CL*EAN*ER WORKSHOP 3

THOMAS EXECUTIVE CONFERENCE CENTER

Duke University

February 2 – 4, 2003

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Executive Summary

The **Engineering Directorate** proposes investment in a **C**ollaborative **L**arge-scale ***E***ngineering ***A***nalysis ***N***etwork for **E**nvironmental **R**esearch program (**CL*EAN*ER**). **CL*EAN*ER** will enable the development of integrated community models of anthropogenically-stressed large-scale environmental systems, such as the coastal margins and river and estuary systems. Dynamically interactive modeling will enhance understanding of how these systems evolve over time and allow testing of alternative theories of adaptive management. **CL*EAN*ER** will consist of a series of complementary sensor networks, each of which will focus on a different aspect of an environmental problem. For example in collaboration with other NSF Environmental Observatories, **CL*EAN*ER** will provide better knowledge of the fate and transport processes of contaminants in rivers, lakes and coastal waters, allowing us to address quality impairment problems in a more cost-effective manner, via engineering analysis.

CL*EAN*ER will provide researchers and educators across the nation access to leading-edge linked sensing networks, characterization tools, and data repositories and computational tools for integrated assessment modeling. Modeling would be the central component for analysis, knowledge synthesis and design of further experimentation. For example, **CL*EAN*ER** would address deficiencies in modeling hydrodynamics, episodic sediment transport, flow diversion, population impacts and biological pathways, and fundamental issues in monitoring and sampling. The integrated models will allow both reductionist and multidisciplinary researchers to synthesize knowledge about diverse environmental settings and to readily identify knowledge gaps leading to improve theory.

CL*EAN*ER will be a networked facility to promote multidisciplinary research on adaptive environmental management and a testbed for engineering cyberinfrastructure investments. This will provide a focus for developing and/or defining:

- user needs and system architecture, software, hardware, technical support, and outreach and training for effectively addressing these needs;
- innovative high-performance sensors;
- configuring, siting, and operating integrated sensor networks;
- advanced modeling capabilities;
- collaborative tools;
- new tools and strategies for storing and accessing, manipulating, analyzing, integrating and visualizing diverse data sets;
- common data handling protocols and standards; and
- integration of experimentation and simulation.

ENG has already funded three workshops for early development of the **CL*EAN*ER** concept. At these workshops, presenters for other potential NSF environmental observatories (CUAHSI, NEON, OOI), other federal agencies (NOAA, EPA, USGS), and cyberinfrastructure specialists (NCSA) highlighted information to assist in developing **CL*EAN*ER**. This August 10-13, 2003, a symposium on **FAME: Frontiers in Assessment Methods for the Environment** will be held at the University of Minnesota -Minneapolis spotlighting **CL*EAN*ER** and providing further guidance in conceptual development.

Background

The Directorate for Engineering at NSF is developing a new funding initiative called **CL*EAN*ER** (**C**ollaborative **L**arge-scale ***E***ngineering ***A***nalysis ***N***etwork for **E**nvironmental **R**esearch). As its developers envision it, **CL*EAN*ER** will be *a networked infrastructure of environmental field facilities that enables formulation and development of engineering and policy options for the restoration and protection of environmental resources.* The goal of **CL*EAN*ER** is to provide options for maintaining and improving the environment through understanding and predicting the behavior of anthropogenically-stressed environmental systems, utilizing large-scale projects involving several environmental field facilities (**EFF**s) collaborating with related large-scale projects (other **RES**s), in an "***E***ngineering ***A****nalysis* ***N***etwork" (***EAN***).

The first planning workshop for **CL*EAN*ER** was held at Stanford University in December 2001, and a second workshop was held in Minneapolis in October 2002. More information about the **CL*EAN*ER** initiative and the workshops can be found on the following Web site: <http://cleaner.ce.berkeley.edu>.

The third workshop on this initiative was held at Duke University in Durham, North Carolina on February 2-4, 2003 at the R. David Thomas Center on the Duke campus. The specific goals of this workshop were to:

1. Provide extant or proposed activities that could be representative of Environmental Field Facilities (**EFF**s)
2. Explore **EFF** linkages:
    a. Within particular **RES**s
    b. Across common environmental themes (e.g., river basins, airsheds)
3. Identify key research issues that would/could be addressed by linked **EFF**s.
4. Identify key scientific, technological, and organizational challenges in the development of **EFF**s and the ***EAN*** infrastructure.

The purpose of this report is to summarize discussion and recommendations from the third **CL*EAN*ER** workshop.

CL*EAN*ER WORKSHOP 3
Duke University
THOMAS EXECUTIVE CONFERENCE CENTER
February 2 – 4, 2003
Co-Hosts:
Profs. Jeffrey Peirce (Duke U.) and Michael Aitken(U. of N. Carolina)
Co-Chairs:
Profs. Kenneth Reckhow (Duke U.) and Arthur Sanderson (Rensselaer)

AGENDA

Sunday, Feb. 2, 2003 6-8PM Dinner (Cash bar)

Introductions—Jeff Peirce, Duke U.
Welcome—Kristina Johnson, Dean of Engineering, Duke U.
Collaborative Large-scale *E*ngineering *A*nalysis *N*etwork for Environmental Research
CL*EAN*ER : An Historical Perspective Mike Aitken (UNC/CH)

Monday, Feb. 3, 2003

7:00 AM Speaker's Presentation Review (if needed)
8:00 AM Workshop Goals…Art Sanderson and Ken Reckhow
8:30 AM The View from NSF…Nick Clesceri (NSF)
9:00 AM Advancement of Environmental Field Facilities (EFF) Concepts…
Session Leader Orie Loucks (Miami U. of Ohio)

- River EFF (Hudson River)…Art Sanderson (RPI)
- River EFF (Neuse River /LTHO)…Ken Reckhow (Duke U.)
- Coastal EFF (Corpus Christi Bay)…Jim Bonner (TAMU)
- "Industrial" EFF (Great Lakes)… Mitch Small (CMU)

10:20 – 10:40 AM **BREAK**

- Bay EFF (Chesapeake Bay)...Nancy Love (VaTech) and Kim Jones (Howard U.)
- Bay EFF (Santa Monica Bay)… Mike Stenstrom (UCLA)
- Lake EFF (MN Lakes)…Pat Brezonik (U. Minn.)
- Urban EFF (Phoenix)… Jon Fink (Arizona State U.)

LUNCH 12:00-1:00

1:00 PM Advancement of EFF Concepts (continued)…

- Global Nitrogen Cycle…Jim Galloway (U. VA.)
- Sediment issues…Danny Reible (LSU)
- Hypoxia in the Gulf of Mexico …Don Scavia (NOAA)
- *EAN* Development…Peter Goodwin (U. of Idaho)

Environmental Cyberinfrastruture (ECI)…Session Leader Bruce Beck (U. of Georgia)

- Dave Brady (Duke U./DISP)
- Tom Prudhomme (National Center for Supercomputing Applications)
- Jim French (NSF/ CISE)

3:20-3:40 PM **BREAK**

Relation to NSF Environmental Observatories…Session Leader Jaci Batista (UNLV)

- NEON Jeff Goldman (AIBS)
- LTER Henry Gholz (NSF/BIO/DEB)
- OOI Terri Paluszkiewiecz (NSF/GEO/OCE)
- ATM Peter Milne (NSF/GEO/ATM)

5:30 PM ADJOURN

Dinner 6-8PM Dinner (Cash bar)

Tuesday, Feb. 4, 2003

8:00 AM Advancement of EFF Concepts (continued)…

- Airshed EFF (Phoenix)…Jo Fernando (ASU)

8:30 AM Path Forward… [Breakout groups drafting plans, with discussion leaders]

- Assoc. of Env. Engr. and Science Profs.(AEESP) Symposium (Fall 2003)… Pat Brezonik (U. Minn.), Mike Aitken (UNC/CH), Nick Clesceri (NSF)
- Research Plan …Ken Reckhow (Duke), Art Sanderson (RPI), Jim Bonner (TAMU), Bruce Hamilton (NSF)
- *EAN* Development…Peter Goodwin (U. of Idaho), Orie Loucks (Miami U.), Don Scavia (NOAA), Jo Culbertson (NSF)
- **CL*EAN*ER** Intellectual Partnering…Horace Moo Young (Lehigh U.), Priscilla Nelson (NSF)

11:00 AM Path Forward Reports… (15 minutes each)
11:45 AM Wrap-up… Art, Ken, Nick

12:00 Noon ADJOURN (Lunch will be available)

Committee Reports

CLEANER Research Plan

Committee: Mike Aitken, Jaci Batista, Bruce Beck, Jim Bonner, Rick Fragaszy, Bruce Hamilton, Nancy Love, Jeff Peirce, Ken Reckhow, Danny Reible, Art Sanderson, Andrew Schuler

Background

In the past, environmental scientists and engineers have had great success in understanding and proposing solutions to targeted critical but well-defined societal concerns; for example:

- Discharge of untreated municipal and industrial wastewater created major water quality problems in receiving waters. To address the issue, engineers developed and advanced the knowledge to design high efficiency wastewater treatment plants that resulted in substantial improvements in the quality of the nation's surface water bodies.
- Contagious diseases spread through inadequate disposal of human wastes, particularly in urban areas. Scientists and engineers developed the principles and engineered public water supply disinfection thereby protecting human health and making living in cities feasible.

Now, we confront complex, multi-compartmental, large-scale environmental problems that are not amenable to traditional science/engineering approaches. These large-scale problems may be linked on the basis of a common subject area or may involve a set of regionally or geographically connected environmental problems. Both types of problems will require synergistic efforts across disciplines. For example:

Subject Oriented:

- Agricultural activities (confined animal feedlots, fertilizer applications) and urbanization are introducing excessive fixed/reduced nutrients (i.e. nitrogen, phosphorus) into the environment. If these nutrients reach surface waters in large quantities, the result can be algal blooms, fishkills, and fundamental changes in aquatic ecosystems. At present, we do not understand how to "scale up" our understanding of basic scientific principles governing nutrient cycles to manage these problems in large watersheds. Basin-scale water quality modeling, integrated with remotely-sensed and in situ monitoring, should allow us to devise effective engineering solutions to control nutrient enrichment.
- Contaminated soils from leaking underground storage tanks, contaminant spills, wastewater lagoon leakage, irrigated agriculture, and other sources are ubiquitous. With potential impacts on the human food chain, air quality in the lower troposphere, as well as on surface/subsurface water supplies, this contamination problem may require large-scale monitoring, understanding and adaptive implementation to develop effective engineering and policy solutions.

Region Oriented:

- Over half of the human population now lives in urban areas. Impacts of urbanization on air quality, water supply and quality, land use, transportation, and energy use are complex and interrelated. We lack integrated monitoring and modeling systems to assess these impacts and provide a scientific basis for solutions.
- Large contaminated sites may remain unremediated due to a regulatory agency assessment leading to a recommendation that no action is necessary. In many instances, this decision is made as a result of knowledge gaps and the lack of consensus for

scientifically credible solutions. Decisions based on a recommendation of no-action result in problems going untreated, or worse, treatments imposed without a positive outcome. Fundamental knowledge leading to engineering and management strategies are needed to bring such cases to closure.

The CL*EAN*ER Research Plan

To address these large-scale problems in environmental science and engineering, the **CL*EAN*ER** program proposes the development of large-scale networked monitoring infrastructure and new programs that would enable engineers and scientists to understand complex environmental problems sufficiently to devise solutions and/or support policy making. This approach may be thought of conceptually in the following manner:

1. Consider large-scale problems of fundamental importance to human health, economic development, national defense and other areas where environmental understanding and management play a pivotal role in our ability to observe, predict, and respond to vital issues. Such issues may arise from natural sources, such as climatic shifts or ecological changes, or from anthropogenic sources, such as population growth, industrialization, and land usage. In each case, these problems of importance often involve large-scale, complex phenomena with interrelated physical, chemical, and biological processes and mechanisms. In addition, such problems also entail the need for engineering analysis, development of risk assessment, and adaptive management. Such large-scale complex problems cannot be addressed by individual research projects within a single discipline.

2. Such large-scale environmental challenges will identify gaps in fundamental knowledge of these complex systems that are needed to address problems. These gaps in knowledge may involve both basic sciences including physics, chemistry, and biology, as well as applied engineering knowledge that may include hydrological phenomena, biochemical processes, atmospheric dynamics, and others. In addition, social science disciplines provide important insight into strategies and impacts.

3. These fundamental knowledge gaps provide the basis for the development of scientific hypotheses as a basis for the **CL*EAN*ER** research program. The research program will itself be fundamentally interdisciplinary, bringing together expertise from many different fields in order to address a common interrelated problem.

4. The proposed research plan, in turn, defines the need for new enabling technologies and infrastructure in order to carry out these investigations. The scale and complexity of such large-scale programs typically define needs for distributed, networked instrumentation and data storage and handling capabilities that links acquired data to modeling, simulation, and visualization capability, as well as provide an integrating data environment to examine complex interactions and relationships.

The **CL*EAN*ER** approach is driven by the need to address wide-ranging environmental issues where our current fundamental knowledge is not adequate and the depth and breadth of infrastructure are not available. **CL*EAN*ER** would address such problems through new infrastructure that supports basic research across a set of common problem domains, such as

river and coastal systems, or urban airsheds, or across a region impacted by complex, interacting phenomena. In addition, the interaction of research on such domains in related geographic regions would offer major insights into the interactions among distinct environmental compartments and the effects of potential engineering solutions that might interact with them.

An Example

Engineered sustainability of a coastal margin region provides a good illustration of a complex environmental systems analysis that should be addressed through the **CL*EAN*ER** concept. Such regions occur where fresh water sources, primarily rivers, reach coastal areas. As shown in

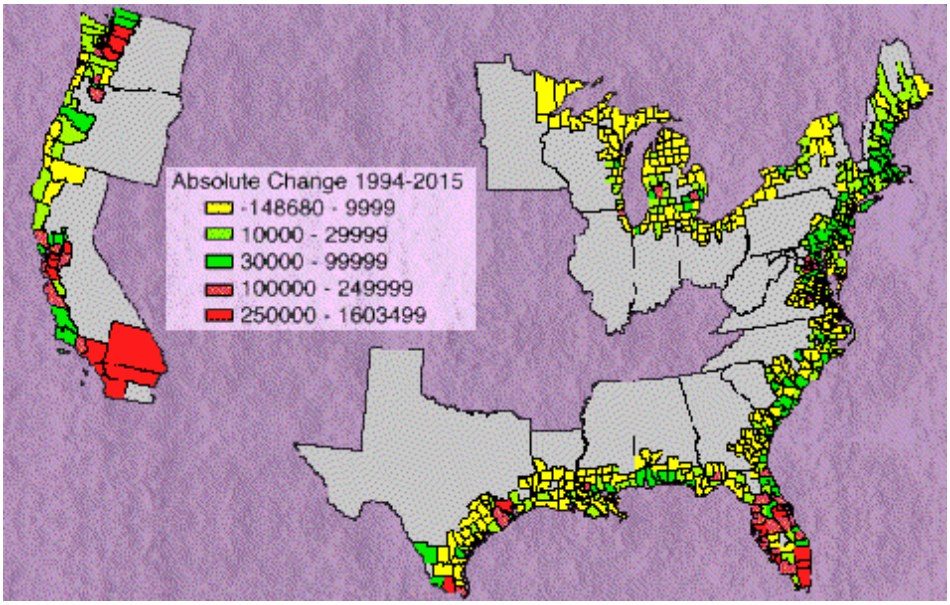

Figure 1. Projected population change from 1994-2015: absolute numbers

Figure 1, the largest recent growth in United States population has occurred within approximately 100 miles of the coasts. These populations are dramatically affected by environmental issues in these rivers, estuaries, and coastal waters. Regions such as the Chesapeake Bay, the Hudson River and estuary, the Neuse River, the Mississippi delta, Corpus Christi Bay, and Santa Monica Bay, and the Colorado River basin are all examples where well-identified events involving contaminants, biological hazards, algal blooms, water shortage, and engineered interventions have affected large populations. These phenomena have been identified and studied, but are not well understood from a scientific or engineering perspective. The lack of integrated and comprehensive knowledge about these systems makes the evaluation of alternative engineered solutions and policies less than desirable. Prior research on these coastal margins has identified clear knowledge gaps that prevent adequate understanding of these phenomena and create large uncertainties in the appropriate response. For example, deficiencies in our current understanding adversely affect hydrodynamic models and flow diversion models, plus limit our ability to characterize episodic sediment transport, population impacts, and biological pathways. Primary underlying issues of monitoring and sampling in problems with multiple interacting phenomena are critical to this domain. These problems are inherently

interdisciplinary and require cooperation across many different areas of expertise and methodologies.

The development of basic research hypotheses and plans for coastal margin phenomena forms the basis for identification of new infrastructure needs. Such infrastructure might include distributed instrumentation involving a wide variety of sensor types, extensive networking of sensors and integration of data received from many such sources. In addition, an extensive cyberinfrastructure is needed to support database systems, visualization, modeling and simulation, and a flexible capability to access and exchange such information through grid computing and data mining.

The capability to monitor and understand such phenomena in coastal regions and large river basins affected by high population growth would provide the basis for management, policy development, and risk analysis. Extensive modeling and simulation encourages the exploration of alternatives and the understanding of many possible outcomes. Management strategies should be implemented adaptively, so that "learning while doing" is possible, leading to improved strategies over time. In addition, the wide ranging data monitoring and visualization supports public outreach and education that engages a wider public participation in the understanding and management of such environmental issues.

EAN Development

Committee: Jo Culbertson, Henry Gholz, Jeff Goldman, Peter Milne, Tom Prudhomme, Orie Loucks, Peter Goodwin

Contents

1. Considering the Experience of other Multi-site networks

Four existing networks, or quasi-networks, operating with NSF support, offer experience that the **CL*EAN*ER** initiative should be considering.

- National Nanotechnology Information Network.

The National Nanotechnology Infrastructure Network (NNIN) is an integrated national network that will provide users across the nation access to leading-edge fabrication and characterization tools and instruments in support of nanoscale science and engineering research, education, training, and technology transfer. NNIN's role is to enable the Grand Challenges defined in the National Nanotechnology Initiative and to support NSF's investments in Nanoscale Science and Engineering research and education. The solicitation requires institutions to submit proposals for a network that meets specified objectives and comprises diverse, geographically distributed sites with complementary capabilities.

- George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES)

NEES was started in FY 00 with competitions for equipment, Phase 1 (NSF 00-6) and system integration (NSF 00-7). This was followed by a competition in FY 01 for Consortium Development and in FY 02 for equipment, Phase 2 (NSF 01-164). The NEES network system (architecture, security, data repository, collaborative tools, simulation tools repository, telepresence, etc.) is being developed at the same time as the equipment sites are under construction. The NEES Consortium, which will be the entity that will operate the NEES IT infrastructure and coordinate operations, (and schedule of research at each NEES equipment site during FY 05 - FY 14), was incorporated in January 2003. Working groups and video teleconferencing forums among all the NEES awardees are being used to discuss integrating concepts such as data/metadata formats and policies, telepresence, simulation tools, etc. At the same time, a National Research

Council study, funded by NFS, is underway to develop an earthquake engineering research agenda that will utilize the full potential of the NEES infrastructure. "

- Long Term Ecological Research Network Office.

Some of the 24 sites making up the LTER network were established over 20 years ago when investigator-led research was the dominant paradigm for a group or site. Now, the scientific community, generally, has expectations of answering larger-scale questions arising from interaction among sites. The LTER "network office" facilitates this research by promoting data standardization and meta-data documentation and standards. It also helps facilitate communications (video conferencing, etc.) and integration among various combinations of LTER sites. The "network office" advances synthesis at individual sites and across several sets of sites for certain questions, but for historical reasons it is not principally responsible for developing or carrying out "network level" research.

- National Center for Ecological Analysis and Synthesis (NCEAS).

This NSF-supported center (in California) is not really a network, but it maintains a virtual-network relationship with scientists in many fields seeking to work on large-scale, inter-site and meta-analysis problems. Although few people in ecology and related fields worked on this kind of research 10 years ago, the number of good proposals being directed to NCEAS now far exceeds the resources available. Many other sources of funding are now being attracted to the center, and the range of region-wide to continental data sources being utilized is expanding every year. Once started, this area of synthesis and integration through a virtual network is rapidly filling a previously unrecognized need, and may soon be "cloned" at another (eastern) site.

The group agreed that all the above models seem to have relevance for a network among **CL*EAN*ER EFF** sites and the ***E***ngineering ***A***nalysis ***N***etwork.

Comments indicated we should think in terms of designing an overall network. To do this we need to define the capabilities that it would provide and consider how the network could be framed to allow these capabilities to grow/evolve with changing needs. In addition, the network capabilities would fit within the context of NSF's goals and research priorities. Important also is how a research agenda be developed for the network; the level of research support that would be needed to use the network and potential sources of research funding, how the network would complement (and promote collaboration with) existing facilities/organizations involved in similar work and the types of tools/facilities that could be developed or supported through the network.

*Recommendation: networking and nationwide coordination developed at NSF in recent years emphasized the importance of designing a network from the initiation of a new program. This experience should be used to draft working papers leading to a complementary engineering analysis network, to be reviewed by a further workshop, with the goal of establishing a functioning **EAN** from the outset of the **CLEANER** program.*

2. Networking among Environmental Field Facilities of CLEANER

Discussion identified a critical challenge for the ***E***ngineering ***A***nalysis ***Network*** (***EAN***) and for Environmental Field Facilities (EFFs) within **CL*EAN*ER**. There are a great many strong EFF-like projects already underway or that could be developed. Their strength is in their capacity to address a major local to regional research problem such as the dynamics of riverine PCB's, coastal enrichment, or urban pollutant transport. However, that strength may run at cross-purposes with the desire to see strength in research being developed through a network of EFF's. These network-based questions also are important, but may detract from the individual strengths of EFF's at least for investigators who might have responsibility for both. The management alternatives below summarize several options for trying to maximize strengths, both in the EAN network and in the individual EFF's.

The group agreed generally that the experience of other networks tells us that it will take time and considerable planning for a community to become aware of the interesting research questions to be addressed from a network platform such as EAN. Because the leaders of EFF's may have other research priorities, it is possible that EAN should first develop experience in equipping useful data and model archives for existing environmental engineering projects, as NCEAS has done, along associated research questions. Such an initiative could be seen as a step toward developing a network among future EFF's, following the models of NNIN and NEES. If EFF'S and EAN were to proceed simultaneously, they would need to show a coordinated but parallel leadership, rather than the retrofitted leadership structure used in the LTER'S.

3. EAN Management Structure Alternatives

The group discussed several possibilities for structuring the EAN and facilitating how it would link with EFFs in **CL*EAN*ER**. A range of management alternatives are outlined here, for illustration only. Elements from any of the alternatives could be merged into some final combined product.

a. 'Top-Down', Traditional Call for EFF Site Proposals

- NSF could call for proposals around pre-selected geographic or problem areas, or on pre-identified themes.
- NSF could call for research on questions that can only be answered by the EAN, working through EFF sites. The theme could be posed *a priori* by an advisory committee – perhaps representing Universities, professional societies or federal agencies
- A cooperative agreement could be used to establish and fully equip a coordinating and achieving center, much like the LTER model.

b. CUASHI type alternative

In this structure, an independent **CL*EAN*ER** non-profit would be established. Funding from NSF could be viewed as seed money and, using additional support from other sources, applied problems of national significance could be addressed. Examples of this type of research problem could be:

- Lessons learned from restoration – how much monitoring is required, how is success defined, was an interdisciplinary approach adopted, could the outcome have been improved with a more interdisciplinary approach?

- What information can be passed along to rapidly growing small cities about air quality that have been learned from the large well-monitored cities like Phoenix, LA, NY?

- Can a better understanding of cohesive sediment transport, erosion, deposition and mobilization of contaminants be developed from a synthesis of national and international sites?

A difficulty with this approach is that it could be perceived as interfering with the mission of existing institutions (for example, the National Academies of Science and Engineering).

c. A **CL*EAN*ER** 'NCEAS'

A virtual ***EAN*** could be initiated to try to capture the essence of the highly successful and productive NCEAS. This would be a "bottom-up" approach beginning with facilities to carry out the archiving of data and models, the development of integrative and meta-analysis questions, hosting of meetings, facilitating the work of post-doc's and welcoming short-term visits by faculty for work related to EFF's and **CL*EAN*ER**. Proposals would be accepted within the ***EAN*-CL*EAN*ER** objectives.

d. **CL*EAN*ER *EAN***/NCEAS

In this approach, the scope of the **CL*EAN*ER** EFF's and ***EAN*** is restricted to selected themes in environmental engineering where network-level investigations are already identified as a priority. Theme constraints could be set by the call for proposals for EFF's through an independent scientific advisory panel, or by specific requests emanating from the environmental engineering community, universities, or professional societies.

e. **CL*EAN*ER** Grand Challenge Proposals

In this approach, NSF could invite EFF research proposals addressing local problems of broad generality, but with an explicit goal of sharing data and models through which a

network of a few sites could begin research. Proposals could come from single institutions or from consortia. The network research would address questions that could only be addressed through an ***EAN*** linked to certain intensive study sites or emerging EFF's. Funding of proposals would be dependent on dual goals, a capacity to use existing scientific and engineering data or studies coordinated through a pilot network (from the EFF level to the national scale), and the site focused research. The purpose of a small number of Grand Challenge proposals would be to begin to show the science and engineering community that two levels of research can be addressed simultaneously, and this goal would be explicit in the call for proposals.

Examples of possible subject areas for *Grand Challenges* include:

- Adaptive engineering and management in an inter/multi-disciplinary engineered services world;
- Inter-site data and model integration with application for similar problems at multiple sites;
- Development and application of new tools, sensors, area-wide sensor networks and data mining for innovative problem solving (such as water quality in urban runoff);
- New approaches to discovery in engineering fields, expanding the knowledge base and breadth of information being considered;
- Opportunistic Research: a rapid deployment ability to take advantage of large perturbations in the environment and the ecologic and physical process response. Examples might include: flood events, dam failure, seismic events or hurricanes.

The above discussion was limited greatly by not having results from the Workshop 3 group discussing researchable questions at EFF's. Having those results at a future time would inform and narrow the ***EAN*** structural choices, and facilitate a recommendation. Unresolved were questions such as: how the network would be organized--at what level various resources (physical, technical, managerial, human) would be provided and coordinated; the role of the sites--the assets they would provide, their distribution, and whether they would be comprised of fixed or mobile tools/instruments; and key coordinating mechanisms and operating policies for ensuring effective operation of the network as a seamless whole.

The group emerged with a consensus that a further workshop would be quite valuable, but no clear agreement was reached at this time on what the theme should be. The possibilities include a workshop on ***EAN*** alone, or ***EAN*** in conjunction with the preliminary report on EFF research questions.

4. Other questions to be resolved

Should the program be promoted as "value-added or independent"?
This question would determine whether ***EAN*** should pursue integrative research on national issues (where scattered data and models are available), or concentrate on the independence

and non-regulatory basic knowledge focus that NSF offers. The objective should not be to solve the local problems for local interests, but contribute to fundamental understanding that benefits the nation for a class of problem. The workshop participants appeared to prefer the 'value-added' view, understood as fundamental knowledge, as there is already extensive local information available at many potential EFF sites.

What knowledge discovery can only be achieved only through a national *EAN*?
A preliminary list was considered, but depending on the management structure this may be best left to a "Grand Challenge" solicitation (see NNIN discussion). Many examples of the problem-type may have to be articulated in order to have broad acceptance of the **CL*EAN*ER** initiative. Examples could include:

- implementation of adaptive engineering and management at the large scale;
- dam de-commissioning outcomes physical, biological and social;
- comparative analysis of the new reservoir flow regulation strategies being used to achieve downstream conservation benefits;
- airshed-watershed interactions at the transboundary scale;
- data mining from a national database on contaminant transport in cohesive sediments;
- other concepts outlined throughout the **CL*EAN*ER** planning process.

Should there be solely a national or an international emphasis?
The group considered whether **CL*EAN*ER** or ***EAN*** can be linked to the international community. It appears that many lessons learned here will benefit engineering applications in the global environment. The workshop participants appeared to be in support of international collaboration of some description, but the scope needs further discussion. Even without international engagement, all data sharing, archiving and modeling will need to be moved toward metric measures as the U.S. scientific community and other countries have done already.

Which programs could be linked at the *EAN* level?
This is not an exclusive list – but it is indicative of the type of collaboration that would be desirable:

- NOAA NERRS
- LTER [Paired comparison of reference sites through LTER might be important.]
- Systems with extensive high quality data (many potential EFF sites have been described in the workshops, e.g. the Hudson River, Neuse and Corpus Christi Bay.
- Data collection programs with little or no analysis/synthesis function to date [e.g. StreamNet, Columbia Basin; Calfed; Colorado River; Mississippi.]

How can CL*EAN*ER knowledge be disseminated and shared in the classroom with students?

- Several options were discussed briefly. Linkage to quick state and local government use of results also was noted at the meeting. Both of these questions could be explored at another workshop.

What is the structure and infrastructure of the *EAN*?

- Central physical location or distributed?
- Role of IT?
- Virtual or real?
- Type of equipment?
- Rapid deployment capability?
- Dedicated satellite time?
- Management structure: traditional or CUAHSI-type model?
- Educational elements / Student involvement? An IGERT type collaboration or other?
- Methods of interaction with agencies, the consulting community and other parties?

Recommendation

The group stressed the need for a fuller discussion of IT planning, including steps toward adoption of metric units for all exportable models. Such planning should include provisions or protocols for general data access, archiving, meta-data standards, communication requirements, data transfer and synthesis, and unrestricted community access to models.

The sample of opinions at the workshop expressed a preference for some combination of the 'NCEAS' and 'Grand Challenge' options. However, ***EAN*** *management and research leadership needs to be linked with the EFF needs, and articulated in a way that is complementary to and supported by other networking initiatives such as NNIN, NEES, NCEAS and LTER. The group suggested that details be developed at a future workshop convened specifically for this purpose.*

Intellectual Partnering

Committee: Horace Moo-Young, Priscilla Nelson, John Fink, Jo Fernando, Donald Scavia, Mitch Small, Delcie Durham, Giorgio Mattiello

1. What are the major Environmental Problems on which to focus?

The major environmental issues include water (oceans, lakes, streams, bay and estuaries), air (air sheds, urban environments), and soil (groundwater and sediment) quality. However, each EFF will need to bring to the table a compelling story that states why this concept will provide improved environmental management options. To scope **CL*EAN*ER** and to distinguish it from other initiatives, it was suggested that management, decision support and risk and uncertainty reduction be a major focal point for the **CL*EAN*ER** concept. The "idea" component of the **CL*EAN*ER** concept will include but not be limited to the following:

- Characterization and Assessment
- Management (Adaptive Management Systems)
- Solution Driven Approach
- Systems Approach to Adaptive Environmental Management
- Uncertainty Reduction
- Linking-Basic Science (e.g., Chemistry, Biology, Geology, Physic, and Hydrology) to Engineering Decision Making Framework.

Of this list, three prevailing themes resonated to the forefront which should be focal points of **CL*EAN*ER**'s intellectual partnering arrangement: Adaptive Management coupled with a systems approach, uncertainty reduction, and the linkage between basic science and decision making framework. Adaptive management is "a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs". Adaptive management will help key stakeholders in the decision making process by setting the goal for continual improvement of the system. The intellectual property generated by **CL*EAN*ER** Environmental Field Facilities (EFF) will also aim to reduce the uncertainty by providing more accurate and reliable measurements using state of the art and state of the science methods. As a result of the reduced uncertainty via improvements in the quality and quantity of data, **CL*EAN*ER** will aim to integrate the basic science and decision-making framework.

2. **Who are the major stakeholders for CL*EAN*ER?**

The major stakeholders for the environmental problems listed above include academia, industry, government (federal, state and local), disciplines, societies, non-governmental organizations (NGOs), and international. Figure 2 illustrates a diagram of the potential stakeholders for **CL*EAN*ER**. In figure 2, at the center of the diagram is the National Science Foundation in partnership with academia. For **CL*EAN*ER** to have impact, participation from local industry, state government and local government is also strongly encouraged. In addition, a

CLEANER EFF will also need to partner with federal agencies and departments to strength the intellectual partnership. Figure 1 illustrates potential federal partners with **CL*EAN*ER**:

a. Department of Defense (DoD)
b. Department of Commerce (DoC)
c. Department of Transportation (DOT)
d. Department of Energy (DOE)
e. Environmental Protection Agency (EPA)
f. National Oceanic and Atmospheric Administration (NOAA)
g. National Aeronautics and Space Administration (NASA)
h. U.S. Geological Survey (USGS)
i. Department of Agriculture (USDA)
j. National Institute of Health (NIH)
k. Center for Disease Control (CDC)
l. National Institute of Environmental Health Sciences (NIEHS)
m. Department of Housing and Urban Development (HUD)
n. Department of Interior (DOI).

Some of the key question that **CL*EAN*ER** must be able to answer include How can better environmental monitoring and assessment tools effect the decision making process? Who will utilize the intellectual property created? What agencies will allow **CL*EAN*ER** to partner?

EPA along with state and local environmental agencies was viewed as a source of information, regulation, partnership, diagnosis, and Cause vs. Effect. **CL*EAN*ER** EFFs must clearly delineate the mechanisms of governmental partnership. For environmental health related issues, the group deemed NIH, NEIHS, and CDC as primary targets for governmental partnerships.

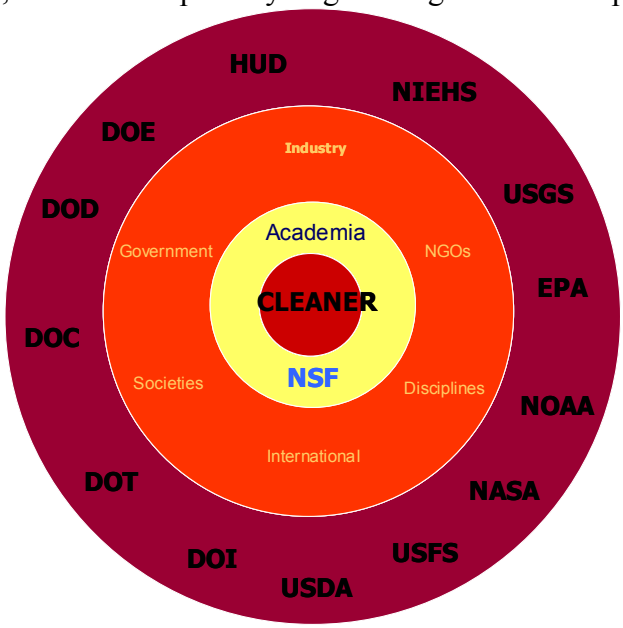

Figure 2 CL*EAN*ER Intellectual Partnership Diagram

Although the origin of **CL*EAN*ER** began in the Environmental Engineering Community, to enhance the opportunities, **CL*EAN*ER** will have enlisted the multidisciplinary nature of the state

of practice. In our discussion on intellectual partnering and stakeholders, the group developed a matrix of potential stakeholders in the academic, government, industry, and non-governmental organizations. As an example, Table 1 illustrates the disciplines that will be considered in developing partnerships. The expertise on the environment may come from a variety of disciplines (*e.g.*, environmental engineering, geology, chemistry, biology, public policy, public health). A multidisciplinary approach towards environmental monitoring, sensing, assessment and decision-making must occur to optimize creativity and innovation. Table 1 is broken up into five categories: Engineering, Science, Social Science, Health and Medicine, and Business.

Table 1 CL*EAN*ER Disciplines for Intellectual Partnership

Engineering	**Science**	**Social Science**	**Health and Medicine**	**Business**
Environmental	Ecology	Geography	Toxicology	Economics
Civil	Biology	Public Policy	Epidemiology	Management Information Systems
Mechanical	Chemistry	Risk Assessment	Public Health	
Electrical	Physics	Decision Sciences		
Computer	Statistics			
Industrial	Geology			
Systems	Applied Math			
	Soil Science			
Chemical	Atmospheric Science			
Information-Technology				
	Zoology			

Societies

The **CL*EAN*ER** initiative will also need to develop alliances and partnerships with professional societies. Potential roles include lobbying, outreach, development of vision, and broadening participation. Table 2 provides a list of various societies that should be contacted by **CL*EAN*ER** organizers for partnering.

Table 2 Lists of Societies

Engineering	Science	Social Science	Health and Medicine	Business
AEESP	ACS	SRA	SETAC	Society for Ecological Economics
ASEE	GSA	Society for Industrial Ecology		
ASCE	AGU			
IEEE				
SPIE	AAAS			
ASME	SSSA			
AWWA				
AWMA				
WEF				

AAAS-American Association for the Advancement of Science
AEESP-Association of Environmental Engineering and Science Professors
AGU-America Geophysical Union
ASCE-American Society of Civil Engineers
ASEE-American Society of Engineering Education
ACS-American Chemical Society
AWMA-American Waste Management Association
AWWA-American Water Works Association
ASME-American Society of Mechanical Engineers
GSA-Geologic Society of America
IEEE-Institute for Electrical and Electronics Engineers
SETAC-Society for Environmental Toxicology and Chemistry
SPIE-Society of Photonic Engineers
SSSA-Soil Science Society of America
SRA-Society for Risk Assessment
WEF-Water Environmental Federation

Industry

Industrial partnerships for **CL*EAN*ER** will be localized and nationalized in nature. For a specific **CL*EAN*ER** EFF, the local industry may potentially be impacted by the data collected at the site. For example, in the Mississippi River, industries that discharge into the river will be affected by hypoxia studies along the river. In addition, the national impact of a **CL*EAN*ER** EFF in the San Francisco Bay will potentially draw interest from east coast industry as well, since the basic science and engineering involved would have global implications. In tailoring an industrial partnership arrangement, it was suggested that **CL*EAN*ER** utilize similar rules as the NEES program or IUCRC program at NSF.

Also, in developing industrial partnerships, **CL*EAN*ER** EFFs will need open information exchange with industry. **CL*EAN*ER** EFFs should make the data accessible using an information technology framework similar to NEES. Specific attention must be paid toward the creation of an open and positive public perception. At some EFFs, there may be a need to set up monitoring on private industrial property. Many industries make or specify to academics that the data generated must be reviewed prior to release. Each **CL*EAN*ER** EFF will have to tailor any collaboration with industry to assure that public perception will be sacrosanct in the process.

In developing a **CL*EAN*ER** EFF, the outcomes and outputs from the site will drive any potential intellectual property agreements with industry. **CL*EAN*ER** EFFs may be engaged in developing new tools for environmental monitoring, assessment, or decision-making. Whether it is the former or latter, the metrics for the site will dictate the level of corporate commitment. In any case, the issues surrounding industry participation will be site- and/or topic-specific.

NGOs

Non-governmental organizations were viewed as a potential partnering organization for **CL*EAN*ER**. **CL*EAN*ER** could utilize NGOs to aid in outreach. Thus, **CL*EAN*ER** EFFs can leverage the academic strengths with the NGOs educational outreach connections. As examples, NGOs can aid **CL*EAN*ER** EFFs in information dissemination, holding local forums, and community based outreach. Potential NGOs include the following:

- NRDC
- Environmental Defense
- Foundations-Macarthur, PEW
- Sustainable Organizations
- The Nature Conservatory
- Industrial Research Institutes.

International

CL*EAN*ER can also benefit from international collaborations. NSF can aid **CL*EAN*ER** sites through facilitation of international collaborations. Other potential organizations that can aid in international collaborations include:

- GEIART (Gestione dell'Inquinamento dell'Aria, Rumore, Traffico)
- Connections with Proposed EU-Center of Excellence
- Proposed International **CL*EAN*ER**-Networks
- U. S. Department of State
- U.S. AID
- World Health Organization.

GEIART (

3. **What types of partnerships are necessary?**

   In the development of the **CL*EAN*ER** network, the following partnerships and components will be considered:
   - Academic Partnerships: Single or Multi-University
   - Diversity-Gender, Intellectual, Sector, University
   - Education and Integration of Research
   - Workforce
   - International Participation
   - Government partnerships
   - State and Local partnerships
   - Society partnerships.

Attendees

Invited Participant	Affiliation
Aitken, Mike	University of North Carolina
Avissar, Roni	Duke University
Batista, Jacimaria	UNLV
Beck, Bruce	University of Georgia
Bonner, Jim	Texas A&M University
Blatecky, Alan	NSF
Brady, David	Duke University
Brezonik, Pat	University of Minnesota
Cavanaugh, Marge	NSF
Clesceri, Nick	NSF
Costello, Andria	Syracuse University
Culbertson, Jo	NSF
Durham, Delcie	NSF
Edwards, Marc	Virginia Tech
Fernando, Joe	Arizona State University
Fink, Jonathan	Arizona State University
Fragaszy, Rick	NSF
French, Jim	NSF
Galloway, James	University of Virginia
Gholz, Henry	NSF
Goldman, Jeffrey	AIBS
Goodwin, Peter	University of Idaho
Hamilton, Bruce	NSF
Johnson, Kristina	Duke University
Jones, Kimberly	Howard University
Loucks, Orie	Miami University
Love, Nancy	Virginia Tech
Mattiello, Giorgio	Embassy of Italy
Milne, Peter	NSF
Moo Young, Horace	Lehigh University
Nelson, Priscilla	NSF
Paluszkiewicz, Terri	NSF
Peirce, Jeff	Duke University
Peters, Catherine	Princeton University
Prudhomme, Tom	NCSA
Reckhow, Ken	Duke University
Reible, Danny	Louisiana State University
Rogers, Peter	Harvard University
Sanderson, Art	RPI
Scavia, Don	NOAA
Schuler, Andrew	Duke University
Small, Mitch	Carnegie-Mellon University
Stenstrom, Mike	UCLA
Waite, Tom	NSF

Dear Dr. Invitee,

The Environmental Engineering cluster within the Division of Bioengineering and Environmental Systems at NSF is developing a new funding initiative called **CL*EAN*ER** (**C**ollaborative **L**arge-scale ***E***ngineering ***A***nalysis ***N***etwork for **E**nvironmental **R**esearch). As its developers envision it, **CL*EAN*ER** will be *a networked infrastructure of environmental field facilities that enables formulation and development of engineering and policy options for the restoration and protection of environmental resources.*

We are hosting the third workshop on this initiative at Duke University in Durham, North Carolina on February 2-4, 2003, and we would like to invite you to participate in the workshop. Nick Clesceri, program director for environmental engineering at NSF and the initiator of **CL*EAN*ER**, provided your name to us as a potential participant.

We expect approximately 45 participants, including a variety of leading environmental scientists and engineers from the academic community and representatives from several federal agencies involved in environmental research. The workshop will be held at the R. David Thomas Center on the Duke campus.

The first planning workshop for **CL*EAN*ER** was held at Stanford University in December 2001. More information about the initiative and the first workshop can be found on the following Web site: <http://cleaner.ce.berkeley.edu>. The second workshop was held in Minneapolis last October.

We are in the process of organizing the workshop agenda; a preliminary version is attached (along with a statement of workshop goals and a PowerPoint presentation on **CL*EAN*ER**) to this message to give you an idea of the topics that will be covered and some of the people who will be involved. We also are in the process of finalizing travel, hotel and other local arrangements (expenses will be covered for all non-federal employees); this information is being sent by Jeff Peirce.

We hope you will be able to participate in the workshop. If you would like more information, you may wish to give Nick a phone call at (703) 292-7940. In responding about your ability to participate, please reply as soon as possible by e-mail to KR (reckhow@duke.edu) and to Nick (nclescer@nsf.gov).

We look forward to hearing from you soon.

Sincerely yours,
Art Sanderson, Rensselaer
Ken Reckhow, Duke University

CL*EAN*ER Workshop 3 (CW3)

CW3 will explore "concept development" of a network of "Environmental Field facilities" (**EFF**s), which constitute a "Collaborative Large-Scale Engineering Analysis Network for Environmental Research" (**CL*EAN*ER**).

The goal of **CL*EAN*ER** is to provide options for maintaining and improving the environment through understanding and predicting the behavior of anthropogenically-stressed regional environmental systems (**RES**), utilizing large-scale projects involving several **EFF**s collaborating with related large-scale projects (other **RES**s), in an "*E*ngineering *Analysis N*etwork" (***EAN***).

The specific goals of this workshop are:

5. Provide extant or proposed activities that could be representative of Environmental Field Facilities (**EFF**s)
6. Explore **EFF** linkages:
    a. Within particular **RES**s
    b. Across common environmental themes (e.g., river basins, airsheds)
7. Identify key research issues that would/could be addressed by linked **EFF**s.
8. Identify key scientific, technological, and organizational challenges in the development of **EFF**s and the ***EAN*** infrastructure.

To: EFF speakers
From: Nick Clesceri, Art Sanderson, and Ken Reckhow

We appreciate your willingness to share your experiences and vision concerning **C*L**EAN**ER***. As time is tight for the workshop, we ask that you limit your speaking time to 15 minutes, and that you cover the following topics as they relate to your EFF:

- Environmental setting
- Environmental issues and impacts
- Scientific challenges
- Technology challenges
- Current status
- Vision for an EFF:
    - Scope
    - Participants
    - Organization
    - Unique benefits

Of particular interest, please consider – *If we had **CLEANER**, what would it allow you to do?*