline sales tax, provides reimbursement of approved site cleanup costs, in excess of $10,000, to the site owners. An insurance feature of the UST fund encourages the use of state-approved alternative (i.e., innovative) technologies at eligible sites by fully covering the cost of replacement, conventional cleanup technologies, in the event the alternative technology does not meet cleanup requirements.

Subsurface geological conditions across much of Illinois restrict the use of ISB technologies. Clay surface soils exist across virtually all of the State, except in areas covered by alluvium. The tight soil conditions limit the opportunities for ISB. Despite those conditions, about 130 LUST sites have alternative technologies approved by the IEPA, of which 53 are ISB. The State does not have limiting criteria for nutrient applications, and all ISB projects involve nutrient additives using subsurface applications (generally trenches). The ISB is being used primarily for sites with petroleum-contaminated areas around and under existing structures and under streets and other physical barriers where conventional ex situ treatment or excavation and off-site disposal is not desirable or feasible.

Regulatory Framework -- Requirements for cleanup of individual tank sites have been driven by ground water protection for drinking water purposes. IEPA does not have a non-degradation or a background level goal for site remediation. But, because LUST sites typically lie above aquifers that are current, or potential, drinking water sources, IEPA has generally required that site cleanup comply with the drinking water maximum levels (MCLs) at the pollution source (i.e., location of the tank). The LUST staff is responsible for implementing the program consistent with the ground water standards.

Current Status -- The UST Fund historically has had insufficient funds to cover the requests for cost reimbursement of corrective actions. In 1993, with the growing backlog of approved, yet unfunded projects, the Legislature authorized the sale of $110 million in bonds to help remove the backlog. In 1995, the legislation was amended again to increase the gasoline sales tax for the UST Fund from 0.3 to 0.8 cents per gallon.

The 1993 amendments also modified the state LUST laws, including the cleanup criteria and point of compliance. The new legislation replaced compliance with drinking water MCLs at the pollution source with a priority-based classification system. Site-specific use of numerical limits less restrictive than MCLs are possible. The amendments also enable the LUST program staff to establish a risk-based cleanup objectives. The overall effect expected from use of less conservative criteria will be to reduce the cost of cleanup at many individual sites. The resulting savings would then be available to cover additional sites.

Findings -- Key findings from this case study follow.

- ISB is used in Illinois primarily for sites where the use of conventional off-site disposal or ex situ treatment is not desired nor feasible. The use of ISB technologies would likely have been even greater if not for the presence of tight clay throughout much of the State.

- The UST Fund is chronically inadequate. This has fostered a willingness to support the use of innovative technologies that will stretch the use of limited monies to additional sites.

- The Illinois LUST program insures the full cost of a replacement technology if an approved innovative technology does not meet cleanup requirements. This feature has increased the application of such technologies, including ISB.

- Until recently, the primary regulatory driver for UST site cleanup has been the requirements of the State ground water program, which required compliance with MCLs for drinking water at the source of contamination (i.e., tank location).

- The 1993 amendments to the State LUST laws changed the criteria to a classification system based on environmental priority that enables greater use of technical judgment in setting case-specific cleanup criteria. The 1993 amendments also provided IEPA authority to use risk-based decision making criteria to determine site-specific cleanup objectives. The combined effect of these changes could result in a greater number of sites having access to the UST Fund, because less conservative, site-specific cleanup goals will likely reduce remediation costs at many sites.

4.4.3 New York Sites -- Chlorinated Solvents

Background -- The Division of Hazardous Waste Remediation (DHWR), Department of Environmental Conservation (DEC) has lead responsibility for remediation of inactive hazardous waste sites in New York State. The Technology Section within the DHWR is a focal point, and an advocate, for innovative technologies for environmental remediation. Section personnel assist site remedial managers with technical issues and with consideration of new technologies.

This case study covers technology demonstrations at two sites contaminated with both petroleum fuels and solvents. The eight-acre McKesson Site at Syracuse is a former tank farm with ten aboveground tanks used to store an array of chemicals. The tanks have been removed, but the soil and ground water contamination remain. ISB was demonstrated for site cleanup of the unsaturated zone soil in 1993 at the request of the site owner and concurrence of DEC.

The Multi-Vendor Site, located near Rochester, involved a cooperative effort among DEC, EPA, and SUNY-Buffalo for pilot studies of three concurrent bioremediation technologies in 1994 and 1995. These were (1) ISB bioventing, (2) ex situ bioremediation (one aerobic/one anaerobic), and (3) a combination of ISB and air stripping using a German UVB technology. The Technology Section of DEC managed the demonstrations using monies from the State Superfund.

Regulatory Framework -- Site-specific cleanup levels under the State Superfund program in New York are based on regulatory requirements set by media-specific environmental programs. Ground water quality standards, which control cleanup levels at most sites, are generally protective of drinking water use at the point of injection. Under the State Superfund law, however, some flexibility exists because the stated goal is to Òrestore a site to predisposal conditions to the extent feasible and authorized by law.Ó DEC can consider site-specific variation from program standards where important factors exist, such as naturally contaminated ground water conditions, prohibitive costs, and lengthy remediation.

The DHWR staff provides encouragement for the selection of innovative technologies in site remediation through use of what they refer to as a "dual remedy" approach in the investigative phases of the Superfund process that are under State control and influence. Through a dual remedy track, innovative technologies are demonstrated and evaluated for site cleanup, within the same time frames as conventional technologies are evaluated.

Current Status -- Based on the results of the 1993 ISB demonstration at the McKesson site, the technology selected for site cleanup of the vadose zone was in situ soil blending with the periodic addition of nutrients and water. This was accomplished in 1994 using special roto-tillers that allowed deep mixing at each of several contaminated subareas on the site. Results were better than expected achieving levels much lower than the 10 parts per million (ppm) target treatment level and approaching 1 ppm in most cases.

At the Multi-Vendor site, the technologies were demonstrated during the summer and fall of 1994. Field work on the ex situ and on the in situ bioventing technologies was completed in December 1994. The UVB technology demonstration had to be extended to September 1995 because of unusual weather and site conditions. As of December 1995, comparative analyses were being conducted by the EPA SITE Program contractor. Preliminary conclusions for the ex situ biovault and in situ bioventing indicate significant contaminant removals. The final data for the UVB Technology are still being evaluated.

Findings A summary of key findings from this case study follow.

Institutional/Regulatory

- The creation of a separate technology support unit within a state remediation or environmental management agency establishes a climate for dedicated professionals to be able to focus attention on, and develop expertise and support for, new technologies in concert with remedial program goals.

- A favorable atmosphere exists for considering, demonstrating, and deploying new technologies at hazardous waste sites in New York due largely to statutory language that allows flexibility in defining site-specific cleanup objectives.

- The Òdual remedyÓ approach for evaluating innovative technology demonstrations concurrently with conventional technologies during the Superfund feasibility study process has worked in New York .

- New York exempts many types of remediation sites from requirements for environmental permits. Consequently, the tension between ground water quality and environmental restoration programs observed in other states, was not observed in the New York case study.

Technical

- Under ideal circumstances, hazardous waste site cleanup can generally be accomplished with ISB over time frames that are comparable to that for conventional technologies.

- DEC believes that ISB is potentially applicable to sites contaminated with chlorinated and non-chlorinated solvents. ISB has been successfully tested at two inactive hazardous waste sites in New York for combined hydrocarbons and chlorinated solvents contamination. Specific applicability of the technology must be evaluated on a case-by-case basis.

4.4.4 South Carolina -- Chlorinated Solvents

Background -- The South Carolina case study involves the Savannah River Site (SRS), which is a 310 square mile DOE facility in which chlorinated solvents contamination is being remediated. The most significant solvent contamination is located in one area of the facility, known as the M Area, where an estimated 3.5 million pounds of solvents were discharged to an unlined settling basin for almost 30 years. The impetus to conduct a site assessment in 1981 was the discovery of solvent contamination in the drinking water supply for M Area. The site assessment revealed the presence of a large plume of solvent contamination associated with the basin and related chemical sewers. DOE approached the South Carolina Department of Health and Environmental Control (DHEC) in 1981 with the site assessment results. Shortly thereafter, it embarked on an overall cleanup program for M Area that included a pump and treat system to contain the major portion of the plume and the demonstration of innovative technologies to be considered as enhancements to the pump and treat system.

Regulatory Framework -- The M Area was subject to corrective action pursuant to a RCRA permit issued, initially, in 1985. Because the cleanup of M Area is proceeding under RCRA (rather than CERCLA), separate water quality and air emission permits have been required for the corrective action activities. The RCRA permit provides a framework to guide the conditions of these other permits and is occasionally modified to incorporate successful technology demonstration results. However, a separate RD&D permit has not been required.

Current Status -- Many of the technologies demonstrated at M Area have been incorporated into full-scale cleanup operations. Those technologies include air stripping, soil vapor extraction (SVE), and horizontal wells. The horizontal wells have been initially used for vapor extraction and air sparging and subsequently used for ISB involving nutrient additions. Early and continual working relationships developed between the SRS and DHEC staffs have helped work through regulatory issues. The person managing the UIC program at DHEC has been particularly helpful with resolving regulatory issues associated with the ISB technologies. DHEC has emphasized technology training and seminar attendance to enable its staff to stay abreast of emerging technologies and DOE has provided some of the training. A multi-program working group in DHEC has also been effective in coordinating and resolving ground water quality issues. Site remediation and innovative technology work continues for the M Area under RCRA. The experiences gained at SRS have been helpful in gaining acceptance of ISB technologies elsewhere in South Carolina and other locations nationally.

Findings -- A summary of the key findings from this case study follow.

- A flexible regulatory framework embodied in a RCRA corrective action permit, issued by the state in 1985, enables new technologies to be rapidly demonstrated and folded into full-scale cleanup at SRS. A separate RD&D permit has not been required.

- Early and continuous communications between SRS personnel and DHEC have helped create mutual trust and opportunities for technical interchanges.

- DHEC has emphasized technical training for its staff regarding emerging technologies; DOE has helped with some of that training.

- The focus for new technologies support in DHEC lies with an identified technology unit (Hydrogeology Division) in the hazardous waste management program. Regarding ISB technologies, an individual, who advocates use of ISB, located in the UIC program, has provided additional assistance.

- A multi-program working group focuses on ground water quality issues that impact all types of remedial activities, including those that utilize innovative technologies.

- SRS analyses of ISB demonstrations indicates that ISB technologies can be effective for removal of dissolved solvents in ground water.

4.4.5 Montana -- Wood Preservative

Background -- This case study focused on the Libby Site, a former wood preservative facility at a lumber mill. Soil and ground water are contaminated with pentachlorophenol (PCP). The site is listed on the federal NPL and remedial activities are conducted under the Superfund oversight authorities of EPA. The ROD was signed in 1986 and remedial activities have been ongoing since 1988. The State chose not to sign the ROD or consent decree because it was seeking more autonomy at the time, was unfamiliar with bioremediation, and did not perceive the need for participation given EPAÕs lead role.

The responsible party proposed ISB as a partial remedy for areas where conventional remedies seemed ineffective and too costly. EPA staff was familiar with the results of EPA studies of ISB, which allowed its inclusion in the remedy selection process. Consequently, the Libby site is among the first wood preservative sites at which ISB was selected for use. A combination of ISB and ex situ treatments were selected, including two ground water treatment systems that inject nutrients into ground water.

Regulatory Framework -- In Montana, the federal Superfund process may be implemented by EPA or the State, through a cooperative agreement. Montana also has a state version of the Superfund program. EPA guidance documents recommend the use of ISB for the treatment of PCP and other contaminants typical of wood preservative sites, in soil, sediments, surface water and ground water.

During 1995, the Montana legislature reduced the preference for treatment under the State Superfund law. Rather than requiring treatment to the maximum extent practicable, treatment now is required only if practicable. The intent is to give due consideration to institutional and engineering controls. The legislature also amended the Water Quality Control Act to allow short-term degradation of ground water for remedial purposes and defines a level of nitrate (a common additive for ISB) acceptable within the ground water mixing zone.

Current Status -- Based, in part, upon the experience at the Libby site, ISB was selected at the Somers, Idaho Pole and Montana Pole sites. All of these sites are federal Superfund sites, however, at both Pole sites, the State was the lead agency responsible for selection of ISB. At all sites, ISB involves the injection of nutrients for treatment of ground water.

Findings --

- At the Libby site, acceptance of ISB occurred because of the following.

- The responsible party's contractor delivered a strong and thorough proposal.

- EPA was the lead agency, and followed its guidance regarding the use of ISB at wood preservative sites. The State adopted a wait-and-see approach.

- ISB was only a portion of a multi-remedy selection. The total remedy was dependent on source control via excavation and treatment of contaminated soil and recovery of free product from the ground water.

- There was not much of a public health and environmental threat associated with off-site migration.

- The Libby site served as a demonstration to the State to make acceptance of ISB for treatment of ground water at other sites easier.

- Recent changes to Montana's Superfund and Water Quality laws may have mixed, unintended effects on the use of ISB in that State.

- The reduced preference for use of treatment technologies at sites that are being remediated under the State Superfund law may discourage the use of ISB.

- Changes to the Montana Water Quality Act add the type of flexibility to the water quality standards, used as ARARs at Superfund sites, which encourages the use of ISB.

4.4.6 Oregon -- Wood Preservative

Background -- The Dant and Russell Site is a former wood preservative site owned by Burlington Northern Railroad. Under the State Superfund program, the Oregon Department of Environmental Quality (ODEQ) issued a ROD for the site on December 21, 1994. The ROD requires hydraulic containment, DNAPL removal, extraction of contaminated ground water, above-ground biotreatment, addition of an electron acceptor such as hydrogen peroxide, and reinjection or reinfiltration of oxygen-enriched water back into the aquifer. The ROD also includes contingency measures if treatment, including ISB, should not meet remedial goals.

The Waste Management and Cleanup Division (WMCD) approved use of ISB for ground water, relying, in part, on the results of the Libby Site in Montana, and EPA guidance regarding the use of ISB at wood preservative sites. The Water Quality Division (WQD) concurred in the selected remedy, but was concerned that ISB would cause a violation of the non-degradation standard. WMCD and WQD are requiring hydraulic containment, modeling of the capture wells, and monitoring wells near the infiltration source.

Regulatory Framework -- The Dant and Russell Site is being remediated under the Oregon Superfund laws. The 1995 Superfund reform bill deletes the preference for treatment except at hot spots. Regulations under the Ground Water Protection Act exempt compliance with ground water requirements at State Superfund Sites, but WQD concurrence in the ROD (issued pursuant to Superfund) is required.

Current Status -- At the Dant and Russell Site, the responsible party has not commenced design or implementation of the selected remedy due to litigation regarding liability.

The 1995 revisions to the State Superfund laws have helped focus the discussions between the two programs regarding compliance with the Groundwater Protection Act. WMCD and WQD are working together to resolve potential conflicts.

Findings -- A summary of key findings include the following.

- ODEQ, by regulation, exempts compliance with ground water non-degradation requirements at State Superfund sites. The exemption should encourage the use of engineered ISB.

- A potential barrier to use of ISB and other innovative technologies is the observed trend among the states to reduce or eliminate a preexisting statutory preference for treatment in favor of containment or institutional controls. However, in the case of ISB, containment is often utilized with ISB treatment of ground water to assure no migration of contamination or other additives occurs.

- ODEQ management policy is that ground water non-degradation requirements not impede remedial activities at State Superfund sites. This policy is in response to the requirement for concurrence by WQD before a ROD is issued and before a remedial design is approved.

- The State has the ability to grant short-term, site-specific variances of water quality requirements for engineered ISB at non-superfund sites (such variance is not required at the studied site).

- ODEQ selected ISB as part of the remedy for ground water contamination at the studied site, and reserved containment and institutional controls as contingency measures in the ROD.

- ODEQÕs observation of ISB in Montana was considered in ODEQ's evaluation and ultimate selection of ISB as part of the ground water treatment remedy at the studied site in Oregon.

- The 1995 State Legislature reduced the preference in the State Superfund law for treatment and encouraged that institutional controls and containment be considered co-equally with treatment at non-hot spots. The effect of this statutory amendment on the use of ISB in Oregon will depend on how the term "hot spots" and the cost threshold for treatment of hot spots are defined by ODEQ in its implementing regulations.

5.0

Conclusions

This section presents the (1) the overall findings of the Task Group, (2) approaches that states use to encourage use of innovative technologies, (3) possible consequences of state actions on the use of innovative technologies that are not specifically directed to innovative technologies, (4) approaches to change pertaining to innovative technologies, and (5) usefulness of the case study methodology. Subsections 5.2 through 5.4 address the primary objective, and subsection 5.5 addresses the secondary objective.

5.1 Overall Findings

An overall review of the case studies reveals several general findings. These are:

- In most states, ground water quality standards (e.g., MCLs), permitting requirements, and their interpretation by the regulators were the primary barriers to deployment of ISB. Application of ground water requirements to specific sites was highly variable among the states in which case study analyses were conducted. The degree to which a state maintained a flexible approach to implementation of ground water protection requirements (e.g., using risk-based cleanup levels, downgradient points of compliance, or temporary waivers or variances), determined the degree of implementation and support of ISB in that state. A trend toward flexibility and a relaxation of ground water requirements was observed among the states.

- A potential barrier to use of ISB and other innovative technologies is the observed trend among the states to reduce or eliminate a preexisting statutory preference for treatment in favor of containment or institutional controls. However, in the case of ISB, containment is often utilized with ISB treatment of ground water to assure no migration of contamination or other additives occurs.

- Most states that have approved use of ISB technologies have resolved fundamental differences between the water quality and site cleanup programs regarding injection of additives into ground water. Because EPA does not regulate ground water (except under the UIC program), each state independently has had to develop its own approach to resolving internal conflicts without any national guidance.

- State agency managers determine the degree to which ISB and other innovative technologies, in general, are demonstrated and deployed in their state. In a few of the states, managers initiated an innovative technologies program. In other states, managers were responsive to the regulated community and/or staff requests to do what was necessary to test ISB.

- Experience gained through use of ISB has allayed many of the concerns of water quality protection staff. Also, proactive education of regulators by experts has helped gain more ready acceptance by regulators of innovative technologies.

5.2 Approaches that States Have Used to Encourage Use of Innovative Technologies

The Task Group selected only case studies that involved injection of nutrients or microbes into the ground water as part of the ISB application. Consequently, concern regarding potentially adverse impacts to ground water quality was a significant barrier to state acceptance of ISB. A related barrier was the requirement for an UIC or state-required ground water discharge permit that involved a lengthy permitting procedure and/or rigid permit conditions that restricted or inhibited the use of ISB. In some of the states, these barriers created interagency conflicts, pitting a ground water protection agency against hazardous waste or Superfund agencies.

This subsection covers the approaches intentionally adopted by the states to address the institutional barriers to acceptance of ISB or other innovative technologies. Table 1 lists these approaches and the states that have adopted them. Brief explanations of each approach follow the table. The reader may cross-reference the state to the case studies in Appendix B to learn about the approach in detail and to identify contacts in the relevant state.

Table 1

Approaches that Encourage Use of Innovative Technologies	States
(1) Discrete innovative technology or technical support group within state environmental agency to support remedial programs.	Illinois New York S. Carolina

(2) Interagency committee set up to address specific innovative technology.	Massachusetts S. Carolina
(3) Evaluation of dual remedies (conventional and innovative) concurrently during feasibility study phase of Superfund cleanup.	New York
(4) Selection of dual remedies (innovative with backup conventional remedy or enhancement).	New York Oregon
(5) State financial guarantee to cover costs of replacement technology if innovative technology does not meet program goals.	Illinois
(6) Waiver of permit requirement for injection of additives into ground water.	Massachusetts New York
(7) Flexible permits that anticipate occasional amendments to cover innovative technology demonstration results.	S. Carolina
(8) Flexible regulations that allow site-specific waiver or variance from ground water quality standards and points of compliance.	Montana New York Oregon
(9) Delayed action to observe how innovative technology works at other sites.	Montana
(10) Centralization of cleanup authority into one agency.	Massachusetts

(1) Discrete innovative technology or technical support group: A dedicated group of technical experts, who are not saddled with day-to-day site remediation managerial demands, can focus on keeping abreast of new technical approaches for site remediation. This group typically takes the form of a centralized work group charged with the mission to provide technical support to the agencies responsible for ensuring cleanup of contaminated sites.

(2) Interagency committee to address specific innovative technology: A committee with representatives from all concerned agencies can encourage the safe use of innovative technologies. In Massachusetts, a pilot study committee squarely identified outstanding issues inhibiting the implementation of ISB and determined data or procedural reforms that were required to resolve these issues. In South Carolina, a ground water quality committee is set up to

address the implications of ground water requirements on the use of innovative technologies used in a variety of programs.

(3) Dual remedy evaluation: Concurrent evaluation and testing of both innovative and conventional technologies assures that innovative technologies are given fair consideration without extending the duration of the feasibility study.

(4) Dual remedy selection: Selection of both an innovative and a backup conventional remedy or conventional enhancement of an innovative remedy in a Superfund ROD reduces the risks associated with an innovative technology failure. These risks include reevaluating remedial alternatives years later when site conditions, cleanup levels, personnel, public opinion, and other factors may have changed.

(5) State financial guarantee of innovative technologies: A statutory program that covers the full cost of a replacement technology if the innovative technology does not meet cleanup requirements clearly encourages the use of innovative technology.

(6) Waiver of permit requirement: Removing the requirement for a permit for injections into ground water processes clearly encourages the use of ISB. A lengthy permitting process and consequent delays to remediation can be avoided. In Massachusetts, the permit waiver was specific to ISB. In New York, permits are waived at many cleanup sites (not just Superfund sites), with the potential result of encouraging the use of ISB.

(7) Flexible permits that anticipate the use of innovative technologies in cleanups: RCRA permits can provide for amendments to closure plans to accommodate innovative technology results and provide the framework for obtaining other types of permits that may be required for implementing or demonstrating the innovative technology.

(8) Flexible regulations that allow for waiver from or variance of ground water quality standards and points of compliance: ISB injection of nutrients, microbes or other additives may cause temporary exceedances of ground water quality standards within a limited area, particularly during startup. Procedures that allow for the short-term exceedances of ground water quality standards without any actual endangerment of human health in view of the ultimate ground water remediation encourage the use of ISB. Downgradient points of compliance and ground water mixing zones also encourage injection to enhance ISB. In Montana, amendments to the Water Quality Act were intended to benefit, in part, ISB. In New York and Oregon encouragement of ISB may have been an unintended consequence of the flexibility afforded in those states' regulations.

(9) Delayed action: Awaiting the results of an innovative technology demonstration at a federal-lead Superfund site or in another state, if information is shared, can encourage the use of ISB. However, this strategy also shifts the risk for implementation of innovative technologies to other state or federal jurisdictions.

(10) Centralization of cleanup authority into one agency. Engineered ISB can create interagency conflicts between the agency responsible for cleanup and the agency responsible for ground water protection. One agency can be responsible for assuring a safe and effective cleanup in a timely manner, and can implement the ground water protection standards in a manner that supports the ultimate cleanup of the ground water resource.

5.3 Possible Consequences of Broad-based State Actions on Innovative

Technologies

During the interviews, state representatives shared their views about the impacts of legislation, rulemaking, and administrative polices that were not specifically directed toward the use of ISB or other innovative technologies, but impacted those technologies, nonetheless. Table 2 summarizes those observations and the observations of the Task Group.

Table 2

Broad State Actions that May Impact the Use of Innovative Technologies	Potential Impact on Innovative Technologies
(1) Deletion of preference in state Superfund statute for treatment in favor of co-equal consideration of containment, institutional controls and treatment	discourage use
(2) Amendments in state cleanup statutes that make cleanup levels in soil and/or ground water health risk-based	discourage & encourage use
(3) Indirect state oversight through licensed professionals, who are not state employees, but are state certified	discourage & encourage use

(1) Deletion of a preexisting statutory preference for treatment. This action is a disincentive for a responsible party to attempt treatment, much less any kind of innovative remedial technologies, even if an innovative treatment technology may prove cheaper, safer, better, and faster in the long-term. Without a preference for treatment, the responsible party and others may not want to assume the risks associated with innovative technologies.

(2) Shift to health risk-based cleanup levels. Frequently, these type of statutory amendments cause cleanup levels to be less stringent. Although this shift will likely lead to less costly cleanup (or no cleanup), it may reduce the initiative for pursuing innovative technologies. Another impact may be to decrease the necessity for innovative technologies if a conventional technology can achieve a less stringent cleanup level. For example, conventional pump-and-treat technologies often cannot reach drinking water-based cleanup levels within a reasonable time, although ISB may be able to achieve those levels within a much shorter period of time. If risk-based cleanup levels are more stringent, the search for new technologies for treatment to lower concentrations is encouraged.

(3) Indirect state oversight. State certification or licensing of environmental professionals who are responsible for safe and effective cleanup can have the effect of discouraging or encouraging the use of innovative technologies. If the certified environmental professional is risk adverse, the effect is to discourage the use of innovative technologies. On the other hand, if the certified environmental professional is not risk adverse, the additional initial resource burdens presented by innovative technologies (e.g., education, monitoring, review) are absorbed by the certified environmental professional, rather than the state regulators. Also, the use of licensed environmental professionals reduces the cost to the state of approving an innovative technology.

5.4 Approaches to Change

A state that is considering how to enhance its support for innovative technologies, or ISB in particular, can obtain guidance from these case studies. The approaches to change include legislative, regulatory, organizational, and policy changes. The most appropriate approach to follow in any state is dependent upon the enabling legislation, the culture of the environmental agency, and the political activity of the regulated community.

5.4.1 Legislative Approaches to Change

Legislation is a powerful means of creating incentives or disincentives for the use of innovative technologies. In Illinois, the financial guarantee for a replacement technology, in the event the innovative technology does not work, is clearly an incentive to demonstrate new technologies. In contrast are the deletions of the statutory preferences for treatment by other state legislatures.

States must take care to avoid the unintended consequences of legislation on policy pertaining to implementation of innovative technologies. As examples, adoption of health risk-based standards for cleanup and the use of state-licensed site remediation professionals may be indirect disincentives to use innovative technologies.

5.4.2 Administrative Approaches to Change

Change may be well within the administrative powers of the regulatory agencies without the necessity of legislative amendment. Changes can take the form of regulatory, organizational, or policy reform.

An example of regulatory change is the process that Massachusetts recently completed. That state promulgated regulations that centralized responsibilities for site remediation in one agency and amended ground water standards to facilitate the use of ISB.

Organizational change in more populous states, such as New York and Illinois, typically involves the creation of a unique technology support unit within remedial programs. However, in less populous states, such as South Carolina, organizational reform may take the form of a dedicated individual (i.e., technology champion).

Change can take place in a less structured manner by redirecting policy. For example, New York evaluates new technologies on a parallel track with conventional technologies.

Change can only be accomplished through committed support of agency management and the dedication of agency staff. In an era of overworked regulators, the expanded sharing of experiences among state (and federal) regulators and between the regulators and responsible parties, technology vendors, other environmental professionals and the public is critical to the success of new technologies and ISB.

5.5 Usefulness of the Case Study Approach

Collection of anecdotal data, from a limited sample, through a case study approach, could have value beyond the primary objective of this report. Such an approach could be used to guide states regarding resolution of institutional/regulatory barriers not only in regards to ISB and innovative technologies, but also with respect to other troublesome issues (e.g., incineration and cost containment of remediation).

The Task Group discovered that the combination of state-to-state contact and a sponsoring organization provided anecdotal data that could be useful in guiding states as to what works (and doesn't work) regarding deployment of ISB or other innovative technologies. The approach of state colleagues interviewing one another created an opportunity for trust, so that the interviewed states could share with candor the process of resolving institutional/regulatory barriers. Also, the ITRC lent credibility to the process as being the sponsoring organization and provided the opportunity to showcase each state's success story.

Appendix A
Case Study Task Group Membership

Case Studies Task Group Membership List

Paul Hadley, Chair, Department of Toxic Substances Control, California Environmental Protection Agency

Michael Chacón, Hazardous and Radioactive Materials Bureau, New Mexico Environment Department

Jim Cummings, U.S. Environmental Protection Agency

Ted Dragovich, Illinois Environmental Protection Agency

Jim Harrington, New York Department of Environmental Conservation

Bob Huang, Bureau of Waste Site Cleanup, Massachusetts Department of Environmental Protection

Roger Kennett, Environmental Program Supervisor, Arizona Department of Environmental Quality

Bill Mason, Oregon Department of Environmental Quality

Tom Singer, Western Governors' Association

Bill Wallace, CH2M Hill

Appendix B
Case Study Descriptions

INTERSTATE TECHNOLOGY AND REGULATORY COOPERATION
IN SITU BIOREMEDIATION CASE STUDY
COMMONWEALTH OF MASSACHUSETTS

1.0 INTRODUCTION

This section addresses why the Massachusetts case study was selected and introduces the interview participants.

1.1 Selection Criteria

Massachusetts was selected for this case study because the Massachusetts Department of Environmental Protection (MADEP) implemented a demonstration program (or "Pilot Study," as the regulators refer to it) to identify how to best initiate regulation of in situ bioremediation (ISB) projects. This case study focuses on the Pilot Study, and not on particular ISB site demonstrations.

1.2 Participants

Interviews were conducted on July 17 and 18, 1995 by Paul Hadley of the Office of Pollution Prevention and Technology Development, Department of Toxic Substances Control, California Environmental Protection Agency and Gary Broetzman of the Colorado Center for Environmental Management (CCEM). The following people were interviewed from the MADEP.

- Linda Benevides, Special Assistant, Office of Deputy Commissioner of Operations (617) 292-5782
- Mark Begely, Response & Remediation Division, Bureau of Waste Site Cleanup (BWSC) (617) 556-1193
- Dean Spencer, Director, Division of Water Pollution Control (WPC), Bureau of Resource Protection
- Robert Huang, Innovative Technology Coordinator, BWSC
- John Fitzgerald, Branch Chief, Metropolitan Boston/Northeast Region
- David Shakespeare, Policy & Program Development Division, BWSC
- Mark Casey, Environmental Engineer, Metropolitan Boston/ Northeast Region

Personal interviews were also conducted with:

- Donald Corey, Professional Engineer (PE), Licensed Site Professional (LSP), Phoenix Environmental Services, Inc.
- John Davey, LSP, Phoenix Environmental Services, Inc.
- James Trenz, PE, Terrane Remediation, Inc.

In addition to personal interviews, numerous letters, internal documents, and external reports were reviewed related to the ISB Pilot Study.

2.0 SETTING

This section addresses (1) the Commonwealth institutional/regulatory framework, (2) factors that influenced institutional/regulatory change, and (3) a description of the Massachusetts' ISB Pilot Study.

2.1 Institutional/Regulatory Framework

The institutional and regulatory framework pertaining to the site is described below. First, the Commonwealth organizational structure related to environmental protection is presented. An organizational chart is attached. Second, the Commonwealth's approach to innovative technologies, and bioremediation in particular, is described. Finally, the regulatory framework relevant to the subject site is explained.

2.1.1 Organization

The MADEP is the State agency responsible for environmental protection in Massachusetts. Three of its bureaus (Resource Protection, Waste Site Cleanup, and Waste Prevention) manage functional programs under the Deputy Commissioner for Policy and Program Development. The Deputy Commissioner for Operations oversees the four regional offices where many ongoing program decisions are implemented. The bureaus relevant to the ISB Pilot Study were the Bureau of Waste Site Cleanup (BWSC) and the Bureau of Resource Protection which contains the WPC.

2.1.2 Regulatory Framework

In the early 1980s, MADEP established a regulatory process for ground water protection under WPC. The program, which is still in effect, focuses on permitting the discharge of regulated contaminants from new sources. It takes upward of one year to process a ground water permit. The ground water protection program is premised on protection of uses of ground water. Ground water quality is important to the Commonwealth because about 30 per cent of the population relies on ground water for drinking water. Even where ground water is unsuitable as a drinking water source, the drinking water use defines ground water quality standards in most areas.

In 1983, MADEP established the waste site cleanup program, now housed in the BWSC. Significant changes made to that program in the 1993 revisions of the Massachusetts Contingency Plan (MCP) for waste site cleanups followed two major themes. One established state licensing of private engineers and scientists as "Licensed Site Professionals (LSPs)" to oversee cleanup work on contaminated sites with limited review by MADEP. The second theme related to increased flexibility for determining the levels of site-specific cleanup and their relative priority. This enabled increased reliance on technical judgment by both the licensed professionals and the BWSC staff for defining cleanup levels using a risk-based approach. Under the revised MCP, responsible parties became exempt from permitting and other procedural requirements at State Superfund sites, similar to the federal Superfund program for air quality, surface water quality, and hazardous waste programs. That exemption, however, did not extend to the requirement for a ground water quality permit.

2.2 Factors Influencing Institutional/Regulatory Change

The internal and external factors influencing institutional/regulatory change are addressed below.

2.2.1 Internal Factors

In the early 1990s, responsible parties and BWSC staff became interested in ISB as a potentially viable cleanup alternative for numerous contaminated petroleum sites. Sparging of petroleum-contaminated ground water was used successfully and did not raise issues for WPC. However, the prospect of applying nutrients and microbes to ground water as a treatment additive presented a procedural dilemma for WPC, which maintained its position that the injection of such foreign substances must be controlled under the ground water permitting process. WPC was concerned that the introduction of these materials could cause pollution problems rather than solutions.

Several factors led to a climate of change relative to this issue within MADEP. These included the following.

- In 1993, MADEP adopted core values that placed greater emphasis on environmental results and less on the procedures for attaining those results.
- WPC was perceived as being hostile to new technologies because its ground water permitting requirements created possible barriers to cleanup through ISB. This appeared to conflict with the core values.
- The workload of WPC was such that it was unable to meet its overall permitting and enforcement responsibilities.
- An "innovative technology initiative" was created within MADEP, which led to procedural changes in several programs for reviewing and encouraging innovative technologies. Under this initiative, an innovative technologies coordinator was created in the BWSC and in other environmental management programs. These positions help focus support and technical assistance to new technologies.

2.2.2 External Factors

With the potential benefits of ISB for cleanup of petroleum-related contamination at many sites, external pressures began mounting in 1993 for both the approval of injection of nutrients and microbes into the ground water and for relief from the ground water permitting process. Technical professionals, particularly LSPs and others skilled in ISB, stressed that the year-long ground water permitting process and the ground water monitoring requirements, were barriers to the use of ISB. These professionals wrote letters to MADEP's upper management expressing strong recommendations for change. Additionally, certain BWSC technical staff advocated regulatory streamlining under their program to utilize ISB at those sites where ex situ remediation was not practicable.

With the support of the MADEP Commissioner, an internal committee was formed in mid-1994. The committee was comprised of representatives from both BWSC and WPC, along with a special assistant from the Office of the Deputy Commissioner of Operations. This committee addressed the concerns raised by WPC that were important in strengthening the water quality monitoring features of the eventual ISB Pilot Study. During October 1994, the Acting Deputy Commissioner for Policy and Program Development, the office that oversees the policy and regulatory development for both BWSC and WPC, signed an announcement creating the ISB Pilot Study.

2.3 Description of the Pilot Study

The October 1994 announcement invited up to 20 sites to apply for participation in the ISB Pilot Study. Limitations included:

- Only petroleum-contaminated sites would be considered.
- Only the introduction of microbes indigenous to Massachusetts would be allowed.
- Ex situ bioremediation would not be included.
- Ground water monitoring of nutrients and total petroleum hydrocarbons was required.

Performance standards for the use and application of nutrients, microorganisms, and other materials are driven primarily by WPC standards for drinking water protection. Of those, the national maximum contaminant level (MCL) for nitrates of ten milligrams per liter (mg/l) appeared to be the most relevant for nutrient control. The injection and/or specific applications were prohibited within 100 feet of a surface water body or 500 feet of a drinking water well.

Monthly monitoring was required for a minimum of six months after the last introduction of nutrients, or for the duration of the ISB activities. The deadline for addition of nutrients and microbes was December 21, 1994. At least one upgradient and two downgradient monitoring wells were required for each site to document safe performance. The compliance point was set at ten meters downgradient of the point of application.

The ISB Pilot Study was conducted under the centralized regulatory jurisdiction of BWSC. The approval process was reduced from requiring approvals from two MADEP agencies (i.e., BWSC and WPC) to a single approval under the BWSC. Embodying the BWSC privatization approach embraced in the MCP, sites in the Pilot Study were subject to LSP oversight and not directly overseen by BWSC personnel.

3.0 CURRENT STATUS

The information contained in this section is current through October 1995.

3.1 Results to Date

Nine sites have entered the Pilot Study. Each is relatively small and not conducive to ex situ treatment, typically because of structural limitations. Also, due to the small size, full-site remediation is being pursued without a demonstration phase. The ISB technologies being used are considered conventional and involve the addition of commonly-available nutrients through dry wells or as surface applications. ISB is used in conjunction with other treatment technologies at a few of the sites.

An example of a typical site is the Rivers School in Bedford, Massachusetts. The school is remediating extensive subsurface fuel oil contamination caused by several years of undetected leaks in its supply lines. Free fuel oil, surrounding building basements, has entered the septic system leach field and threatens an adjoining recreational pond. The free fuel oil is being skimmed from the ground water prior to utilization of ISB.

At eight of the nine sites, ground water quality standards downgradient of the point of application were not violated. Curiously, at two of the sites, ground water standards were violated upgradient of the point of application (a drainage field for a large septic system at one of those sites could be the cause of the violation).

The Pilot Study generated evidence that reduces the original concerns of WPC regarding the use of ISB. Some concerns remain for WPC regarding potential adverse water quality impacts from excessive nutrient/microbe additives. But, overall, it is believed that the favorable technical results along with the experiences gained from these technologies by the staff has helped gain confidence towards ISB technologies.

In the absence of the ISB Pilot Study, none of the nine projects would have likely commenced because of the lengthy ground water permitting process. The Pilot Study has not only accelerated the implementation of these projects, but has also streamlined the regulatory process for approval of the use of ISB at petroleum-contaminated sites.

3.2 Prospective Institutional/Regulatory Changes

In September 1995, the MADEP promulgated in regulations what it created administratively in the ISB Pilot Study. The new regulations codify the regulatory streamlining pertaining to permitting and privatization features of the Pilot Study. With these regulatory changes, WPC relies upon the BWSC to review the water quality features for ISB projects thereby enabling WPC to shift limited resources to higher priority tasks. In addition, the regulations broadened the provisions of the Pilot Study by enabling BWSC approved site cleanup with any ground water discharge (i.e., resulting from a ground water treatment system effluent, bioremediation additive, etc.) to proceed without the need for a WPC ground water discharge permit.

There was broad public interest, including LSPs, real estate sales people, and responsible parties, in MADEP's amendments to the ground water regulations. Although consultants supported the overall concept of allowing BWSC to implement ground water quality standards, they advocated less frequent monitoring and a more distant point of compliance.

3.3 Prospective Expansions

Consultants involved in the Pilot Study projects believe that the enhanced acceptance of ISB for petroleum-contaminated sites by MADEP will serve to further the use of ISB at other types of contaminated sites. MADEP representatives believe that the streamlined regulatory features of the ISB Pilot Study may be expanded into other bioremediation areas -- involving other chemical additives and larger sites -- and into other types of innovative technologies. However, MADEP cautioned that with the changing role of government, new technologies will be influenced primarily by the market place rather than by MADEP.

4.0 CASE STUDY FINDINGS

MADEP created the ISB Pilot Study for the purposes of encouraging the use of ISB and to determine how to best regulate it. Until the Pilot Study, it was perceived by environmental professionals and MADEP technical staff that application of ISB in Massachusetts had been limited by institutional and regulatory constraints and not by technical issues. Information gathered during the case study confirmed that perception. Other key findings from the case study follow.

- The 1993 revisions to the MCP embodied two major themes:
  - private Licensed Site Professionals' oversight of site cleanup
  - more flexible definition of site-specific cleanup levels, using a risk-based approach
- The ISB Pilot Study was established to address several vexing issues primarily related to ground water drinking water protection. Key points follow.
  - Fundamentally important internal support for the Pilot Study came from top management and the WPC program staff. Other MADEP technical staff provided meaningful contribution and commitment to the study design.
  - The regulated community, including private technical professionals, also provided major external support for the Pilot Study.
  - Ground water monitoring and documentation were required.
  - The point of compliance was moved downgradient of the injection point.
  - Limiting approval authority to one agency streamlined the approval process.
- Results of the Pilot Study have helped achieve acceptance of ISB within MADEP.

- The Pilot Study was partially responsible for recent regulatory changes, including the following.
  - A site cleanup, including any ground water discharge, approved by the BWSC can proceed without a WPC ground water discharge permit.
  - The experimental changes from the Pilot Study in organizational roles and procedures for ISB review and approval, are codified in the new regulations.
  - The point of compliance is moved downgradient of the contamination source.
- The MADEP emphasis on innovative technologies, as demonstrated by its innovation echnology coordinators, helped create the Pilot Study and is responsible for greater use of other innovative technologies.

INTERSTATE TECHNOLOGY AND REGULATORY COOPERATION
IN SITU BIOREMEDIATION CASE STUDY
STATE OF ILLINOIS

1.0 INTRODUCTION

This section addresses why the Illinois case study was selected and introduces the interview participants.

1.1 Selection Criteria

The State of Illinois ("Illinois" or "the State") Leaking Underground Storage Tank (LUST) Program was selected primarily to illustrate how regulatory issues were successfully resolved leading to deployment of in situ bioremediation (ISB) at sites contaminated with petroleum products.

1.2 Participants

Interviews for this case study were conducted on August 28 and 29, 1995, by Paul Hadley with the California Department of Toxic Substance Control, California Environmental Protection Agency, and Gary Broetzman of the Colorado Center for Environmental Management. Interviews took place at the offices of the Illinois Environmental Protection Agency (IEPA) with the following IEPA representatives:

- Ted Dragovich, Permits Section, Division of Land Pollution Control, Bureau of Land
- Doug Clay, LUST Section Manager, Division of Remediation Management, Bureau of Land
- Eric Portz, Manager, Engineering Unit, LUST Section, Division of Remediation Management, Bureau of Land (217) 782-6762
- Bur Filson, Manager, Upstate Unit, LUST Section, Division of Remediation Management, Bureau of Land
- Chris Kohrmann, Engineer, LUST Section, Division of Remediation Management, Bureau of Land
- Ron Steward, Division of Public Water Supplies, Bureau of Water

Harry Chappel, former head of the Permits Section of the Division of Land Pollution Control and currently with the engineering firm of CDS Environmental Services, was also interviewed to gain his perspective on the State LUST program and on the prospects for ISB for storage tanks remediation. In addition, IEPA personnel took the interviewers to two sites, one in which ISB was used for cleanup in a confined city setting, and the second where ex situ bioremediation is underway for the remediation of fuel tanks for a large hospital complex.

In his December 15, 1995 and February 9, 1996 comments to the drafts, Eric Portz provided current information relevant to the case study.

2.0 SETTING

This section addresses (1) the State organizational structure pertaining to environmental protection, (2) a description of the Illinois LUST program, (3) the regulatory framework, and (4) the emphasis Illinois places on innovative technologies.

2.1. Organization

Under the three main bureaus of air, water and land, the IEPA is responsible for environmental management programs for the State. All environmental remediation programs (Superfund, Resource Conservation and Recovery Act [RCRA], solid waste, and LUST programs) are contained within the two divisions (Division of Land Pollution Control and Division of Remediation Management) of the Bureau of Land. About 35 employees are in the LUST Section of the Division of Remediation Management, which is responsible for carrying out the State program consistent with federal program requirements and in cooperation with the federal EPA program staff.

2.2 LUST Program Description

The initial Illinois LUST law was enacted by the State Legislature in 1987 and has been periodically modified since then. The Illinois program responded to the national LUST regulatory requirements for controlling contamination from many underground tanks. In 1989, the law was modified to include the establishment of a dedicated Underground Storage Tank (UST) Fund for reimbursement to tank site owners of State-approved remedial expenses. Revenues have been derived from a 0.3 cent per gallon gas tax, or about $18 million per year annually. About 13,000 UST sites have been identified across the State. Information on leaking tanks can come from a variety of sources, although the State Fire Marshall determines if tanks are leaking and refers those that are to the LUST program staff.

Site cleanup costs average about $60,000 per site. The Fund reimburses all but a $10,000 standard deduction of approved costs for site cleanup at fund eligible sites. IEPA requires that all applications be submitted by a registered professional engineer. The applications are automatically approved within 120 days if IEPA does not respond. Projects are funded in the order they are received and have not been prioritized by their relative environmental impacts or improvements.

2.3 Institutional/Regulatory Framework

Requirements for cleanup of individual tank sites have been driven by ground water protection for drinking water purposes as established by the State ground water protection program under the Bureau of Water. Ground water protection for drinking water is important because it is the source for about one-half of the State's population. The IEPA does not have a non-degradation or a background level goal for site remediation. But, because LUST sites typically lie above aquifers that are current, or potential, drinking water sources, IEPA has generally required that site cleanup comply with the drinking water maximum contaminant levels (MCLs) at the pollution source (i.e., location of the tank).

Although the overall ground water management framework is defined by the Bureau of Water, each program within IEPA is responsible for implementing the ground water requirements. The Bureau of Water does not review the individual project decisions.

2.4 Technology Emphasis

To encourage alternative (i.e., innovative) technologies, the 1991 amendments to the State LUST law embodied a proposal offered by the IEPA and supported by the private sector. Basically, the amendments provide an insurance package at eligible sites to those proposing alternate technologies. First, it reduces the deduction for cost reimbursement to $5,000 (from the $10,000 level standard amount) for those technologies approved by the LUST program. Second, and perhaps more importantly, the site owner has protection from the UST Fund covering the full cost of a replacement technology if the alternative technology for approved projects should not meet program requirements.

IEPA offered this proposal primarily because of its:

- Stewardship responsibilities in supporting more cost-effective solutions as a means for reducing long-term demands on the UST Fund and eventually spreading limited resources over more projects.
- Desire to reduce demands on the capacities of existing landfills by encouraging use of on-site and in situ solutions, rather than use of conventional off-site disposal of contaminated soils from these sites.

3.0 LUST PROGRAM RESULTS TO DATE

UST site cleanup in Illinois appears prompted by three factors:

- Requirements of financial institutions
- Reimbursement of cleanup costs under the UST Fund
- IEPA enforcement actions where pollution poses a significant threat to public health.

About 3,500 of the tanks in the State have been certified for "no further action" meaning that adequate cleanup has occurred or that no further cleanup is feasible. In 1993, at the urging of the regulated community, the Legislature authorized the sale of $110 million in bonds to supplement the UST Fund to be repaid with the annual revenue gained from the 0.3 cent per gallon gas tax (about 2/3 of that annual revenue). The bond offering reduced the backlog, but did not eliminate it as had been anticipated. In fact, the list continues to grow due to old tanks being discovered and new tank failures covered by the program. The financial shortfall has continued to be a chronic problem.

Much interest exists in the IEPA and the regulated community regarding the alternative technologies feature of the State LUST program. Subsurface geological conditions restrict the use of ISB technologies, however. Other than in alluviums and other isolated areas of lighter soils, clay surface soils exist across virtually all of the State. The tight soil conditions limit the opportunities for ISB at those locations. Despite those conditions, about 130 LUST sites have alternative technologies approved by the IEPA, of which 53 are ISB. The State does not have limiting criteria for nutrient applications, and all ISB projects have nutrient additives involving subsurface applications (generally trenches). The ISB is being used primarily for sites with petroleum-contaminated areas around and under existing structures and under streets and other physical barriers where conventional ex situ treatment or excavation and off-site disposal is not desirable or feasible. To date, none of the alternative technologies have required replacement. The increase in innovative technologies represents about 2-3 percent of the total projects, a level believed to be much higher than would otherwise be without the LUST insurance provisions.

IEPA program representatives indicated that ISB is also being considered and possibly used in some of the State and federal Superfund activities in Illinois.

4.0 EMERGING CHANGES IN THE LUST PROGRAM

Program changes continue as the result of amendments made in the State Law in 1993 and funding provisions before the State Legislature. In December 1995, Illinois enacted a user fee of 0.8 cents per gallon of fuel on gas station owners and other bulk users of fuels.

The 1993 amendments to the State LUST law modified the cleanup criteria and point of compliance. The new legislation replaced compliance with drinking water MCLs at the pollution source with a priority-based classification system. The 1993 amendments also allowed use of risk-based corrective action (RBCA) criteria. In January 1996, IEPA finalized a risk-based corrective action procedure for generation of cleanup objectives. This procedure is also being proposed for promulgation as a regulation. It consists of a tiered approach, derived from ASTM ES 38-94, to establish cleanup objectives based upon site-specific conditions and actual risk to human health and the environment. Greater judgment may be utilized in selecting the appropriate point of compliance. This idea originated from the regulated community. State staff, however, may benefit from its features because of the increased flexibility available to its decision-making.

Under the previous legislation, IEPA staff were sometimes faced with making the difficult decision of "no further action" at a site where full compliance with the regulatory criteria was technically infeasible. Although the MCLs may still be used, IEPA can exercise greater technical judgment in defining specific criteria protective of public health. The overall effect expected from use of less conservative criteria will be to reduce the cost of cleanup at many individual sites. The resulting savings would then be available to cover additional sites. In some cases, site cleanup may not be needed because the pollutants may not reach, or be expected to reach, the point of compliance. State staff indicated that this risk-based approach is likely to be extended to other site remediation programs.

5.0 CASE STUDY FINDINGS

Key findings from this case study follow.

- ISB is used in Illinois primarily for sites where the use of conventional off-site disposal or ex situ treatment is not desired nor feasible. The use of ISB technologies would likely have been even greater if not for the presence of tight clay throughout much of the State.
- The UST Fund is chronically inadequate. This has fostered a willingness to support the use of innovative technologies that will stretch the use of limited monies to additional sites.
- The Illinois LUST program insures the full cost of a replacement technology if an approved innovative technology does not meet cleanup requirements. This feature has increased the application of such technologies, including ISB.
- Until recently, the primary regulatory driver for UST site cleanup has been the requirements of the State ground water program, which required compliance with MCLs for drinking water at the source of contamination (i.e., tank location).
- The 1993 amendments to the State LUST laws changed the criteria to a classification system based on environmental priority that enables greater use of technical judgment in setting case-specific cleanup criteria. The 1993 amendments also provided IEPA authority to use risk-based decision making criteria to determine site-specific cleanup objectives. The combined effect of these changes could result in a greater number of sites having access to the UST Fund, because less conservative, site-specific cleanup goals will likely reduce remediation costs at many sites.

INTERSTATE TECHNOLOGY AND REGULATORY COOPERATION
IN SITU BIOREMEDIATION CASE STUDY
STATE OF NEW YORK

1.0 INTRODUCTION

This section addresses why the New York case study was selected and introduces the interview participants.

1.1 Selection Criteria

The case study of in situ bioremediation (ISB) at sites in New York was selected to illustrate how regulatory issues were successfully addressed and resolved leading to the demonstration of these technologies at sites contaminated largely with a variety of chemicals including chlorinated solvents.

1.2 Participants

Interviews for this case study were conducted on October 12 and 13, 1995, by Michael Chacón of the New Mexico Environment Department and Gary Broetzman of the Colorado Center for Environmental Management. The interviewers met with the following members of the New York Department of Environmental Conservation (DEC) in Albany:

- Jim Harrington, P.E., Chief, Technology Section, Bureau of Program Management, Division of Hazardous Waste Remediation (DHWR) (518) 457-0337
- Joseph White, P.E., Section Chief, Bureau of Western Remedial Action, DHWR
- Robert Shick, P.E., Section Chief, Bureau of Western Regional Action, DHWR
- Michael Ryan, P.E., Technology Section, Bureau of Program Management, DHWR
- Nick Kolak, P.E., Technology Section, Bureau of Program Management, DHWR
- Angus Eaton, P.E., Water Quality Standards Section, Division of Water

2.0 SETTING

This section addresses (1) the State institutional/regulatory framework, and (2) the site overviews.

2.1 Institutional/Regulatory Framework

The institutional and regulatory framework pertaining to the site is described below. First, the State organizational structure related to environmental protection is presented. An organizational chart is attached. Second, the State's approach to innovative technologies, and bioremediation in particular, is described. Finally, the regulatory framework relevant to the subject site is explained.

2.1.1 Organization

Environmental programs in New York are located within six environmental divisions under the Office of Environmental Quality and Remediation in the Department of Environmental Conservation (DEC). The Division of Hazardous Waste Remediation (DHWR), with 200 to 300 employees, is the lead program for the remediation of inactive hazardous waste sites at DEC. The State program includes sites from the federal Superfund program as well as sites that meet the

State definition of inactive hazardous waste sites, but do not score high enough to be listed on the federal national priorities list (NPL).

2.1.2 Technology Emphasis

Lead agency responsibilities in DEC for innovative technologies related to major site remediation lie with the Technology Section of the DHWR. That section (composed of two technical professionals) is a focal point, and an advocate, for innovative technologies for environmental remediation. Section personnel assist site remedial managers with technical issues and with consideration of new technologies.

The DHWR staff provides encouragement for the selection of innovative technologies in site remediation through use of what they refer to as a "dual remedy" approach in the investigative phases of the Superfund processes under State control and influence. Through a dual remedy track, innovative technologies are demonstrated and evaluated for site cleanup, where appropriate, within the same time frames as conventional technologies are evaluated. To further help promote new technologies, DEC is about to enter into the Western Governors' Interstate Technology and Regulatory Cooperation (ITRC) multi-state memorandum of understanding for sharing new technology demonstration results.

2.1.3 Institutional/Regulatory Framework

The overall strategy of DEC for contaminated sites is (1) source elimination (treatment/removal), (2) contaminant migration control, and 3) plume remediation.

Site-specific objectives for site remediation for the Superfund programs aim for cleanup levels consistent with regulatory requirements set by the media-specific programs in DEC. Ground water quality standards are often an important cleanup driver at those sites. Those standards are generally protective of drinking water usage at the point of discharge (injection). Under State law, however, the stated goal for site remediation is to "restore a site to pre-disposal conditions to the extent feasible and authorized by law." This provides flexibility in applying those program standards to a specific site, particularly at the State Superfund sites. DEC does consider site-specific variation from those standards where important factors exist, such as elevated background ground water quality, prohibitive costs, and lengthy remediation time. Program guidance memoranda issued by the DHWR present a basis for accomplishing generally consistent decisions on several major issues at inactive hazardous waste sites. They include guidance for defining appropriate soil cleanup levels when cleanup to predisposal conditions is not feasible and a methodology for selection of specific remedial actions for a site.

For technology demonstrations in general, Resource Conservation and Recovery Act (RCRA) Research, Development and Demonstration (RD&D) permits are required to establish the regulatory framework with supplemental permits required from other programs (e.g., air quality, surface water quality, underground injection control [UIC]), as appropriate. Demonstration projects at Superfund sites do not require those supplemental permits, although substantive compliance with regulatory requirements for those programs is necessary. Further, permits are not required at inactive hazardous waste sites where an administrative or judicial order controls. At those sites, demonstration of compliance with substantive requirements must be made and approval is issued by the DHWR Project Manager.

2.2 Site Overview

Two sites are addressed. These are the McKesson Site and the Multi-Vendor Site.

2.2.1 McKesson Site

This site is located on the south shore of Onondaga Lake within the City of Syracuse. Site releases are considered a relatively small contribution to the overall contamination of the lake, which is being addressed through a comprehensive lake restoration effort by federal, State, and local interests. However, the McKesson Site is being remediated under the State Superfund program consistent with the terms of a 1987 consent order between the State and the McKesson Corporation. The site is a former tank farm with ten large aboveground tanks. Although used for fuel products many years ago, it was primarily a storage terminal for solvents. The tanks were removed in the early 1980s. Ground water levels are only a few feet below the surface. Hydrocarbon and solvent contamination remain in the ground water and vadose zone. The ground water in this area is naturally saline.

The site owner proposed consideration of ISB for the vadose zone as part of a dual remedy approach, in parallel with soil incineration and low temperature thermal desorption. Biological treatment using in situ soil blending with nutrient additions (phosphorus and nitrogen) was proposed for demonstration, the first such remedial effort for solvent contamination in the State. The DHWR worked with the Water Division in the DEC to reach an internal agreement to proceed with the demonstration, even though this technology was not believed capable of achieving cleanup in the vadose zone compatible with the ground water cleanup standards. Factors that helped support consideration of the ISB approach were: (1) naturally saline ground water not suitable for drinking water; (2) prospects of low costs; (3) short-term cleanup period; (4) lack of volatilization of solvents; and (5) actual reduction of pollutants to the environment. No permits were required. The demonstration occurred during the summer of 1993. Nutrients were applied to the surface and roto-tilled into the soil every three days using special roto-tillers that allowed deep mixing. Water was also applied and micro-organisms were measured periodically throughout the demonstration period.

2.2.2 Multi-Vendor Site

This demonstration involves a cooperative effort begun in 1993 among DEC, EPA, and the New York Center for Hazardous Waste Management (SUNY Buffalo) for the purpose of promoting and demonstrating the viability of various technologies for accomplishing remediation of solvent contamination. The project entailed concurrent pilot studies of three technologies, each involving bioremediation, at a common site. The site selected, near Rochester, had a permit to receive construction and demolition waste. Although never permitted to receive drummed chemical wastes, it was believed that the site operator initially used drummed wastes to stabilize the construction and demolition material in the wetlands to allow continued disposal of those materials. In the early 1990s, all drums and debris had been removed by the State under an interim remedial action measure, but site contamination remained, consisting of chlorinated and non-chlorinated solvents. Site characterization information was developed under the State's Superfund program in 1992 and 1993. All responsible parties have not yet been identified.

Using State Superfund resources, the Technology Section managed the project for DEC, providing the site-support facilities such as roads, utilities, and other common services, oversight of construction and treatment activities, workplan approval, and vendor procurement. The Environmental Protection Agency's (EPA) technical contractor performed sample collection, data analyses, and documentation of the results. SUNY Buffalo established the sampling protocol and helped with sampling. Technologies selected for the pilot included:

- Two ex situ vaults using plastic liners -- one aerobic and the other anaerobic, each using nutrient additives.

- In situ bioventing in the vadose zone in an area with ground water as shallow as three feet. Anhydrous ammonia and methane were injected into the soil for stimulating micro-organism growth.
- Augmented in situ bioremediation using a German patented (UVB) ground water system that combines bioremediation and air stripping. Air was extracted and brought to the surface for ex situ treatment.

Regulatory issues arose related to ground water protection because the ground water is suitable as a drinking water source. For the purpose of the demonstrations, the concentrations of subsurface additives were required to be within the drinking water standards at the point of application.

Each vendor was required to document performance and costs and to do mass balance analyses for determining volatilization in comparison with bioremediation. Field work began in the summer of 1994 and was to last five months.

3.0 CURRENT STATUS

The current status of the two sites is addressed below.

3.1 McKesson Site

Based on the results of the treatability demonstration, bioremediation using in situ soil blending was selected for site cleanup of the vadose zone. Soil treatment levels (which defined how much the soil would be treated) were selected based on the levels that (1) could be reasonably achieved if the technology was moderately successful and (2) would result in a reduction of the contaminants of concern. Soil cleanup levels were defined using a "knee-of-the-curve" approach, wherein differing cleanup levels were related to the soil volume to be treated and to the total amount of contamination to be removed from the site.

The site was divided into subareas covering all contamination pockets within the site. Remediation in each subarea occurred over a 60-day period for each subarea and extended over a staggered time frame during the entire summer of 1994 construction season. DEC and the site owner agreed on a residual contaminant concentration target level of no greater than 10 parts per million (ppm) for each of the contaminants of concern. As with the treatability demonstration, nutrients and water were applied on the soil surface and roto-tilled into the soil during the treatment period. Continual monitoring occurred during that treatment period, including monitoring of micro-organism growth.

DEC continued to work closely with the site owner during site cleanup. Mutual trust grew between the two parties. Site cleanup approached 1 ppm at the end of the treatment period for most of the constituents. The site owner is now proceeding with initial investigations of ISB for ground water cleanup at this site. Furthermore, the owner's consultant and other engineering professionals in New York are examining ISB for other sites and contaminants across the State.

3.2 Multi-Vendor Site

During the project testing period in the summer of 1994, heavy precipitation at the site complicated progress and impeded success of the individual pilot projects. Two of the technologies (in situ and ex situ bioremediation) were completed in December 1994. The UVB demonstration was extended to September 1995 and has recently been completed.

Technology results follow:

- For the ex situ bioremediation vaults, preliminary results show that 90 percent pollutant removal was achieved. Costs for full scale treatment is estimated to be $50 per ton of soil treated.
- For the in situ bioventing, despite a diminished vadose zone due to rainfall occurrences, contaminants were significantly removed. It may not be possible to define the relative effectiveness of surface water flushing as compared to bioremediation.
- For the UVB demonstration, the vendor ran into difficulties when the water levels rose appreciably. Because of those and related issues, the project did not operate sufficiently in 1994 for project evaluation. The project was extended into 1995 with final sampling occurring on September 29th. Preliminary reports on the project performance are pending.

Pending receipt of the three final reports, no conclusions have yet been reached regarding selection of bioremediation for full-scale site remediation.

4.0 CASE STUDY FINDINGS

Several significant key findings emerged from this case study. They can be grouped into institutional/regulatory lessons and technical lessons.

4.1 Institutional/Regulatory

- The creation of a separate technology support unit within a state remediation or environmental management agency establishes a climate for dedicated professionals to be able to focus attention on, and develop expertise and support for, new technologies in concert with remedial program goals.
- A favorable atmosphere exists for considering, demonstrating, and deploying new technologies at hazardous waste sites in New York due largely to statutory language that allows flexibility in defining site-specific cleanup objectives.
- The "dual remedy" approach for evaluating innovative technology demonstrations concurrently with conventional technologies during the Superfund feasibility study process has worked in New York .
- New York exempts many types of remediation sites from requirements for environmental permits. Consequently, the tension between ground water quality and environmental restoration programs observed in other states, was not observed in the New York case study.

4.2 Technical

- Under ideal circumstances, hazardous waste site cleanup can generally be accomplished with ISB over time frames that are comparable to that for conventional technologies.
- DEC believes that ISB is potentially applicable to sites contaminated with chlorinated and non-chlorinated solvents. ISB has been successfully tested at two inactive hazardous waste sites in New York for combined hydrocarbons and chlorinated solvents contamination. Specific applicability of the technology must be evaluated on a case-by-case basis.

INTERSTATE TECHNOLOGY AND REGULATORY COOPERATION
IN SITU BIOREMEDIATION CASE STUDY
STATE OF SOUTH CAROLINA

1.0 INTRODUCTION

This section addresses why the South Carolina case study was selected and introduces the interview participants.

1.1 Selection Criteria

The Savannah River Site (SRS) in South Carolina was selected to illustrate how regulatory issues were successfully addressed and resolved leading to the demonstration and deployment of in situ bioremediation (ISB) for remediating sites contaminated with chlorinated solvents.

1.2 Participants

Interviews for this case study were conducted on October 16 and 17, 1995, by Michael Chacón of the New Mexico Environment Department and Gary Broetzman of the Colorado Center for Environmental Management. On October 16, interviews took place with the following representatives of the South Carolina Department of Health and Environmental Control (DHEC):

- G. Kendall Taylor, Director, Division of Hydrogeology, Bureau of Solid and Hazardous Waste Management (803) 896-4011
- Randy Thompson, Director, Division of Hazardous and Infectious Waste Management, Bureau of Solid and Hazardous Waste Management
- Jack Gelting, Division of Hydrogeology, Bureau of Solid and Hazardous Waste Management
- Rob Devlin, Division of Ground Water Protection, Bureau of Drinking Water Protection

On October 17, Brian Looney, Principal Investigator with the Ground Water Group, Westinghouse Savannah River Company, SRS, was interviewed. He also took the interviewers on a visit of the cleanup activities showcased for this case study. Discussions also took place with the following SRS representatives:

- Terry Hazen, Manager, Biotechnology Group, Westinghouse Savannah River Company
- Chris Bergren, Regulatory Support staff, Westinghouse Savannah River Company
- Joette Sonnenberg, Manager, Ground Water Group, Savannah River Technology Center

2.0 SETTING

This section addresses (1) the State institutional/regulatory framework and (2) the site overview.

2.1 Institutional/Regulatory Framework

The institutional and regulatory framework pertaining to the site is described below. First, the State organizational structure related to environmental protection is presented. Second, the State's approach to innovative technologies, and bioremediation in particular, is described. Finally, the regulatory framework relevant to the subject site is explained.

2.1.1 Organization

Environmental programs in South Carolina are managed by DHEC. Those programs are in seven bureaus under the Assistant Commissioner for Environmental Quality Control. Most remedial programs (e.g., Superfund, solid and hazardous wastes, and radioactive wastes) are in the Bureau of Solid and Hazardous Waste Management (BSHWM). The Division of Hydrogeology provides broad technical and technology support for BSHWM, particularly related to ground water quality protection associated with remediation of contaminated sites. The underground injection control (UIC) program is in the Bureau of Drinking Water Protection and the air quality and water pollution programs are in their respective bureaus. Since the interviews, the underground storage tank (UST) program has been moved out of Environmental Quality Control, but at the time of the interviews was housed in the Bureau of Drinking Water Protection.

2.1.2 Technology Emphasis

DHEC does not have a defined technology development program. The Division of Hydrogeology is the primary remedial technical group, responsible for Superfund and hazardous waste remediation. The UIC program manager also played a significant role in ISB technologies, particularly for SRS. Approvals under the state UIC and hazardous waste programs are required for the implementation of ISB at SRS.

2.1.3 Institutional/Regulatory Framework

Remediation activities at hazardous waste sites must conform with appropriate environmental regulations. Air quality standards and water quality classifications and standards for both surface water and ground water are established by the respective bureaus. Presently, ground water is classified as a current or potential drinking water source. Thus, the water quality standards are defined largely by maximum contaminant levels (MCLs), prescribed by EPA under the Safe Drinking Water Act. Environmental remediation program managers are directly responsible for complying with those requirements. Thus, the Water Pollution Bureau does not typically review or approve individual remedial projects. Because of the importance of ground water quality to all remedial programs and to both the individual drinking water and water pollution bureaus, a multi-program working group coordinates and addresses common ground water activities and issues. That group plays a key role in addressing vital issues associated with site-specific cleanup levels, points of compliance, and concentrations of constituents in ground water additives. Although DHEC has not yet formally adopted use of risk-based approach for defining cleanup levels, use of that concept is emerging in a number of programs in DHEC, particularly the UST program.

DHEC has a federal facilities liaison responsible for coordinating activities and issues at federal facilities among the various bureaus. Similarly, permitting and enforcement coordinator positions exist for coordinating those functions. All liaison/coordinator positions are located in the Assistant Deputy Commissioner's office.

2.2 Savannah River Site Demonstration Activities

SRS was the primary focus of the South Carolina case study.

2.2.1 Background

The historical mission of the Department of Energy's (DOE's) SRS has been to support national defense efforts through the production of nuclear materials. Located on 310 square miles in southwestern South Carolina near the Savannah River (the state line with Georgia), SRS has been operating since the 1950s. It is surrounded by rural areas and farming communities. One area, the M Area, contains the administrative buildings and one of the large manufacturing complexes. An estimated 3.5 million pounds of solvents, primarily tetrachloroethylene (PCE) and trichloroethylene (TCE), have been discharged to an unlined settling basin in this area from 1958 through 1985. Underlying the M Area, are moderately permeable, relatively homogeneous soils with ground water levels typically greater than 100 feet below the surface.

In 1981, DOE initiated the M Area site assessment, which showed a large subsurface ground water plume of solvent contaminants associated with the settling basin and the sewer line from the manufacturing complex to that basin. Under a Resource Conservation and Recovery Act (RCRA) permit, issued in 1985, DOE soon began initial cleanup activities by installing 11 pump and treat wells to contain the plume and remove contaminant mass. DOE also pursued a phased approach for demonstrating new technologies and for incorporating them into the full cleanup plan, where appropriate. A pilot air stripper was installed and operated from 1981 through 1983. In 1986, a soil vapor extraction (SVE) demonstration was conducted. A pivotal point in the technology development occurred in 1989, when the DOE Office of Technology Development supported the concept of using horizontal wells as conduits for innovative in situ treatment technologies. Two horizontal wells, constructed in 1988, were initially used for SVE and air sparging in 1990. An ISB demonstration, using the same two wells, was initiated in 1992. Gaseous nutrient additives of phosphorous, nitrogen, and carbon were injected to stimulate microbial degradation of contaminants.

Other biologically-related technologies are being demonstrated at SRS.

- Root zone remediation of the chlorinated VOCs
- Bio sparging at sanitary landfills
- Land farming for hydrocarbons (prepared bed bio-treatment)
- Full-scale bioventing at 3 sites

2.2.2 Regulatory Coordination

SRS personnel approached DHEC shortly after completion of the 1981 M Area assessment to discuss, and gain, State support for corrective action plans. DOE started pilot work for cleanup in 1983 in conjunction with an upcoming RCRA corrective action permit. That permit included requirements for a phased approach for closing the impoundment, characterizing the plume, developing a treatment plan, initiating pumping and treatment of the solvents, and conducting an annual evaluation of technology demonstrations for deployment into the corrective action plan, as appropriate. A separate Research Demonstration and Development (RD&D) permit was not required. Permit flexibility was cited by both DHEC and SRS personnel as important for efficiently incorporating the innovative technologies results into site cleanup. That regulatory structure remains today for this area.

The DHEC RCRA staff had some initial concern over proposed nutrient additives with the horizontal wells. The UIC program manager concurred in concept with the ISB technology being proposed and was instrumental in gaining State approval. The Bureau of Air Quality conducted a more extensive review of the technology responsive to the changes in the 1990 Clean Air Act. This led to the need for offgas treatment for the ISB conducted in 1992, a requirement that did not exist with the earlier air sparging.

3.0 CURRENT STATUS

This section addresses the recent developments at the SRS regarding institutional/regulatory issues and the technologies used. The expansion of ISB into other sites is also discussed.

3.1 Regulatory Support at SRS

Regulatory barriers at DHEC have not been a problem for ISB technologies and other innovative technologies at SRS chiefly because of: (1) trust developed between the respective staffs, based upon continuous working relationships; (2) continual efforts at DOE to strive for improved technological solutions for source remediation; and (3) ongoing efforts of DHEC to keep its staff trained on emerging technologies. Both DOE and DHEC emphasized the value of the ongoing working relationship. DOE stressed a partnership relationship with the State by meeting monthly on progress meetings, supplemented with technical seminars including bringing in outside, independent technical experts. All such coordinate actions have continued since the early 1980s during a time when that was not typical within the DOE complex and culture. The lead State agency, the Division of Hazardous and Infectious Waste Management in BSHWM, with help from the UIC staff person, has also emphasized the need to keep abreast of ISB and other innovative technologies through national seminars and special training sessions. Communications between DOE and DHEC are augmented by DHEC participation on the SRS Citizens' Advisory Board and by activities of the DHEC liaison with SRS and other federal facilities.

The initial RCRA permit provided flexibility to proceed with innovative technologies and established a framework for integrating favorable technology results into the cleanup plan for the M Area. Because cleanup of that area is proceeding under RCRA corrective action (even though the full site has since been listed on the national priorities list under the federal Superfund law), separate surface water quality, UIC, and air emission permits have been required. The RCRA permit provides a framework to guide the conditions of the other permits being issued. Modifications to the RCRA permit are being made to incorporate successful technology demonstrations results. This is particularly relevant to the acceptance of ISB results for solvent removal. Although regulatory activities mostly reside with the State, both DHEC and DOE keep EPA apprised of the demonstrations and cleanup efforts as they relate to the integration of remedial activities occurring under the Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA) and RCRA for the entire site. The SRS Federal Facilities Agreement defines the relationship between RCRA-based cleanup areas (under State lead) and CERCLA areas under EPA lead.

3.2 Status of Technologies

Many of the technologies first installed and demonstrated have been implemented as full-scale cleanup operations for the M Area. A full-scale pump and treat system of 11 to 16 wells has been operational since 1985. Five SVE wells are operating. Seven horizontal wells are a significant, integral part of the cleanup operations. Technical analyses show that ISB with nutrient additives increased the removal of solvents by about 45 percent beyond that accomplished with the vapor extraction aspects of that technology demonstration.

3.3 Technology Expansion Beyond SRS

DHEC confidence in ISB technologies (both at SRS and other sites in the State) has evolved largely from the support of the UIC program manager for those technologies. ISB has expanded from the initial work at SRS to upward of 75-80 sites across the State (primarily for petroleum cleanup). The horizontal environmental wells have also gained much acclaim nationally.

Hundreds of horizontal wells are being used across the country for a combination of ground water extraction, SVE, air injection, bioventing, and petroleum recovery.

4.0 CASE STUDY FINDINGS

A summary of the key findings from this case study follow.

- A flexible regulatory framework embodied in a RCRA corrective action permit, issued by the state in 1985, enables new technologies to be rapidly demonstrated and folded into full-scale cleanup at SRS. A separate RD&D permit has not been required.
- Early and continuous communications between SRS personnel and DHEC have helped create mutual trust and opportunities for technical interchanges.
- DHEC has emphasized technical training for its staff regarding emerging technologies; DOE has helped with some of that training.
- The focus for new technologies support in DHEC lies with an identified technology unit (Hydrogeology Division) in the hazardous waste management program. Regarding ISB technologies, an individual, who advocates use of ISB, located in the UIC program, has provided additional assistance.
- A multi-program working group focuses on ground water quality issues that impact all types of remedial activities, including those that utilize innovative technologies.
- SRS analyses of ISB demonstrations indicates that ISB technologies can be effective for removal of dissolved solvents in ground water.

INTERSTATE TECHNOLOGY AND REGULATORY COOPERATION
IN SITU BIOREMEDIATION CASE STUDY
STATE OF MONTANA

1.0 INTRODUCTION

This section addresses why the Montana case study was selected and introduces the interview participants.

1.1 Selection Criteria

The case study for the State of Montana ("Montana" or "the State") focuses primarily on a federal Superfund site, listed as "the Libby Groundwater Site" (Libby Site) on the national priorities list (NPL). This site was selected to examine the regulatory and institutional resolution of issues associated with the successful approval of in-situ bioremediation (ISB) at a wood preservative facility. Also, of significance, was how the federal lead in approving ISB at this site, impacted future efforts at other sites. The approval of ground water ISB at the Libby Site was an early application of the technology, and therefore, the path to approval is significant.

1.2 Participants

Interviews were conducted on October 24, 1995 by Roger Kennett, Environmental Program Supervisor, of the Arizona Department of Environmental Quality and Shaun Egan, Senior Fellow, of the Colorado Center for Environmental Management (CCEM). The following people were interviewed.

- Jim Harris, P.E., Superfund Branch, Montana Operations Office, Environmental Protection Agency (EPA) Region VIII.
- Brian Antonioli, Environmental Engineer, Environmental Remedial Division, Superfund Program, Montana Department of Environmental Quality (MDEQ) (Contact Niel Marsh, at (406) 444-1420, in lieu of Mr. Anonioli for information).
- Ken Wallace, Senior Project Geologist, Woodward Clyde.
- Carol Fox, Manager, Environmental Remedial Division, Superfund Program, MDEQ (406) 444-1420.

Additionally, follow-up phone interviews were conducted by Nettie Rosenthal, Regulatory Specialist with CCEM, with Brian Antonioli, Carol Fox, and Jim Harris, on December 8, 1995.

2.0 SETTING

This section addresses (1) the institutional/regulatory framework, and (2) a site overview.

2.1 Institutional/Regulatory Framework

The institutional and regulatory framework pertaining to the site is described below. First, the State organizational structure related to environmental protection is presented. An organizational chart is attached. Second, the State's approach to innovative technologies, and bioremediation in particular, is described. Finally, the regulatory framework relevant to the subject site is explained.

2.1.1 Organization

The Montana state agency responsible for environmental protection is the Montana Department of Environmental Quality. The Superfund Program of the Environmental Remediation Division provides state oversight at the federal Superfund sites addressed as part of this case study, as well as addresses state Superfund sites. A copy of the organizational chart for MDEQ is included as part of this Appendix.

2.1.2 Technology Emphasis

The MDEQ does not have a defined technology development program in conjunction with site remediation or other environmental management activities. Approval of innovative technologies is the responsibility of the State Superfund program and MDEQ.

2.1.3 Institutional/Regulatory Framework

The Libby Site, which is the focus of this case study, is being remediated under the federal Superfund program. Thus, the federal Superfund program is described below. Although not relevant to the sites in this case study, a brief description of the state Superfund program is included because of the potential impact of recent revisions in the state Superfund statute on the use of innovative technologies. Finally, the Montana water quality requirements, as described during the interviews, are addressed briefly below.

Federal Superfund

In Montana, the federal Superfund process may be implemented by EPA or the State, through a cooperative agreement under the Comprehensive Environmental Restoration, Compensation and Liability Act (CERCLA). The process typically includes a site assessment phase, remedy selection phase, a proposed plan, a record of decision (ROD), a remedial design phase, and remedy implementation phase. The site assessment phase includes a preliminary assessment/site investigation, a removal site evaluation, a remedial investigation (RI), or some combination of these. The remedy selection phase typically consists of a feasibility study (FS) of candidate remedies.

In order to shorten the remediation process, EPA has initiated the Superfund Accelerated Cleanup Model (SACM). SACM includes use of the presumptive remedy approach as one tool. Presumptive remedies are preferred technologies for common contamination problems or categories of sites, based on historical patterns of remedy selection. EPA intends to issue guidance regarding presumptive remedies for wood preservative sites, but in the interim has issued the *Technology Selection Guide for Wood Treater Sites*, (May 1993) (EPA540-F-93-020). In the interim guide, EPA recommends the use of ISB for treatment of pentachlorophenol (PCP) and creosote in sludge, soil, sediments, surface water and ground water. However, EPA recognizes that full-scale performance data is missing. According to Jim Harris, EPA's draft directive regarding presumptive remedies pertaining to wood treater sites was released, for internal EPA use, in May 1995, and includes ISB as one of the presumptive remedies available for treatment of soil and ground water at this type of site.

Superfund cleanups must be protective of human health and the environment and must meet applicable or relevant and appropriate requirements (ARARs). ARARs consist of state and federal promulgated requirements that are substantive, rather than procedural, in nature. Thus, state water quality standards would be considered ARARs (i.e., would define ground water cleanup levels), unless waived by EPA or a variance is granted by the relevant state.

State Superfund Program

Montana also has a state Superfund program. The Montana Superfund program is utilized by the State at sites that do not rank high enough to be listed on the federal NPL and that are not regulated as hazardous waste under Subtitle C of the Resource Conservation and Recovery Act (RCRA) or as underground storage tanks (UST) under Subtitle I of RCRA.

The State does incorporate presumptive remedies into its program and follows the federal lead, using EPA guidance documents. However, it was noted during the interviews that the use of presumptive remedies raises concerns with the public because analysis of remedial approaches is abbreviated, leaving less opportunity for public input.

During the 1995 legislative session, the Montana legislature reduced the preference for treatment and resource recovery technologies under the state Superfund law. Rather than requiring use of these technologies to the "maximum extent practicable", their use is required, only "if practicable". The legislative intent was that by reducing the preference for treatment, due consideration of institutional and engineering controls would be given.

State Water Quality Requirements

State ground water quality standards are the ARARs (i.e. become the cleanup levels for ground water) at most Superfund sites. During the 1995 session, the State legislature amended the Water Quality Act, which included changes to the protectiveness of water quality standards, site-specific standard setting, and anti-degradation requirements. These amendments did not exist at the time ISB was selected for use at Libby. However, these changes may be relevant to the Libby Site during the federally-mandated review cycle and may be relevant to other sites in Montana now or in the future.

Originally, the water quality standards for carcinogens were based on one-in-one million (10^{-6}) excess cancer deaths. This year, that risk level was changed to one-in-one hundred thousand (10^{-5}) unless the resulting water quality standard would exceed the maximum contaminant level (MCL) prescribed by EPA under the Safe Drinking Water Act. Thus, the ground water cleanup level is the more stringent of the MCL or the 10^{-5} risk level.

The previous statute provided that the prohibition against degradation of state water (an ARAR) is not violated if proposed activities (including remedial activities) result in non-significant changes in water quality. The amendments itemize criteria that are to be considered in a rulemaking for the determination of non-significance. Among these is the length of time the degradation of water quality will occur. This is relevant to the use of ISB which may degrade water temporarily, but ultimately provide remedial benefits. Also, the revised statute contains levels of nitrate (a frequent additive of ISB) in ground water that are considered non-significant at the boundary of the ground water mixing zone. The concepts of allowing temporary degradation of ground water, mixing zones, and specified levels of nitrate, all serve to relax ground water ARARs associated with the use of ISB, thereby encouraging use of the technology.

2.2 Site Overview

The Libby Site was the primary focus of the Montana case study. It was the among the first, if not the first site at which ISB was selected for use at a wood preservative site. During the interviews, three other sites were discussed. These were: the Burlington Northern Somers Site (Somers Site), Idaho Pole Site, and the Montana Pole and Treating Plant (Montana Pole) Site. All sites are being remediated under the federal Superfund. At the Somers Site, EPA is the lead regulatory agency. At the Montana Pole Site, under cooperative agreement with EPA, the State is the lead regulatory agency. At the Idaho Pole Site, the State was the lead agency through the issuance of the ROD; EPA is the lead agency during remedial design and implementation.

2.2.1 Technical Background

The Libby Site is a former wood treating operation at the Champion International (now Stimson) lumber mill. It includes a ground water plume of dissolved constituents that extends into the town of Libby, Montana. The soil and ground water are contaminated with PCP and the site is listed on the federal NPL.

2.2.2 Regulatory Background

Remediation of the Libby Site is being led by the EPA under the federal Superfund program. The ROD was signed in 1986 by EPA and the responsible party, Champion International (Champion). Remedial activities have been ongoing since 1988.

The State elected not to sign the ROD or the consent decree for a variety of reasons. The State remedial program was not well developed and was looking for more autonomy at the time, the State was unfamiliar with bioremediation as provided in the ROD, and the State did not perceive a need for its participation given EPA's lead regulatory role. Although EPA structured the consent decree to reserve Montana's rights to seek damages for the residual injury to the State's natural resources after remediation, Montana's program was too new to identify possible injury.

A combination of in situ and ex situ remedies was selected.

- Source area contaminated soil was excavated and treated in aboveground bioremediation treatment units.
- Ground water at the source area is extracted from one well, is treated by an oil/water separator, nutrients (specifically nitrate to stimulate microbial action) are added, the ground water is fed through a fixed film bioreactor system, and then is reinjected.
- Surface water is withdrawn, oxygenated, nutrients are added, and the water is injected into the ground water through three wells downgradient of the pollution source.
- Near the downgradient property boundary, oxygenated water only is injected into the dissolved phase of the plume.

During the FS, it was recognized that the ground water pump and treat system, alone, would not be adequate. Champion proposed bioremediation in the upper aquifer. EPA's Ada, Oklahoma Laboratory reviewed the FS, had funding to investigate bioremediation, and had an interest in the site. Using the FS evaluation criteria, it was determined that bioremediation was a preferred remedial alternative, especially due to its cost effectiveness; the capital and operating and maintenance costs would be less expensive for bioremediation. EPA quickly approved Champion's proposed remedy because it was well thought through, supported by the data at the time, and there were not many remedial alternatives.

There was little public interest in the remedy selection. Only the Clark Fork River Coalition objected, claiming that ISB was unproven for ground water remediation and that less expense may not mean that the remedy is better than conventional (i.e., pump and treat) technologies.

3.0 CURRENT STATUS

This section addresses the recent developments at the Libby Site regarding institutional/regulatory issues and the technologies used. The expansion of ISB into other sites is also discussed.

3.1 Institutional/Regulatory

At the Libby Site, the CERCLA-mandated five-year review was completed a year ago. This review included an evaluation of (1) whether the remedial systems were installed as envisioned in the ROD, and (2) the degree to which the remedy protects human health and the environment.

The review of protectiveness of the remedy revealed that adjustments in cleanup levels in ground water are required. The adjustments that are now being made to the cleanup levels are due to changes in risk assessment procedure and the promulgation or proposals of MCLs since issuance of the ROD. For example, since issuance of the ROD, EPA has promulgated an MCL for PCP that is 1000 times more stringent than the ROD-defined cleanup level. Also, MCLs have been promulgated or proposed for individual constituents that, in the ROD, were grouped together for defining cleanup levels. It is unclear at this juncture how the changes in Montana's Water Quality Act will affect cleanup levels in ground water. According to Jim Harris, adjustments in cleanup levels will not impact further implementation of ISB at the site.

3.2 Technologies

The ROD addressed a phased approach to the remediation of ground water. Phase I consists of source removal/treatment and the three ground water treatment systems described above. Phase II involves an evaluation of the performance of the existing ground water treatment systems and a refinement of the existing systems, as required. EPA is in the process of evaluating the effectiveness of all three ground water treatment systems. Modeling is underway to determine the necessary length of treatment.

3.3 Expansion of Technologies

Subsequent to the selection of ISB at the Libby Site, ISB also has been chosen at the Somers, Idaho Pole and Montana Pole sites. The acceptance of ISB has been less difficult for the regulators and the public due to the previous experience at the Libby Site and the growing use of the technology at other sites across the country. However, during the interviews, the State noted that although ISB shows some promise, significant source control or source removal and treatment has been required in addition to ISB. A cleanup has not been completed using it, and they still consider the technology to be innovative. It was further indicated, by a State representative, that ISB required case-by-case design and operation.

<u>Somers Site</u>

The Somers Site is located at the north end of Flathead Lake. It is a tie-treating plant, owned by Burlington Northern Railroad. The site is contaminated with polycyclic aromatic hydrocarbons (PAH). PCP is not present. The Somers Site is also a federal Superfund site under EPA enforcement. The ROD was signed in 1989.

The degree of public involvement differed at the Somers Site from the Libby Site. At this site, a citizens advisory group (CAG) met approximately 30 times over the course of four years. Based, in part, upon the experience of Libby, the CAG agreed with the selection of ISB for the treatment of ground water.

The ground water treatment system became operational in 1994. The ground water is extracted, treated in a carbon unit, and is reinjected following nutrient additions and oxygenation. EPA's preliminary evaluation of the effectiveness of the ground water treatment system indicate that it may take 50-100 years to clean up the ground water to ROD-defined levels in the most contaminated portions of the site. This is due to the presence of silty clay soil that reduces ground water extraction and injection rates. Regarding long-term ground water remediation, in general (i.e., not just with respect to ISB or the Somers Site), Montana may require bonding or some other form of financial surety to assure continued operation of the long-term remedy.

Idaho Pole and Montana Pole Sites

The Idaho Pole Site is located in Bozeman. The Montana Pole Site is located at Butte. Both are wood preservative sites that are being remediated under the federal Superfund. However, at these sites, the RI/FS and ROD were prepared by the State. The ground water treatment system at both sites will be similar to the system at the Somers Site, and will include ISB.

There was a high level of cooperation between the State and EPA in preparation of the RI/FS, ROD, and remedial design and in the selection of ISB. The interviewees indicated that communication between the two regulatory agencies was fostered by the proximity of the EPA field office to the State offices. It was thought that face-to-face communication on a daily basis between the State and EPA is the key to reducing and resolving disagreements between the two regulatory agencies.

4.0 CASE STUDY FINDINGS

- At the Libby site, acceptance of ISB occurred because of the following.
  - The responsible party's contractor delivered a strong and thorough proposal.
  - EPA was the lead agency, and followed its guidance regarding the use of ISB at wood preservative sites. The State adopted a wait-and-see approach.
  - ISB was only a portion of a multi-remedy selection. The total remedy was dependent on source control via excavation and treatment of contaminated soil and recovery of ree product from the ground water.
  - There was not much of a public health and environmental threat associated with off-site migration.
- The Libby site served as a demonstration to the State to make acceptance of ISB for treatment of ground water at other sites easier.
- Recent changes to Montana's Superfund and Water Quality laws may have mixed, unintended effects on the use of ISB in that State.
  - The reduced preference for use of treatment technologies at sites that are being remediated under the State Superfund law may discourage the use of ISB.
  - Changes to the Montana Water Quality Act add the type of flexibility to the water quality standards, used as ARARs at Superfund sites, which encourages the use of ISB.

INTERSTATE TECHNOLOGY AND REGULATORY COOPERATION
IN SITU BIOREMEDIATION CASE STUDY
STATE OF OREGON

1.0 INTRODUCTION

This section addresses why the Oregon case study was selected and introduces the interview participants.

1.1 Selection Criteria

The site selected in the State of Oregon ("Oregon" or "the State") case study is being remediated under the state Superfund laws. It was selected to study how in situ bioremediation (ISB) at wood preservative sites was chosen and implemented under the Superfund program.

1.2 Participants

Interviews of state personnel were conducted on October 25, 1995 by Roger Kennett, Environmental Program Supervisor, Arizona Department of Environmental Quality. The following people were interviewed.

- Bill Dana, Project Manager, Site Response Section, Waste Management and Cleanup Division, Oregon Department of Environmental Quality (ODEQ) (503) 229-6530.
- Richard Kepler, Program Coordinator, Water Quality Division, ODEQ
- Rodney Struck, Senior Project Hydrologist, Waste Management and Cleanup Division, ODEQ

Additionally, follow-up phone interviews were conducted by Nettie Rosenthal, Regulatory Specialist with CCEM, of Bill Dana.

2.0 SETTING

This section describes the relevant institutional/regulatory structure and the overview of the site selected for this case study, the Dant and Russell Site.

2.1 Institutional/Regulatory Structure

The institutional and regulatory structure pertaining to the site is described below. First, the State organizational structure related to environmental protection is presented. Organizational charts are attached. Second, the State's approach to innovative technologies is described. Finally, the regulatory framework relevant to the subject site is explained.

2.1.1 State Organization

ODEQ is composed of eight divisions. The Waste Management and Cleanup Division (WMCD) is comprised of six sections. The Site Response Section of the WMCD is responsible for implementing the State Superfund requirements. The Water Quality Division (WQD), responsible for ground water protection, is also one of the eight divisions.

2.1.2 Technology Emphasis

ODEQ does not have a defined technology development program in conjunction with site remediation or environmental management activities. Approval of innovative technologies is the responsibility of WMCD.

2.1.3 Institutional/Regulatory Framework

The Oregon Superfund process typically includes a site assessment phase, remedy selection phase, a proposed plan, a record of decision (ROD), a remedial design phase, and a remedy implementation phase. The site assessment phase includes a preliminary assessment/site investigation, a removal site evaluation, a remedial investigation, or some combination of these. The remedy selection phase typically consists of a feasibility study (FS) of candidate remedies.

State Superfund cleanups must be protective of human health and the environment to the extent feasible. Strict compliance with applicable or relevant and appropriate requirements (ARARs) is not required. Generally, federal and state water quality standards are considered to be protective. These standards serve as required cleanup levels in cases where ODEQ believes attainment is feasible. However, in cases where attainment is not likely to be achieved (such as sites with DNAPL contamination) these standards simply become remedial action objectives or goals, and the selected remedy includes contingency measures such as containment and institutional controls.

Ground water requirements include a non-degradation standard, which can impede injection of additives to the ground water as part of ISB treatment. However, under the 1991 revisions to the ground water protection regulations, State Superfund sites are exempt from the ground water requirements. According to Bill Dana, the Site Response Section must obtain the concurrence of WQD before issuance of a ROD, but strict compliance with ground water regulations is not always required.

During 1995, the Governor signed into law the state Superfund reform bill. Major changes included the following, as described in an article by Brooks Koenig, ODEQ Cleanup Policy and Program Development. "First, under the new law, 'protectiveness' can be achieved through 'risk reduction' or through 'risk management.' 'Risk reduction' usually means treatment or reducing concentrations of contaminants. 'Risk management' often means containment (e.g., capping) or access restriction (e.g., deed restriction). Second, the least expensive remedy shall be preferred although other factors are to be 'balanced.' Although undefined in the bill, the cost threshold for remedies at 'hot spots' will be greater than for non-hot spot sites. Third, the 'preference for treatment' (i.e., actual reduction of concentrations) is restricted to hot spots" (*Oregon Insider #133* [August 1, 1995]).

Under the new State Superfund statutes, cleanup goals for ground water must be "protective" and must consider the current and likely future beneficial use of the aquifer. For drinking water aquifers, an additional lifetime cancer risk of one in a million, from ingestion of ground water, is considered "protective" by statute. However, other cleanup levels may also be considered protective on a case-by-case basis. In cases where ODEQ believes that cleanup may not be technically feasible, cleanup goals are established in place of enforceable cleanup levels. Cleanup levels are therefore now determined in part by risk assessment, and in part by technical feasibility.

According to Richard Kepler, the state ground water standards do not allow for degradation of existing ground water quality. However, the rules include a variance for remedial actions conducted under the State's Superfund program. WQD requires that such remedial actions be designed to minimize ground water degradation, by providing the best practicable water treatment prior to reinjection and/or hydraulic containment of reinjected water. Also, ODEQ's Director and the Environmental Quality Commission can grant a site-specific concentration limit variance (CLV) for non-superfund discharges to the ground water.

2.2 Site Overview

The Dant and Russell Site is a former wood preservative site, located in North Plains and owned by the Burlington Northern Railroad. It will be remediated under the State Superfund program. ODEQ issued the ROD on December 21, 1994. Detailed design plans have not yet been developed.

The ROD requires hydraulic containment, DNAPL removal, extraction of contaminated ground water, above-ground biotreatment, addition of an electron acceptor such as hydrogen peroxide, and reinjection or reinfiltration of oxygen-enriched water back into the aquifer. The intent behind the additives was to facilitate the biodegradation of polycyclic aromatic hydrocarbon (PAH) compounds The ROD also includes contingency measures if treatment, including ISB, should not meet remedial goals. The contingency measures consist of hydraulic containment of the contaminant plume and deed restrictions regarding future use of ground water at the site.

WMCD approved use of ISB for ground water. WMCD staff relied on experience gained through a visit to the federal Superfund site at Libby, Montana. At the Libby Site, Oregon regulators got the idea of using ISB and adding hydrogen peroxide to ground water. At that time, ground water monitoring at the Libby Site indicated that ISB was doing some good. Also, WMCD relied on Environmental Protection Agency guidance indicating that use of biotreatment at wood preservative sites was a commonly selected remedy. The technology was selected during the FS, based upon a pilot-scale test of biotreatment of PAH compounds of waste water in onsite tanks.

WQD was concerned that the reinfiltration of effluent from the biotreatment plant would (1) cause expansion of the contaminant plume, and (2) violate the non-degradation standard for ground water (i.e., any constituent, hazardous or not, at greater concentration in the treatment system effluent than in the receiving ground water would be of concern).

WQD concurred in the selected remedy in the ROD with the understanding that injection of the additives into ground water will be fully addressed during the remedial design phase of the State Superfund process. WQD relied on WMCD to ensure that hydraulic containment would prevent the migration of ISB additives or other contaminants. WMCD and WQD are requiring that the responsible party do ground water modeling of the capture zones for the hydraulic containment and place monitoring wells around the infiltration galleries.

During the interviews, the Union Pacific Railroad Site, a wood preservative site located at the Dalles, also briefly was discussed. At that site, bioventing of vadose zone soil was selected as treatment for PAH compounds. However, the ground water remedy consists of hydraulic containment, DNAPL removal, ground water withdrawal, above-ground physical/chemical treatment, reinjection/reinfiltration, and deed restrictions. WQD again raised concerns about potential degradation of ground water associated with reinjection/reinfiltration. These concerns have not yet been resolved. WQD wants to be assured that reinjected water will not significantly degrade background water quality outside the capture zone of the extraction wells.

3.0 CURRENT STATUS

At the Dant and Russell site, the responsible party has not begun design or implementation of the selected remedy. The responsible party is litigating its liability (not the selected remedy) under the State Superfund laws.

WMCD cleanup activities and WQD ground water protection activities approach the implementation of ISB from different perspectives. The 1995 revisions to the state Superfund Law have helped to focus the discussions between the two programs regarding compliance with the Groundwater Protection Act. WMCD and WQD are working better together to resolve potential conflicts.

4.0 CASE STUDY FINDINGS

- ODEQ, by regulation, exempts compliance with ground water non-degradation requirements at State Superfund sites. The exemption should encourage the use of engineered ISB.
- ODEQ management policy is that ground water non-degradation requirements not impede remedial activities at State Superfund sites. This policy is in response to the requirement for concurrence by WQD before a ROD is issued and before a remedial design is approved.
- The State has the ability to grant short-term, site-specific variances of water quality requirements for engineered ISB at non-superfund sites (such variance is not required at the studied site).
- ODEQ selected ISB as part of the remedy for ground water contamination at the studied site, and reserved containment and institutional controls as contingency measures in the ROD.
- ODEQ's observation of ISB in Montana was considered in ODEQ's evaluation and ultimate selection of ISB as part of the ground water treatment remedy at the studied site in Oregon.
- The 1995 State Legislature reduced the preference in the State Superfund law for treatment and encouraged that institutional controls and containment be considered co-equally with treatment at non-hot spots. The effect of this statutory amendment on the use of ISB in Oregon will depend on how the term "hot spots" and the cost threshold for treatment of hot spots are defined by ODEQ in its implementing regulations.

Appendix C
Acronyms

Acronyms

ARAR	Applicable or relevant and appropriate requirement (under CERCLA)
AST	Aboveground storage tank
BWSC	Bureau of Waste Site Cleanup (Massachusetts)
CAG	Citizen's advisory group
CCEM	Colorado Center for Environmental Management
CERCLA	Comprehensive Environmental Recovery, Compensation and Liability Act
DEC	Department of Environmental Conservation (New York)
DHEC	Department of Health and Environmental Control (South Carolina)
DHWR	Division of Hazardous Waste Remediation (New York)
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DOIT	Develop On-Site Technologies
DWPC	Division of Water Pollution Control (Massachusetts)
EPA	Environmental Protection Agency
FS	Feasibility Study
IEPA	Illinois Environmental Protection Agency
ISB	In situ bioremediation
ITRC	Interstate Technology/Regulatory Cooperation
LSP	Licensed Site Professional (Massachusetts)
LUST	Leaking underground storage tank
MCL	Maximum contaminant level
MCP	Massachusetts Contingency Plan
MDEP	Massachusetts Department of Environmental Protection
MDEQ	Montana Department of Environmental Quality
NPL	National priorities list (under Superfund)
PAH	Polycyclic aromatic hydrocarbons
PCE	Tetrachloroethylene
PCP	Pentachlorophenol
PE	Professional Engineer
RBCA	Risk-based corrective action
RCRA	Resource Conservation and Recovery Act
RD&D	Research, Development and Demonstration (under RCRA)
RI	Remedial investigation (under Superfund)
ROD	Record of decision (under Superfund)
SACM	Superfund Accelerated Cleanup Model
SITE	Superfund Innovative Technology Evaluation
SRS	Savannah River Site
SVE	Soil vapor extraction
TCE	Trichloroethylene