INTEGRATED, HIERARCHICAL SYSTEMS ANALYSIS AND MANAGEMENT: HOW IS IT DONE AND WHY BOTHER?

K.E. KOLM, Colorado School of Mines, Golden, Colorado, and
Argonne National Laboratory, Argonne, Illinois*
J.C. BURTON, Argonne National Laboratory, Argonne, Illinois

A hierarchical systems analysis (HSA) has been designed to characterize the components of a given environmental system, identify potential impacts to those systems, and evaluate the extent of those impacts. The landscape can be viewed as a mosaic of dynamic systems that operate through complex interrelated processes. By understanding how systems function separately, one can predict the collective function of the broader environmental system. This goal can be accomplished by using HSA to qualitatively conceptualize and quantitatively characterize natural or anthropogenic impacts to the environmental system.

Hierarchical systems analysis is an iterative process that begins with problem definition. Preliminary conceptualization and characterization are based on existing data, field characterization, and a general knowledge of surface and subsurface processes, as well as a three-dimensional system framework (including geology, soils, geomorphic deposits, and ecologic information such as vegetation and animal distribution). This preliminary work is followed by analysis and a refinement of understanding. Additional data collection, data analysis, and refinement are conducted as necessary.

Hierarchical systems analysis requires addressing various subsystems that compose the environment, including land surface, geomorphic, subsurface (geologic), and groundwater subsystems. Because these subsystems are interdependent, understanding each subsystem depends on understanding the others. After system characterization is complete, HSA focuses on identifying potential environmental changes that may result or have resulted due to natural or human activity. The potential impacts are then evaluated to determine acceptable strategies for further characterization and remediation (environmental cleanup). HSA uses a stepwise approach to break complicated issues and concepts into smaller, easier-to-understand components. Expanded understanding might enable consensus building, for example, between regulators or permitting agencies and developers and might ensure responsible environmental development while limiting environmental concerns.

For environmental systems characterized by HSA, assessment, evaluation, and management are best accomplished by using the QuickSite® process. The key features of this process are (1) a multidisciplinary, geoscience-based, experienced technical team that remains constant throughout the program; (2) the presence of a technical leader and a senior team in the field, as well as in the office; (3) the use of integrated, complementary technical methodologies; (4) emphasis on nonintrusive and minimally intrusive investigation methods; (5) a dynamic work plan with on-site analysis and decision making; and (6) frequent sponsor and regulator input.

The QuickSite® process begins with the organization and selection of a technical manager, plus a team of appropriate scientists. A critical evaluation of existing data is made by using HSA, and the team visits the site/system for field conceptualization. After the initial visit, a dynamic work plan is created that incorporates the elements of HSA and the appropriate multiple, noninvasive technologies. The manager and the team return to the site/system to perform daily data reduction and integration until characterization is complete. During this process, the field and analysis program is modified as necessary by iteratively incorporating new input data to achieve an understanding of the site/system, and the field program is optimized to solve the defined problem.

Hierarchical systems analysis and QuickSite® draw on established methods, such as the ASTM Expedited Site Characterization (ESC) and the ASTM Conceptualization and Characterization of Ground-Water Systems (C&C); established field and laboratory protocols; and established modeling tools, such as HSPF and MODFLOW. HSA differs from other approaches to systems analysis that have dealt with individual components of environmental systems, in that it incorporates geologic, hydrologic, chemical, and biological factors and associated interactions at a level of scientific credibility that satisfies the stand-alone disciplines, yet is accessible to managers and decision makers.

QuickSite® is a scientific approach to site and system investigations that is technically superior to and more cost- and time-effective than traditional methods in which regulatory guidance is frequently followed without a sound scientific approach. QuickSite® differs from other approaches to environmental system assessment and management by having a consistent, experienced team (a non-pyramidal structure); by using multiple, convergent technologies that are nonrandom and minimize invasive data collection; by maximizing the use of existing data to converge on a multitask solution; by developing and incorporating a dynamic work plan utilizing experienced senior staff and a manager in the field; and by minimizing and optimizing the field program through daily data reduction and interpretation and through real-time modification of the field program.

ACKNOWLEDGMENT

This work was supported by the Commodity Credit Corporation of the U.S. Department of Agriculture under interagency agreement through U.S. Department of Energy contract W-31-109-Eng-38.

* Corresponding author address: Kenneth E. Kolm, Division of Environmental Science and Engineering, Colorado School of Mines, Golden, CO 80401; e-mail: kkolm@mines.edu.