NEED FOR ADDITIONAL FIELD

RESEARCH SITES

FOR ENVIRONMENTAL

REMEDIATION RESEARCH

Prepared by a Subcommittee of the
Biological and Environmental Research
Advisory Committee

April 2004

REPORT BY A SUBCOMMITTEE OF THE BIOLOGICAL AND ENVIRONMENTAL RESEARCH ADVISORY GROUP EVALUATING THE NEED FOR ADDITIONAL FIELD RESEARCH SITES IN SUPPORT OF THE OFFICE OF BIOLOGICAL AND ENVIRONMENTAL RESEARCH'S ENVIRONMENTAL REMEDIATION RESEARCH MISSION

Executive Summary

In July 2003, Dr. Raymond Orbach, Director of the Office of Science, U.S. Department of Energy (DOE), asked the Biological and Environmental Research Advisory Committee (BERAC) to evaluate the need for the establishment of additional field research sites to support the environmental remediation science mission of the Office of Biological and Environmental Research (BER). This evaluation was performed by the Environmental Remediation Sciences subcommittee of BERAC. That subcommittee found that the field research center (FRC) developed at the Oak Ridge National Laboratory (ORNL) by the BER-supported Natural and Accelerated Bioremediation Research (NABIR) program has been effective in attracting a number of strong field studies and supportive laboratory projects focused on an extant radionuclide contaminant plume. Based on the demonstrated success of this FRC and related research and the considerable potential for field research to meet the broad goals of BER's Environmental Remediation Sciences Division (ERSD), the subcommittee recommends that additional field sites be developed, as consistent with available funds.

With regard to the specific questions posed by Dr. Orbach:

Assess the need for additional field research sites for the BER programs involved with the science of environmental remediation of subsurface and surface contamination.

The subcommittee recommends that

1) Additional Field Research Centers be developed by ERSD;
2) Additional Field Research Centers be focused on the conditions and environmental problems extant at DOE sites that differ from those at the ORNL site;
3) New Field Research Centers have broad applicability to the research programs supported by the ERSD, and not simply the research focus of the NABIR program;
4) New Field Research Centers focus on scientific questions that arise from the need to remediate contamination due to radionuclides and mixed wastes (radionuclides with associated contaminants), contaminants that, within the United States, are predominantly the responsibility of DOE.

If the above recommends additional sites, provide recommendations on the desirable features of such sites, and provide advice on prioritizing the selection of sites.

The subcommittee recommends that

1) Future sites be focused on important environmental contaminants found at DOE sites;
2) Future sites be located on DOE property and that there be long term commitments for the maintenance of those sites;
3) Site characterization be as thorough as possible, including hydrobiogeochemical properties and waste stream history;
4) Financial support for the site and the consequent research be balanced against the value of the knowledge expected to be gained at that site.

Provide advice on how to design field experiments to optimize data sets for model development and validation.

The subcommittee believes that the interplay between experiment and model development is critical both for experimental design and for model development and validation. The full report provides guidance on the role of modeling in data interpretation, conceptualization and hypothesis testing, prediction, and scaling.

Comment on the relative desirability of a few comprehensive "all-purpose" sites versus a possibly larger number of sites, each with a more focused or restricted set of goals and purposes.

The subcommittee believes that a limited number of more comprehensive sites would be of much greater scientific value than a greater number of highly focused sites.

Provide advice on how to best balance the resources expended on field sites against other competing demands for research funds.

The subcommittee recommends that 10 – 15% of available research funds be spent in the support of field research centers.

REPORT BY A SUBCOMMITTEE OF THE BIOLOGICAL AND ENVIRONMENTAL RESEARCH ADVISORY GROUP EVALUATING THE NEED FOR ADDITIONAL FIELD RESEARCH SITES IN SUPPORT OF THE OFFICE OF BIOLOGICAL AND ENVIRONMENTAL RESEARCH'S ENVIRONMENTAL REMEDIATION RESEARCH MISSION

In July 2003, Dr. Raymond Orbach, Director of the Office of Science, U.S. Department of Energy (DOE), asked the Biological and Environmental Research Advisory Committee (BERAC) to evaluate the need for the establishment of additional field research sites to support the environmental remediation science mission of the Office of Biological and Environmental Research (BER). The full charge letter is found in Appendix A. The specific requests in Dr. Orbach's charge letter were that BERAC should:

- Assess the need for additional field research sites for the BER programs involved with the science of environmental remediation of subsurface and surficial contamination;
- Provide recommendations on the desirable features of such sites;
- Provide advice on prioritizing the selection of sites;
- Provide advice on how to design field experiments to optimize data sets for model development and validation;
- Comment on the relative desirability of a few comprehensive, "all-purpose" sites *versus* a possibly larger number of sites, each with a more focused or restricted set of goals and purposes;
- Provide advice on how to best balance the resources expended on field sites against other competing demands for research funds.

The Environmental Remediation Sciences subcommittee of BERAC was asked to address this charge. Membership of this subcommittee includes members of BERAC and additional experts in relevant scientific disciplines. The full membership is found in Appendix B.

The subcommittee held two meetings and several teleconferences during the course of its evaluation. The first meeting was held September 22 – 24, 2003, at Oak Ridge National Laboratory (ORNL). The second meeting was held February 24 – 25, 2004, in Washington, DC. This report represents a consensus opinion based on deliberations during those meetings and the associated teleconferences.

Background

One of the hallmark programs within BER's Environmental Remediation Sciences Division (ERSD) is the Natural and Accelerated Bioremediation Program (NABIR). In 2000, the NABIR Program established a field research center (FRC) at Oak Ridge National Laboratory (ORNL), consistent with the program's strategic plan to transition from a purely laboratory-focused program to one that incorporated field-based research. Three multi-investigator field projects are currently underway at the Oak Ridge FRC, and more than 30 other NABIR-funded projects use material or data from the site in their research. It is worth noting that in the discussions leading to the preparation of this report, subcommittee members unanimously voiced the opinion that long-term field research centers such as the existing Oak Ridge FRC or future ERSD FRC sites are rare in providing a venue for the integration of modeling and critical laboratory research with field-based data. The focus on fundamental, but mission-linked, science, especially involving radionuclide contaminants, is unique to DOE and represents a method of scientific inquiry of which the Department should be proud.

Responses to the specific questions posed

Assess the need for additional field research sites for the BER programs involved with the science of environmental remediation of subsurface and surface contamination.

The field research site approach, as implemented by the NABIR program managers at BER and leaders at the ORNL FRC, has provided the following benefits:

1) The fundamental research that is performed as part of the NABIR program has a direct connection with the contaminant mix that is extant at the site under actual environmental conditions. Further, site-based research raises awareness of the economic, regulatory, and institutional issues that are encountered outside of the laboratory.

2) The complexities and heterogeneities present in the field are evident and must be addressed. By way of contrast, such factors are often better controlled in laboratory or intermediate ("meso") scale experiments, but they are central to understanding the targeted processes and to the eventual development and application of remediation strategies.

3) It helps to foster more field research than would otherwise occur. Without the expertise of site personnel, some of the challenges of working in the field might seem insurmountable, especially to the novice field investigator. Site personnel provide background site data, help with routine sampling, and help troubleshoot unexpected problems. Further, several research projects can be facilitated at the same time, thus increasing the cost effectiveness of the work.

4) Projects tend to be more multi-disciplinary than might otherwise be the case. Because of their complexity, field experiments require expertise from more than one discipline. Ongoing field experiments cross-fertilize other experiments by providing samples and complementary data that might not otherwise be available, thus increasing the ultimate knowledge derived from a given set of experiments. Further, such research leads to the identification of knowledge gaps that require the expertise of yet additional disciplines; this, effectively, brings new researchers and new approaches to critical environmental problems.

5) As implemented at the Oak Ridge FRC, the working group program stimulates coordination, involvement of researchers new to the projects, and more robust experimental planning.

While there is no question that field research is itself critical for understanding contaminant behavior at actual sites, an equal if not greater value comes from quality samples from the field site and site experiments that are provided to additional investigators. This insures that many other researchers have more relevant samples than those to which they might otherwise have access, and complementary data are provided for their studies that aid analysis or more global interpretations.

Despite the many advantages of a field research site, there are associated limitations. Any given field research center limits the range of contaminant problems that can be investigated. In the case of the Oak Ridge FRC, a considerable amount of high quality information has been – and will be – learned about acidic uranium and nitrate contaminant plumes in a saturated saprolite matrix. Without concomitant investment elsewhere, investment in this site necessarily restricts what can be learned about other DOE site problems. The solution to this trade-off is to have additional field research centers, with each representing substantially different waste mixes and environmental conditions. New FRCs should be balanced with a laboratory-based research portfolio that addresses other, complementary DOE-relevant environmental problems.

In summary, the subcommittee believes that the field research program, as implemented for NABIR, has been effective and has developed in appropriate directions. The field research center approach should be important to some of the Environmental Management Sciences Program (EMSP) research directions and themes. Hence, it is recommended that:

1) Additional Field Research Centers by developed by ERSD;

2) Additional Field Research Centers be focused on the conditions and environmental problems extant at DOE sites that differ from those at the ORNL site ;

3) New Field Research Centers have broad applicability to the research programs supported by the Environmental Research Sciences Division, and not simply the research focus of the NABIR program;

4) New Field Research Centers focus on scientific questions that arise from the need to remediate contamination due to radionuclides and mixed wastes (radionuclides with associated contaminants), contaminants that, within the United States, are predominantly the responsibility of DOE.

If the above recommends additional sites, provide recommendations on the desirable features of such sites, and provide advice on prioritizing the selection of sites.

Many of the research problems studied by ERSD investigators will be driven by the specific environment and waste streams present at ERSD field sites. To diversify the science supported by ERSD, future ERSD field sites should have some combination of physical and biological properties that are distinct from those present at the current FRC. These differences can be hydrologic (e.g., an extensive vadose zone, or prevalent groundwater-surface water connections), lithologic (fractured igneous rock or a greater prevalence of expanding clays and zeolites), and/or chemical in nature (ambient alkaline pH or a highly reduced environment), with compositions distinct from those at the Oak Ridge FRC. Any future sites should have hydrobiogeochemical properties and waste streams that are prominent in the DOE complex. Additionally, each future FRC should have an array of chemical waste streams of different composition to facilitate a broad range of biological, chemical, hydrologic and geophysical studies.

In setting priorities for the establishment of additional FRCs, both scientific considerations (as identified above) and practical considerations must be evaluated. Some of the key considerations that we would like to highlight are:

1) Hydrobiogeochemical processes are noted for their long time scales. Research on these processes at ERSD sites will require continuous efforts over decadal time scales. Thus, ERSD investigators must be able to have long-term access to any ERSD site for their research efforts to be completed and for application of the research into remediation strategies to reach fruition. It is likely that this can best be accomplished if future ERSD FRCs are restricted to property owned and managed by the DOE.

2) Knowledge of the composition of local waste streams, their distribution in surface and subsurface environments, their source terms (such as landfills, tanks, burial crypts and trenches, and lagoons), and the overall hydrobiogeochemical properties of the site would be highly desirable prior to the successful deployment of any field experiment. If previous information is unavailable, significant resources must be expended by FRC site managers and FRC investigators to obtain this background information. Future FRCs should capitalize on previous site characterization efforts. Whereas such information will not preclude the need for additional characterization efforts, it should assist the FRC site management and FRC investigators in optimizing any future characterization activities. The presence, extent, and quality of previous site data sets should be evaluated in the selection of future FRCs.

3) Successful research at ERSD field sites is costly and requires a significant commitment of local resources in the form of infrastructure, local analytical capabilities, and onsite personnel. The existence of such local resources should be carefully weighed in the selection of future ERSD FRCs. Access to the subsurface must be available by drilling and other sampling and monitoring techniques. Not only is year-round access to a given site critical, but the ability to ensure ongoing access to ERSD field sites for research personnel, including students and foreign nationals, is considered to be an important feature of any new FRC.

4) Selection of additional ERSD FRCs must also consider the relative costs associated with specific activities at proposed sites. For example, extensive

groundwater monitoring networks can be more expensive at sites that have deep vadose zones than at those locations with shallow water tables.

5) Field sites that have environmentally sensitive resources that might be impacted by experimental activities at the proposed FRCs should not be considered.

6) Given the range of environmental concerns across the DOE complex involving radionuclide contamination, priorities that have been set for site remediation, especially those involving problems intractable with current technology, should be used as a factor in establishing priorities for site selection for scientific exploration.

Of course, it is important that all reasonable efforts be taken to avoid "reinventing the wheel." Thus, any lessons learned at the Oak Ridge site, technical or practical, or at field sites established by other agencies (albeit focused on contaminants not of direct interest to DOE), workshop reports on field research, and relevant reviews of other sites should be given appropriate consideration.

Provide advice on how to design field experiments to optimize data sets for model development and validation.

In the realm of contaminant hydrology, models are often considered as engineering design tools for predicting the future behavior of geohydrologic systems and as a means to design cost effective remediation or contaminant management strategies. However, they also serve an equal, if not more important, scientific role as a forum for integrating experimental research that involves coupled flow, chemical, and biologic behavior in field-scale systems. Scientific hypotheses regarding particular behavior or interactions in these kinds of systems are often posed as conceptual models that require validation by comparing experimental results with prediction. For this to occur, numerical models, based on these conceptual models, should be used in the design of experiments to ensure that the data needed for characterizing processes, testing hypotheses and validating the models are collected, and that the scale and features of the experiment are sufficient to test conceptual models.

Field-scale systems are notoriously difficult to access, characterize, and monitor. This creates a significant degree of conceptualization and observational uncertainty. Field systems are dominated by natural, small-scale spatial heterogeneity in their physical and chemical attributes. Wells, trenches, and noninvasive geophysical techniques are expensive to construct and operate, and they cannot fully reveal a complete or focused picture of underground structure or processes. Monitoring and measurement of underground properties, flows, chemical concentrations, bacterial activity, or biogeochemical reactions will be limited in terms of the number of monitoring locations, the kind and range of sampling scales or sensing technologies, availability of proper instrumentation or analytical techniques, and other types of indirect observations that provide a window into the behavior and dynamics in geohydrologic systems.

With regard to conducting experiments in field scale geohydrologic systems, models can help in several ways, both in the initial phases of experimental design and conceptualization, as well as later stages of experimental operation and interpretation:

1) They compel the interpretation of all data on the same terms. Measurements may be made of water levels in piezometers, soil type and mineralogy from a collection of cores, electrical resistivity in a formation, aqueous chemistry in a fully penetrating well, or other biogeochemical properties in a soil sample, but the processes they are related to and their integrated behavior are defined by the mathematical models that form the basis of simulation models. Thus, models are a basis for integration.

2) Development of models can help clarify and organize what is known and what is unknown about a system in terms of properties and other physical or chemical features of a system. This can be used as a means to drive data collection, or temper interpretations of simulation results.

3) As a result, models may compel the development of a basis to "fill in" what is unknown from conceptual models, and thus, force revision of ideas and conceptualizations of the system as new data is collected or as different kinds of observational data are collected and need to be reconciled. This illustrates the iterative nature of model design and evolution as it pertains to characterization and simulation of a dynamic experimental system. Ultimately, as greater and greater consistency between observables and the model is obtained, confidence in the model improves, and the benefits of the iterative nature of the modeling process become realized.

4) Finally, models force thought about the scales at which processes are observed in an experiment and at which to predict future behavior. Proposed conceptual models are often based on the scale of features or processes observed at the scale of the experiment. Larger scale predictions require that there be an examination of scale dependency of processes and parameters used in the model. Therefore, field experiments should be designed to provide the opportunity to gain an understanding of the behavior of the system at different scales.

Thus, the interplay between modeling and field experimentation is critical. In the spirit of the preceding paragraphs, the subcommittee recommends that explicit thought be given to contribution to modeling studies that will ensue from each field based experiment. One way of doing this would be to require that the suite of projects to be associated with a given FRC includes project components that are dedicated to hydrogeologic characterization, geologic modeling, and surface and groundwater flow and reactive transport simulations. These would have direct relationship to the contaminants and biogeochemical processes under consideration at the site. They would serve as a basis for conducting hypothesis-driven research related to reactive transport processes and to important impacts of geologic heterogeneity that affect such processes, as well as providing important parameterization needed for realistic scaling of these processes in model calculations.

Comment on the relative desirability of a few comprehensive "all-purpose" sites versus a possibly larger number of sites, each with a more focused or restricted set of goals and purposes.

There are several key points with regard to the number and types of sites that should be considered for support:

1) There should be a sufficient number of sites to represent the overall variety of hydrogeology and waste forms that are most important for the DOE cleanup mission. The existing Oak Ridge FRC is well suited to studies of uranium and technetium in a humid climate with a shallow water table. New sites are needed to provide research opportunities in very different environments representative of other DOE facilities such as an arid site with a deep water table and thick vadose zone or a more temperate site with contaminated surface waters.

2) It is very important that any new FRC have a level of user support, site characterization, and infrastructure similar to that provided by the Oak Ridge FRC. It is clear that the success of that FRC is largely due to such support provided to external investigators. This level of support is sufficiently expensive that within foreseeable funding levels the division can probably support only a few (three or four) such sites.

3) Experience at the Oak Ridge FRC has demonstrated the advantage of concentrating research projects in a common site. The investigators have been able to develop complementary projects, to apply knowledge from one project to the others, and to share the considerable infrastructure and site characterization information. This synergy would be much harder to obtain with a larger number of less well-characterized sites.

4) A new FRC should have the potential to expand to different waste streams and geohydrologic environments at the same site. The initial program may concentrate on a single contaminant site and environment, but the potential to expand to additional, near-by locations is important.

5) A library of materials from a variety of DOE sites could be provided by providing the resources to collect "samples of opportunity" when drilling takes place at sites without an FRC. This could be done with a relatively small cost and would increase the diversity of characterized materials available to ERSD investigators at much lower cost than if an equivalent number of FRC centers were established.

6) New FRCs should be developed to meet the needs of the broadest possible spectrum of ERSD-supported researchers without detracting from its suitability to meet specific research goals.

Thus, for practical considerations, a limited number of more comprehensive sites would be much preferable to many highly focused sites.

Provide advice on how to best balance the resources expended on field sites against other competing demands for research funds.

The initial FRC is having significant positive impact on the research conducted by the NABIR community. Over half of the NABIR awardees obtain samples from the Oak Ridge site, and the three field projects underway continue to attract an expanding interdisciplinary group of investigators. The heavy utilization of this site shows the importance researchers place on having a consistent mechanism to validate laboratory results, scale up methods, and develop predictive models for complex problems.

Assuming that the annual ERSD budget for investigator initiated research remains on the order of $50 million (as currently available to the combination of NABIR and EMSP), the subcommittee recommends that 10 – 15% of this total budget should be used to provide operational support for FRCs. If additional sites are as well characterized, initially, as was the ORNL site, this should enable the establishment of two additional sites. An additional 15 – 25% of the research project budget should support field research projects. The majority of the remaining budget, 50 – 60% of the total, should be used to support laboratory-based studies, including those that use samples from the FRCs, and complementary modeling studies. This allocation of resources could leave up to 25% of the total budget for additional activities, such as those discussed below.

In making these budgetary recommendations, it is recognized that the overall budget available to this important program many change significantly, in either a positive or negative direction. Thus, the subcommittee would like to review the program balance every two years to make sure that the alignment is consistent with the science that can be accomplished.

Additional comments

It is important that the scientific projects supported at any given site be as broad-based as possible. A diversity of projects will help to ensure that different projects at a given site provide unique information. That being said, a given problem may be the subject of multiple investigations, but the problem should be attacked in multiple ways, not simply with minor perturbations of an otherwise similar experiment.

In addition to actual field studies, there is very significant value in laboratory experiments on samples taken from field sites. Such field sites should, of course, include the ERSD FCRs, but ERSD staff should try to leverage interactions with other programs and laboratories across the DOE complex to facilitate sample acquisition from a range of relevant sites. As appropriate, and in proper balance with other important investigations, laboratory research should be linked to field experiments and to modeling studies. Further, as research progresses and hypothesis are formulated and tested, mesoscale experiments – more complex than laboratory-based experiment but also more controlled than experiments run under field conditions – will become very valuable. The capability to establish mesoscale experiments in close proximity to field experiments may be more efficient than establishing such facilities in lab-based settings.

As part of its deliberations, the subcommittee considered the question as to whether there are other facilities, beyond mesoscale capabilities, that would augment the field based or laboratory based studies. It is clear that the synchrotron based technologies available for environmental samples have the potential to play increasingly important roles in furthering our understanding of a number of physical and biological subsurface phenomena. It is also clear that there currently is not sufficient beam team for environmental studies, nor is there sufficient support personnel at the synchrotron sources to assist in environmental studies. In the short term, if funds are available, we recommend that $300,000 – 500,000/ year be made available to support activities at existing facilities. Decisions as to the nature of these expenditures should be undertaken only after consultation with the relevant community (such as the investigators who comprise EnviroSync (http://www.cems.stonybrook.edu/envirosync/). In the longer term, additional beam time must be made available for environmental studies, including studies on subsurface samples. The EnviroSync has recently completed a report on the use, current and projected, of synchrotron experiments in environmental studies. Given the importance of synchrotron research to a broad array of scientific and technological disciplines of national importance, and hence given the competition between possible applications of available synchrotron time, the subcommittee supports the concept of an interagency group, perhaps under the auspices of the Office of Science and Technology Policy, that would evaluate the competing demands, both scientific and budgetary, for the “unclaimed” sectors remaining at U.S. synchrotrons.

Clearly, computational modeling is a critical aspect of developing a comprehensive understanding of subsurface phenomena that are critical to DOE’s environmental mission. As appropriate, the subcommittee urges a strong partnership between ERSD and the Office of Advanced Scientific Computing Research. Similarly, the subcommittee has the perception that there is very limited availability of the enormous computational capability within EMSL to investigators supported by ERSD. If this is, indeed, the case, consideration should be given to a reallocation of some of the computational cycles at EMSL for modeling studies that make explicit use of the experimental data that come from ERSD-supported studies.

As noted above, one of the critical aspects of contamination at DOE sites is the presence of radionuclides and mixed wastes. It is absolutely critical that the research programs supported by ERSD are capable of working with radionuclides. This is true both in field research and in laboratory based experiments. With regard to the latter, all efforts should be made to enable experiments with radionuclides to be conducted within the Environmental Molecular Sciences Laboratory (EMSL). Further, the infrastructure at the FRCs should include the facilities and support needed to package and transport hot samples to off-site laboratories.

The FRCs should be designed with the possibility of expansion. That is, the infrastructure should be sufficiently robust to be able to accommodate the work necessary to support research at proximate locations. Thus, with only incremental additional budget, a greater breadth of environmental conditions can be studied.

Summary

The field research center (FRC) as implemented by NABIR program managers at BER and leaders at the ORNL has been effective in attracting a number of strong field and supportive laboratory projects addressing a radionuclide contaminant plume at the Oak Ridge Reservation. Based on this record and the considerable potential for field research to meet ERSD goals, the subcommittee recommends that additional field sites be developed consistent with available funds.

The FRC concept is also important for some of the EMSP goals, and hence we recommend that EMSP resources and program targets be identified for FRC implementation. As a start, EMSP could have a special call encouraging researchers to use the current FRC infrastructure and/or research results. Any new FRCs that are established must be able to support both NABIR and EMSP research, and these FRCs should be developed in a sufficiently robust way that they will be useful to future research directions or programs that ERSD may support.

The recommendation in support of additional FRCs is based on the fact that field research is necessary to bring reality, validation and scaling to the Division’s environmental remediation research. However, field research facilities can easily become a burden if basic values are not meet, especially providing for addressing attractive, important researchable questions; reasonable cost relative to Division resources; numbers and breadth of investigators served; and effective site personnel and infrastructure. As noted in this report, program and site personnel currently meet these values, but they also need regular attention and review to insure that this investment remains productive and useful to DOE.

APPENDIX A
CHARGE LETTER

Department of Energy
Office of Science
Washington, DC 20585

Office of the Director

July 23, 2003

Dr. Keith O. Hodgson
Director, Stanford Synchrotron Radiation Laboratory
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Stanford, CA 94305

Dear ~~Dr. Hodgson~~ Keith:

Over the past two decades, the Office of Biological and Environmental Research (BER) has had an increasing commitment to understanding processes controlling the fate and transport of contaminants in the environment, particularly those contaminants released as a result of the DOE's (and its predecessor Agencies') nuclear weapons production and testing activities. Beginning with the Subsurface Science Program in the 1980's, and continuing today with the Natural and Accelerated Bioremediation (NABIR) Program, BER has sponsored interdisciplinary research aimed at understanding the processes that affect how contaminants are transported in the subsurface. This year, BER's activities in this area were further expanded by the transfer of the Environmental Management Science Program and the Savannah River Ecology Laboratory from DOE's Office of Environmental Management to BER.

These programs have resulted in scientific advances that have already had significant practical applications, including the development of *in situ* redox manipulation techniques to immobilize or destroy selected contaminants in groundwater, methods for stimulating the activity of bacteria already present in the subsurface such that they more effectively degrade organic contaminants, and providing a scientific basis for assessing the mobility of radioactive cesium and uranium beneath leaking waste storage tanks at the Hanford Site. More recently, NABIR researchers have shown that microbes capable of transforming metals such as U, Tc, and Cr to insoluble, chemically reduced form are common in subsurface environments, and research continues on the role of microbes in the transport of redox-sensitive elements.

Given the large number of factors that affect the fate and transport of contaminants in the environment, both model predictions and laboratory-scale experimental results require confirmation under the actual conditions present in nature. To facilitate this, the NABIR Program has operated a Field Research Center at the DOE's Oak Ridge Reservation since 2000. The soil and water at that site is contaminated by multiple substances, including radionuclides, metals, and organic compounds, and the site has been an excellent resource for investigators in the NABIR Program to conduct research and obtain samples

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related to *in situ* bioremediation. Based on this experience, and from input received from knowledgeable environmental researchers, we believe that there is a need for a suite of additional field research sites that encompass the range of environmental conditions and problems relevant to DOE. These sites would permit researchers to conduct long-term experiments and observations, test new subsurface characterization and measurement methods, and test model predictions.

To assist our planning, I am asking the Biological and Environmental Research Advisory Committee (BERAC) to evaluate the need for additional field research sites, and if such sites are found necessary, provide guidance on how BER might best set priorities for establishing them. More specifically, the Committee should:

- Assess the need for additional field research sites for the BER programs involved with the science of environmental remediation of subsurface and surficial contamination

  Provide recommendations on the desirable features of such sites

  Provide advice on prioritizing the selection of sites

- Provide advice on how to design field experiments to optimize data sets for model development and validation.

  Comment on the relative desirability of a few comprehensive, "all-purpose" sites *versus* a possibly larger number of sites, each with a more focused or restricted set of goals and purposes.

- Provide advice on how to best balance the resources expended on field sites against other competing demands for research funds

Please develop a interim report for me on these issues by January 15, 2004. I would like to have a final report from BERAC prior to but no later than the Committee's spring meeting.

Thank you and your Committee for your continuing help as we plan the future of BER and for your advice on the role of environmental science in the DOE research portfolio.

Sincerely,

Raymond L. Orbach
Director

APPENDIX B:

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