Title
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Abstract
In 1998, the California Regional Water Quality Control Board (RWQCB) scientists were trained to use the Geospatial Waterbody System (GeoWBS), developed by the Information Center for the Environment (ICE.) The Regional Board scientists are currently using the system to report waterbody assessments to the EPA, as mandated by the Clean Water Act. As part of ICE's continuing work with the GeoWBS database, ICE staff members visited each RWQCB in California to assist the scientists with geographic delineation of waterbodies that will be included in the 303(d) report.

Introduction
"Murky Waters," a report recently issued by Public Employees for Environmental Responsibility (PEER), has drawn attention to contemporary problems existing within both federal and state agencies charged with maintaining the quality of our nation's water resources (PEER, 1999). This report was written by managers within the United States Environmental Protection Agency (USEPA) and employees from various state agencies. The crux of "Murky Waters" is that it calls attention to numerous shortcomings in agency policy and action that have resulted in faulty water quality monitoring. In order to ensure that our waters will be fishable, swimmable, and drinkable for future generations, a new paradigm is warranted. Namely, a new paradigm based on shared information technology and dedicated to remedying environmental degradation. The Information Center for the Environment (ICE) at the University of California, Davis, is using GIS to develop and provide resource management professionals with several analytical tools and environmental resource databases, such as the GeoSpatial Waterbody System, California Rivers Assessment, and Water Quality Standards Inventory Database. These GIS-based solutions can, when implemented in concert, provide not only a means of addressing the problems raised by PEER, but also a framework for a new paradigm in water quality monitoring and reporting.

Background
As part of the Clean Water Act (CWA), Section 305(b) requires each state to submit a status report of the quality of its waterbodies to USEPA on a biannual basis. The 305(b) report should contain water quality information for all of the waterbodies in that state, providing a means by which USEPA can evaluate the status of the nation's waterways. The CWA also mandates that USEPA accept responsibility for implementation and oversight of the water-quality reporting process, and should states fail to submit a report, or if the report submitted is not approved by USEPA, the CWA mandates specific actions.

PEER has brought to light numerous issues, both programmatic and performance based, within the state and federal agencies responsible for water quality reporting, including USEPA. The PEER report questions the accuracy of data presented by state agencies in charge of water quality. This report also charges that states often report erroneous, manipulated data or, in some cases, no data at all. Additionally, PEER observed that methods of water quality monitoring and sampling lack consistency and are not scientifically sound. For example, some states measure dissolved oxygen or suspended solids alone and conclude that water quality standards have been attained, completely ignoring other parameters, including biological criteria. A related problem is the use of presumed assessments: states report water-quality attainment for waterbodies based on data that is more than five years old, based on extrapolated and estimated data, even though EPA guidelines describe this practice as unacceptable (PEER, 1999).

Adding even more confusion to the process of water quality reporting are the numerous levels of assessments. "Monitored," "evaluated," "assessed," and "surveyed" are all used to describe differing levels of examination by agencies. According to PEER, waterbodies are now being surveyed, rather than assessed. "Monitored" means that the waterbody has actually been monitored at some point within the last five years. This data is site-specific and may be derived from physical or chemical monitoring, biological monitoring, toxicity testing, and habitat assessment, among other forms of examination. An evaluated waterbody is one that has monitoring data over five years old, or data based on land use, location of pollutant sources, surveys of resource agency employees, or citizen complaints (PEER, 1999).

Water Quality Standards and Designated Uses are another source of potential error. Maryland has been using deficient Water Quality Standards since 1990. Designated Uses vary from state to state, as well as within states, leading to confusion and inaccuracy. This is important because Designated Uses are the basis for classification of Water Quality Standards, and Water Quality Standards are the basis on which a waterbody is judged impaired (PEER, 1999). Water quality assessments cannot be considered valid if they are not based on valid water quality standards.

More inaccuracy was introduced with USEPA's Reach File 3 (RF3), a digital hydrography dataset. RF3 caused the number of waterbody miles for which states are responsible to increase, and many states chose to conveniently ignore these more accurate figures. States often report using outdated estimates of waterbody miles, thus altering the percentage of miles assessed and the percentage of waterbodies impaired (PEER, 1999). Obviously, this results in a very skewed picture of water quality in those states.

Perhaps the issue most detrimental to water quality is that states are not held accountable by USEPA for the accuracy of their data, nor are they held accountable for delivering the data. Part of this problem stems from the fact that numerous states do not have the necessary infrastructure to support accurate water quality monitoring or reporting programs, and USEPA does not provide adequate support or guidance to states. The programs developed by USEPA for water quality recording are seriously flawed, lacking the accuracy and detail necessary to provide credible data on the health of our rivers and

streams. Double counting of records and further discrepancies have been noted in data reported by two programs used by states for water quality reporting purposes: the Index of Watershed Indicators (IWI) and the National Water Quality Inventory. Inconsistencies between state reporting practices preclude any analysis of national water quality trends. Furthermore, it is not possible to tell how many streams have been examined along their entire length. PEER argues for the necessity of a national water quality reporting program (PEER, 1999). Integrating GIS into such a program can provide more refined spatial analyses, and more accurate water quality reporting, and thus fulfill the deficiencies detailed in "Murky Waters."

Numerous programs and projects developed by ICE incorporate GIS in an effort to remedy California's water quality problems. Among them, the GeoSpatial Waterbody System, California Rivers Assessment, Clean Water Action Plan, Water Quality Standards Inventory Database, and Designated Uses all address a facet of water quality assessment through shared information technology within a geospatial framework.

California Rivers Assessment (CARA)
"CARA is a computer based data management system designed to give resource managers, policy-makers, landowners, scientists and interested citizens rapid access to essential information and tools with which to make sound decisions about the conservation and use of California's rivers" (Viers, 1998). CARA makes environmental data at the watershed and statewide level available in an Internet database using MapObjects technology. Anyone who has internet access can obtain data on any of California's watersheds. CARA uses GIS to store, query, and display its data, allowing the user to access localized data without losing a statewide perspective.

Clean Water Action Plan (CWAP)
The Clean Water Action Plan is an attempt, through President Clinton's initiative, to assess this nation's water. The Clean Water Action Plan is based on four tools: a watershed approach, strong federal and state standards, natural resource stewardship, and informed citizens and officials (NRCS, 1998). The Unified Watershed Assessment (UWA) is an important part of the CWAP; it is intended to guide fund allocation to the watersheds most in need. As part of the UWA in California, ICE collaborated with various state agencies to develop specific GIS databases to classify watersheds of high value, high risk, and high opportunity. "High Value" applies to waterbodies displaying richness of native fisheries, rare aquatic species, and the presence of wetlands and vernal pools. "High Risk" watersheds are those with impaired water quality, high human population densities, threatened and endangered species, and sedimentation. "High Opportunity" watersheds are those with funding mechanisms and local watershed projects. These classifications, along with public comments and the priorities of the California State Water Resources Control Board (SWRCB), contributed to the development of the final list of priority watersheds. Although this is an ongoing process, the watersheds identified in the UWA process are expected to receive additional funding to initiate sustainable watershed projects (SWRCB and NRCS, 1998).

Designated Uses
Designated uses, such as drinking water, recreation, species habitation, and water supply, etc., are also known as "beneficial uses" by SWRCB. Designated uses provide a means by which waterbodies can be assessed under the Clean Water Act. If a waterbody fully supports each of its assigned designated uses, that waterbody receives an assessment of "fully supporting." However, if one or more of the designated uses are impaired, the waterbody receives a "partially supporting" or "not supporting" assessment. Thus, the designated uses are an integral part of the assessment process. ICE is currently creating a statewide matrix of Beneficial Uses as they pertain to waterbodies and watersheds with a GIS framework. Currently, the nine Regional Water Quality Control Boards (RWQCBs) in California are responsible for determining both the type of use and the parameters which constitute its quality.

Due to the semi-autonomous nature of these Boards and the imprecision in their spatial definitions of waterbodies, there is currently no single data source that captures this information. Therefore, the matrix being developed by ICE must fulfill two needs. One, it must be spatially compatible with other GIS-driven products; and two, it must also represent designated uses uniformly across the state. Thus, the beneficial uses reported for any waterbody represent the range of possibilities; any waterbody might have one or more of the beneficial uses listed in a RWQCB Basin Plan. There are numerous complications in attempting to consolidate all of the designated uses for California's waterbodies. Beneficial use definitions are not standardized, they vary by region, and sometimes regions "redefine" beneficial uses, necessitating interpretation and introducing inaccuracy. Also, the codes used by the state and federal agencies do not correspond with one another, thereby contributing to confusion, inaccuracy, and lost opportunities to assess water quality across the nation.

Water Quality Standards Inventory Database (WQSID)
This database consists of Water Quality Standards, as developed by RWQCBs, in addition to the waterbodies, designated uses, and related hydrologic subareas. Valid for the state of California, this online database is integrated with several GIS applications used by resource agency managers throughout the state. There are some complications with the WQSID, which include but are not limited to the following: invalid hydrologic unit coding, incomplete spatial relationships, incomplete waterbody inclusion, inaccurate data reporting, misspellings, inconsistent naming conventions, etc.

National Hydrography Dataset (NHD)
The origins of the National Hydrography Dataset began withevolved from USEPA’s Reach File. There are three versions of the Reach File, RF1, RF2, and the most recent, RF3. The dDigital hydrography data was initially produced by United States Geological Survey (USGS); USEPA subsequently enhanced this data to create the reach Reach fileFile. A unique code was added to each stream segment, or "reach," thus delineating distinguishing each reach from the nextrest. The NHD incorporates RF3, USEPA’s latest version of the reach Reach fileFile, RF3, and USGS’s digital line graph hydrography. Because these data were incorporated, rather than replaced, NHD will be familiar to users of the Reach File, with added refinement. (USEPA, 1999; USGS, 1999) ICE personnel

have recently completed the two year processing the NHD data for of refining California's portion of the NHD. The NHD will result in a more accurate estimate of the number of rivers in each state, thus leading to a more accurate assessment of the percentage of impaired waterbodies impaired.

GeoSpatial Waterbody System

Perhaps the most pertinent application is the GeoSpatial Waterbody System. In collaboration with USEPA and the SWRCB, ICE developed the GeoSpatial Waterbody System (GeoWBS). Based on an older DOS program known as the Waterbody System (WBS), GeoWBS provides a GIS interface to increase spatial accuracy for water quality assessments. This improved spatial refinement of waterbodies combines data integrity checking, GIS-based data tabulation and population, and standardized data compilation with procedural requirements. Data entry is based on pull-down menus and picklists, leaving less room for user error. These enhanced data standards lend greater reliability to the data, thus resulting in more accurate water quality reports. GeoWBS provides a statewide spatial view of each assessed waterbody; displaying the entire length of the waterbody assessed.

This framework is consistent throughout the State, providing a basis for comparison between regions. There are no discrepancies or conflicting data within the state due to numerous water quality reporting programs, since each RWQCB is using GeoWBS. Furthermore, the program is based on the RF3, which forces the state to report the correct number of river miles; outdated or altered river miles cannot be reported to produce a more favorable outlook.

The Clean Water Act also mandates that water quality information be made available to the public. In California, this is accomplished through dynamic Internet queries run from the GeoWBS homepage.

Conclusions

Water quality issues raised by the PEER report are addressed by a number of projects developed by ICE.

- The California Rivers Assessment provides accurate data on every watershed in California. Water quality information, watershed characteristics and links to other sources of information are all available to resource managers and the general public.
- The Clean Water Action Plan prioritizes waterbodies in need of funding, thus concentrating restoration efforts where they are most effective.
- A database of standardized Designated Uses throughout the State will contribute to increased accuracy in water quality reporting.
- The Water Quality Standards Inventory Database will ensure that standards used by California managers are valid and accurate.
- The National Hydrography Dataset will result in a more accurate estimate of total number of river miles in each state, leading to a more accurate assessment of impaired miles, and percentage of waterbodies impaired.

- The GeoSpatial Waterbody System increases the accuracy of reported data through standardized data entry procedures.

In summary, it can be seen that the points brought to light by the "Murky Waters" report are indeed valid. Although California was not specifically named by the PEER report for inadequacies detailed therein, many of these issues could be applied to the nature of water quality monitoring, assessment, and reporting within this state. However, it can also be shown that many of these problems, such as inaccurate data or lack of data, are currently being remedied. Shared information in a technological framework can lead to a better understanding of our natural world. With this in mind, the Information Center for the Environment, in collaboration and consultation with many agencies and colleagues, has undertaken the challenge of bringing water quality into the new paradigm for California.

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