Large-scale Environmental Challenges: CLEANER as the Engineering Approach

Richard G. Luthy
Dept. of Civil and Environmental Engineering
Stanford University, Stanford, CA
Environmental challenges
What’s special about these challenges?

- Common elements:
  - Large-scale
  - Anthropogenic impacts
  - Stressed systems
  - Solutions unclear
  - Interactions among multiple processes
  - Knowledge vs know-how

Huntington Beach Closure
July-August, 1999
What’s needed… a new approach!

• Measuring with a purpose; outcome based
• Getting the big picture right among many compartments and pathways; models
• Coping with inherently unpredictable systems; embracing adaptive management
• Working with various disciplines and incorporating values and ethics
Getting the big picture right...

- Understanding linked processes…
  microscale [contaminant binding]
  macroscale [bioaccumulation and food webs]

- Outcome-oriented [how to apply knowledge]

Shoal Point Bayou
Panama City, FL
Wrestling with inherently unpredictable systems...

Restoration of the Greater Everglades

- Can’t predict outcomes
- Phased implementation
- Real-world experiments
- Adaptive assessment and management

Example large-scale regions/systems: aquifer storage and recovery
Different disciplines see things differently...

NRC Committee on Bioavailability of Contaminants in Soils and Sediments

- Environmental Eng.
- Biology
- Geology
- Zoology
- Ecology
- Toxicology
- Agronomy
- Environmental Law
- Risk & Exposure
Incorporating values and ethics...

- Community empowerment
- Performance standards and work changes
- ... “equal parts science and sociology.”

New York Times
Sunday, 4/21/2002
Answer: CLEANER!
Collaborative Large-scale Engineering Assessment Network for Environmental Research

Workshop, Stanford University, December 4-5, 2002
CLEANER

- Collaborative Large-scale Engineering Assessment Network for Environmental Research
  - A network of instrumented environmental field facilities
  - Virtual data repository for modeling and analysis
  - A mechanism for multidisciplinary research and education to formulate engineering and policy options
  - A collaboration among engineers, natural and social scientists, industry, governmental organizations, and the public
CLEANER: The goal

- Devise science and engineering implementation options that are problem driven for environmental decision support and resource management

Example large-scale regions/systems:
major estuaries or bays
CLEANER: An instrumented network

- Well-instrumented field facilities
  - Distinctive stressed systems or representative systems
  - Development of real-time and newly-designed sensors
  - Material and energy balance approaches and relation to anthropogenic impacts
  - Innovative monitoring methods for design and calibration of engineering models
CLEANER: A data network

- Collection and organization of existing data
- New models and integration of existing models and hierarchies
  - Open architecture for modification and retrospective and prospective research
  - Identify data gaps and suggest needs for new measurements and sensor technologies

Example large-scale regions/systems: major river basin systems
CLEANER: Integrated activities

- Integrated research, decision-making, management, and education
- Collaborative projects with inter- and intra-site inquires
- Modeling a central part of experimental design/analysis; support technical and policy options
- Experiential learning, community education
CLEANER: Collaboration

- Facilitate interaction among academics, industry, policy makers, NGOs, and the public
  - Support materials flow accounting including perturbations to natural materials flows
  - Help understand local and large-scale impacts
  - Improved pollution prevention and remedial efforts
  - Enhance economic, engineering, and sustainable perspectives
CLEANER: Why now?

- Urgency of need
- Reductionist and discrete disciplinary methodologies no longer adequate to model complex environmental systems and anthropogenic stresses
CLEANER: Problem driven and focused on anthropogenically stressed systems
CLEANER: Intellectual merit and impact

- Improve data standardization, comparability, and critique
- Better measurement tools and integrated predictive models
- Identify key processes and reduce assumptions in models
- Technology transfer between fields and institutions
- Cultural change through pooling of capabilities

Example large-scale regions/systems: major airsheds
CLEANER: Workshop II

- Refine concept of EFFs
- Examples of research questions
- Physical infrastructure
- Management structure
- What’s effective & what’s not

Stanford foothills