The Use of Geographic Information System Images as a Tool to Educate Local Officials About the Land Use/ Water Quality Connection

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Land use management is the key to improving water quality. This is particularly true for nonpoint source pollution, which cannot be controlled solely with standard regulatory permitting and enforcement techniques. In many areas of the United States, land use decisions are made primarily at the local level by a combination of elected, professional, and volunteer municipal officials. Because the cumulative water quality impacts of these local decisions can be enormous, educating municipal officials about the relationship of land use to water quality is a critical step to watershed management.

The current proliferation of laws, regulations, and technical guidance directed at nonpoint source management will further increase the need for education. As this wave of information cascades from federal to state to local agencies, the task of making this material understandable, or at least accessible, to municipal implementers has been given little consideration. Adding to these difficulties are the traditional problems associated with local volunteer decision makers (e.g., the limited time that most people can devote to this one issue in the course of their routine responsibilities, and the high turnover rate in membership typically experienced by municipal commissions).

This paper describes an ongoing pilot project in Connecticut, *Nonpoint Education for Municipal Officials (NEMO)*, in which a method for dealing with this educational challenge is being developed and tested. One area being explored is the use of geographic information system (GIS) technology as a teaching tool to help others understand the links between land use and water quality.

Project Overview

Project Development

NEMO is a 3-year project funded by the U.S. Department of Agriculture Extension Service (USDA-ES) as part of a national USDA water quality initiative. NEMO and a few sister projects in the Northeast are being funded in an effort to contribute to the U.S. Environmental Protection

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Agency's (EPA) National Estuary Program (NEP). Under the NEP, partnerships between federal, state, and local governments, citizens, and other interest groups are established to research, characterize, and develop management plans for addressing major environmental problems threatening estuaries of national importance. Nonpoint source pollution has been found to be a problem in virtually all of the estuaries in the NEP, and Long Island Sound, upon which NEMO is focused, is no exception.

NEMO is an outgrowth of several ongoing projects of the Connecticut Cooperative Extension System (CES). CES has staff working on water quality and natural resource planning issues, and, as part of the Sea Grant Marine Advisory Program (a cooperative venture with the Connecticut Sea Grant College Program), other staff working on similar issues along the coast. CES and Sea Grant's involvement in the Long Island Sound Study provided the impetus for NEMO.

As part of the work done under the auspices of the Long Island Sound Study Nonpoint Source Working Group, Dr. Dan Civco of the University of Connecticut conducted remote-sensing research resulting in a land cover map for the entire State of Connecticut. Satellite images were analyzed for land cover, which is principally derived from the reflectivity of the land, and the data were incorporated into a GIS. The land cover information is being used by the study in an effort to rank watersheds according to their nitrogen export to the Sound.

CES and Sea Grant staff involved with this aspect of the Study realized that the educational potential of the land cover GIS information was at least as great as its research value. With support from USDA, the NEMO project team was formed, composed of CES staff with water quality and natural resource planning expertise, Sea Grant staff with water quality and coastal zone management expertise, the GIS expertise of Dr. Civco and his students at the Natural Resources Management and Engineering/Laboratory for Earth Resources Information Systems, and Dr. Marilyn Altobello of the University's Department of Agricultural and Resource Economics.

Project Structure

Municipal officials, particularly volunteer commissioners, are the target audience of NEMO. The core of the project is an educational slide presentation that makes heavy use of GIS images. (This presentation is outlined in more detail later in this paper.)

Two other educational media will also be used in support of the slide presentation. A 12-minute educational videotape is being made which introduces the viewer to nonpoint source pollution problems and solutions. The video is being made both as part of the introductory section of the core NEMO presentation for municipal officials and with an eye to wider use for general audiences. The video is a cooperative effort between NEMO and the New York Sea Grant Extension Program. In addition to the video, a series of fact sheets are being written to provide more detailed information corresponding to the topics covered in the presentation. The fact sheets cover nonpoint source issues and management techniques and are organized by land use type (i.e., residential, commercial, etc). Much of the material is adapted from the work of the *Land Management Project* in Rhode Island.

At this point, NEMO is being piloted in three areas/towns. In order to get a wide range of experience in the applicability and usefulness of the program, towns were

chosen that differed in three important characteristics: the degree of development, the type of water pollution problem of local concern, and the complexity and sophistication of town governance. A common criterion was a desire on the part of the chief elected official and/or town planner to participate in the project. Interest in the project was high. Although the project was not publicized, word of mouth resulted in more towns "applying" for inclusion in the project than could be accommodated.

Because of the way that land use decisions are made in Connecticut, it was decided to work at the town level. Connecticut has no regional or county government, and, like much of New England, municipal "home rule" is strong. As explained in the next section, this municipal orientation does not preclude a watershed-based approach. However, after working with two towns in eastern and central Connecticut in early 1993, NEMO will be applied to two small watersheds in western Connecticut, one of which is shared between two adjacent towns. This third pilot project is being jointly conducted with the USDA Soil Conservation Service, which has been doing an extensive GIS analysis of the area.

GIS as an Educational Tool

Geographic information systems allow geographically-referenced data to be manipulated, analyzed, and displayed in ways that would be prohibitively time-consuming (or impossible) using conventional maps and overlays. Because of this, GIS is rapidly becoming an invaluable management and planning tool in a wide range of professions. GIS is often used for natural resource management applications at the national, state, or regional level. At the local level, GIS, if used at all, seems largely reserved for demographic and logistic applications such as tracking property transactions, or determining optimal bus routes. In many cases, GIS has been tried and then abandoned as expensive, overly complicated, and personnel-intensive.

NEMO's emphasis is not on the analytical capabilities of GIS, but on its potential as a highly effective visual tool to help nontechnical citizen volunteers intuitively understand the relationship of land use to water quality in their town. It is important to note that we are not advocating adoption of GIS technology by the target towns, nor is our degree of GIS sophistication very great. While the project relies heavily on the GIS expertise of Dr. Civco and his students, all of NEMO's work is done with personal computers (as opposed to the more powerful workstation environment typical of GIS work).

The land cover data developed by Dr. Civco are the primary source of NEMO's GIS images, but other data layers are used as well. These data layers are procured from town, state, and regional planning agency sources. At this point, the project team has been lucky in that all data necessary to the program have already been digitized. For Waterford, our first target town, we are currently using hydrography, roadways, soils, topography, and town zoning. However, it is anticipated that a different set of layers may be used for each town, depending on availability and the problems at hand. For instance, in our second town, Old Saybrook, where there are ground-water problems and controversy over a proposed sewage treatment plant, the *septic versus sewered areas* layer will be an important NEMO component.

One general comment: GIS technology poses pitfalls, as well as opportunities, for educational programs. The powerful and

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colorful imagery creates a desire to use complicated, multilayer images, simply because you can. Our feeling is that these "GIS pizzas" are probably more effective as modem art than as educational tools. Based on this intuition and our experience in working with municipal commissions, our tendency throughout the project development stage has been to continually simplify the GIS images and shorten the slide presentation. The core NEMO presentation described in the following section now runs about 60 minutes.

The NEMO Slide Presentation

The core NEMO presentation can be roughly divided into four parts. The first part makes use of the project videotape to introduce the audience to nonpoint source pollution—its causes, effects, and management. The emphasis is on the need to change both personal behaviors and municipal policies and decision-making criteria. In addition to the video, new federal and state nonpoint source laws that focus on storm water management and coastal nonpoint pollution control programs are briefly reviewed to emphasize the need for towns to get up to speed. GIS is described in general terms.

The second section focuses on water quality and watersheds. Regional (Long Island Sound) water quality issues are mentioned, but the emphasis is on local water quality problems, both current and historical. To the extent possible, these are shown on a GIS map of the town. Examples of each major type of nonpoint source pollution (from pathogens, nutrients, toxic contaminants, sediment, and debris) are illustrated with local photographs. Following the water quality discussion, the water cycle and the watershed concept are introduced. It is here that the project makes the first real use of GIS technology—town and regional hydrography, drainage basin boundaries, and topography are used to show how and why water systems are connected. The initial reaction of the NEMO team and other observers is that these three-dimensional images are very effective in communicating the concept of watersheds and the need for watershed management.

The third section of the NEMO presentation focuses on land cover/land use. The original satellite photography and its resultant 24-land cover analysis are shown and explained. Although in general the program does not explain the technical background or analytical techniques behind the GIS data, the difference is explained between *land cover* (derived by reflectivity from what is seen by the satellite) and *land use* (what is zoned or planned for a given area).

The 24 land covers are then condensed into six basic categories, approximating traditional land use types that municipal commissioners are familiar with: commercial and industrial land, water, roadways, residential land, agricultural and open land, and forested and wetland areas. GIS images of the town are shown highlighting each of these "land use types." The images are interspersed with local aerial and ground-level photographs, followed by word slides summarizing characteristic nonpoint source problems and management options associated with each land use type. More detailed information on these topics is contained in the fact sheets.

The last part of the NEMO project focuses on impervious surfaces. A growing body of evidence suggests that there is a linear relationship between the amount of impervious surface in a given watershed, and the impairment of water quality in the receiving stream of that watershed (Klein, 1979; Schueler, 1987 and 1992; Schueler et al., 1992). Existing land use (the six-

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category GIS information) is used as the basis for estimating the present degree of imperviousness of watersheds draining to key town water resources, such as a coastal cove or a reservoir. This is compared to a *buildout* analysis of imperviousness based on the zoning regulations of the town, assuming a scenario of 100 percent development to zoning specifications (for instance, that all land zoned as residential will be developed as such). The analysis is applied only to land available and suitable for development (i.e., all dedicated open space, wetlands, and other nondevelopable areas are removed from the buildout scenario). The resultant estimates of current and future levels of imperviousness are calculated and displayed by watershed, which we feel is the most appropriate and useful way to consider the implications of the data.

It is not within our capabilities at present to estimate amounts of impervious surface directly from the satellite-derived land cover data. Therefore, both current and future estimates use literature values for the percent imperviousness of given land use types, using the land cover data and the zoning regulations, respectively, as the basis to which these values are applied.

By showing which watersheds, and which sub-basins within these watersheds, are likely to experience dramatic increases in the amount of impervious surface, NEMO allows local officials a "quick and dirty" look at the present and future effects that their land use plans and policies might have on their town's water resources. With this knowledge in hand, the project team can suggest a number of options for the town. Best management practices, site plan considerations, maintenance policies, zoning changes, and other techniques are briefly outlined. These options are covered in greater detail in the NEMO fact sheets which, in turn, contain reference lists. It should be noted that the program does not act as a consultant and offer specific solutions—these are left up to the town officials. However, detailed follow-up seminars on such topics as best management practices or soils-based zoning will be available to interested commissions, and hard copies of key GIS images and analyses will be left with the town officials for future use.

NEMO's emphasis on impervious surface is admittedly simplistic. NEMO is an educational program and is not designed to take the place of technical guidance. It is, however, our hope that the simple yet scientifically valid relationship between impervious surface and water quality can be used as an underlying theme that town officials can understand and remember during the course of their day-to-day processing of site development applications. The danger of over-simplification pales in comparison to the danger that, faced with an avalanche of technical guidance and regulations from an army of agencies, local officials will be too confused and intimidated to act at all.

Project Status and Future

The NEMO program is scheduled to be conducted in the first target town in April 1993. Obviously, there is no way yet to evaluate either the effectiveness of the educational program or its implications as a model for wider application. Even so, developmental work is being done to expand upon the original project, in terms of both geographic scope and application of GIS. More detailed GIS analysis, and larger, multijurisdictional watersheds (perhaps bistate watersheds) are being discussed with the CES and Sea Grant programs in both Rhode Island and New York, and the National Sea Grant College Program has expressed interest in working with USDA-ES on advanced pilot projects.

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It is difficult to tell whether or not a model project of this type can ultimately craft a program capable of overcoming the twin obstacles of commission turnover and (for lack of a better term) attention span. To do so, a program must be simple, inexpensive, and easily implemented, yet effective. However, several trends in the GIS industry, including the proliferation of digital natural resource data, the dropping costs of computer hardware, and the development of user-friendly GIS "browsing" technology (which allows users to manipulate and display existing data sets), make us think that we are heading in the right direction. By retaining our focus on devising an effective educational package, rather than on providing technical guidance or using our GIS capabilities primarily for data analysis, we hope to emerge with a program of practical use to local decision makers, and therefore be effective in helping to manage nonpoint source pollution.

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