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Consensus Building and Grass Roots Efforts in a Comprehensive Urban Watershed Management Program

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Wayne County's Rouge River National Wet Weather Demonstration Project (Rouge Project) is a comprehensive program to restore the water quality of the Rouge River. This federal/state/local cooperative watershed management effort is supported by multi-year federal grants with matching funds being provided by local communities. The Rouge River Watershed includes 48 communities in three counties of southeastern Michigan, encompasses 467 square miles and 125 miles of river channel and is home to 1.5 million people.

A variety of pollutant sources has contributed to the historical and continued pollution of the Rouge River. The Remedial Action Plan for the Rouge River, prepared by the Michigan Department of Natural Resources (MDNR) and in conjunction with the Southeast Michigan Council of Governments, concludes that progress has been made with point source controls but wet weather sources such as combined sewer overflows (CSOs) and storm water runoff/NPS source pollution need to be addressed. Sources of nonpoint pollution are varied and dispersed across the watershed. The Rouge Project has developed its watershed-wide management program based on the concept that each citizen has the right to expect clean

water from their upstream neighbor and are also expected to assure that their downstream neighbor is given the same consideration.

The early days of the Rouge Project were focused on alleviating the current loads of sewage and storm water flowing to CSOs and the construction of 11 demonstration CSO retention basins in several watershed communities. Additional study showed that nonpoint sources of pollution, like storm water runoff, needed to be addressed. One way to address these forms of pollution was to inform the watershed's residents and businesses that they had a stake in restoring the Rouge River and that there were things they could do to help restore it.

This necessitated creating a strong consensus building public involvement program to address the concerns of area residents, educate the community about the effect of their current activities on the watershed and include all stakeholders in the mission to restore the Rouge River. A Rouge River Public Involvement Action Plan (Action Plan) was devised in the Fall of 1994 based upon a survey and focus groups involving stakeholders living and working in the Rouge River Watershed.

The goal of the Action Plan is to engage numerous stakeholders, inform them, and hopefully gain their support and encourage them to change their behavior to help achieve and maintain a healthy watershed. This paper will define the consensus building strategies being used for each of the plan's seven target stakeholder groups and present an overview of the specific activities being carried out with these groups.

The Action Plan identified seven stakeholder groups whose support was critical to the success of the Rouge Project: the general public, the media, local government officials, educators, industry and business, environmental and community groups and the technical community. To accomplish its objectives, the project must inform people and receive feedback. Communication must be continual, consistent, truthful and always two-way.

For each target audience the objective is to move the group along a communications continuum.

- First, develop the members' general knowledge of the Rouge Project (inform);
- Second, inform them on how point-source and nonpoint source pollution currently affects the Rouge River and the targeted remediation efforts of the Rouge Project (educate);
- Third, work with them to identify and change attitudes and behaviors that negatively affect the water quality of the Rouge River (change);
- Fourth, gain their support in fully championing new attitudes and behaviors that positively impact the Rouge River (support);
- Fifth, build on the relationships developed to actively engage people in constructive environmental behavior and support of improving water quality in the Rouge River in general (involve).

The road to support and consensus-building should be paved with open communication and quick response to questions or concerns. In many cases, the fair and open treatment of one group of

stakeholders can help garner the support and advocacy from another group of stakeholders.

For example, when communities who are building CSO retention basins expressed concern about public reaction to the construction of the basins, the Rouge Project conferred with the community leaders about the appropriate message and means of distributing the information. Six meetings were held with local elected officials and technical staff to identify what questions were most asked by the public, what information would satisfactorily address their concerns, and what was the best way to deliver the information.

Rouge Project staff and the local communities started with a list of the most asked questions about the basins. Coupled with answers, this list served as an outline for an easy-to-understand brochure for distribution to the general public. The brochure, entitled "When It Rains," describes why the basins are needed, what will accomplished by building them, and where they are located. To date, 27,000 brochures have been mailed by five local governments to their residents.

Because of the relationship struck by that partnership, the Rouge Project received support from the mayor of Dearborn Heights, Michigan, and the City Council in establishing Golfview Manor Civic Association as a pilot participant in the Clean Neighborhood Program, a pollution prevention program that incorporates household hazardous waste education, stream monitoring and storm drain stenciling.

The Clean Neighborhood Program is targeted at the general public and was developed to:

- Inform individuals that nonpoint sources contribute pollution to the Rouge River;
- Inform individuals that they live in the watershed and contribute to nonpoint pollution;
- Provide residents with opportunities to help clean up the Rouge River by demonstrating how they can minimize nonpoint source pollution thereby improving the river's quality.

Rouge Project staff made initial contact with the Golfview Manor Civic Association leadership to outline the program in advance of a presentation to the general membership. The Golfview Manor Subdivision is made up of 500 middle-income families whose backyards, in some cases, abut the Rouge River. They participate in Rouge Rescue, an annual clean-up of the river sponsored by Friends of the Rouge.

Once the general membership agreed to become a pilot Clean Neighborhood, the Rouge Project staff designed a survey to measure residents' knowledge of the Rouge River and pollution prevention strategies, concerns about the general environmental health of the neighborhood and to define neighborhood demographics.

A focus group of ten residents reviewed the proposed survey, made revisions and agreed to include it in their next newsletter. At the same time, they were asked to define the characteristics of their neighborhood, identify businesses with whom they had a good relationship and outline any environmental concerns they may have. The discussion provided a snapshot of the neighborhood and also helped identify possible participants for a parallel program for watershed businesses called The

Clean Business Program.

The Mayor's Office and the City Council also reviewed the survey. The surveys and a self-addressed stamped envelope were distributed in the association's monthly newsletter. Residents will help compile the results which will be presented to the general membership and be used to tailor the Clean Neighborhood Program to the Golfview subdivision.

The activism of another Clean Neighborhood pilot formed the bridge between the community, a local business and the Rouge Project. Although, the Clean Neighborhood program in the Brightmoor Community of Detroit is in the embryonic stage, residents contacted both the Friends of the Rouge and the Rouge Project when they feared a local business owner's expansion would negatively impact the Rouge River, which runs the length of their neighborhood. The business was purchasing surplus park land from the city so it could expand a used car lot into a large urban neighborhood park which adjoins the River. Ultimately, certain restrictions were put on the expansion based on input by the residents, the Friends of the Rouge and the Rouge Project.

The businessman, who was feeling a bit bruised by the reaction of the community group and others, was approached about being one of several businessmen to help develop the Clean Business Program, that will encourage small businesses to be Rouge-Friendly in their operations. After he began participating several things were discovered: he was raised in the Brightmoor neighborhood, he was very aware of the Rouge and its problems and he was willing to allow his business to be used for a site audit to collect data for the Rouge Clean Business Program. In addition, the community group will ask him to participate in plans for a Riverfest in the park near his business. The Riverfest, to kick off the Clean Neighborhood Program, will be done in conjunction with Rouge Rescue sponsored by the Friends of the Rouge.

Other bridges are being built. The Rouge River Watershed is fortunate to have a number of active environmental awareness organizations. In the past, there has been some resentment on their part because they perceive that the Rouge Project is marching full steam ahead without asking for their input, or ignoring it when it is given. Through a partnership with the Friends of the Rouge and The Rouge Remedial Action Plan Advisory Council that perception is being changed and real work is getting done.

For instance, representatives from all three organizations are using the recommendations of the Rouge Remedial Action Plan and the Rouge Project Public Involvement Strategy as a framework to: develop the Rouge Project message for the general public; decide what is the best way to get the message out and develop a plan to bring more people to the river for recreational activities. In addition, the group is developing a slide presentation for a Speaker's Bureau.

The media can play an important role in Rouge River Watershed restoration efforts. Ten years ago, when the Rouge River was being written off as a viable resource, a local newspaper chain printed a tabloid insert about the Rouge River entitled: "Our River: We discovered it, We settled along its banks, We built homes, farms and factories, and slowly, steadily we began to kill it." After being approached by the Rouge Project, the chain has agreed to publish an update pegged to the Rouge Rescue efforts in June to

educate their readership about the restoration of the Rouge River.

The Rouge Project is using a number of strategies to keep the technical audience informed. It is sponsoring a number of workshops for local community engineers which not only presents Rouge Project findings, but allows local community engineers to ask questions and use the tools the Rouge Project has developed. In addition, the Rouge Project Public Involvement Team created a Rouge Products Catalog which lists all Rouge Project technical memoranda, maps, and data sets, that can be ordered free of charge. The Rouge Project has also placed a complete collection of materials from the products catalog in public libraries in seven municipalities across the watershed.

These are just a few ways the Rouge Project is forging bonds and creating partnerships to educate the public and ultimately restore the Rouge River. Since implementation of the Action Plan, we have seen remarkable accomplishments. There is still much to do. Public involvement work is time-consuming, but ultimately rewarding. It operates under the assumption that we're all in this together and that the more inclusive the process is, the easier it is to build consensus. We are now dealing with more subtle forms of pollution which necessitates changes in the practices of the majority of watershed stakeholders. Consensus building is vital to the successful completion of a comprehensive urban watershed management program. This new approach may be slow, but the progress is real. Our success is dependent on our ability to build on this progress.

Meaningful public involvement goes beyond holding public meetings, creating educational materials and providing easy access to information. It requires careful planning to create real opportunities for stakeholders to influence decisions. It assumes there is a willingness to share power and authority for making decisions with those most affected. Above all, public involvement requires that those making decisions listen and respond to concerns, suggestions and ideas provided so that there is a collective ownership of the project by as many stakeholders as possible.

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Partnerships That Pay Off: TVA's Watershed Approach

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Introduction

The mission of the Tennessee Valley Authority (TVA) is to provide for the "unified conservation and development of the Tennessee River system" (TVA Act, 1933). The Tennessee River drains a 41,000-square-mile watershed, covering portions of seven southeastern states and includes more than 30 major reservoirs, operated by TVA for navigation, flood control, power production, water quality, recreation, and other purposes.

In 1991, the TVA Board adopted a reservoir operating plan that increased the emphasis placed on water quality and recreation (TVA, 1990). This plan delayed the drawdown of ten tributary reservoirs to extend the recreation season and included a five-year, $50 million program to improve conditions for aquatic life in tailwater areas by providing year-round minimum flows and installing aeration equipment at 16 dams to increase dissolved oxygen levels.

In 1992, to prevent these improvements from being negated by nonpoint pollution and to respond to growing public interest in water quality, the TVA Board launched the Clean Water Initiative (CWI)-a unique effort to break down the traditional geo-political, attitudinal, and financial barriers to watershed protection and improvement by forging alliances with governments, businesses, and citizen volunteers.

Program Description

The goal of TVA's Clean Water Initiative is to ensure that each lake, river, and stream in the Tennessee Valley is ecologically healthy, biologically diverse, and supports sustainable uses. To accomplish this goal without regulatory or enforcement authority, TVA is placing River Action Teams in each of the Tennessee River's 12 major subwatersheds. These teams are responsible for assessing resource conditions and building partnerships to address protection and improvement needs.

River Action Teams

CWI represents a transformation of TVA's water management organization from a hierarchy organized around technical disciplines to a dynamic organization based upon cross-functional teams. These teams, known as River Action Teams or RATs, are unique in several ways:

- RATs combine the skills of aquatic biologists, environmental engineers, and other water resource professionals with the skills of community specialists and environmental educators. Technical team members learn to communicate with the public in nontechnical language and to build partnerships with farmers, waterfront property owners, businesses, recreation users, and local/state government officials.
- RATs serve specific watersheds, enabling them to address the causes rather than just the symptoms of pollution impacts and to coordinate efforts across political boundaries. Assigning teams to a geographical area for the long-term also allows the teams to gain a better understanding of resource conditions, builds community trust, and enhances the development of cooperative relationships with stakeholders.
- RATs are self-managed. They are empowered to decide how to focus resources and address protection and improvement needs, allowing a rapid response to evolving or newly discovered problems and opportunities.
- RATs use resource-based, results-oriented performance measures to evaluate project success and ensure that limited resources are focused on the most critical problems. Outcome measures for fiscal year 1996 focus on increasing the number of hydrologic units meeting beneficial uses and decreasing the level of TVA resources in targeted hydrologic units. Monthly performance is monitored through key indicators--i.e., the number of hydrologic units with current stream assessments, problem causes identified, correction/protection activities, coalitions under development, and sustainable coalitions in place.

Resource Assessment

A distinguishing feature of TVA's Clean Water Initiative is the use of monitoring data rather than suppositions to guide watershed protection and improvement activities. River Action Teams start by assessing the status of individual streams and rivers in their watersheds, including ecological health and land use. They take a comprehensive inventory of the aquatic resources in major streams and rate each stream's health compared to what it would be like if it were in an undisturbed, or pristine, condition.

RATs conduct stream inspections and use selected biological indicators to take a "snapshot" of a stream's

ecological condition. Team members collect information about the number, type, and condition of the fish and benthic organisms, and analyze it for clues about what is occurring in the watershed. They also examine existing data and seek input from resource users and other stakeholders. This information is used to decide where to focus team resources and to evaluate improvement activities.

Physical and chemical monitoring of streams and reservoirs is conducted when additional information is needed to assess specific water quality issues--for example, how nutrients, pathogens, sediment, or habitat losses affect aquatic life or beneficial uses. In watersheds having significant impacts from nonpoint source pollution--and agency or local interest in nonpoint source control--aerial remote sensing is used to locate and characterize nonpoint pollution sources in order to target specific sites for treatment.

RATs are continuing to pioneer new methods to collect high-quality information at low cost with the objective of spending less money on studying problems and more on fixing them.

Coalition Building

The fundamental strategy of TVA's River Action Teams is coalition building. Team members share monitoring information with key stakeholders--regulatory agencies, state and local governments, businesses and industries, citizen-based action groups, and watershed residents--and seek their support in developing and implementing protection and mitigation plans. The challenge is to persuade potential partners that solving a given water resource issue is important to meeting their personal economic, social, and environmental needs, and the needs of their community.

RATs have found that building effective partnerships not only requires a significant investment of resources; it often takes technical experts outside their comfort zone. Team members who are more comfortable sampling water resource conditions and developing engineering solutions to problems spend much of their time meeting with potential partners, making presentations to local groups, providing information to reporters, organizing stream cleanups, and otherwise working to increase public awareness of watershed conditions and resource needs.

The first River Action Teams to take to the field offer this advice for developing effective partnerships:

- Potential cooperators must be involved from the outset of the project. Their needs and priorities must be considered in identifying, assessing, and solving problems.
- Successful cooperative efforts are inclusive. All stakeholders must be involved in the project planning process--critics as well as eager volunteers.
- It helps to offer incentives to encourage local participation. Cost-sharing assistance clearly will make a difference in the number of landowners willing to change their operation.
- Local ownership is critical. One or two local leaders dedicated to the success of the project can accomplish more than an army of technical advisors.
- It is important to choose projects carefully, or as one writer put it, to "pick battles big enough to matter, small enough to win." RATs weigh a variety of factors in resource allocation decisions,

including public interest, the value of the waterbody (e.g., is it a source of public drinking water?), the impact of the problem on the waterbody, and the probability of project success.

Results

River Action Team efforts to build partnerships already are paying off. Last year, 22,500 volunteer hours were logged in monitoring, habitat enhancement, cleanup, and protection activities. Acting as catalysts for change, RATs helped start or worked in partnership with 43 local coalitions to solve water quality problems; conducted 412 stream and reservoir assessments; established 20 native aquatic plant stands; installed 4,500 habitat structures; stabilized 9,300 feet of shoreline; and implemented 43 best management practices, including constructed wetlands, fencing, and streambank revegetation. Team members also spearheaded a variety of communications activities designed to educate people about water quality and involve them in solving pollution problems.

By focusing on partnerships, RATs are able to accomplish more with less, as these examples show:

- The Hiwassee RAT brought together a cost-share grant from the National Fish and Wildlife Foundation, heavy equipment from the North Carolina Department of Transportation, and technical assistance from the U.S. Forest Service and the North Carolina Wildlife Resources Commission to stabilize critically eroding streambank along Shuler Creek in western North Carolina. The project reduced sedimentation in a section of the Hiwassee River that harbors a variety of rare mussel species. Trout Unlimited volunteers are continuing to work with the TVA team to monitor sedimentation and siltation in the Hiwassee watershed.
- The Chickamauga-Nickajack RAT is partnering with Friends of North Chickamauga Creek Greenway, a nonprofit citizen group dedicated to reviving North Chickamauga Creek near Chattanooga, Tennessee. The group is coordinating the efforts of federal and state agencies, Chattanooga and Hamilton County governments, and area and regional businesses to identify and address a variety of issues. These include a multiyear project to reduce acid mine drainage by installing passive treatment systems, an ecological restoration training workshop for the community, acquisition of land for extension of the Greenway and protection of water quality, streambank stabilization, and educational activities in schools and communities in the watershed.
- The Holston RAT worked with the Middle Fork Holston Water Quality Committee to teach teachers in Southwest Virginia how to map a watershed, document land uses, sample streams for water quality, and locate pollution sources as part of an innovative Adopt-A-Watershed project. Teachers and their students have adopted sections of the Holston River and are working together to solve pollution problems with technical support and funding from local, state, and federal agencies. The project was recently awarded an environmental justice grant which is being used to fund a full-time coordinator.
- For the last year, the Wheeler-Elk RAT has facilitated the Paint Rock River Initiative in northeastern Alabama. The 450-square-mile watershed supports 98 fish and 44 mussel species, many of which are threatened by sedimentation. Landowners are concerned about flooding and streambank erosion. Landowners and 20 agencies and organizations are working together to

increase awareness, stabilize streambanks, and implement best management practices.

Critique

As TVA moves forward in implementing its watershed approach, several weaknesses are being addressed. RATs are working to include a wider group of public interests in team projects; to overcome barriers to interagency cooperation, such as changes in agency representation, conflicting priorities, and distrust among potential cooperators; and to develop more effective strategies for achieving the voluntary use of best management practices, especially in areas with below-average income. Efforts also are underway to develop better biological assessment tools and resource-based performance measures.

These challenges, however, are offset by the demonstrated advantages of a partnership approach. As facilitators of cooperative efforts, RATs are able to address needs and issues that often cannot be addressed effectively under single programs. RATs are able to:

- Factor in the needs and expectations of all stakeholders-including resource users, land owners, and cooperators-to increase the likelihood that voluntary solutions will be implemented widely and successfully.
- Tackle resource issues from a broader perspective, unrestricted by political boundaries, legislative requirements, or jurisdictional constraints related to resource area, pollutant type, or technology.
- Develop and promote strategies that balance human use of the resource with resource integrity to achieve economic sustainability.
- Protect resources before uses are impaired or ecological integrity is degraded.
- Leverage funds through cooperative interagency ventures to fund large-scale projects that otherwise would be unaffordable.

CWI's success already has attracted national attention. Water Quality 2000, a coalition of 70 different national organizations, evaluated TVA's approach in June 1994 and concluded that it should be "expanded, promoted, and replicated in other watersheds." In June 1995, CWI received a Hammer Award from Vice President Al Gore. The Vice President specifically recognized TVA's River Action Teams for reinventing government by developing new approaches for water pollution cleanup and by cutting red tape to better serve customers.

Six River Action Teams already are in place, and TVA plans to establish teams in the remaining six subwatersheds in the Tennessee Valley. The goal is to improve the beneficial uses of the water resources and transfer the responsibility for sustaining these improvements to the user public by 2015.

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Parkers Creek Watershed Management Plan-A Local, State, and Federal Partnership

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Introduction

The Parkers Creek Watershed Management Plan is the result of a local, state, federal, and private partnership to preserve, protect, and manage the natural resources in a watershed with rapid growth potential. The watershed is located in Calvert County, Maryland, a peninsular county lying between the Chesapeake Bay and the Patuxent River. The county, though rural, is experiencing greater than a 4% growth rate (highest in Maryland). However, the Parkers Creek watershed has experienced very little growth except in its northwest section which encompasses part of the Prince Frederick Town Center.

Prince Frederick is the major growth center in the County for government, medical, and retail activity and is targeted for high density residential growth. The greatest challenge of this Plan is to promote economic viability of the Prince Frederick Town Center while preserving the pristine nature of a large portion of the Parkers Creek watershed.

Prior to the watershed management initiatives, major development projects in the Prince Frederick Town Center which required some fill of nontidal wetlands where reviewed by State and Federal Agencies on a site by site basis. The review was without regard to the fact that the site was within a designated growth area and that over the entire watershed the County was being very protective of sensitive areas and was promoting preservation of habitat and open space. Local, state, and federal agencies agreed that a comprehensive watershed management approach would be the best way to evaluate future projects in the watershed. The citizen based Parkers Creek Watershed Task Force was formed to guide the development of the Parkers Creek Watershed Management Plan.

Parkers Creek

Parkers Creek flows from west to east and becomes tidal before flowing into the Chesapeake Bay. The watershed, encompassing approximately 12.6 square miles, includes the mainstem of Parkers Creek and sixteen tributaries and associated wetlands flowing from the north and south into the Creek. The watershed contains some of the largest unbroken woodlands left in Calvert County. These surround non-tidal wetlands and the only pristine salt-water/fresh-water marsh on the Western Shore of the Chesapeake Bay. Parkers Creek flows through woods and marsh, across a barrier beach, and into Chesapeake Bay. The high cliffs at each end of the beach, the open bay, the creek, marsh, wetlands, and woods are all still in their natural state. This combination is unique.

Parkers Creek Watershed Management Plan

Approach

The Plan follows the model given in "A Guide to Developing Nontidal Wetlands Watershed Management Plans in Maryland." This document is a result of the Maryland Nontidal Wetlands Protection Act (MNWPA, 1989) which followed from the Chesapeake Bay Agreement in (1987). The MNWPA mandated that the State assist local governments in the development of watershed management plans which address wetland protection, cumulative impacts, mitigation, water supply, and flood management. This plan, when certified by the State and adopted by Calvert County, will be used to evaluate proposed wetland impacts in the watershed under section 404 of the Clean Water Act.

Visions and Goals

The Parkers Creek Watershed Task Force,after reviewing the functional assessment, and getting direction and information from federal, state, and local agencies, developed visions for the Parkers Creek Watershed and from these visions, set goals and developed an action plan.

Though the action plan is too lengthy to include here, the visions and goals are listed below:

- Preserve open space, wildlife corridors, and vistas

Goal Preserve the eastern 2/3 of the watershed
Goal Preserve, extend, and improve wildlife corridors

- Foster productivity
  Goal Support non-polluting farming operations
  Goal Maintain water quality in the watershed
- Encourage ecological and cultural research
  Goal Encourage ecological research center in watershed
  Goal Conduct cultural resources survey for the watershed.
- Maintain and improve water quality
  Goal Establish water quality monitoring program in Parkers Creek
  Goal Decrease impacts from developed areas on watershed
- Maintain land values
  Goal Provide programs for land preservation that maintain property values

Natural Resource Identification

As part of the Watershed Management Plan, attempts have been made to locate, map, and document as many of the natural resources in the watershed as possible. These resources include wetlands and waterways, hydric soils, floodplains, water supply, forests, and rare, threatened, and endangered species habitat.

Wetlands. Wetlands within the Parkers Creek watershed were identified using the FWS National Wetland Inventory maps. Data were collected from the majority of these wetlands to assess their functional value.

In the "Parkers Creek Watershed Wetland Assessment" (PCWWA, 1995, Dewberry and Davis and Chris Athanas, Ph.D. & Associates, Inc.) the functional value of each of the wetlands, based on an assessment of 52 out of a total of 88 wetlands, was estimated using the WET II (Adamus et al., 1987) and New Hampshire (Ammann & Stone, 1991) wetland functional assessment procedures. In addition, an expanded wildlife habitat procedure was developed to obtain a broader perspective of habitat than that obtained by either the New Hampshire method or Wet II.

An examination of all of the freshwater wetlands in the Parkers Creek watershed as a functioning system provides insight into the watershed. Most of the nontidal wetlands along the Parkers Creek mainstem provide the pollution removal/transformation and water-oriented wildlife functions in the watershed. The forested PFO1A wetlands extending up along the tributaries of the creek provide several important functions in the watershed that do not show up in the WET II and New Hampshire method assessments. These wetlands provide stable conduits for the transfer of water and forest organic material to Parkers Creek from the surrounding uplands. In addition, the wetland forests, along with the contiguous upland forests, remove fine sediment and nutrients from the non-channel runoff leaving agricultural fields. A very important function of these forested wetlands is providing habitat diversity within the landscape.

Habitat of Special Concern. The Maryland Department of Natural Resources (DNR) has identified several rare, threatened or endangered species within the watershed. Bald Eagles (Haliaeetus leucocephalus), Northeaster Beach Tiger-Beetles (Cicindela dorsalis), single-headed pussytoes (Antennaria solitaria), and large-seeded touch-me-nots (Myosotis macrosperma) exist in the watershed. In addition, the large tracts of contiguous forest area are potential forest interior dwelling (FID) bird habitat.

Forest Cover. Parkers Creek has over 5,594 acres of forest (76% of the watershed) and 80% of this forest qualifies as potential FID bird habitat. It is therefore important to preserve this large contiguous core natural area and link it by forest corridors to other significant blocks of undisturbed natural area.

Cumulative Impacts

The cumulative impacts to wetlands in the watershed were evaluated based on two build-out scenarios in conjunction with the wetland functional analysis. A flood study was also conducted in conjunction with the COE, Baltimore District.

In terms of nutrient and sediment inputs, the two subwatersheds draining the Town Center are predicted to have the greatest increases in loadings under full build-out, and among the highest in total loadings. It was concluded in the functional analysis that, due to the pollutant loadings and the town center zoning and its associated impervious surfaces, that the stormwater runoff from these two subwatersheds could best be treated with regional stormwater basins. This approach is currently being discussed with federal, state, and local agencies.

By contrast, the low density clustered development that could occur on much of the land in the remaining subwatersheds can be treated by on-site stormwater management basins. For those areas where agriculture or forestry is to be preserved, non-structural stormwater runoff management practices could be used.

With the expanding traffic demand, options to accommodate the additional traffic loads are being considered by the Maryland State Highway Administration. One of the alternatives was an eastern Prince Frederick bypass. This proposed bypass would have resulted in the displacement of 20 to 30 structures, and the filling of 24 acres of wetland in the Parkers Creek Watershed. The COE found the eastern bypass the least favorable alternative due to the greatest loss of wetlands and greatest costs. The Parkers Creek Watershed Management Plan based on the functional analysis supports this conclusion.

Partnerships

The development of the Parkers Creek Watershed Management Plan has been and continues to be a collaborative effort by local, state, federal, and private entities (Table 1).

Table 1. Matrix of Local, State, Federal, and Private Partnerships in the Development of the Parkers Creek Watershed Management Plan

	Local	State	Federal	Private
Funding	CCG	DNR-CZM MDE-WMA	EPA COE FWS NOAA	ACLT CBT TNC
Natural Res. Inventory	CCG PCWTF CSCD	DNR MDE	FWS NRCS	Consultants
Visions and Goals	PCWTF CCG*	DNR-CZM* MDE-WMA*	EPA-BP*	ACLT* Consultants*
Cumulative Impacts	CCG CSCD* PCWTF*	DNR* MDE*	COE* FWS* NRCS*	Consultants
Monitoring	CCG PCWTF CCS	DNR		ACLT
Flood Study	CCG	DNR*	COE FEMA*	Consultants
Certification of Plan		MDE-WMA MDE* DNR*	COE* FWS*	
Adoption of Plan	CCG CCC PCWTF*			

ACLT = American Chestnut Land Trust; **BP** = Chesapeake Bay Program; **CBT** = Chesapeake Bay Trust; **CCG** = Calvert County Government; **CCC** = Calvert County Citizens; **CCS** = Calvert County Schools; **COE** = Army Corp of Engineers; **CSCD** = Calvert Soil Conservation District; **CZM** = Coastal Zone Management Division; **DNR** = Maryland Department of Natural Resources; **EPA** = Environmental Protection Agency; **FEMA** = Federal Emergency Management Administration; **FWS** = US Fish and Wildlife Service; **MDE** = Maryland Department of the Environment; **NOAA** = National Oceanic and Atmospheric Administration; **NRCS** = Natural Resources Conservation Service; **PCWTF** = Parkers Creek Watershed Task Force; **TNC** = The Nature Conservancy; **WMA** = Water Management Administration. ***** = Advise and/or review.

The partnership begins with a recognition by all parties of the value and appropriateness of the watershed planning approach and a recognition of the interest that each of the groups play in its formation and implementation. The cooperation continues throughout the watershed planning effort including aspects such as: funding, providing a natural resources inventory, developing the visions and goals of the plan, estimating cumulative impacts, monitoring water quality, and certification of the plan. The PCWTF was responsible for developing the visions, goals, and an action plan for the watershed. They consulted with local, state, and federal agencies as well as with private consultants during this process. The Maryland Department of the Environment, Water Management Administration is responsible for the certification process in which they consult with other state and federal agencies. The adoption process is a County Government responsibility though comments from state and federal agencies and the public are invited during the public hearing process.

Summary

It is a local, state, and federal goal to preserve as much of this watershed, especially its wetlands, outside of the town center as possible. It is also a goal to protect the pristine portions of the watershed from the impacts of the development of the town center while maintaining the towns economic viability. The Parkers Creek Watershed Management Plan represents a partnership among local, state, federal, and private entities to accomplish these goals.

Acknowledgements

Funding for this study was provided by: Calvert County Government; the Coastal and Watershed Resources Division, Maryland Department of Natural Resources, through a grant (NA 370 ZO 359) from NOAA; the Water Management Administration, Maryland Department of the Environment through a grant (CD 003918-01-0) from EPA; Chesapeake Bay Trust; and COE, Baltimore District. The views, opinions, or policies expressed herein are those of the authors and do not necessarily reflect the views, opinions, or policies of the funding agencies.

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Savannah River Basin Watershed Project: Implementing Strategies, Building Partnerships

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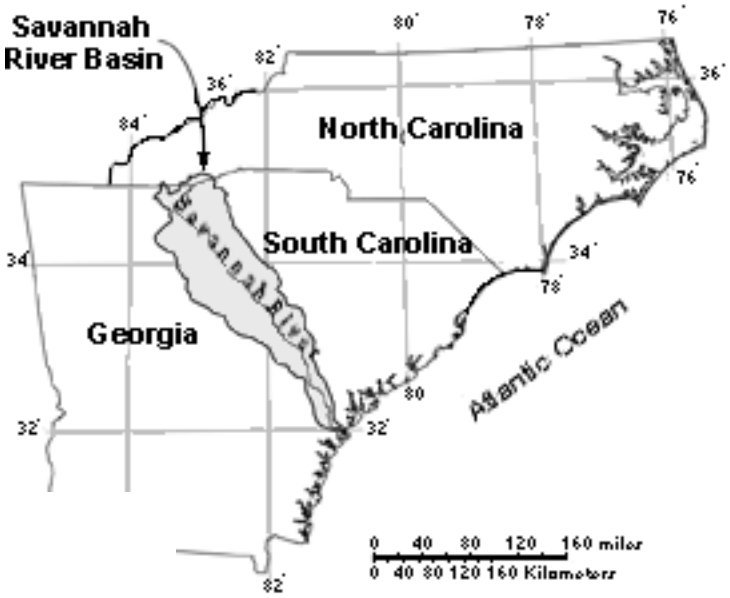
The emphasis of many environmental programs is shifting towards an integrated, holistic management approach in order to cohesively address the many diverse environmental threats to the water, air, and land. This approach, often termed "ecosystem protection," emphasizes the achievement and measurement of environmental results and builds on a water quality protection approach utilized by many agencies. This water quality protection approach is being applied in the Savannah River basin (Figure 1) to reduce environmental and human health risk through improved resource protection, with water quality as a primary indicator of program success.

The watershed protection approach in the Savannah River basin is built on three main principles: (1) identification of the primary threats to human and ecosystem health within the watershed, (2) involvement of the people, or stakeholders, most likely to be concerned or affected or most able to take action, and (3) the development and implementation of actions in a comprehensive, integrated manner. The vision of project participants is to manage comprehensively the Savannah River basin to conserve, restore, enhance, and protect its ecosystems, especially aquatic ecosystems, in a way that allows the balancing of multiple uses. The goal is to develop and implement a multi-agency/organization environmental protection project which incorporates the authorities and expertise of all interested parties in the future management and protection of the basin's resources.

At the initiation of the Savannah River Basin Watershed Project, eighty-eight (88) environmental issues

related to the Savannah River basin were identified by basin stakeholders. These issues included impacts to fish resources, riparian habitat degradation, reservoir discharge impacts, and wetlands impacts, for example. The issues formed the basis for the development of a project structure, which consists of six (6) Resource Committees, three (3) Technical Advisory Committees, a Management Committee, and a Policy Committee (Figure 2).



.. Savannah River Basin Watershed Project Location Map.

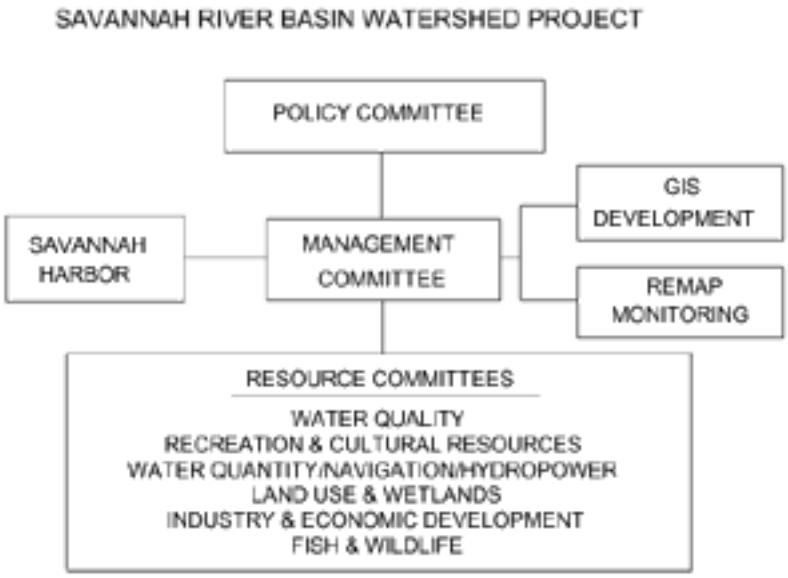


Figure 2. Project Structure.

The Resource Committees have completed Baseline Assessments that describe their resource of concern in the basin (i.e., fish and wildlife, water quality, land use and wetlands, water quantity/navigation/hydropower, recreation and cultural resources, and industry and economic development), identify known or suspected impacts to the resource, describe the available data concerning the resource, identify data gaps, and propose recommendations for resource improvement. The six Baseline Assessments have been merged into the Initial Assessment and Prioritization Report for the Savannah River Basin (Initial Assessment Report) by the Management Committee. The Initial Assessment Report is the basis for development of a watershed strategy for the Savannah River basin.

As the Management Committee met to discuss and prioritize the recommendations from the six Baseline Assessments, there were several general areas of predominant interest to the members. The first of these related to best management practices (BMPs). There were recommendations to create, improve, develop incentives for, and educate citizens and industry about BMPs. These consistently received priority

ranking by many different groups of stakeholders in the membership.

Another area with virtually the same level of agreement concerned the lack of coordination, communication, and cooperation by stakeholders around this great central resource, the Savannah River. The members found a need for improvement in all levels of government (federal, state, and local), within different agencies in the same levels of government, and between the public and private sectors.

A third general area of concern involved data and information technology. This included the lack of appropriate scientific data needed for decisions, the lack of common data (different data is now used by different entities to address the same issue), the need for common models (multiple models are now used by different entities to address a single issue), and the need for a geographic information system accessible to all stakeholders.

The Management Committee found that there were many worthwhile and valid efforts being made to improve the Savannah River and its resources. These endeavors could be improved with increased communication and coordination. A collective plan, or watershed strategy, with all stakeholders involved will make more efficient use of the limited financial resources available to the Savannah River basin community of resource managers and users.

The Policy Committee is developing and implementing a watershed strategy from the Initial Assessment Report. Both short-term and long-term objectives are being developed to address the priority recommendations of the Initial Assessment Report. Specifically, the watershed strategy will: identify the highest priority problems and opportunities, as presented in the Initial Assessment Report; describe specific actions to address problems and opportunities and identify who will take these actions; specify problems or issues that require additional data gathering and analysis; identify opportunities for cooperative efforts among stakeholders; and delineate ways to leverage resources from project participants.

This multi-stakeholder process will accomplish short- and long-term basin management and protection efforts utilizing the expertise, authorities, and resources of all basin stakeholders. It will promote coordination, cooperation, and planning among the stakeholders, ultimately maximizing resources and environmental results.

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The Nexus of Agency Reinvention and Water Resource Management: Incorporating a Watershed Approach into Agency Activities

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Most people know the Bureau of Reclamation as the builder of big dams and the largest supplier of water in the 17 western states, delivering each year 30 to 35 million acre-feet of water for agriculture, municipal, industrial, and domestic uses. However, BOR projects often serve multiple purposes, including flood damage reduction, hydropower generation, recreation, and fish and wildlife protection and enhancement. BOR now recognizes the tremendous changes in and losses to riparian and aquatic habitat that were brought about by its large dams and inter-basin transfers. BOR now appreciates the significance of watersheds and associated ecosystems and the natural beneficial functions they provide. Consequently, BOR is striving for better ways to manage water and related land resources. The agency has redefined its approach to water resource management to be responsive to society's current environmental and economic needs. While the agency has made significant progress, it has a long way to go to achieve a better balance between the multiple stakeholders that often see their interests at odds with each other.

BOR's transition from a construction-oriented agency to one focusing on water resource management started several years ago--new work was not being authorized by the Congress and changes in public opinion were forcing BOR to consider new directions. Its traditional program had come to an end. New political realities--reinvention and deficit reduction--profoundly influenced BOR's approach to establishing new directions. The need to become a water resource management agency and the need to change the way of doing business converged--helping the agency to examine and alter its structures and functions to efficiently and effectively foster water resource management.

The mission and structure of BOR's organization has significantly changed since 1993. In the past 36 months, BOR has reduced its work force by 20 percent. By December, 1996, we will have 25 percent fewer positions than the 8,200 people we had just over 2 years ago. The number of senior level managers has been reduced by 50 percent. BOR reduced its own budget request by $100 million--more than a 12 percent reduction--in the last two years. Field offices have been restructured and empowered, and now have the responsibility for making day-to-day decisions. Area office employees now have the authority--indeed the responsibility--to make decisions, be creative and take risks. BOR is in the process of divesting itself of ownership and operational responsibility for many smaller structures that are not identified as having national significance. BOR has reviewed all of its activities to either take certain responsibilities entirely "off its plate" or to alter its approach to these actions. By divesting itself of some of these responsibilities, BOR hopes to concentrate on the new priorities and goals of managing the limited water resources of the western United States.

Streamlined decision making, an empowered staff, increased flexibility, and elimination of regulations and internal requirements and are now the norm at BOR. Responsible water resource management decision making is the agency goal. The current dilemma facing BOR is how to incorporate all the philosophical underpinnings and techniques comprised by the concept of a watershed approach into the culture of the agency and its individuals without detailed directives or onerous regulations. This paper discusses what BOR is doing to impart to BOR activities a watershed philosophy. BOR believes that watersheds should be used to help define appropriate geographic boundaries, while "problemsheds" and ecosystems should be used to guide selection of the appropriate scales of analysis. They reflect the need for multi-scalar (large and small scales) and multi-temporal (short- and long-term) examination of direct and indirect impacts and their cumulative effects in problem identification and alternative solutions' development.

Old Missions, New Missions

BOR, founded in 1902, had as it original mission the development of the water resources of the arid western United States to promote the settlement and economic development of the region. As a water resource developer, BOR created a substantial infrastructure making it the largest wholesale supplier of water in the United States and the country's sixth largest electric power generator. BOR, its original mission complete, now manages 45 percent of surface water in the western United States.

Like any business, BOR found it needed to change to meet new market conditions. Water resource policies in the western United States were originally conceived and implemented to meet the needs of agriculture and mining. BOR's construction and diversion approaches were acceptable so long as there were ample water supplies, and plentiful government funds, and so long as environmentalists and indigenous peoples had limited influence in political or legal proceedings. All that has changed. The western United States is experiencing the most rapid growth of the nation and is becoming increasingly urbanized. Urban residential and industrial demands on the existing water resource system differ from those of agriculture and mining. A number of converging forces mandate new approaches to western water resource management:

- Lack of new acceptable storage sites for large quantities of water.
- Diminished public support for subsidies to a small number of agricultural producers and landowners (the economic foundation of many BOR projects).
- Scarcity of federal funds for large, long-term projects.
- Increased concern over domestic water pollution.
- Greater competition for water.
- Increased broad-based, public support for protecting non-consumptive uses and protecting the environment.

These factors compel change in BOR's approach to problem solving and business practices. These factors will also require new and more flexible approaches by water districts, cities, and states to water resources and water law.

A watershed philosophy to water resource management decision making is reflected in both BOR's mission statement and its organizing principles. BOR's new mission is "To manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public." Six organizational principles guide BOR's efforts; BOR will:

- Facilitate changes from current to new uses of water in accordance with state law when such changes increase benefits to society and the environment.
- Emphasize the coordinated use and management of our existing facilities to improve the management of existing water and hydroelectric supplies.
- Encourage conservation and improvements in the efficiency of use of already developed water and hydroelectric supplies.
- Promote the sustainable use of water and associated land resources in an environmentally sensitive manner throughout the 17 western states.
- Facilitate integrated water resources management on a watershed basis, stressing interagency cooperation, public participation, and local implementation.
- Conduct all activities in a fiscally responsible manner and ensure the use of sound business practices in all that BOR does.

Reflecting a Watershed Philosophy in Agency Structure and Policy

BOR is also changing how decisions are made and problems solved. One means of affecting the change has been to diversify the agencies' managers. No longer is leadership of area and regional offices the domain of engineers. While BOR is maintaining certain key engineering expertise, is also developing a staff with skills in computer programming, data management and analysis, geographic information systems, negotiations, alternative dispute resolution, and public deliberation. Each of these actions are initial steps toward realizing BOR's goal of being recognized as the world's premier water management agency.

Cultivating a watershed approach as a standard way of doing business has been the challenge. A

watershed approach helps set the stage involving the wider range of constituencies to which BOR must now respond. To these ends, BOR has incorporated the watershed concept by traditional means of policy and guidelines development. However, in keeping with its reinvention, BOR policy establishes only a general framework for decision making--providing broad direction and parameters within which the decision-maker will generally work. Line managers have discretion to exercise their duties creatively and flexibly within the policy framework. BOR's guidelines on the watershed approach to water resource management provide practical interpretations of policy to aid its implementation. Guidelines, however, do not need to be followed. To help ensure that the final policy and guidelines have broad acceptance by those who will be expected to operate within this framework, BOR uses a team approach involving practitioners from its regional and area offices. Further, BOR is incorporating the watershed approach into new policies and guidelines on floodplain management, wetland enhancement and mitigation, and endangered species conservation.

Watershed Approaches in Agency Activities

Coincident with terminating and curtailing its involvement in some traditional areas, BOR has launched a series of new and important initiatives. To reinforce the importance and value of a watershed approach in decision making that supports sustainable development, BOR is attempting to reflect the watershed approach in all of its activities. BOR's projects affect water resources both individually and cumulatively along with other activities in a watershed. Project operations can influence adjacent land use activities, which, in turn, can affect water quality and in-stream flow. Likewise, activities occurring in a watershed can affect the quality and supply of water reaching BOR's projects. Given this relationship, there is broad recognition among BOR staff and management that actions cannot be considered in isolation from other activities occurring within a watershed. Proposed actions cannot be considered in isolation from the attributes of the watershed or the effect on the watershed functions and values. In setting management objectives, managers now consider how project operations are interrelated with other activities in the region and what impacts operations will have on the watershed. Upstream activities affect downstream operations, and changes in project operations downstream may alter requests for upstream water. Downstream impacts may include sediment transport and sandbar development, river stage and reservoir elevation, and water quality and temperature. These impacts have implications for the protection and enhancement of natural, cultural, recreational, and environmental resources, in addition to consequences for downstream power operations. BOR's current emphasis on the movement of water from one use to another (as opposed to trans-basin diversions)--by increasing water use efficiency, encouraging demand-side management, and supporting water reuse activities--requires the application of techniques inherent to the watershed philosophy. Any water resource management decisions should reflect watershed conditions and involve the stakeholders within the affected watershed(s) in order to provide real economic benefits to a broader range of interests.

One exciting example of BOR's new approach to water resource management is an accord reached in California in December 1994. Watershed principles were applied to reach this historic agreement where three agencies of the federal government and the State of California agreed to implement a coordinated package of actions to protect the San Francisco Bay and Sacramento, San Joaquin River Delta while

strengthening the state's long-term economic health. Business leaders, state officials, and agricultural as well as urban and environmental interests joined with federal officials in endorsing a plan designed to restore and protect this important, yet stressed, aquatic ecosystem. It is expected that this agreement will provide the certainty that California agricultural interests require and the stability to a region that has been long embroiled in heated rhetorical and legal battles over California's water supply needs.

The development of BOR's dam operations and resource management plans typically reflect a watershed approach to decision making. In augmenting stream flows, BOR is investigating coordinated operation of projects within a basin to help meet in-stream flow objectives. In integrating facility operations, a watershed approach to water supply, hydropower generation, and environmental demands allows the flexibility to provide water supplies to uses which historically received only ad hoc consideration. Ideally operations are coordinated with other (i.e., non-BOR) activities in the watershed. This is happening in both the Columbia and Colorado River systems. Greater opportunity to address multiple stakeholder needs exists in multi-reservoir systems. BOR encourages that dam operation objectives be selected only after recognizing that each individual project is an integral component of a basinwide water management system. To integrate reservoir operations, complex system models are used to develop reservoir operating criteria.

Often the water user community can be flexible enough to institute in-stream flow programs through simple measures, such as water transfers or the added-value concept whereby water is moved through a system so that in-stream benefits accrue while pre-existing functions are satisfied. These decisions require a broad look at both benefical and adverse environmental, ecomonic, and social impacts. Again the watershed approach is the approach used to identify issues and help select the appropriate course of action.

BOR is looking for incentives to enhance water conservation. The decision to conserve water must be weighed carefully--not only in the obvious economic cost and benefit terms but also in light of the environmental effects that more efficient use of water may have on a watershed and the habitats that have developed as a result of inefficient practices. The issue of conserved water, as well as irrigation return flow water quality, are best dealt with using a watershed approach to problem definition, opportunity identification, and, ultimately decision making. BOR plans to enhance its relationships with states and irrigation districts to ensure that proposed increases in water efficiency do not aggravate adverse conditions in a watershed (e.g., dry out valuable wetland habitats) and we will look for opportunities where efficiency gains can contribute to improvements in water quality.

With new water sources dwindling and the increased interest in obtaining and maintaining fishable and swimmable waters, attention is focusing on potable and non-potable water reuse. Closed water treatment systems that pump water to ground water offer municipalities a means to avoid increasingly strict discharge permit requirements but such activities can have adverse consequences for riparian and wetland habitats that have grown dependent upon wastewater flows. In setting priorities for funding water reuse endeavors, BOR plans to employ a watershed approach to decision making. A watershed approach will help BOR to determine the appropriate type of assistance and ensure protection and enhancement of environmental resources.

BOR's Western Partnership Initiative, initiated in 1995, brings traditional BOR partners, such as irrigation districts, together with BOR and other stakeholders to define an area's goals for water management as well as other objectives and mutually establish a framework for achieving these goals. These principles correspond to those embodied by the watershed approach concept. BOR's purpose for forming these partnerships is to resolve existing resource related problems; address watershed and river basin resource issues and future concerns; remove institutional legal and contractual issues that constrain good resource management; improve efficiencies of services provided; and/or provide expertise, assistance and training for the purpose of improving the water management skills of its partners.

Applicants for funding from the BOR through the National Fish and Wildlife Foundation for environmental restoration activities must demonstrate that their proposed project applies techniques and principles inherent to an ecological approach to stream and watershed restoration. The guidelines specify that the proposed projects should involve habitat protection, restoration, or enhancement that considers species needs and ecosystems needs, as well as the species' linkage to its watershed and ecosystem.

Conclusion

A watershed approach is not enough to ensure that BOR makes wise water management decisions, but it does helps set the stage for the broader thinking required for water resources and related land management issues facing the western United States. The BOR has changed its historic emphasis on construction and is working hard to focus on water resource management. Despite progress, BOR's water resource management roles and responsibilities need to be further defined. Regardless of how the agency's roles are defined, BOR must approach the problem of competing water demands in a manner that allows the short- and long-term environmental and economic consequences of proposed actions and policies to be recognized and to find means to sustainable manage water resources in the west. The next step is for BOR to work collaboratively with states to ensure corresponding support for sustainable water resource management. Only through the involvement of states and other stakeholders will the fundamental issues facing western water resource managers be solved. Broader adoption and implementation of the principles inherent to watershed approaches to decision making may provide the common thread needed to to ensure that western water management proceeds in an environmentally and economically sustainable manner.

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Return to the Future: Watershed Planning-The Quest for a New Paradigm

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Abstract

Regulatory agencies, EPA in particular, have been leading an initiative to conduct natural resources related planning at the watershed level. The focus has been on coordinating programs at the intra-agency level to better serve watershed needs. Coordination, by itself, does not constitute watershed planning. So far, no recognizable planning and evaluation framework designed for coordinated comprehensive, joint inter-agency endeavors has emerged. Intra-agency programmatic integration is a prerequisite to, not a substitute for comprehensive planning. The Water Resources Council's (WRC) hierarchy of nested river basin planning levels should serve as a starting point for devising a new watershed-level planning process. Such planning should be strategic in nature, rather than project specific. Agency programs, authorities and capabilities would be matched, leveraged and dedicated to deal with priority problems identified through watershed planning. Such planning should focus on formulating alternative strategies towards achieving sustainable development. Opportunity costs would serve as the basis for economic analysis rather than the more stringent benefit-cost procedures associated with conventional water resources project planning, in consideration of the greater emphasis on environmental protection and restoration as primary planning purposes. The current WRC "Principles and Guidelines" (P&G) could serve as the basis for developing watershed planning guidelines.

Introduction

Watersheds have become the physiographic organizing framework of choice for many federal and state

water and natural resources management programs and initiatives. There is nothing new in this concept, for federal and state water resources agencies have been operating within such a framework in an organized fashion since at least the 1930's. The Natural Resources and Conservation Service (NRCS, formerly Soil Conservation Service) has been operating under PL 83-566 which set up the "Small Watershed Program" (less that 250,000 acres or 391 sq. mi.) to deal with soil, water and other related natural resources problems. Much of the work of water resources management agencies has been conducted on a watershed level, and countless conferences, guidelines and regulations all attest to the program and project management focus on the river basin and watershed level as the basic hydrologic unit for analysis. Hydrology determines the appropriate level and boundaries for water resources analysis and, concordantly is the primary determinant for aquatic ecosystems.

The integration of water quantity, water quality and aquatic ecosystem needs has been the quest of federal agencies since well before the enactment of the Water Resources Planning Act of 1965. This Act expressly required the development of "comprehensive, coordinated joint plans" (CCJP's) for river basins. A recent National Academy of Sciences Report on "Restoration of Aquatic Ecosystems" (NRC: 1992) merely reaffirmed what has been known by all practitioners, i.e. "[B]ecause aquatic ecosystem are interconnected and interactive, effective restoration efforts should usually be conducted on a large enough scale to include all significant components of the watershed." (pg 5).

What then, is the basis for the renewed interest in watershed planning? How is it different from the traditional approach to water resources planning as expressed in the WRC's P&G (WRC, 1983)? Finally, what are the requisite conditions for watershed planning to succeed and what should be the outcomes of such efforts? These are the issues that will be addressed further.

A Renewed Interest in Watersheds

It appears that the new interest in watersheds as the basic planning unit is currently driven by two principal issues: (1) the proliferation of disparate regulatory agency programs that protect various aspects of water-dependent public health and environmental quality concerns and (2) the increased emphasis by all federal resources management agencies on improving ecosystem management and restoration through their respective programs and authorities. The difficulty that this poses for interagency cooperation and collaboration as part of the implicit requirements of watershed planning is that there is an incompatibility among the various regulatory agencies and between the traditional water resources management agencies as to the basic philosophy of what integrated, multi-objective planning means. That incongruity is not something that increased coordination can overcome, even if every agency conducted their respective planning efforts at the watershed level.

Additionally, two other significant factors played into the realization that watersheds represent the proper context for future intra- and inter-agency planning and management efforts. First, budgetary constraints are forcing greater cooperation and complementarity among federal programs. Second, a very good case can be made that the watershed scale, rather than the larger river basin scale, makes comprehensive planning efforts more tractable. It is also more compatible with the desires of state and local entities to

take on responsibilities for implementing the actions and initiatives of such efforts. Indeed, the recent "National Water Policy Charter" of the Interstate Council on Water Policy (1996) lays out a series of principles for its member states, attesting to their understanding that effective stewardship of water and related natural resources is best accomplished at the watershed level, and their desire that states should bear primary responsibility, authority and accountability for water management.

All agencies need to deal with project and programmatic integration. Numerous water-related environmental protection laws have been enacted, and a vast array of programs have materialized, many pursuing very worthy, but narrow and often conflicting objectives. Coordination among programs by itself, whether mandated or voluntary, could not keep up with the growing number of initiatives and increasing complexity and diversity of problems that emerged over the past few decades. So, the first level of administrative restructuring must occur at the intra-agency level. EPA, for example was motivated to integrate the objectives and outcomes of its various instream and drinking water quality programs, combined sewer overflow program, wastewater and sanitary sewer program, and non-point source pollution efforts with an overarching need to protect ecological integrity (wetlands, riparian habitat and aquatic ecosystems). The Corps of Engineers is charting a similar path (Shabman, 1993), as it attempts to reconcile conceptual differences in the respective planning, regulatory and operations and maintenance philosophies and guidelines as part of their renewed watershed-based management focus.

The Traditional Water Resources Planning Model

While most now agree that the watershed should be the basic scale for organizing resource management programs, a framework for planning and decisionmaking has not yet been devised. The USDA Forest Service is, perhaps, furthest ahead in developing a watershed analysis framework for ecosystem management (Montgomery, et .al., 1995). Programmatic integration does not resolve the larger issue of the purposes of watershed planning and integration across agency programs (what are we planning for, who takes the lead and what evaluation framework is to be used?). The now defunct WRC, established by the Water Resources Planning Act of 1965, had a sensible notion in its three-tier hierarchy of nested planning levels:

- Level A - Framework studies, multiple river basin or large systems (e.g. Great Lakes);
- Level B - Single river basin at the two-digit USGS/WRC level, strategic plans and project priorities;
- Level C - Project feasibility studies at the watershed level/political boundaries.

What is currently being suggested by the still vague agency initiatives is a level of analysis that lies between Level B and Level C, i.e. strategic planning to achieve sustainable development at the watershed level (6-digit USGS designated code). The USGS system of watershed designation should serve as starting point for defining the scale of these studies. The purpose of this planning should not necessarily be to define projects, but to better define priority problems and to match existing agency resources and

authorities which could be used to complement one another to solve those problems.

But the WRC also developed an internally consistent planning and evaluation framework (P&S) in 1973 that were revised in 1983 as the P&G. Today, they are in use for Level C project feasibility studies conducted at what is essentially the watershed scale. A uniform planning framework, to be applied by all federal agencies operating in watersheds is essential if programmatic coordination is to be turned into true planning collaboration. Originally, in 1971, when the draft WRC P&S were issued for review, all federal agencies (including EPA, FWS, FERC, etc.) that interacted with the principal water resources management agencies were covered by the provisions of the P&S. The intent was to ensure that a common set of evaluation principles and frame of reference for the planning process itself was used by all the agencies in their mutual dealings, coordination and review of reports. The final regulations however, applied only to the Corps, Bureau of Reclamation, TVA, SCS and the Forest Service, exempting the federal regulatory agencies.

As a consequence, there are now four distinctly different evaluation philosophies that have emerged from the milieu of federal water-related programs (Table 1). Evidence already exists that watershed planning efforts conducted by different agencies operating under their own planning process and evaluation criteria, will result in different outcomes. However, the real crux of watershed planning is to encourage inter-agency collaboration; to ensure complementarity of their respective programs; leverage budget-constrained resources; and develop comprehensive plans designed to attain the elusive goal of sustainable development. Hence, a uniform evaluation framework is yet another prerequisite for collaborative watershed planning, to ensure that the outcomes are comparable.

Table 1. Four Extant Planning & Evaluation Philosophies

DESCRIPTIVE- (to delineate, classify rather than explain)	Assessment-oriented: describe options; layout possibilities. Decisionmaking based on consensus without normative, formal replicable evaluation procedures. (e.g. Coastal Zone Mgmt.)
INDICATIVE- (to demonstrate the need for)	Evaluation-oriented: assess problems; formulate options to address multiple objectives; evaluate according to normative decision criteria, public preferences, BCA, EIA, financial, etc. (e.g. Water Resources Council P&G)

PRESCRIPTIVE- (to establish as a rule or law)	Prescribed standards, targets, criteria, technologies. Purpose of analysis is focused on single objective. Little flexibility in formulating options.(e.g. EPA Section 208)
PROSCRIPTIVE- (to prohibit, exclude)	Generally single objective planning, problem solving; assessment of problems, needs and solutions subject to constraints. Focus on environmental issues. Follow "NEPA-process", EIS decisionmaking framework. Little risk or economic analysis

The "New" Watershed Planning Paradigm

The scope (purposes, approach and outcomes) of watershed planning is still to be determined. The administrative integration of agency programs is a prerequisite for comprehensive, multi-objective planning--the essence of planning for sustainable development. What then is the nature of such planning? How are plans to be formulated? How are choices about sustainable development to be evaluated? This should be the essence of a watershed planning framework.

Fortunately, there already exists a firm conceptual and procedural basis in existing WRC guidelines as a starting point. While it is perfectly appropriate to rely on the current P&G, and the underlying benefit-cost principles for project planning and evaluation, supplemented by the NEPA/EIS process, it is not particularly well-suited for the type of collaborative watershed planning that is suggested by the evolving notions of a more participatory style of planning. Indeed, both Shabman (1993) and the NRC report (1992) on aquatic ecosystem restoration recommend an evaluation approach based on "opportunity costs". Rather than the stricter ideas of maximizing economic efficiency, this approach provides the analytical rigor needed to determine the relative economic and ecological "worth" of alternative strategic plans. It is based on a human-based determination of value but looks to collective action to define the value of the need for protection, restoration, mitigation and/or development. Thus, watershed planning should serve as the basis for defining water-dependent problems and formulating alternative strategies (courses of action) which fulfill different attainment levels of sustainable development. It should facilitate the evaluation, within a uniform framework of internally consistent principles, of which course of action is "optimal"; which one is preferred; and what relative social, economic, and environmental benefits and costs that each path engenders.

This planning philosophy is embodied in the P&G, but is not practiced by the regulatory agencies. Nevertheless, a series of recent laws and executive orders, capped by the just-released report of the President's Council on Sustainable Development (1996), all endorse the need for improved resource management performance, buttressed by a greater stress on economic efficiency considerations (benefit-

cost analysis, risk-cost analysis, opportunity costs) in pursing the goals of environmental protection. In addition, EPA and other federal regulatory agencies are being directed by the implementing guidelines which the White House Council of Economic Advisors set forth in "Best Practices for Preparing Economic Analysis of Regulatory Actions" (1996), as a complement to EO 12866 (1993), to assess costs and benefits of various regulatory options and to select the one that maximizes the greatest net gain for society. Similarly, the Government Performance and Results Act of 1993 (PL103-62) directs all agencies to "establish performance indicators to be used in measuring or assessing the relevant outputs, service levels and outcomes of each program activity". All these recent directives reflect a convergence on the principles and objectives of indicative planning (See table 1), making it easier for the regulatory agencies to convert to the practices embodied in the P&G.

A Prospective Strategy for the Corps

As a first step, the Corps should continue their efforts to better integrate the many water resources management programs and consolidate the evaluation procedures so that they are more internally consistent. Some steps have already been taken, but there are gaps between the project planning, regulatory and operations arms of the Corps (Shabman, 1993). Second, the Corps should continue to focus their project planning and restoration efforts in the river corridor_i.e. that part of the watershed which is covered by overlapping authorities that deal with activities in the flood plains, riparian zones and wetlands. Multi-objective river corridor management is an apt term for the watershed emphasis that the Corps ought to address as their primary mission. This would enable the Corps to serve two purposes_project level analysis along with comprehensive environmental resources management.

However, before the higher, integrating level of comprehensive, collaborative watershed planning can be achieved by any single federal agency, a new evaluation framework needs to be fashioned to reflect the strategic purposes of such planning. The previous WRC P&S and existing P&G should serve as a starting point for an interagency group to develop a more general framework oriented to developing alternative paths towards achieving sustainable development, with a coordinated implementation strategy. The Corps should take the initiative in leading this effort.

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Citizen Partners in Water Quality Monitoring: The Volunteer Monitoring Movement

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What is Volunteer Monitoring?

Across the country, people of all ages and backgrounds are learning about water quality issues and helping protect our Nation's water resources by becoming volunteer monitors. Five hundred and twenty programs with over 350,000 volunteers were known to exist in 1994, and the number of programs is continually growing (EPA, 1994).

Volunteers may analyze water samples for constituents such as dissolved oxygen, pH, temperature, and nutrients; evaluate the health of stream habitats and aquatic biological communities; inventory streamside conditions and land uses that may affect water quality; catalog and collect beach debris; or restore degraded aquatic habitats. They do this during all hours, in all kinds of weather, for the simple satisfaction of knowing that their efforts can make a difference in protecting our valuable streams, lakes, beaches, bays, and wetlands.

Some of these volunteer monitors are organized and trained by coordinators from state water quality or natural resource agencies. We currently know of about 35 such agency-supported volunteer monitoring programs.

Many other volunteer monitors belong to small, grassroots community organizations concerned about a particular waterbody or watershed. In fact, the median size of volunteer programs is about 25 volunteers, and 60% of programs have annual budgets of less than $10,000.

Some large environmental organizations support volunteer monitoring programs, as do many schools, universities, city or county governments, and even corporations. And on the federal level, agencies as diverse as the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture, and the National Park Service all recognize the value of volunteer monitoring and provide some type of support. EPA's support consists primarily of technical and program planning guidance, some funding through grants to the states, and outreach tools such as regular conferences, a national newsletter, and electronic communications.

Why Does EPA Support Volunteer Monitoring?

EPA has supported volunteer monitoring since 1988 for two primary reasons: to help encourage improved stewardship of water resources, and to increase our knowledge of water quality conditions nationwide.

First, let me address the issue of water stewardship. In monitoring training sessions, volunteers learn about water pollution and how natural systems work. To many, this knowledge is an eye-opener. They come away from the training sessions and their work as volunteers with much more awareness of the impacts of their own personal actions on water quality, and may well become involved in follow-up activities such as stream restoration and watershed planning. They become, in short, educated stakeholders.

Second, the data they collect can be of inestimable value to local, state, and federal water quality planners. Volunteers can monitor waters that state and local agencies don't have the time, staff, or money to monitor.

Why is this important? Because, as the states tell us in the 1994 National Water Quality Inventory Report to Congress (EPA, 1995), we have water quality information for only about 17% of the nation's 3.5 million river and stream miles, 42% of its 40.8 million acres of lakes, 78% of its 34,000 square miles of estuaries, and 9% of its 36,000 shoreline miles. Clearly the need for information on water quality conditions is vital if we are to make intelligent management decisions, and volunteer monitors can help in this task.

When volunteers are properly trained and follow quality-assured methods, their data proves very credible. EPA has developed a series of monitoring methods manuals and a guide to quality assurance project plans for volunteer programs to help encourage the collection of high quality data that will be useful to state and local water quality managers.

In fact, according to the National Directory of Volunteer Environmental Monitoring Programs (EPA, 1994), state and local government agencies are the leading users of volunteer data. Volunteer data is used, most commonly, to educate the community about water issues, to screen for water quality problems (which might then be further investigated by the water quality agencies) and in local decision making.

Here are some examples of how government agencies use volunteer data:

- The Maine Department of Marine Resources relies on data collected by volunteers on septic systems along the state's 5,000-mile coastline. Volunteers conduct "shoreline surveys" looking at septic systems and documenting other potential problems such as erosion or oil slicks. Identified problems are further investigated by the state. The volunteer data is then used along with state-collected water quality information to help determine if coastal areas should be opened or closed to shellfishing.

- In Minnesota, volunteers have been collecting lake quality data since 1973. The Minnesota Pollution Control Agency publishes regular reports on the volunteer data that are used by lake associations, county planners, and government agencies to help make decisions about lake management issues such as septic system upgrades, algicide treatments, dredging, and shoreline construction. Data from the lake monitors also is used in the state's biennial water quality assessment report to the EPA (the 305(b) report).

- Maryland's Save Our Streams program works in partnership with the State Highway Administration to monitor stream conditions before road projects are begun, to assess the impact of road projects on streams, to determine whether sediment control regulations are being met during construction, and to help with mitigation measures where construction-related impacts are demonstrated.

How Are Volunteer Monitoring Programs Changing?

As in all things, change is coming to the volunteer monitoring movement. Volunteer programs are branching out. Increasingly, they are taking a whole-watershed approach to monitoring_not just looking at one specific type of water body, such as lakes or streams, but recognizing that different types of waters and the land they drain are interconnected. Of the volunteer monitoring programs listed in the National Directory, 38% monitor more than one waterbody type.

Volunteer programs are also moving away from simple physical and chemical measurements of water quality, which is how many programs began. More and more programs are evaluating such things as the biological health of aquatic communities and the integrity of aquatic habitats. They are looking at nonpoint source pollution impacts and land use conditions. They are inventorying storm sewer outfalls, mapping wetland vegetation, testing wells, and conducting angler surveys.

Volunteer monitoring programs are also learning that they can become players in watershed protection. Volunteer data can be of great value to watershed planning councils and associations. The volunteers themselves often become involved in the resource management process. Many volunteers are showing interest in restoring the waters they have spent years monitoring. They are also looking at environmental justice issues by reaching out to communities that have long been neglected and seeking to engage and empower people whose very health may depend on clean water.

These changes point to a vibrant, growing community of dedicated, educated people who are taking personal responsibility for their local environment. All indications are that their role will continue to expand as water resource managers increasingly focus on nonpoint source pollution, integrated watershed management, and public involvement.

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Swan Creek Watershed Assessment and Restoration

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

The Swan Creek Watershed is located in eastern Harford County, Maryland and drains directly into the Chesapeake Bay. The City of Aberdeen and Town of Havre de Grace are located on the edges of the watershed which encompasses 26.5 square miles. In the early 1990s, the City of Aberdeen proposed the construction of an in-stream storm water management pond on a small tributary to Swan Creek. During the wetlands review process questions were raised about the pond's location and it's effectiveness in addressing significant pollution problems within the watershed. In response to the concerns raised, the Corps of Engineers (COE) brought together federal, state, and local government agencies that shared

environmental interest in the Swan Creek area. A series of meetings were held to determine the interest and available resources that the different agencies could devote to this project, as well as to better define the work that needed be done.

During these early meetings the participants recognized the need to find new ways to assess and manage natural resources on a watershed basis. Currently, most agencies are organized to deal with individual resource management issues, or in the case of permitting agencies, are often restricted to site specific assessments. Finding new ways to coordinate management and permitting activities in a watershed context was seen as mutually beneficial to all parties. Therefore, a partnership to promote a watershed approach to stream protection and restoration within the Swan Creek Watershed was developed. The Swan Creek Restoration Partnership was formed in the Spring of 1994 and its members include Harford County Government, the Baltimore District of the U.S. Army Corps of Engineers, the Maryland Departments of Natural Resources and Environment, the City of Aberdeen, and Aberdeen Proving Grounds.

During the initial organization of the Swan Creek Restoration Partnership the Ecosystem Recovery Institute, a non-profit private organization, was contracted to serve as the project's integrator. The use of a independent integrator was helpful because no single agency could initially devote sufficient resources to organize and manage this project alone. An independent integrator also does not have many of the perceived biases that a representative from a single agency may have and can enlist greater cooperation among different agencies. Unfortunately, funding for the integrator was limited and the contract was eventually terminated. The integrator's tasks were divided among the Partnership's members. Harford County assumed the role of project coordinator while the state and federal agencies contributed their time and expertise.

The Partnership's first task was to assess and inventory the overall condition of Swan Creek. This was done using two approaches. The first approach involved field surveys of water quality, stream habitat, fish, and benthic macroinvertebrates during the Summer of 1994 along with a review of historical environmental information on the stream.

A synoptic survey of water quality was conducted at 23 stations. This survey provided a snapshot of the water quality conditions in Swan Creek during a summer base flow period. The survey examined a variety of water quality parameters including flow, water temperature, pH, conductivity, total suspended solids, biochemical oxygen demand, fecal coliform, total coliform, and nutrient levels. The results of the water quality surveys indicated that bacteria, suspended sediment, and nutrient levels were elevated at some sections of the stream.

Stream habitat, fish, and macro benthic surveys were conducted at 6 stations. These surveys were done using a modified version of EPA Rapid Bioassessment Protocols. Benthic samples were collected using a surber sampler. A total of 23 benthic families with diversity ranging from five to 16 families were present at individual stations. Using several indices of biological integrity (ie. IBI) the stream was classified as moderately impacted.

Fish samples were collected using a backpack electrofishing unit during two passes over a 75 meter stream reach. The fish surveys found between 9 and 17 different species of fish. Differences in fish assemblages among stations appear to be related mainly to habitat conditions at each site.

The second approach to assess and inventory the overall condition of Swan Creek involved a stream walk survey of the entire drainage network in the Spring of 1994. The survey used was a modified version of one developed by Maryland Save-Our-Streams. At the beginning of the survey, 45 volunteers from various government agencies were trained to identify potential problems and restoration opportunities within the stream corridor. Potential environmental problems recorded during the stream walk survey are shown in Table 1. The watershed was divided into four major subwatersheds. A team leader was assigned to each of the four major subwatersheds. Groups of two or three individuals were then assigned to a basin within the subwatersheds. Each team leader was responsible for the activities within the subwatershed and answered any questions the volunteers had. Over a three-day period, the volunteers walked 96 miles of stream recording information on data sheets about potential problems and restoration opportunities. The volunteers also indicated site locations on 200 scale topographic maps, and photographing sites for future analysis.

The information from the field data sheets was entered into a relational data base and the site locations were digitized into a geographic information system. Each site was assigned a unique identification number that linked the data base to the mapping information. This allowed for the production of maps showing the location of individual problems within the watershed. An example of this is displayed in Figure 1 which shows the locations of fish migration barriers within the watershed. The site identification number was also used to organize photographs into a photo-library of problem sites.

A total of 453 problems were identified at 332 sites. The number of problems reported in each of the survey categories are presented in Table 1. The survey found that many sites have several different problems. For example, in areas where livestock were permitted unrestricted access to the stream, the streams were often unshaded and the stream banks showed evidence of erosion. In addition, 65 sites were identified as potential wetland creation and/or water quality retrofit sites.

Table 1. Potential environmental problems and restoration opportunities reported in Swan Creek.

Potential Problems	Problems Observed
Evidence of Erosion	179
Trash Dumping Areas	84
Unshaded Stream Sections	66
Fish Migration Barriers	49
Channelized Stream Sections	40
Pipe Outfalls	29
Instream Construction	6
Total	453
Potential Wetlands or Water Quality Retrofit Site	65

The most frequently identified problem was stream bank erosion that was common in both the mainstem and small tributaries throughout the drainage network. Approximately 54 percent of the sites showed some evidence of stream bank erosion. Severity of the problems varied from small isolated erosion sites to large reaches with incised channels below the root zone of adjacent riparian vegetation. Unshaded stream sections were reported at 20 percent of the sites. The adjacent land use at unshaded sites was split between agricultural and residential uses despite the fact that most of the non-forested land in the watershed is used for agriculture.

Blockages to fish migration were reported at 15% of the sites. Three partially breached dams along the streams mainstem were determined to be the only barriers to anadromous fish migration on the lower portion of Swan Creek. Follow-up surveys found excellent spawning habitat for blueback herring and alewife above these dams and that removal of these structures could eventually lead to the restoration of anadromous spawning runs in the stream.

While results of the water quality, biological, and stream walk surveys indicated that the system does have some problems, Swan Creek is in relatively good environmental condition. The surveys also indicated that no single problem alone is profoundly affecting aquatic resources. Instead the cumulative impact of many small environmental insults is the main problem.

Once the overall environmental condition of the watershed was assessed, the next task of the Partnership was to begin considering restoration opportunities. Because of the amount of data collected was so large, organizing the information was a challenge. During the Winter of 1994, follow-up field visits were conducted by the four team leaders to rectify any inconsistent data and rank the problems. Each problem was ranked based on severity of the problem, restoration potential, and access to the site. Photographs taken of each of the sites during the stream walk survey were also very helpful in this work.

The ranking of problems within the different problem categories has allowed the Partnership to develop a restoration strategy and set priorities for restoration efforts. The Partnership is now working with other governmental agencies which are best suited to address specific problems. Some of these agencies include: Natural Resource Conservation Service, Maryland Agricultural Extension Service, DNR Forestry, Maryland Transportation Authority, Harford County Public Schools, National Civilian Conservation Corps, and Maryland Conservation Corps.

Because a majority of the land within the watershed is privately owned, the Partnership is striving to involve the citizens within the watershed in the decision making process. A presentation of the study by the Partnership was given at a special public meeting in the watershed. The reaction of the over one hundred citizens that attended was very positive. Additional community based environmental projects have also been organized in the watershed including tree planting, steam side trash cleanup, and stormdrain stencilling.

Some additional accomplishments of the Partnership are as follows:

- Harford County received a $60,000 grant from the Maryland Department of the Environment to hire a consultant to study the practicability of storm water management retrofits. Based on the findings of the study an additional $400,000 may be available for design and construction.

- Because the initial environmental assessment identified a unique opportunity to restore blueback herring and alewife spawning runs to Swan Creek, the Partnership has designated this as a restoration priority. The COE is working with a commercial developer, who was having difficulty finding a suitable wetlands mitigation site, to remove the three partially breached dams as out-of-kind mitigation.

- Aberdeen High School received a $5,000 grant from the Chesapeake Bay Trust to purchase an spectrophotometer and other supplies to monitor water quality in Swan Creek. A training session was held to introduce teachers to the ecology of local streams and to demonstrate ways students can monitor changes in them. As part of this effort, the Aberdeen Wastewater Treatment Plant will also periodically analyze water samples collected by the students to insure the validity of their data collections.

- The Partnership completed two stream stabilization projects and removed a culvert pipe that was causing a barrier to fish movement using AmeriCorps volunteers.

- A manure discharge from a dairy farm identified during the survey as a significant pollution problem has been corrected through the combined efforts of the landowner, MDE and NRCS.

- The watershed evaluation of the City of Aberdeen's proposed storm water management pond found that it would help manage a significant pollution problem and the necessary environmental permits have been issued.

By inventorying and then prioritizing environmental problems in the watershed the Swan Creek Restoration Partnership has been able to effectively target available resources where they will have the greatest benefit. The Swan Creek Restoration Partnership has also been successful in bringing together local, state, and federal resource management and environmental permitting agencies as well as schools, landowners, and businesses for a coordinated effort to protect and enhance the natural resources of Swan Creek. While direct funding for this initiative has been limited, the Partnership has demonstrated that by pooling participants resources, comprehensive

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Save Money and Increase Community Support: Targeted Volunteer Monitoring

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The Tennessee Valley Authority (TVA), like many agencies, is challenged with doing more with less. In an effort to address water quality issues on a local level, The Clean Water Initiative (CWI) was formed in 1993 to identify the root causes of water resource problems and bring together the people and organizations necessary to fix them. CWI divided the Tennessee River watershed into 12 uniquely different subwatersheds and began assigning River Action Teams (RATs) to each. Six teams composed of biologists, environmental engineers, and education specialists have formed and are in various stages of assessing water resource conditions.

These teams all face the same problem_finding enough money and staff to collect the water quality monitoring data needed to target cleanup and protection activities. With cost of conducting professional monitoring on the rise and pressing needs to provide timely and accurate information to focus scarce resources on the most pressing problems, CWI teams decided to take a fresh look at using volunteers to collect some of this information. Aside from the obvious financial advantages of free labor, local volunteers bring a perspective and expertise to the table that might not otherwise be available. Hands-on participation also encourages feelings of ownership. Agencies can provide valuable technical assistance and funding for specific projects, but interested citizens, local officials, and landowners are the key to any long-term success in solving water quality problems and protecting water resources.

Our challenge was to develop a flexible framework that individual River Actions Teams (RATs) could use to:

- Enable volunteer groups or individual citizens to collect useful scientific data.

- Reduce agency costs.
- Educate the local community about water issues.
- Encourage citizens to participate in restoration and cleanup efforts.

CWI did not to want to develop and manage a large volunteer program. We wanted to facilitate the recruitment/development of self-sustaining groups or individual volunteers to supply needed information and provide a means for collectively receiving, analyzing, and reporting data. CWI's goal was to enable volunteers to contribute useful data, yet maintain group or individual autonomy.

Developing the Framework

Representatives from each CWI RAT team formed a working group to develop the framework in 1994. River Watch Inc. was brought in to facilitate the process and demonstrate use of their 11-step organizational planning model to develop self-sustaining volunteer groups. RAT members agreed the program should:

- Provide CWI RATs, other water management agencies, and communities with useful data on the condition of local water resources and alert RATs to potential water quality problems.
- Provide citizens with opportunities to get involved in water quality issues by testing water quality in their own communities.
- Develop community awareness and ownership of water quality issues.
- Create an understanding of watersheds and the interrelationships between water quality and land use.
- Encourage communities to take actions to protect and improve water quality.
- Demonstrate the effectiveness of protection and improvement projects.

RAT members identified the types of information volunteers could collect or assist in collecting. Parameters selected include habitat assessments, temperature, dissolved oxygen, biological oxygen demand, pH, nitrates, phosphates, total dissolved solids, conductivity, turbidity, sediment, benthic macroinvertebrates, and fecal coliforms.

To make sure that the data collected by different volunteer groups was comparable, CWI decided to develop a manual of accepted procedures for volunteers to follow. An EPA Volunteer Monitoring Manual was already in draft, so TVA secured permission to use it as a template. Individual procedures

were modified so they were consistent with TVA monitoring protocols and other protocols used in the seven-state Valley region. To make the manual more useful as a tool to develop self-sustaining volunteer groups, additional information was added on developing a volunteer program, organizing and training volunteers, and educating volunteers about water quality issues.

Recruiting Volunteers

Each RAT is responsible for recruiting and training their own volunteers. Community interest and severity of problems dictate where RATs focus their efforts. RATs recruit potential volunteers from existing clubs and groups, local schools and colleges, and citizens who express an interest in a particular area by attending a meeting or calling the team. Areas where volunteer help could be useful is determined in part by the teams assessment of hydrologic units (HUC) within their watershed and projects ongoing in that HUC. Some volunteer projects are also citizen initiated.

Targeting Volunteer Efforts

Each team has used volunteers in different ways depending on their needs and the issues in the watershed. Volunteer projects range from monitoring trends and conditions to identifying water quality problems to monitoring the success of best management practices (BMPs). The key to success has been involving volunteers in efforts to collect useful data the teams need while involving the community. The following are specific examples of how RATs have used volunteers to monitor conditions in their watersheds.

Stream Surveys

One of CWI's bigger costs is to assess the biological condition of streams and identify potential water quality problems. Recons, a 4-hour per site form of rapid bioassessment which includes evaluating fish and benthic communities and riverine habitat quality, are conducted on major streams within a RAT's watershed. Depending on the size of the watershed and number of streams, between 100-200 recons may be conducted over a 2-3 year period by each RAT. The average cost to perform a combined biotic index for streams or a "recon" is about $1000 per site including biologists, contractors, equipment rental and supplies, travel, lab work, and data management. The field crew usually includes between 2-4 biologists and/or 4-6 contractors depending on the site; deeper sites require more crew and equipment. It was determined that only one benthic taxonomist and one fish taxonomist were actually needed onsite to perform the work. If contractors were replaced with volunteers, approximately $300 could be saved per site or about $15 per volunteer hour.

The Holston RAT put a priority on using volunteers. One member of the RAT devoted a portion of his time (about 10% or $5,000 per year) to identifying and recruiting volunteers and coordinating their participation. The team also agreed to provide transportation, meals, and lodging cost reimbursement to volunteers as appropriate to cover any out-of-pocket expenses. These costs ($500 per year) were minimal

because most volunteers were local. In 1994, 7 volunteers logged 890 hours on stream surveys in the Holston watershed and in 1995, 19 volunteers logged, 1012 hours. The value of volunteer time was estimated at $13,500 for 1994 and $15,000 for 1995. When you subtract the team costs of $5500 per year, the team estimates a savings of $8,000 for 1994 and $9,500 in 1995 to perform the work. But the value of their participation goes far beyond dollars and cents. These volunteers have seen first-hand the condition of their local streams, and you can bet they will be sharing this with their community.

Swimming Beach Fecal Coliform Monitoring

TVA has traditionally monitored fecal coliforms at selected swimming beaches throughout the Valley during peak use in the summer months of July or August and published these results in RiverPulse, an annual report detailing water quality conditions in the Tennessee River by watershed. To get an accurate picture of fecal populations, a single site is sampled 10 times in 30 days. Depending on the location of the swim beach, costs to perform this service range between $500 - $1,500 per site (10 samples) including travel. A lab-certified technician is used to collect and process the samples in accordance with standard methods established by EPA.

The highest cost to perform swim beach samples was in the Holston Watershed because of the distance to the sites and the need for overnight travel. But instead of eliminating the program in this watershed, CWI's Monitoring team worked with the Holston RAT to explore other alternatives. The Monitoring Team decided that a lab-certified technician might not be necessary given this is a screening program. If unusually high results were found, it would cost a lot less to send out a lab-certified technician to only the site in question. The teams decided to approach two local colleges in the area, which already had the equipment and supplies necessary to run the samples, to discuss the possibility of enlisting their help to sample swimming beach sites.

Eastern Tennessee State University (ETSU) and Carson Newman College both agreed to participate. ETSU sampled 9 sites on Fort Patrick Henry, South Holston, Boone, and Wautauga. Carson Newman monitored 2 sites on Cherokee and Douglas. A contract of $1,000 per year was prepared for ETSU to cover travel costs and supplies. The Monitoring Team provided approximately $200 directly to Carson Newman in lieu of a contract to sample their sites. The Monitoring Team would have paid $14,400 to obtain this information. Instead, it cost them approximately $1,200 to recruit and train the two schools and $1,200 in contracts and supplies for a savings of $12,000 per year. CWI was able to include their data in RiverPulse and both colleges were able to incorporate the program into their field studies classes and give students hands-on experience they might not otherwise have gotten.

Sediment Monitoring

The Hiwassee River supports an excellent trout and small mouth bass fisheries, but sediment was threatening this resource. Pinpointing the exact source of sediment loading is especially difficult and costly. Intensive sampling was needed to locate the source, but the team didn't have the money or the time to do it themselves. Local interest in fly fishing has always been high and sediment could potentially

hurt game fishing, so the Hiwassee RAT decided to enlist local fisherman_Trout Unlimited (TU) volunteers.

In 1995, the Hiwassee Rat and TU volunteers installed sediment samplers vertically on posts in the river to capture silt transported in storm events. Six samplers were set up at the mouth of 12 Hiwassee River tributaries. Volunteers collect the samples after rain events and deliver them to Hiwassee RAT members who have them analyzed at TVA's Environmental Chemistry Lab to determine the amounts of suspended solids in each sample. They also collect daily rainfall data which is correlated with the sediment data. Initial findings show that Turtletown watershed, the most developed and populated area in the sampled watershed, is the major source of the sediment. In order to pinpoint specific sources, 5 new stations are being installed at mouths of tributaries in the Turtletown watershed in 1996.

Most studies of this type are contracted out to local universities. The average cost to CWI to conduct a study of this type is about $18,000 including university overhead. The cost for the team to perform the work would have been about $12,000 including travel. Instead the program cost the team $2,400 to process the samples, a savings of $9,600. Because of the intense local involvement and the desire to protect the fisheries, you can be sure there will be a lot of local interest and resources made available to correct the problems once the sources are identified.

Acid Mine Drainage BMP Monitoring

Once a problem is identified, it can be quite a challenge to solve the problem, especially if the technology being used to solve the problem is new and unproven and more than one site needs to be reclaimed to complete the project. The Chickamauga-Nickajack RAT and the Friends of the North Chickamauga Creek Greenway (FNCCG) found this out as they applied for numerous grants to control acid mine drainage by installing constructed wetlands at several key sites at abandoned shaft-type coal mines on Waldens Ridge at the headwaters of North Chickamauga Creek. Granting institutions want proof the solution is working before they commit more funds. Also, many granting organizations, especially EPA/State 319 grants, require an education component in the program to educate others about the effectiveness of the solution. Demonstrating the effectiveness of BMPs can also be very costly if professional teams are used to monitor the sites.

The Chickamauga-Nickajack RAT and FNCCG decided the solution was to develop a school-based volunteer water quality monitoring program to monitor the effectiveness of the BMPs and educate area residents about the problems facing North Chickamauga Creek. High quality water quality data was needed which would be comparable with professional data being collected with a Hydrolabr by the University of Tennessee at Chattanooga who were contracted to provide baseline data. The Corning Checkmater, a multi-sampler probe which tests for temperature, pH, dissolved oxygen, conductivity, and total dissolved solids, was chosen because it would provide reliable data at a relatively low cost and could be operated by teachers and students.

In 1995, a grant for $5,000 from the Fish and Wildlife Foundation was obtained to buy probes and begin

the program in 5 schools. Five local schools and the county Center for Advanced Sciences (which serves 6 high schools) agreed to participate and were trained in November. The cost for the RAT to monitor 8 sites 4 times a year is approximately $300 per site including labor, equipment rental, and travel. In 1995-1996, 8 schools (instead of 5) will monitor one site each 4 times a year at a savings to the team of $2,400 per year. In addition to the required monitoring, 3 schools will be monitoring fecal sites which would cost the team $1,000 per site or $3,000 per year and 4 schools will be collecting grab samples for nutrient analysis which will cost the team $25 per site to process at our environmental lab instead of the $300 per site for professional collection and processing. In 1995, the value of the monitoring program to the Chickamauga-Nickajack RAT was estimated to be $6,600. But the real value of the program is the community buy-in the project is receiving. Participating students serve as ambassadors of the creek and educate the whole community about its condition. FNCCG has received a second grant of $5,500 to expand the program in 1996-1997.

Assessing the Program's Value

It has become increasingly clear to CWI that relying on volunteers is an effective way to do more with less. Without volunteers, many of the monitoring, cleanup, and protection activities would not have been done. Involving the public early on, in meaningful activities, can really pay off. From October 1994 to September 1995, volunteers logged over 22,500 hours in monitoring, streambank stabilization, habitat enhancement, cleanups, and storm drain stenciling in the 6 watersheds where RATs are active. Between October and December of 1995, volunteers clocked over 4,700 hours, an increase of 2000 hours over the same time period in 1994. Over 40 percent of these hours was spent on monitoring projects. Many volunteers begin monitoring streams and come back to participate in other cleanup and protection activities. CWI saved an estimated $38,000 in 1995 just by using volunteers to conduct the four projects highlighted in this paper. It would have cost CWI over $100,000 in 1995 to use professional staff to perform the same monitoring, cleanup, and protection jobs completed by volunteers.

But you can't measure the value of the community buy-in you get when you involve local people in protection and improvement efforts. When volunteers learn about the problems first-hand and share this with others in their communities, they bring a credibility to the problem an army of agency professionals cannot. Professionals may understand the problems, but volunteers understand their communities needs and values. And when the communities needs and priorities become the driving force, water quality problems can and do get solved. Doing more with less, has turned out to be doing more with more.

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Demonstrating Partnerships for Habitat Restoration: Experiences in the Chickahominy Watershed

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State and federal agencies, even local government can no longer restore degraded environmental areas by themselves. They must learn to work in partnerships; interagency partnerships, intergovernmental partnerships, and partnerships with various types of volunteer or non-governmental organizations. There has often been a reluctance by professionals in governmental agencies to work with volunteers. However, in a time of diminished budgets, volunteers are a great source of human talent, skills, and energy to accomplish desired tasks. There are process issues of how to find willing volunteers and how to get them involved. Since there are many different kinds of volunteer organizations, an agency must also ask themselves what are the barriers and opportunities presented by partnerships with different types of organizations or groups organized around different interests.

A description of the watershed begins the presentation, followed by some discussion of volunteer organizations and habitat restoration. The purpose of this research is to document barriers and opportunities for governmental agencies in establishing government/volunteer partnerships to undertake riparian habitat restoration.

Physical Description of the Watershed

In the 264,518 acre watershed that makes up the Chickahominy River Basin in Virginia, there is increasing urbanization leading to the destruction of riparian forests and wildlife habitat. The watershed covers five counties and part of the City of Richmond (see Table 1).

Table 1. Chickahominy Watershed.

County/City	Total Acres	Acres in watershed	% of county in watershed	% of watershed in county
New Kent	143,956	75,606	53%	28%
Henrico	155,612	74,972	48%	27%
Hanover	303,309	46,464	15%	17%
James City	117,295	41,232	35%	15%
Charles City	131,011	33,790	26%	12%
City of Richmond	40,017	2,451	6%	1%

Source: Virginia Hydrologic Unit Atlas 1991.

The population changes for these six jurisdictions over the last 40 years varies from a 451% increase for James City County to a loss of 11% for the City of Richmond. The average population change is a 65% increase.

The freshwater portion of the Chickahominy River is 237 miles long from its headwaters in northwestern Henrico County to Walkers Dam. Part of the UUC 02080206 James River Subbasin from the Fall Line to Hampton Roads, the Chickahominy River basin has been subdivided into four hydrologic units: GO5 Morris Creek/ Chickahominy River, GO6 Chickahominy River/Diascund Creek, GO7 Chickahominy River/Possum Creek, and GO8 Upper Chickahominy Creek/Stony Run. The 1993 Nonpoint Assessment document of the Division of Soil and Water Conservation (DSWC) of Virginia's Department of Conservation and Recreation (DCR) evaluated the hydrologic units for agricultural and urban nonpoint source impacts. Old hydrologic unit GO8* rates in the top 5% and GO7 is in the top 10% of all watersheds statewide for urban pollution potential. These are clearly watersheds in need of attention.

The destruction of riparian forests in the Chickahominy River watershed as a result of development, has allowed increased nutrients, sediments, and other pollutants to be carried down to the James River and ultimately into the Chesapeake Bay. As the 1994 Virginia Nonpoint Source Management Implementation Report notes "Streamside forests act as sinks for nutrients and sediments, trapping and absorbing them as they run off of adjacent land. Streamside forests maintain cooler water temperature regimes, reducing fluctuation in stream temperatures that rob stream of dissolved oxygen essential to aquatic life. By increasing biological diversity, watershed system stability and available habitat, streamside forests maintain and enhance stream system integrity and benefit aquatic life." Riparian forests have also been recognized by state and federal agencies as a key component to reducing nonpoint source pollution and restoring the living resources of the Chesapeake Bay.

The watershed has many nontidal wetlands which play an important role in the hydrology of the watershed. They store water, filter pollutants from stormwater runoff, reduce stream velocity, serve as groundwater recharge areas and provide important habitat for aquatic and terrestrial species.

The Chickahominy River Basin system contains three waterbodies used for drinking water supplies. The Chickahominy Lake, Diascund Creek and Little Creek are all water supply reservoirs. Because the river supplies drinking water, the State has set special effluent standards limiting phosphorus for the entire Chickahominy Watershed above Walker's Dam (see Virginia regulation VR680-21-07.1m for more detail).

Volunteer Organizations

The United States is a nation of volunteers and voluntary organizations. Early in childhood, we are exposed to voluntary groups like Boy Scouts, Camp Fire Boys and Girls, and Pee Wee Football. There are the ecology and language clubs in Junior and High School as well as church youth groups and student orchestras. As adults we can choose to belong to church groups, civic organizations like neighborhood associations, Civitan, political parties, and the Chamber of Commerce, social organizations, sports and recreation organizations, professional organizations, business organizations, and advocacy groups, just to name a few categories. Many people belong to a number of different organizations. The most active people in a community belong to many organizations, using their network of connections with different groups as a means of communication and a source of volunteers to get things accomplished.

We are using several different types of voluntary organizations as a basis for partnerships in undertaking habitat restoration along the Chickahominy River, especially degraded stream segments and wetlands areas. The partnerships are between Soil and Water Conservation Districts and volunteer groups. One partnership will be with a homeowners association in a new subdivision located in the headwaters of the Chickahominy River. Another will be with the Chickahominy Watershed Alliance, a group composed of a variety of stakeholders in the watershed, and a third partnership will be with a youth group. An advisory group of wetlands professionals, facilitated by each of the three Soil and Water Conservation Districts involved, will provide a technical component for selecting the site for restoration. This group will evaluate data, conduct field evaluation and verification, advise on restoration alternatives and assist with each project.

Each of the above partnerships present opportunities for knowledge transfer and participant satisfaction as well as barriers to participation in the habitat restoration. Participation will mean taking time to do physical work, giving up the opportunity of doing something else. The neighborhood association is a group of people interested in their own area of the watershed, but who may not have much interest in the total watershed. They probably do not even realize where their little stream goes, nor its relationship to the larger Chesapeake Bay. They have joined together to create a better environment for their families. Can they be motivated to care for the larger community? The Chickahominy Watershed Alliance is a group of people representing different areas of the watershed. They certainly have the larger watershed in mind and many come from professional backgrounds so their overall knowledge will be high. But will they be willing to come together for habitat restoration in an area not in their own "backyard"? The youth group will have less demands on their time, but will have a lesser knowledge base, and therefore may not understand why they are doing some of the activities they are asked to do. Not having their own transportation, they will require the backing and participation of other family members. We are

documenting the interactions with each group so as to help those who want to develop partnerships in the future will some understanding of the barriers and opportunities involved in these types of partnerships.

We will also survey participant satisfaction with the process. Will the volunteers participate again in a partnership for habitat restoration? What were the barriers and opportunities to working in the partnership from their perspective? Have they changed in how they view watershed processes and how they live day-to-day as a result of this experience?

Habitat Restoration

Habitat Restoration can be thought of as a short term effort and a long term effort. In the short term, degraded stream segments and wetlands can be the sites for habitat restoration projects. Restoration includes removing trash and planting trees, shrubs, and other plants where they have been destroyed through misuse or deliberately at the time of construction activities. Restoration may also mean stream bank stabilization and earth moving efforts to restore topography for flooding or excavation of excess sediment from stream bottoms. These are immediate kinds of activities that will have longer term impacts.

However, in the long term, habitat restoration must come from changes in how we, as people, use our riparian areas. It must come from understanding the impacts of our actions on the hydrologic system which includes streams, wetlands and riparian habitat. We are linking this concept with short term physical actions through environmental education. When we first work with a group, we are asking them to fill out a survey about their knowledge of watersheds, nonpoint pollution prevention, wetland functions, riparian forest buffers, habitat restoration, and the tie between tributary ecological health and the health of the Chesapeake Bay. Then we are conducting, as part of the preparation for habitat restoration, environmental education focused at those areas where the survey showed gaps in knowledge. There will also be a survey after the restoration work to see if people have made any changes in how they perform their day-by-day activities as a result of doing the restoration work and getting new information.

Summary

Watersheds make the ideal analysis and work-based unit for improving water quality, especially for nonpoint sources. As rural areas become more urbanized there is a change in nonpoint sources from those dominated by agricultural practices to those characteristic of urban areas: degradation as a result of construction practices be it for utility lines, new homes and commercial areas, road runoff, or human activities which trash wetlands and riparian areas. The ultimate goal of all restoration activities is clean and productive streams, rivers, and estuaries.

Government, at any level--federal, state, regional, or local--does not have the funds to clean up and restore all the wetlands and riparian areas that have been degraded by human activities. However, government does have the expertise to form partnerships with citizens so that together they can restore degraded habitat. There are lots of ways to work with citizens, but one that shows great promise is to

work with existing organized groups. This project is exploring the opportunities and barriers in working with different kinds of voluntary groups to develop partnerships that will undertake habitat restoration, both in the short term,as physical activities, and in the long term, as changes in personal behavior, that will benefit the watershed.

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Lake Decatur, Illinois, Case Study: Nitrate Reduction for SDWA Compliance in an Agricultural Watershed

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Introduction

Lake Decatur was created as an impoundment of the Sangamon River in 1922 to serve as the water supply and a recreational resource for Decatur, Illinois, an industrial and agribusiness center with a population of 84,000. The upper Sangamon River watershed above the Lake Decatur dam comprises 925 square miles, 87 percent of which is used for row crops, mainly corn and soybeans.

Nitrate concentrations are a problem in Lake Decatur. Most of each year, the concentration is well below the drinking water Maximum Contaminant Level (MCL) of 10 mg/l (as N) but peak concentrations in the range of 10 to 16 mg/l are often reached in the spring.

In 1992, the City of Decatur signed a Letter of Commitment to the Illinois Environmental Protection Agency (IEPA) to achieve compliance with the Safe Drinking Water Act (SDWA) nitrate standard no later than the year 2001. IEPA initially proposed that the City either remove nitrates in the water treatment plants or switch to a water source with lower nitrate levels. The City negotiated a revision that identifies watershed management as the preferred approach for meeting the nitrate standard.

This paper discusses the technical feasibility of a watershed approach to solving Lake Decatur's nitrate problems and, equally important, the economic, social and political issues involved in implementing a successful management strategy in an agricultural watershed.

Background

Decatur is located in central Illinois, 180 miles southwest of Chicago, 40 miles east of Springfield. The Upper Sangamon River watershed extends from the Lake Decatur dam to the northeast across parts of seven counties (Figure 1). The watershed is located on the Bloomington Ridged Plain, a subdivision of the Till Plains section of the Central Lowland physiographic province characterized by low broad morainic ridges with intervening wide stretches of relatively flat or gently undulating ground moraine.

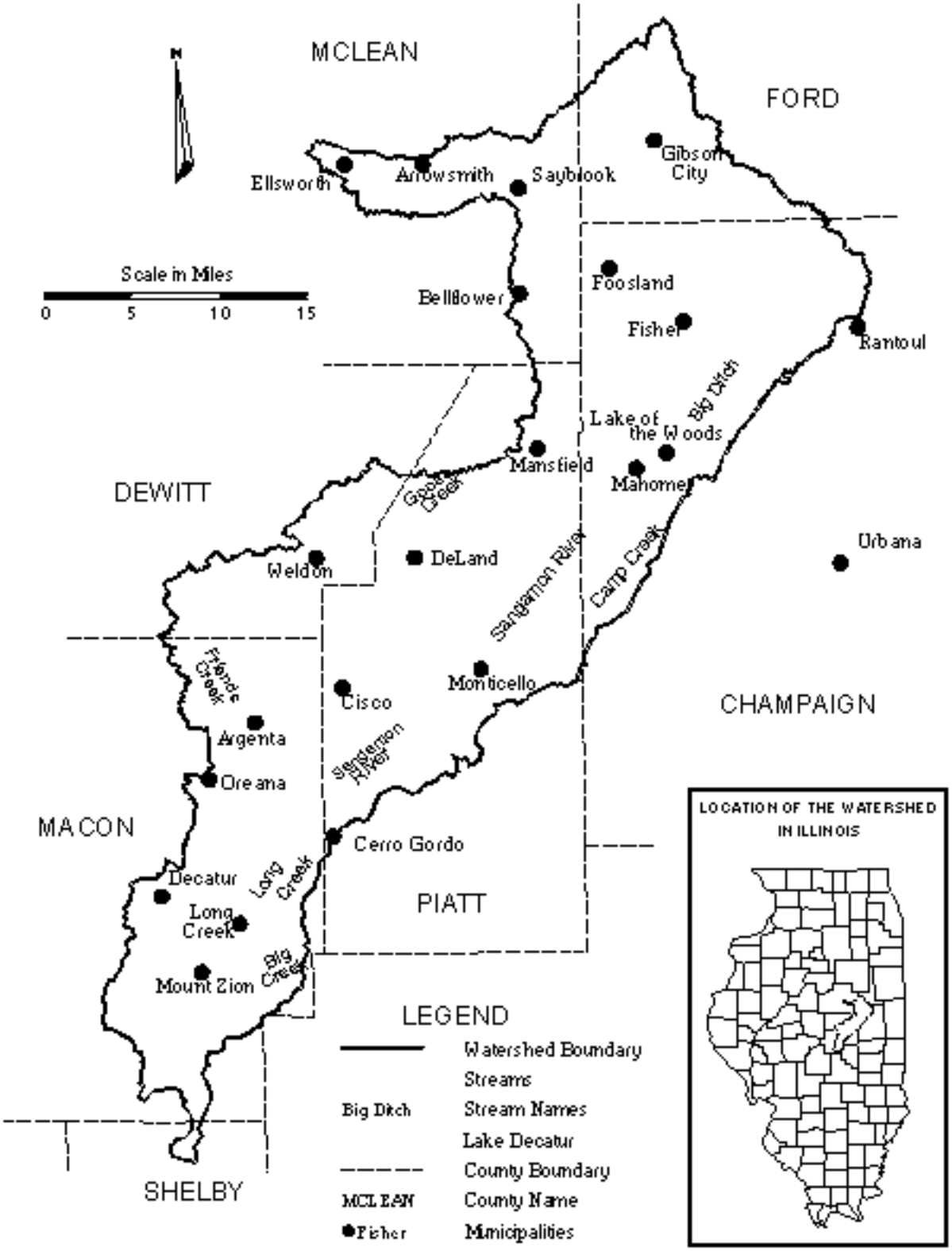

Figure 1. Location of the Lake Decatur Waterhshed.

Soils in the watershed typically formed under prairie or forest vegetation in more than 40 inches of loess over glacial till. Organic content, available water holding capacity and fertility are high. Macon County, in which Decatur is located, has an average farm size of 403 acres and average corn yield of 162 bushels per acre.

Agricultural land use accounts for over 87 percent of the total watershed area. Before 1960, grassy crops

such as wheat, oats and hay comprised a significant portion of the agricultural acreage. From 1950 through the 1970s, acreage devoted to these crops declined and today they make up a fraction of a percent. The major nonagricultural land uses are urban land at 4.5 percent of the total watershed area, nonagricultural rural land at 3.9 percent, and woods/open space at 3.1 percent.

The peak nitrate concentration in Lake Decatur has equaled or exceeded the MCL every year from 1980 to 1992 (Figure 2). Nitrates are not effectively removed by coagulation/sedimentation, lime softening, filtration or disinfection, the treatment processes already in place in Decatur's water plants. Adding ion exchange treatment to achieve a blended finished water nitrate concentration below 10 mg/l was estimated to have a $12 million capital cost and $400,000 annual operating cost. Switching to a permanent groundwater supply would be even more expensive and would place the City in conflict with present users of groundwater resources.

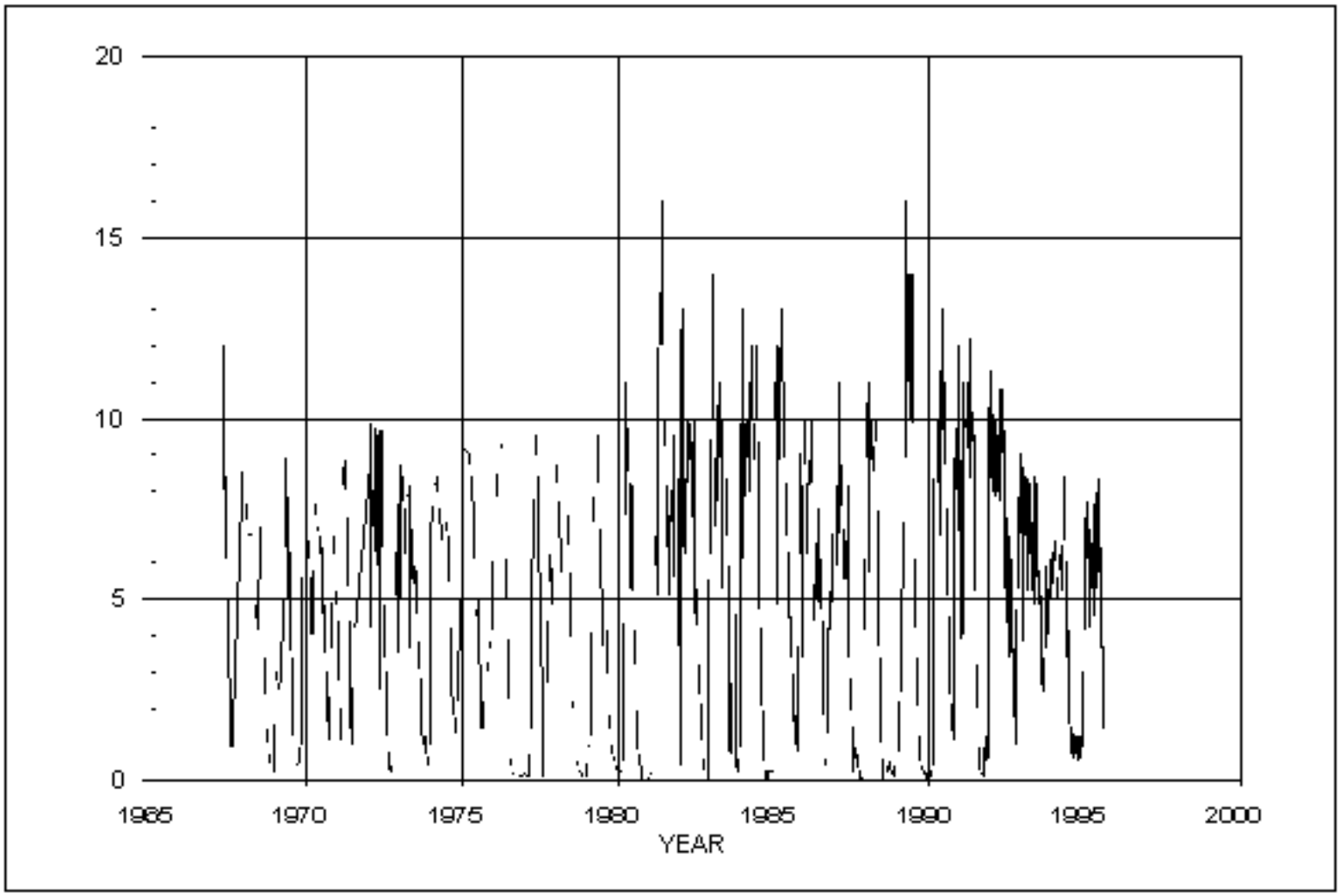

Figure 2. Nitrate Concentrations in Lake Decatur (1967-95).

Well before 1992 when IEPA forced the issue by presenting the City of Decatur with a draft Letter of Commitment, Decatur officials had begun working with the agricultural community to address water quality problems including soil erosion and sedimentation, as well as nitrates. With this experience and an awareness of the cost of more traditional approaches, the City was predisposed to seriously consider a

watershed approach to the nitrate problem. IEPA officials accepted this change to the draft LOC and agreed to a timetable that permitted a fair opportunity to evaluate and implement a watershed solution.

Significant milestones contained in the LOC are:

- June 1992: Implement agricultural outreach program
- October 1992: Monitor major tributaries for nitrate levels
- June 1993: Perform hydrological characterization of watershed
- October 1993: Rank hydrologic units by nitrate levels
- June 1994: Implement detailed plan including soil conservation practices, sediment basins, artificial wetlands, streambank and shoreline vegetation establishment, reduced nitrate usage, and/or other agreed upon mitigation methods
- June 1994: Submit preliminary alternatives study on water treatment, other water sources, watershed protection and financing
- December 1994: Submit final plan of proposed solutions, compliance milestones, permit and construction scheduling, results and recommendations of watershed study
- June 1995: Submit preliminary justification for continuing the plan
- June 1998: Submit final justification, if watershed management not viable then treatment and/or blending must be implemented
- April 2001: SDWA compliance achieved

Watershed Monitoring and Modeling

Decatur contracted with the Illinois State Water Survey (ISWS) to study nitrogen sources, movement and control options in the Lake Decatur Watershed. Hydrologic and water quality monitoring and modeling are being performed to evaluate the effect of Best Management Practices (BMPs) on lake nitrate loadings and alternative strategies for maintaining the nitrate concentration below the MCL. Monitoring data was collected from April 1993 through April 1995. The monitoring report was completed in January 1996 (ISWS, 1996) and the final report is due in May 1996.

ISWS established monitoring stations at selected locations on the main river and tributary streams to generate reliable and current hydrologic and water quality data to identify the sources and quantify the

amounts of nitrate generated in the watershed. Eight major stations equipped with continuous stage recorders and three supplementary stations with staff gages near the lake were installed. Additional sampling sites were located in two tributary watersheds. All sites sampled for nitrate-nitrogen, ammonium-nitrogen, and total Kjeldahl nitrogen.

Precipitation records in the watershed show that the first year data collection period was wetter than normal, with more than 10 inches of rainfall above normal for most of the upper portions of the watershed. On the other hand, precipitation for the second year was below normal by more than 10 inches for most of the watershed. Total runoff for the first year was more than three times that of the second year. Low flows during the first year were well above normal with some record highs, whereas most of the tributary streams were almost dry during the summer in the second year.

Historical nitrate concentrations have a seasonal cycle as shown in Figure 3. Concentrations start out low in the fall, rise slightly during the winter months, then drop in early spring. The highest concentrations occur in late spring to summer, then they drop again through to fall. This general cycle is apparent in the study period samples with some exceptions due to climate variability.

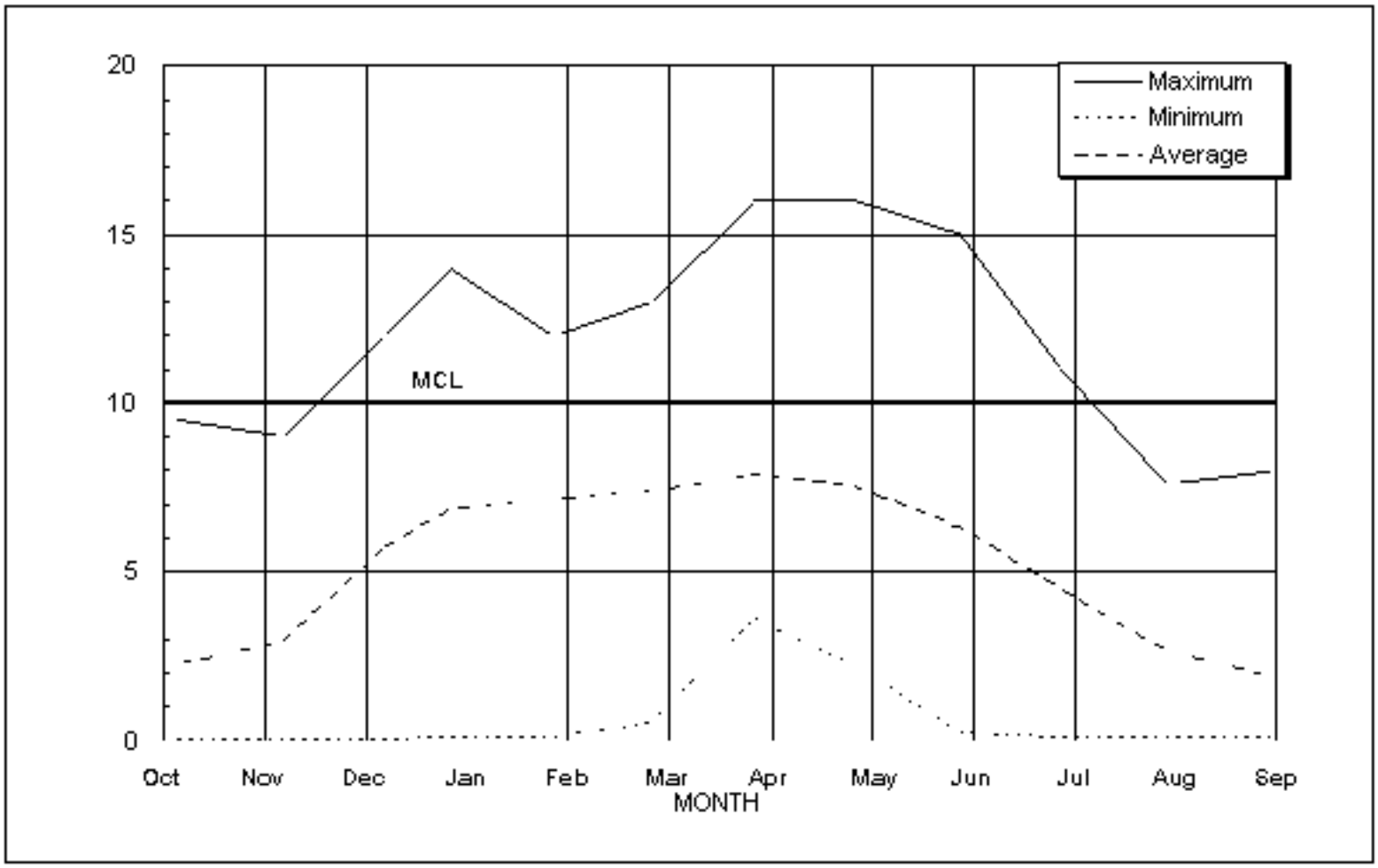

Figure 3. Monthly maximum, minimum, and average nitrate concentraions in Lake Decatur from 1967-1995.

For the first year of data collection, the nitrate concentrations in the tributary watersheds were generally above 4 mg/l. The highest concentrations were in May and June of 1993 when concentrations above 14 mg/l were measured. For a period of almost nine months from August to April, nitrate concentrations at all the stations were generally between 4 to 10 mg/l. The concentrations stayed elevated even during the summer months when they were expected to have dropped significantly. During the second year, for three and a half months from mid-July to the end of October, nitrate concentrations were near zero at all of the monitoring stations. Nitrate concentrations were generally lower in the second year than the first year except during March and April when second year concentrations were higher than the first year. The highest concentrations in the second year were measured in March and April as opposed to May and June for the first year.

The Sangamon River stations also show the significant difference between the first and second year data similar to conditions observed in the tributary streams. During the first year data collection, nitrate concentrations almost never fell below 2 mg/l. The second year, nitrate concentrations were zero or near zero for a period of three and a half months from mid-July to the end of October. During the first year, nitrate concentrations were high at all stations in May and June, started to drop in July, and essentially stayed between 2 and 8 mg/l for the rest of the year.

The overall average annual load for the tributary streams was 14 lb/acre in the second year compared to 39 lb/acre for the first year. Main river station average annual load for the first year was 37 lb/acre as compared to 15 lb/acre for the second year. Based on the nitrate load data, we can conclude that the source of nitrate in the Lake Decatur watershed is truly dispersed throughout the watershed. More than 80 percent of the drainage area yields nitrate at almost a uniform rate.

One of the main objectives of this project was to evaluate the potential effects of alternative agricultural best management practices (BMPs) at different locations of the Lake Decatur watershed on nitrate level reduction at Lake Decatur. The AGNPS (Agricultural Nonpoint Source Pollution) model for agricultural watersheds was used for quantitative evaluation of the effects of alternative management practices on nonpoint source pollution from the Lake Decatur watershed. This model has been developed and distributed by the North Central Soil Conservation Research Laboratory of the U.S. Department of Agriculture Research Service.

Four broad categories of BMPs were evaluated: nutrient management, mitigation projects, conservation practices, and a combination of nutrient management and conservation practices. Different scenarios of these four BMPs were applied to sub-watersheds. Reductions and reduction efficiencies of nitrate loadings into Lake Decatur were computed.

The modeling results show that reducing the fertilizer application rate was the most effective and reliable BMP in reducing nitrate loading into the lake. Nitrate loading into the lake was directly proportional to the amount and area of nutrient application. For example, a 25 percent reduction in N fertilizer application over the entire watershed was projected to result in a nitrogen concentration of 8.9 mg/l in water flowing into Lake Decatur after a one-year storm, compared with 11.6 mg/l for the base run with

current application rates.

Similarly, mitigation projects such as wetlands or buffer strips that remove nitrate were also effective in reducing nitrate loading into the lake. However, it is difficult to quantify the extent to which mitigation projects are needed.

Conservation tillage practices reduced runoff but could either reduce or increase nitrate concentrations in the lake depending upon the locations of applications with respect to the lake. Conservation practices applied over the entire watershed and over areas closer to the lake reduce nitrate concentrations in the lake. Conservation practices applied over areas further away from the lake tend to increase nitrate concentrations in the lake if nutrient applications remain the same. However, when conservation practices are combined with nutrient management they are found to be very effective.

City Involvement in the Watershed

Decatur's active involvement in watershed management goes back at least to 1941 when the City employed two soil conservationists to promote soil erosion control in the Lake Decatur watershed. These early efforts continued through the 1950s. Program accomplishments included conservation plans, crop rotations, contour lines, terraces, waterways, pastures, wildlife and tree plantings, surface and tile drainage, ponds, fertilizer plans, and public education (City of Decatur, c.1959). The program was later discontinued but available City records do not indicate when it ended.

The Lake Decatur watershed is large relative to the size of the lake. Despite the generally flat topography, soil erosion and sedimentation are a significant problem in the watershed. From its construction in 1922 through the most recent sedimentation survey in 1983, Lake Decatur's average annual sediment accumulation rate was 160,000 tons, or about 150 acre-feet (ISWS, 1987). In 1956, bascule gates were added to the dam to raise the lake level and increase storage capacity to 28,000 acre-feet. Thus the historical sedimentation rate is about 0.5 percent of reservoir capacity. In 1985, a City Sedimentation Control Committee recommended a selective lake dredging program. Since then, about 2,000 acre-feet of sediment has been dredged from the lake and placed on an adjacent upland site.

The current City involvement in the watershed began in response to another recommendation of the Sedimentation Control Committee. In 1985, the Decatur City Council approved a $45,500 contract with the Macon County Soil and Water Conservation District (MCSWCD) to support conservation activities, primarily for reducing soil erosion. Annual contracts have been approved every year since 1985. The focus of these efforts has gradually expanded to emphasize nitrate reduction. The 1995-96 contract amount was $91,500 for salaries, administrative expenses, public education activities and locally designed cost-share incentives. These incentives are targeted to local priorities and augment the cost-share programs administered by the Natural Resource Conservation Service of the U.S. Department of Agriculture.

A stakeholder group called the Lower Lake Decatur Watershed Resource Planning Committee (LDWC)

was established in 1989 by local government agency representatives, watershed landowners and agribusiness interests. From an initial focus on seeking federal technical and financial assistance, the Committee's role has expanded to include promotion of water quality improvements throughout the watershed. The LDWC brings together key stakeholders and technical experts from government and the University of Illinois.

Over the years, relations between the City of Decatur and its agricultural neighbors have sometimes been strained. Much of the conflict has centered on water resource management issues. Long-time area residents remember a Corps of Engineers proposal in the 1960s and early '70s to construct a new impoundment on the Sangamon River upstream of Lake Decatur. This project, which was supported by Decatur officials, was defeated by public opposition. After the severe drought of 1988, Decatur constructed water supply wells as a supplemental water source. This project generated opposition from small communities and farmers concerned about the effect on their own wells. The City has so far made good on its pledge to use the wells only on a short term basis during droughts and to remedy impacts on private or municipal wells resulting from City groundwater withdrawals.

The ongoing City involvement with watershed landowners through the MCSWCD and the Watershed Committee has contributed to improved mutual understanding between urban and rural people. In seeking a watershed solution for the Lake Decatur nitrate problem, Decatur officials have stressed the importance of communication and cooperation among watershed stakeholders, a strong preference for market-based strategies rather than regulatory approaches, and support for techniques such as wetlands restoration that provide multiple benefits.

Market-Based Solutions

The annual MCSWCD contracts have incorporated a watershed approach to reducing nitrate loadings and concentrations in Lake Decatur. To date, the City's financial commitment to watershed programs has been relatively modest. With the completion of the ISWS monitoring and modeling study, the City has the essential information to support a preliminary conclusion that using watershed management strategies to achieve compliance with the SDWA nitrate standard is technically feasible.

Before making a final decision to adopt the watershed approach, an evaluation of its costs and implementability still must be done. The ISWS modeling results identify combinations of BMPs and mitigation practices that would be expected to keep the peak nitrate concentration below the 10 mg/l MCL. Key questions now include: Can enough watershed landowners be convinced to change their nitrogen management practices or implement mitigation projects to meet the nitrate standard? If so, how and at what cost to the City of Decatur? From the City's perspective, the bottom line test of feasibility is whether the cost to City water ratepayers of meeting the nitrate standard through watershed management is less than the cost for upgrading water treatment or developing an alternate supply.

The Watershed Committee, made up of city, farm and industry stakeholders, attempts to find and implement win-win strategies that can both improve water quality and increase, or at least maintain, net

farm income. We stress that, if a pound of fertilizer nitrogen ends up in Lake Decatur, the City's water supply is damaged and the farmer's money is wasted. Furthermore, there are mutual advantages to city-farm cooperation. A healthy farm economy is good for the City and maintaining competitive water rates is good for local farmers. They receive a premium price for their crop because of their proximity to major grain processors located in the City of Decatur. If Decatur must raise water rates to finance nitrate removal, the cost of doing business would go up and agri-industry could shift production elsewhere.

The Lake Decatur watershed project is ongoing and its outcome is not yet certain. At deadline time for the Watershed '96 proceedings, we have successfully implemented a number of relatively small scale programs to reduce soil erosion and control nitrogen loadings but we do not have a clear blueprint for expanding the scale of these or other activities sufficiently to meet the nitrate MCL. The following sections present some preliminary thoughts from the farm perspective and the city perspective. The former is by Tim Hoffman, co-chair of the LDWC and a farmer in the watershed; the latter by Stephen John, the other LDWC co-chair and a former Decatur City Councilmember.

The View from the Farm

As a farmer in this watershed, it was apparent to me from the beginning that a watershed that is 87 percent farmland and has a nitrate problem has to have farmer cooperation for successful improvement in water quality. The high nitrate levels in Lake Decatur and the high percentage of farmland as land use don't necessarily mean that farmers in the watershed are negligent in their application of nitrogen fertilizer. Indeed the ISWS study has shown that the levels are widespread and evenly dispersed throughout farmland in the watershed. No "hot spots", which might suggest severe over-application in certain locations, were found.

This leads me to believe that education could be a reasonable solution. Farmers could benefit from education on problems created for the City water supply that are related to typical farming activity. A basic understanding of the hydrology of the watershed, and how a farming activity translates into a watershed problem are key elements of a solution from their standpoint. The farmer needs to believe that there is a problem and the perception of the problem is the same for all parties. The City partners could benefit from education on the reasons farmers make the decisions they do about fertilizers, herbicides and pesticides. A basic understanding of the social and economic pressures exerted on farmers are key elements of a solution from their standpoint.

Farmers have always been concerned about environmental pressures resulting from normal farming activities. However, we do not have the ability to pass along any added expenses. Any remedies to watershed problems that would possibly impact farmer productivity would probably meet opposition. Therefore remedies must be workable solutions in both practical and economic aspects for those involved. Solutions must be readily adaptable and economically feasible if they are to be successful. As with any project that involves a diverse population, all parties involved should have extensive input from the beginning. This not only gives everyone a chance to represent their interests but it gives them the sense of ownership needed to make the basic philosophical changes that are necessary.

We have adapted this process and so far it has proven to be successful. With a watershed as large as ours, 925 square miles spread out over six counties, it is a formidable task to undertake. Add to this an IEPA mandate to have a nitrate reduction plan implemented by 1998 and compliance by 2001 and we then need to instill in everyone involved a sense of urgency. After we get through this stage of ownership, everyone involved should feel this sense of urgency.

We have designed our programs to meet these criteria and also to be tools that build bridges where gaps exist. We are attempting to practice the old adage that you can get anywhere if you first build the road.

One specific market-based idea that deserves consideration is to impose a special tax on land in the watershed. The tax should apply to all land, not just farmland. With a watershed area of nearly 600,000 acres, a tax of $5 per acre would yield nearly $2 million per year. Landowners that implemented nutrient management practices would receive a rebate that could be up to twice the amount of tax they paid. This would be in effect an incentive to encourage nutrient management and help to cover any associated costs. The system could be designed so that the net tax revenue (taxes revenue collected minus rebates/incentives distributed) was zero. If needed to meet water quality goals, City contributions could be added to increase the funds available for incentives.

The View from City Hall

The hard line view sometimes expressed around City Hall is simple: we didn't put the nitrates in our lake and we shouldn't have to pay to remove nitrates. Cities must ensure that their public water supplies meet Safe Drinking Water Act standards. Farmers, shown to be the source of much (although definitely not all) of the problem in Decatur's case, are not legally obligated to prevent the pollution of our water supply. The Clean Water Act which would logically control farm runoff does not deal effectively with such nonpoint sources.

As we began to research other watershed-based efforts to improve water quality we were directed to the literature on point source/NPS source trading. The approach we are using draws on this concept but there is a fundamental difference. PS/NPS trading involves two types of polluters, one subject to strict permit limitations and the other not. In our case, there are not two categories of polluters but rather one group of polluters and a downstream injured party. It hardly seems equitable that the legal mandate to abate the problem falls on the latter.

I do not subscribe to the hard line view. Recognizing our mutual interests, city and farm should make every effort to craft solutions that work for everyone concerned. Participation in the Watershed Committee has helped to educate me and other city dwellers about issues of farm economics that Tim Hoffman raises. Farmers in the watershed generally appear to follow the established fertilizer guidelines pretty closely. Through my work as an environmental planner, I have come to prefer market approaches, such as cost internalization, over command-and-control style regulation, especially for addressing pollution that results from overuse of common products ranging from fertilizer to gasoline to wasteful

packaging.

Iowa has shown what can be achieved through "a large and varied network of on-farm demonstration and implementation projects ... coupled with an aggressive marketing and information plan to accelerate voluntary adoption" (Iowa Department of Natural Resources, 1991). In a single demonstration project involving 48 farmers in one Iowa county, fertilizer nitrogen use was reduced by over 240,000 pounds with no reduction in yields resulting in a significant increase in net return.

In our LDWC discussions it has become clear that many farmers and farm managers focus on maximizing yields, even though that may not always maximize profits. We have heard estimates that typical nitrogen application rates may be as much as 15 to 20 percent higher than optimum in part because, when using equations in the fertilizer guidelines, there is a natural tendency to use overly optimistic yield goals. Since nitrogen has been a relatively small part of total input costs, it has been easy to over-apply to some extent to make sure that nitrogen does not limit yields. Recent increases in the cost of nitrogen and the increased use of fertilizer monitors have helped to make farmers more aware of using nitrogen efficiently.

If administrative and political hurdles can be overcome, I could easily support the system of taxes and incentives Tim Hoffman outlined. The same objective could be accomplished through a fertilizer tax with rebates to farmers adopting BMPs. This concept has the advantage of directly targeting overuse but it would also be cumbersome to administer and it would face political opposition.

Another concept we have discussed is a voluntary nitrogen risk-share program. MCSWCD has used Decatur contract funds for a small, locally designed risk-share program to promote adoption of no-till farming. A risk-share program could be designed to encourage reduction in the nitrogen application rate to corn. Participating farmers would apply nitrogen at a reduced rate resulting in lower cash inputs. Some of the cash savings would be retained by the farmer; some would be deposited in a risk-share pool that would insure participants against lost revenue from reduced yields. If necessary, City contributions could be used to capitalize the insurance pool. Like the tax/rebate concepts, a risk-share strategy would pose administrative difficulties. On the plus side, it would be unlikely to generate opposition if it were entirely voluntary.

The role of wetland restoration should be further evaluated as we move toward a final watershed plan. ISWS modeling has shown that such mitigation projects can help to reduce nitrate loadings to Lake Decatur. University of Illinois researchers have successfully demonstrated the water quality benefits of small wetlands constructed at the outfalls of farm field tiles. To the extent that wetlands provide multiple benefits, mechanisms to spread the costs among the beneficiaries needs to be explored. Decatur could contribute in proportion to benefits related to removal of sediment, nutrients and pesticides; conservation agencies or private organizations could contribute toward enhancement of habitat and recreation.

To me, prospects for a watershed solution to Lake Decatur nitrate problems are great enough to justify the City's commitment to the effort to develop and implement a plan that is good for City water users and

good for our farm neighbors.

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Comprehensive Solutions for an Urban Watershed- A Case Study of the Beaverdam Creek Watershed

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Introduction

Historically, counties focused on solving flooding problems within watersheds. In the late 1980's water quality and habitat concerns emerged as a focus of many watershed studies. In 1989, the Prince George's County Department of Environmental Resources determined that a comprehensive program was needed to simultaneously address flooding, water quality, and habitat concerns in the County watersheds. The Beaverdam Creek watershed was selected because the flooding, water quality, and habitat conditions in the watershed are typical of urban watersheds in the region.

The Beaverdam Creek Watershed Study, which was completed in June 1995, evaluated existing flooding and water quality conditions and identified methods to improve conditions in the watershed. In addition, the study resulted in the development of a comprehensive "generic work plan" for application in other county watersheds. The County's intent for this work plan, which was refined through the course of the project, is to apply it to other watersheds in the County.

Background

The Lower Beaverdam Creek watershed drains approximately 14.9 square miles of central Prince

George's County and is generally located east of the Baltimore-Washington Parkway, west of Interstate 95, south of Maryland Route 450, and north of Marlboro Pike. The stream is located in the coastal plain province and is thus characterized by relatively mild stream slopes and wide flat floodplains. The stream outfalls into the Anacostia River near Kenilworth Avenue at the District of Columbia and Prince George's County line.

The watershed, which is located east of Washington, D.C., is heavily developed with a mixture of medium-density residential, commercial, and industrial land uses. The watershed consists of the main stem of Beaverdam Creek, two large tributaries (i.e., Cabin Branch and Cattail Branch), and 19 smaller tributaries to these three streams.

The Beaverdam Creek watershed is typical of many urban watersheds in which a majority of the extensive development in the watershed occurred during the post World War II era, preceding the adoption of storm water management regulations. Therefore, the watershed shows the effects of uncontrolled urban runoff in the form of flood-prone structures, stream bank erosion, and numerous water quality problems.

To address these issues, the two-part study consisted of a Flood Management Study and a Water Quality Improvement Study. The Flood Management Study involved determining the water-surface elevations for storms of various recurrence intervals, identifying the flood-prone structures, and identifying and evaluating potential solutions to eliminate the flooding hazards. The Water Quality Improvement Study focused on identifying existing conditions in the watershed that contribute to nonpoint source pollution, identifying existing controls to mitigate nonpoint source pollution, and identifying and evaluating solutions to improve the water quality, habitat, and physical conditions in the watershed.

Because of the extent of existing development in the watershed, the flooding and water quality problems are wide-spread and retrofit opportunities are limited. Therefore, to be effective, the study focused on both traditional improvements (e.g., SWM ponds) and on innovative structural and non-structural approaches.

Flood Management Study

The team conducted detailed hydrologic and hydraulic analyses to determine the existing and ultimate land use conditions flood elevations for over 25 stream miles (22 streams) in the Beaverdam Creek watershed. Using the Soil Conservation Service's TR-20 program, the team estimated discharges for various locations in the watershed. The resulting discharge calculations were input into the U.S. Army Corps of Engineers HEC-2 program to determine the flood elevations.

Next, the team performed computations to estimate the depth of flooding for various storms under existing and ultimate land use conditions. Based on the 100-year ultimate land use floodplain boundaries, 280 potential flood-prone residential and non-residential structures were identified. Of the 280 structures, 29 of these are anticipated to be flooded by the 2-year event.

Based on these assumptions, the structure and contents damages were also estimated based on the depth of flooding and on the type of structure (e.g., two-story, one-story with basement). The estimated flood annual damages are significant: $224,000 for residential structures and $4,719,000 for non-residential structures.

To reduce flooding potential in the watershed, the team identified and evaluated traditional structural flood control measures. Several traditional structural flood control measures, such as levees, floodwalls, and storm water management facilities, were identified; however, only a few of these were recommended for implementation due to significant downstream impacts, environmental impacts, or because they would be ineffective at reducing the flood hazard. Channelization was not considered due to adverse environmental impacts.

To augment the structural controls, non-structural/non-traditional alternatives were identified to eliminate potential flood hazards. In general, flood insurance is recommended for all flood-prone structures. We recommended acquisition and flood-proofing for the flood-prone structures that would not be protected by the structural controls. Other flood control options, such as flood warning and land use planning, were considered for the watershed as well.

Water Quality Improvement Study

The team used a wide variety of approaches to assess existing environmental and water quality conditions. First, we conducted a detailed field reconnaissance to evaluate the water quality, habitat, and physical stream conditions. Also, we used aerial photographs to identify environmental resources such as large wooded areas, wetlands, and other significant habitat and wildlife areas.

The team then estimated annual pollutant loads and in-stream concentrations for six pollutants (i.e., copper, lead, total suspended solids, total phosphorus, total nitrogen, and biochemical oxygen demand) using a computer spreadsheet-type model based on Metropolitan Washington Council of Governments loading rates. Limited baseflow sampling and a macroinvertebrate analysis and habitat assessment were conducted at 18 representative stations in the watershed to assess relative water quality conditions.

The results of the assessment of environmental/water quality conditions indicate that the Beaverdam Creek watershed is a typical urban stream system which suffers from the effects of uncontrolled urban runoff. Most of the problems occur in the areas of intense development, which is along the Beaverdam Creek main stem and tributaries, as well as in the Cattail Branch subwatershed. In these areas, environmental conditions in the watershed are degraded. Existing wetlands in the Beaverdam Creek watershed are typically confined to the floodplain corridors, and many of the stream systems lack riparian habitat and buffers. Portions of the stream system are conveyed in concrete channels. Because much of the watershed was developed before the implementation of storm water management regulations, there are few existing storm water management facilities.

To improve the degraded conditions in the watershed, traditional water quality/habitat alternatives identified and evaluated included water quality ponds, regional facilities, and stream restoration alternatives. Conceptual designs and feasibility analyses were conducted for each of the structural improvements in the watershed. Similar to the flood control measures, the potential water quality and restoration measures were constrained by steep slopes, potential wetlands impacts, utility line impacts, and lack of space. In addition, the potential sites often consisted of floodplain, wetlands, or parkland areas.

Opportunities for improvements in the watershed were driven more by available sites than by problem areas. The team designed facilities to provide the maximum water quality benefit that could be obtained. For example, due to insufficient storage, many of the regional facilities were designed to provide only water quality control. Based on the analysis, the team recommended eleven water quality facilities, seven regional storm water management facilities, and eleven stream restoration opportunities for implementation.

The team considered non-structural alternatives, such as the industrial action plans and watershed-wide alternatives, an important supplement to the structural water quality alternatives, especially in areas where open space is limited. To improve the quality of runoff from the industrial facilities in the watershed, we developed a three-phase Action Plan. The components in the Action Plan consist of:

- Determining NPDES status.
- Assessing the pollution potential for each of the industries.
- Identifying best management practices.
- Assessing the potential for education and outreach programs.
- Water quality sampling.

The Plan calls for a County liaison to be assigned to each group of industries to implement the Action Plan. In general, the Action Plans developed for the industrial facilities would focus on pollution prevention rather than treatment after the runoff has reached the stream.

Watershed-wide alternatives represent another important component for improving water quality. Typically structural and non-site specific, these focus on improvements that can be implemented on a watershed-wide or county-wide basis. Components considered include public education, public involvement, stormdrain maintenance, storm water pollution prevention plans, street cleaning, debris cleanup, winter road treatment management, riparian reforestation, mowing limitations, and creation of nature trails. Recommendations included both improvements to existing programs and implementation of new programs. In general, these improvements are recommended for implementation on a county-wide rather than watershed-wide basis.

Implementation Program

The implementation program for improvement measures in the Beaverdam Creek watershed took a

segment-focused approach which recommends that all restoration opportunities for a given stream segment be implemented concurrently. The benefits to this approach include minimizing disturbance to homeowners and stream systems. A better evaluation of the proposed improvements can be generated from a segment-focused approach. In addition, many of the components within a watershed are related which makes the order of implementation critical. For example, storm water control should be provided prior to implementing stream restoration measures. Further, potential negative impacts stemming from implementation of an alternative can be mitigated during the same time period. In general, the priority of implementation was based on the severity of the problem and the extent of the expected improvement by each alternative.

A comprehensive schedule including design, permitting, and construction, was developed for implementation of the alternatives. The implementation schedule includes all of the recommended flood control alternatives, water quality and regional facilities, stream restoration alternatives, and the Industrial Action Plans. The watershed-wide alternatives were not included in the schedule because, for the most part, these alternatives will be implemented on a county-wide basis rather than just in the Beaverdam Creek watershed.

Summary

The challenges in restoring the Beaverdam Creek watershed are very similar to those experienced in virtually all developed watersheds. Development in the watershed occurred prior to storm water management. As a result, the stream systems suffer from the effects of uncontrolled runoff and opportunities for improvements are limited by space and potential impacts.

To effectively reduce flooding potential and improve water quality and habitat conditions in the watershed, it is necessary to identify and study a wide variety of opportunities, including traditional structural alternatives and non-structural alternatives. Through the implementation of the recommended measures, significant improvements to the Beaverdam Creek watershed will be realized. In addition, and perhaps more importantly, insights gained through this evaluation may be used to improve watersheds throughout the region.

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Integrated Watershed Planning and Management: Growth, Land Resources, and Nonpoint Source Pollution

Joseph F. Tassone, Richard E. Hall, Nevitt S. Edwards, and Deborah M.G. Weller

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Background/Introduction

It is widely recognized that management of growth and new development is an essential part of watershed protection and control of nonpoint source pollution. Methods to plan and manage growth for these goals, however, are not well established at the watershed scale.

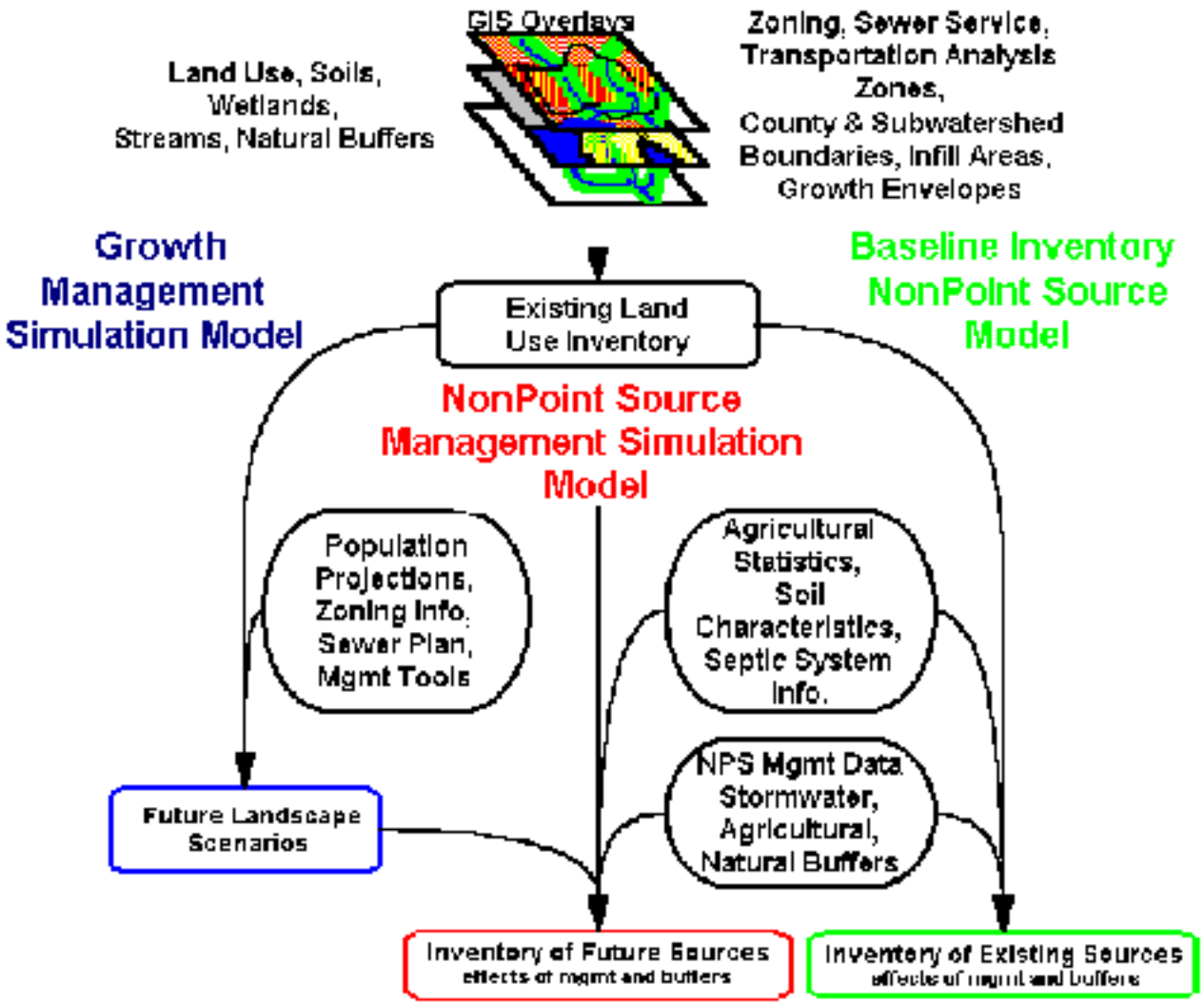
One obstacle to systematic use of existing information for this purpose is the inability to integrate the diverse and abundant data, available from research, monitoring, and modeling exercises, for land use management decision support. To accomplish this, we must use the information to clearly gauge the effects of population growth and alternative development patterns at the watershed scale, in relation to the effects of other pollution control activities. Perhaps most important, we must be able to relate this information to the land use decision-making processes of the responsible government agencies. A corollary to these observations is that a sound, long-term nonpoint source management strategy must emphasize and account for both the effects of traditionally recognized NPS control practices and the effects of the types of growth and growth management that will occur in the watershed.

Local governments in Maryland (23 counties, Baltimore City, and municipalities) have regulatory authority for land use management. They also are responsible for resource land conservation, local water resources, protection of environmentally sensitive areas, the local economy and jobs (in part), and balancing conflicting issues relating to private property rights. These are just a few of the things that influence growth management policies and programs.

An important goal for Maryland as a signatory to the interstate Chesapeake Bay Agreement is to reduce 1985 nutrient pollution loads from each of 10 major Maryland tributaries (Tributary Strategies) to the Bay by 40%, and to "cap" pollution at those levels thereafter. In rapidly growing (population) areas, the ways in which local governments exercise their land use management authority will be critical to success. Consequently, local governments are being asked to contribute in this regard and, conversely, want their contributions recognized. The challenge therefore is to conduct a watershed planning process that integrates across activities (growth management and pollution control), objectives (local responsibilities and the 40% reduction goal), and levels of geography and government (local, state, and interstate).

The Watershed Planning and Management Process

Over the past four years, the Maryland Office of Planning has worked with State agencies, counties, and soil conservation districts to develop and implement such an integrated watershed planning and management process. Participants are directly involved through a team approach with analysis, evaluation, and strategy development. To facilitate the process, a series of geographic information system (GIS) based models, collectively called the "Watershed Planning System" (WPS), was designed to evaluate the individual and cumulative effects of both alternative land management and nonpoint source pollution control measures in an integrated fashion. The watershed approach and the WPS models are designed to accommodate both local and watershed-scale perspectives and priorities. It is illustrated in a most general way in Figure 1, and is described in more detail in another paper from this conference (Weller et. al., 1996). The System has been developed in context of applications in the Piney-Alloway Creeks Watershed in Carroll County, the Patuxent River Watershed (covering parts of seven counties), and, most recently, the Winter's Run Watershed (38,000 largely rural acres) in Harford County.



The goal of the Winter's Run project was to identify measures that would accommodate projected growth in the watershed through the year 2010, while addressing County growth management and environmental objectives. These objectives include preservation of agricultural land, environmentally-sensitive areas, and resource lands, particularly forest, wetlands, and riparian buffers. They also include minimizing nonpoint source nitrogen pollution loads to ground and surface water supplies in the area, and identifying ways to implement the Upper Western Shore Tributary Strategy through the County's plans and programs. The Upper Western Shore, of which Winter's Run is a part, is one of Maryland's ten Chesapeake Bay tributaries mentioned above, for which draft 40% nutrient-reduction strategies have been formulated through a cooperative State and local effort.

The project examined the effects of a number of management options. These included purchase of development rights (PDR) and transfer of development rights (TDR). Together, these techniques would shift new development from land in the County's agricultural zoning district to land in County-designated rural residential in-fill areas. Options also included cluster development in the rural in-fill areas, and the use of innovative, nitrogen-removing septic systems for new development in un-sewered areas. Also examined were the impacts of existing County management programs, specifically for forest conservation, storm water management, and riparian buffer protection.

Figure 2 shows the estimated amount of land needed to accommodate projected growth in the watershed from 1990-2010. The graph compares land consumed under a "Directed Growth" scenario, in which the County would use the growth management techniques described above, and a "Base Zoning" scenario, in which it would not. While both watershed scenarios accommodate the 11,867 new households projected for the area, "Directed Growth" techniques would consume far less agricultural land, and increase the amount of land in forests and forested stream buffers.

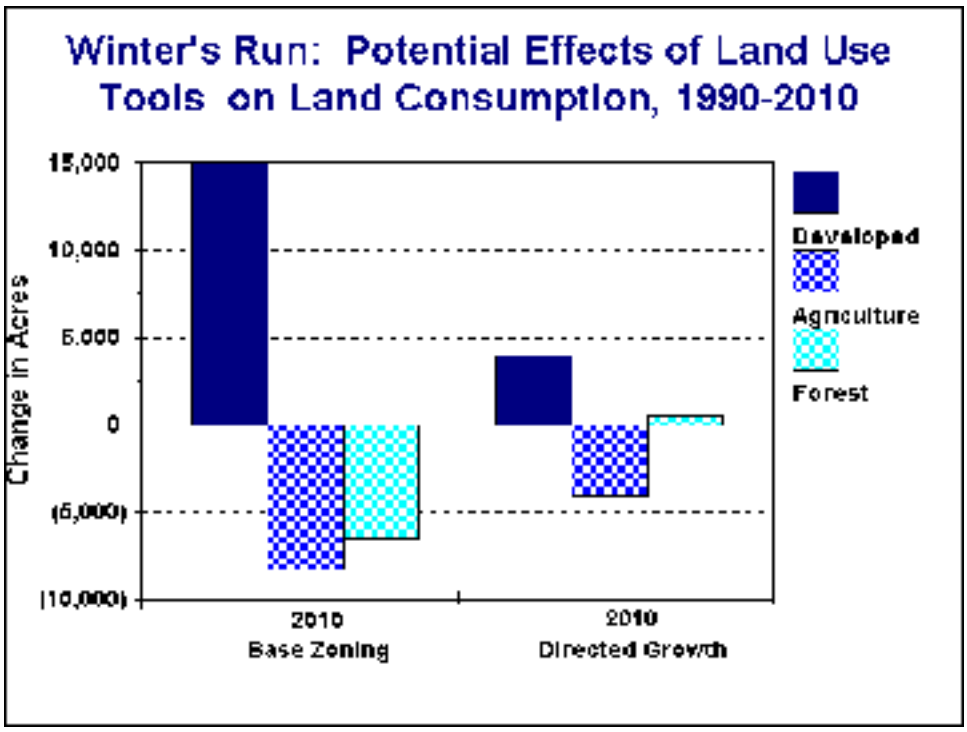
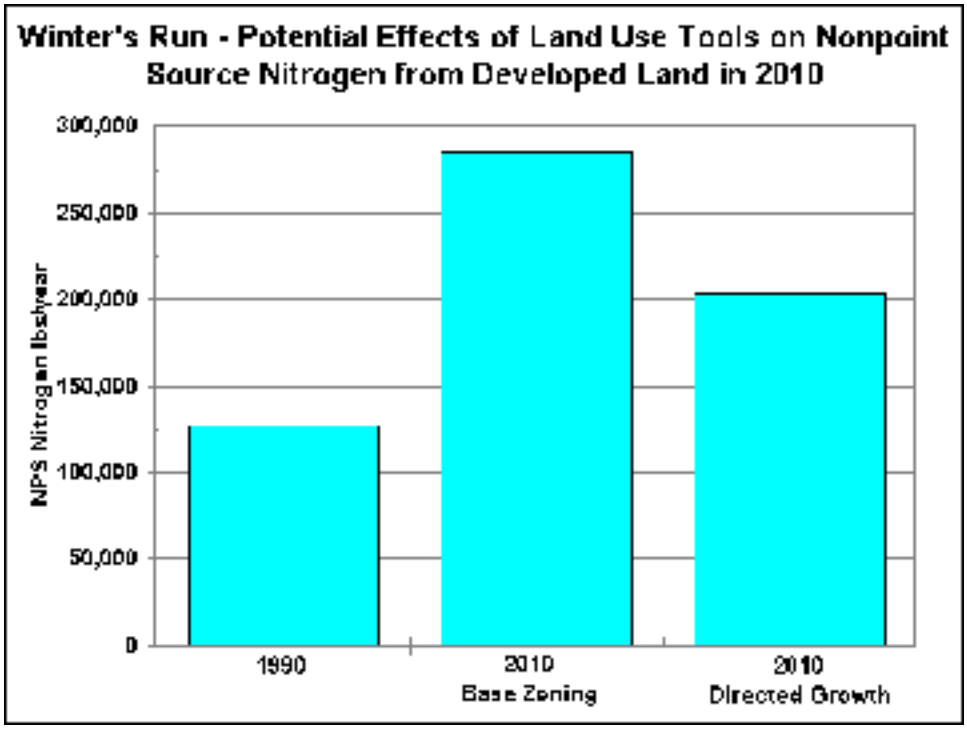


Figure 3 compares estimated levels of nonpoint source nitrogen pollution from developed land in 1990, and for the two scenarios described above in the year 2010. The 2010 load is significantly less under the "Directed Growth" scenario. This results from the effects of both the growth management options considered, and the County's existing management programs (mentioned earlier). The greatest effects result from the combined use of the PDR, TDR, and clustering options to direct growth, followed by the effects of forest and riparian buffer protection, use of nitrogen reducing septic systems, and storm water management, in that order.



These findings indicate some solutions that can be pursued by Harford County to best address multiple objectives. More agricultural and natural resource lands can be preserved in the watershed through judicious use of growth management options. Through the same activities, the County can minimize nitrogen pollution from new development, minimize nitrogen load increases to water supplies, and optimize the County's contribution to the success of the Upper Western Shore Tributary Strategy.

The results of Phase I of the Patuxent River Watershed Demonstration Project (the Patuxent is an entire "Tributary") illustrate findings from the watershed planning process in a larger, 7 county, 930 square mile watershed. Figure 4 shows the estimated effects of growth management tools on land use in the Patuxent Watershed for the year 2010. Both of the 2010 scenarios accommodate the same number of projected housing units. Clustering growth, forest conservation, and stream buffer conservation account for significantly less land consumed for development, preserving more forest and agricultural land. The nature and effect of these management tools was different in each county. They had the greatest effects in areas projected for rapid growth with sufficient buildable land zoned for their use. These techniques are already established through programs and procedures in some of the counties (existing tools), while in others they represent enhancements of existing tools (enhanced tools). For both existing and enhanced tools, the effects simulated represent rigorous use of the management techniques in all counties from 1990 through 2010.

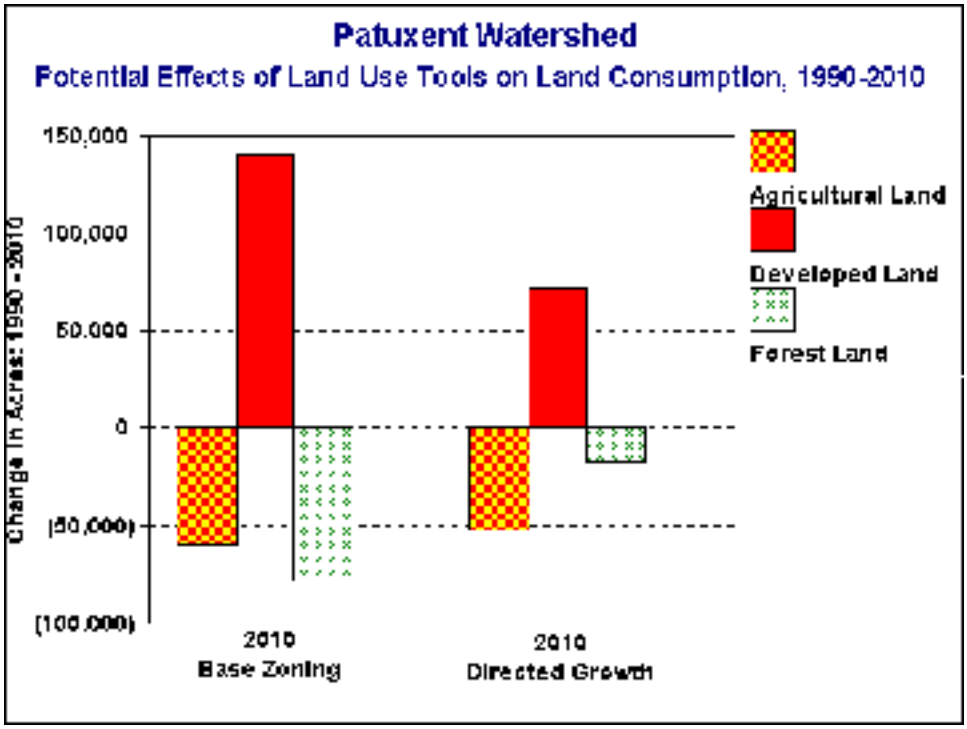


Figure 5 shows total nonpoint source nitrogen loads for the Patuxent Watershed in the year 2010 based on the estimated effects of land and nonpoint source management tools. A theoretical nonpoint source "cap" for the watershed was estimated using assumed point source load reductions from the Patuxent Tributary Strategy. The estimated 2010 load under the "Directed Growth" scenario suggests that the 40% reduction goal, which we expect to reach by the year 2000, may be compromised as a result of additional growth by the year 2010. Management tools to be evaluated in Phase II of the project will include a number of additional directed growth techniques. These tools are likely to be necessary to maintain the "cap."

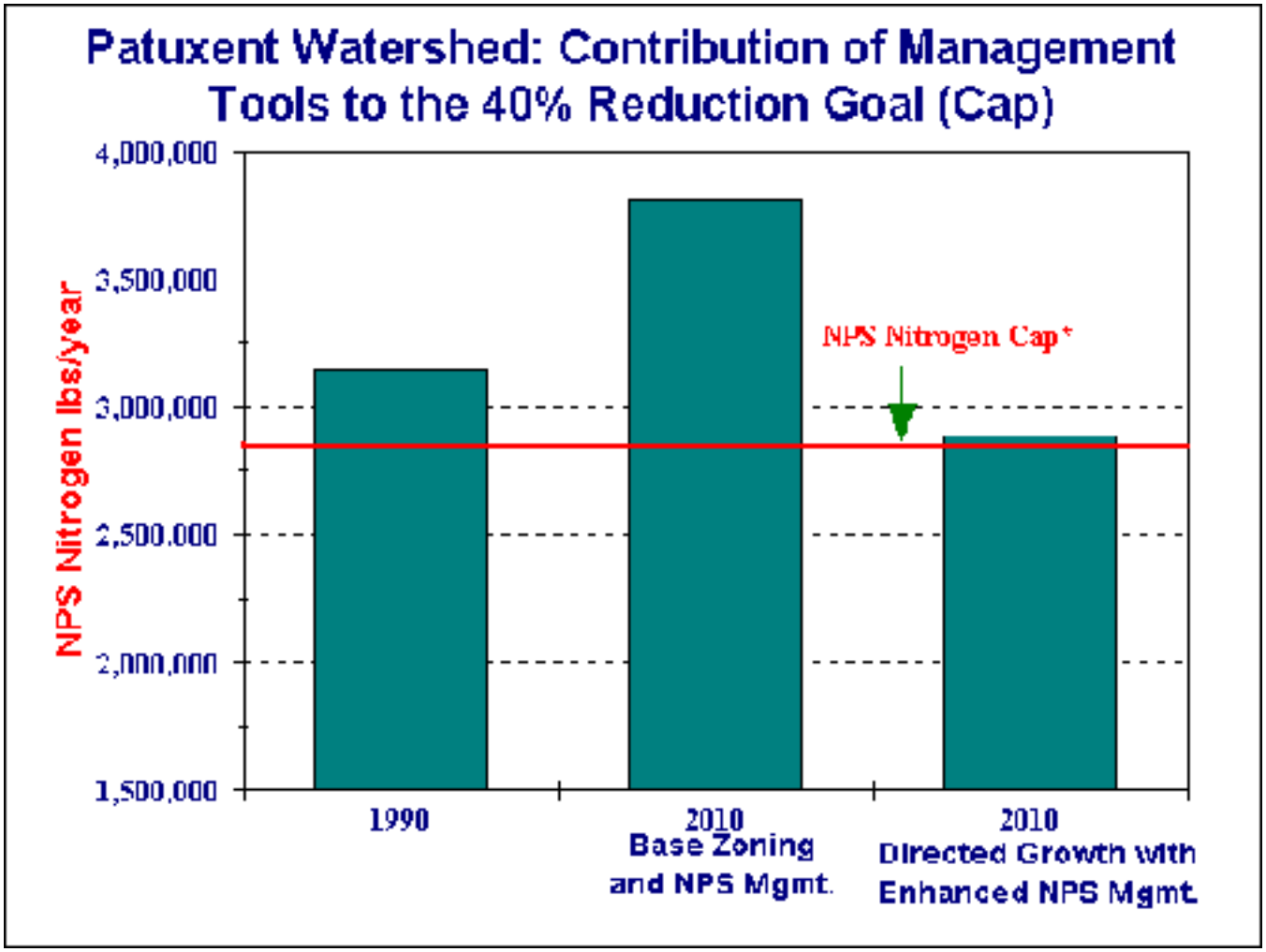


Figure 6 shows the potential reductions in year 2010 nonpoint source nitrogen loads estimated for both existing and enhanced land management and pollution control techniques. All of the effects are significant, but it is interesting to note that four of the techniques, including two of the "top three," are implemented through growth management procedures, such as comprehensive planning, zoning, water and sewer planning, and the subdivision process. Traditional nonpoint source "best management practices" (Agricultural BMPs and SWM (storm water management)), and conservation of forested stream buffers on agricultural land, will also play important roles. Taken collectively, these results suggest that the effects of additional land use management tools to be examined in Phase II of the project have great potential to be significant.

Conclusion

The keys to achieving meaningful (on-the-ground) results from this type of work are the local and state planning, political, and management processes. Both levels of government are responding to multiple constituencies and objectives, so it is critical to "package" findings, in a timely manner, in ways that can be used and understood by agencies, politicians, interest groups, and the development and agricultural communities involved in these processes. Collectively, these processes comprise the public decision-making process which, in turn, determines many actions. Through the "Watershed Planning and Management" approach described here, and its other efforts to implement Maryland's 1992 Economic

Growth, Resource Protection, and Planning Act, the Maryland Office of Planning is committed to supporting sound public policy and management by providing information to decision-makers.

To this end, counties collaborating in the watershed planning process to-date are using results in several capacities. Harford County has initiated a second project with the State to apply the approach County-wide. They will use results from Winter's Run and the County-wide effort to illustrate to local officials and affected communities the implications of proposed management strategies for local and regional goals. Examples are the merits of redirecting growth through a transfer of development rights program, and of targeting sensitive area protection and restoration in locations with greatest potential to reduce pollution loads. Benefits of these techniques, as shown for specific subwatershed areas of the County, will be used in elements of the County Master Plan and in the County's Community Planning Program, to show effects on land and water resource goals of direct interest to specific communities, and the implications for related goals at the County, watershed, and Tributary scales.

In the Patuxent Watershed, a revision of an inter-jurisdictional Patuxent Policy Plan is being prepared in Phase II of the Demonstration Project. Revisions are based on the collective experience of the counties since the Policy Plan was originally developed, and on the analyses conducted through the watershed planning process. Phase II of the process is being used to identify area-specific land management needs within the watershed to effectively address land resource and pollution control objectives. As an example, Calvert County, one of the counties in the watershed, is using the watershed planning approach to contribute to its Comprehensive Plan update. That effort focuses on concentrating growth in village centers and using various techniques to preserve rural and agricultural land. The potential for more widespread use of nitrogen reducing septic systems is also being examined. The watershed planning process in the Patuxent will provide an important part of the basis for policies and management decisions, for both the watershed and for many of the counties.

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Sawmill Creek: A Multi-disciplinary Watershed Restoration Project

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Abstract

The Sawmill Creek project is a comprehensive multi-agency watershed restoration effort. The goal is to demonstrate that existing programs can be coordinated in order to improve water quality, and habitat for living resources. Coordination of multiple restoration projects has been a major factor in addressing the cumulative impacts in the watershed.

Water quantity management includes reducing stormwater discharge rates and increasing stream base flow. Habitat improvement projects were designed to match the best possible stormwater discharge rates. The habitat projects include stabilizing and revegetating 1737 meters of eroded stream channels with natural materials. These projects will provide sediment and erosion control as well as restore fish, invertebrate and riparian habitat and eliminate 5 fish passage blockages.

Water quality improvements include reducing nutrient loadings through bio-retention as well as isolating and treating several types of industrial chemical discharges. Funding for most of these restoration projects has been incorporated into existing budgets for the development and maintenance of the business and community infrastructure.

Introduction

Currently most management and regulatory strategies address environmental impacts of individual land

use practices. This project-by-project approach developed at a time when the cumulative impacts of human activities were far less significant. Today many agencies recognize that this approach is no longer adequate to protect or restore the Chesapeake bay or its tributaries. As a result, Sawmill Creek was chosen as one of four targeted watersheds by the Governor's Bay Work Group. These watersheds were selected in order to develop, demonstrate, and evaluate a coordinated approach to improving water quality and the habitat conditions for living resources.

Description of Sawmill Creek Watershed

Sawmill Creek is a second order freshwater stream on Maryland's coastal plain. The watershed drains approximately 8.4 square miles and the creek flows about 5 miles from its headwaters until it empties into a tidal estuary near the mouth of the Patapsco river and Baltimore Harbor. The region was originally known for its productive fruit and vegetable farms. Approximately two thirds of the watershed has been converted to residential and light industrial land uses over the past 50 years. Development of a major transportation network has had a significant effect on the watershed, with Baltimore Washington International Airport as the center of a web interconnecting rail lines and interstate highways. Ground water usage for municipal drinking water has increased dramatically. Due to excessive pumping from an unconfined aquifer, annual base flow in the creek was reduced from an average 6 cubic feet per second (cfs) to as less than 1 cfs during dry years.

Organization of the Project

At the beginning of the project two inter-agency teams were identified. The first was an overall monitoring group which immediately began to document existing biological conditions. The implementation team used the monitoring data to target restoration projects and to subsequently measure their environmental benefits.

A wide spectrum of land owners and land management agencies have contributed to the restoration efforts. Five Anne Arundel county government departments and seven state agencies have been involved in various capacities. Three federal agencies, five nongovernmental organizations, numerous private citizens and several local businesses have been participating. An important mandate was to use existing programs to achieve the restoration objectives. No new funds were allocated for implementation projects.

The implementation team used biological indicators to determine which land management activities were having the most significant impacts on the watershed. A restoration strategy was drafted which described the geographic distribution of environmental problems and explained how they had evolved during the development of the watershed. For each major environmental problem, a restoration strategy was proposed and the responsible management agencies were identified. The monitoring and planning process evolved over a 3 year period. The implementation phase began in 1994 and will continue for another 3 to 4 years.

Restoration Projects

Figure 1 shows the distribution of problems and restoration projects that were identified by the inter-agency teams. Each letter indicates a different type of project. In some areas restoration projects have been linked together in order to address cumulative impacts to water quantity, water quality, and habitat problems within specific sub-basins of the watershed.

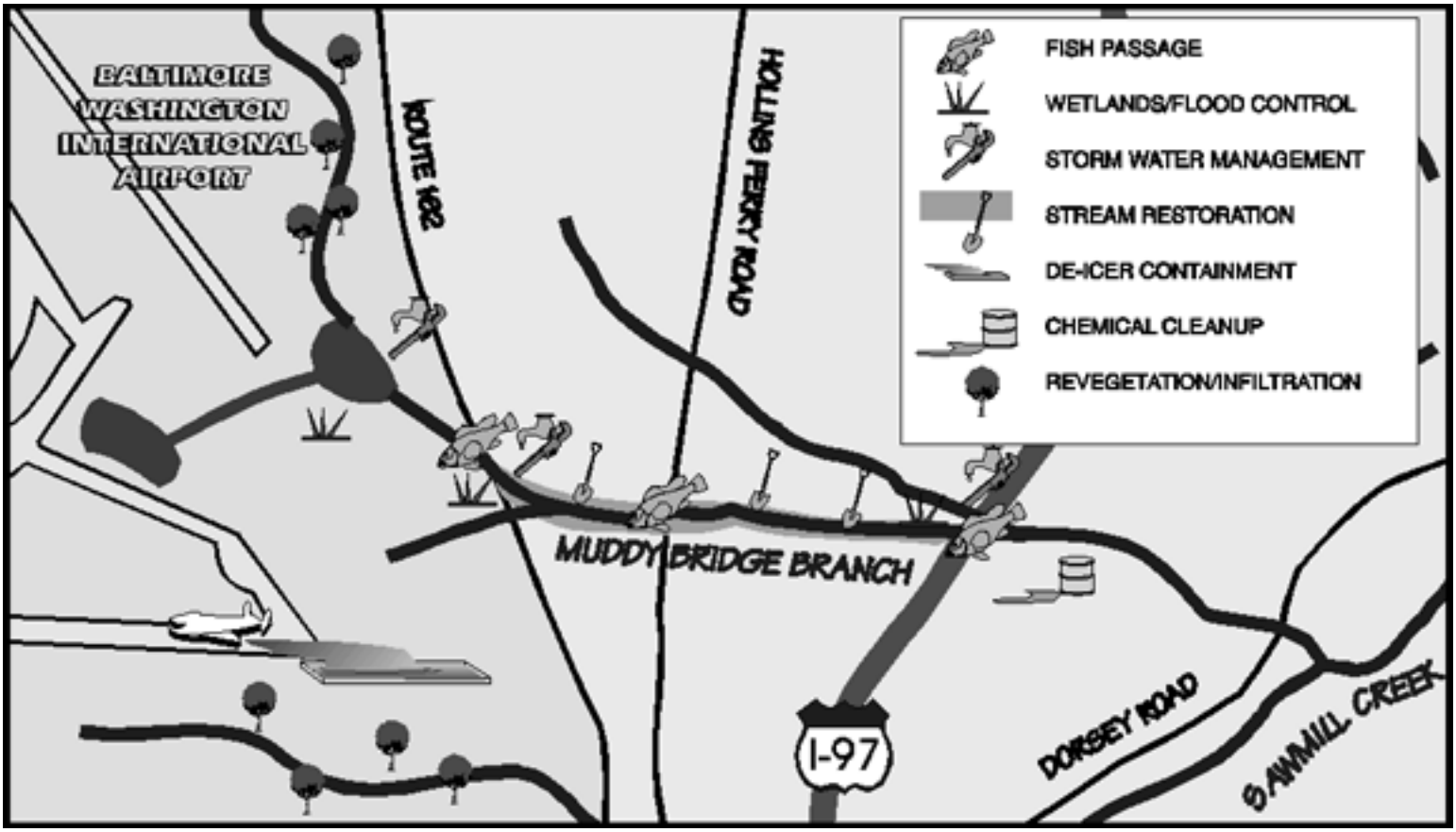

Figure 1. Sawmill Creek showing location of restoration projects.

The sub-basin known as Muddy Bridge Branch provides a good example of the cumulative impacts of commercial and residential development. Stream habitat has been degraded by stormwater erosion, despite the presence of 4 stormwater management (SWM) basins. Additional stormwater related impacts include; degraded water quality, fish passage blockages, and sedimentation of the large pond and wetlands downstream. Runoff from airplane deicing has caused chemical oxygen demand as high as 2700 mg/l and laboratory bioassays have documented significant mortality rates in fish and invertebrates. Urea is used for runway deicing and NH3 concentrations as high as 35 mg/l have been recorded. The loss of baseflow in this tributary has negatively impacted habitat space, temperature, dissolved oxygen, and the dilution rates of the chemical pollutants mentioned above.

Figure 2 provides a schematic of some of the coordinated restoration projects on Muddy Bridge Branch. In order to restore aquatic habitat, 1341 meters of stream channel will be stabilized using bio-engineering techniques, including tree root wads to stabilize failing banks and vortex rock weirs to provide grade

control. The Rosgen stream classification system was used to design the restored channel geometry, non-erosive flow capacity, and channel cross section. All the stormwater management ponds were analyzed in order to determine the most economical way to produce a non-erosive discharge rate that would be compatible with the rebuilt stream channel dimensions.

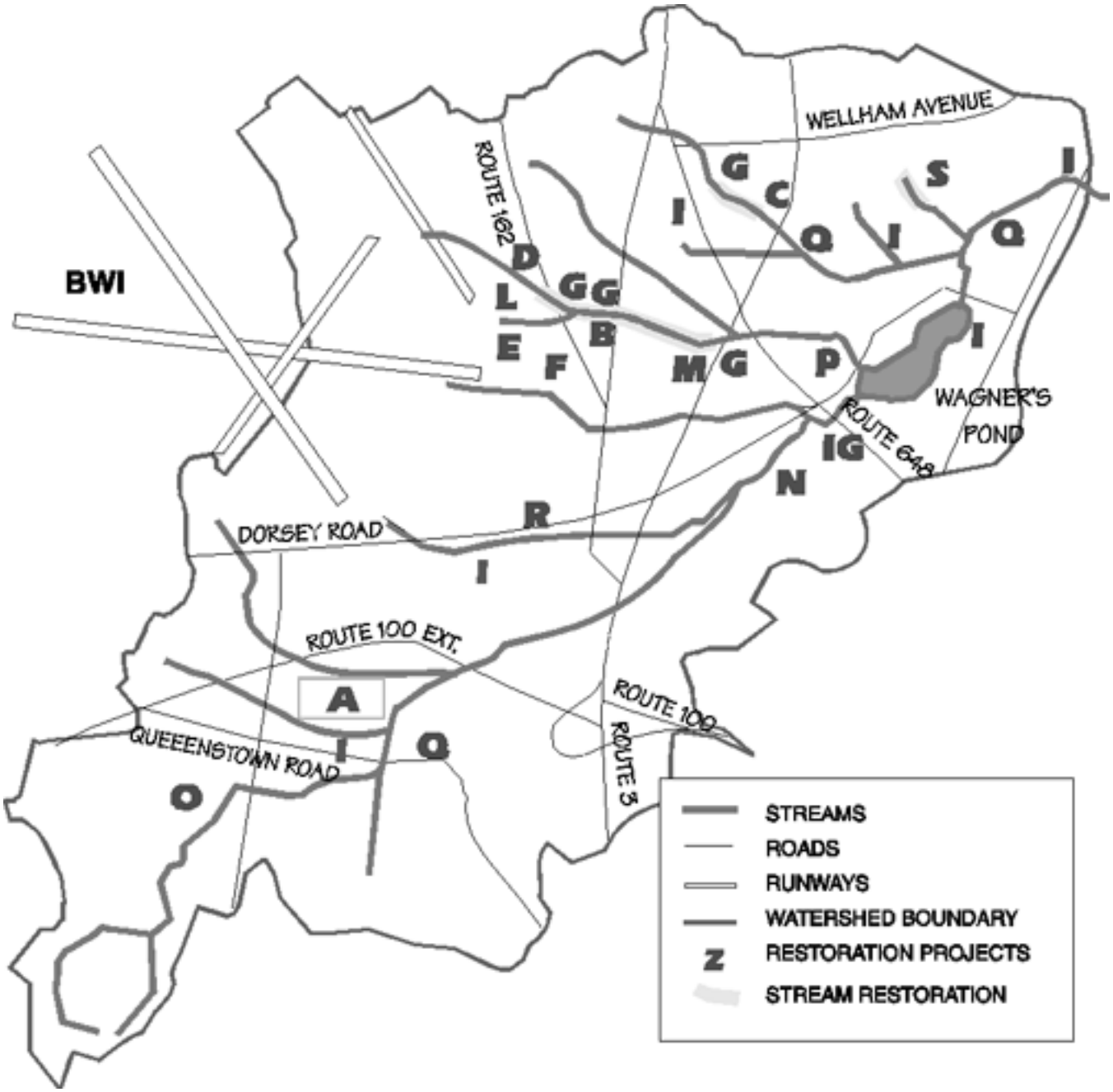

Figure 2. Muddy Bridge Branch restoration projects.

In order to achieve a more stable hydrologic regime a variety of stormwater management (SWM) techniques are being combined. The outlet structures at the airport's two largest SWM basins will be modified. Additional storage capacity will be created by raising the height of the lower impoundment. The two year storm discharge rate will be reduced from 3.3 cubic meters per second to 1.6 cubic meters per second. Additional volume reductions will be accomplished by diverting some of the runoff from the

upper SWM pond back into an adjacent drainage basin that was cut off during earlier airfield construction.

As part of their new regional stormwater management plan the MD Aviation Administration has begun to re-vegetate many of its drainage swales and open spaces. This will have several benefits including; increases in infiltration, nutrient uptake and evapo-transpiration as well as reducing runoff times of concentration and thermal loadings to the stream.

Several of the downstream road crossings are built on berms that act as unintentional detention structures during large storm events. Upland areas behind these crossings will be excavated and planted with wetlands vegetation in order to increase floodplain storage, wetland habitat, sediment trapping and nutrient assimilation.

Two of the culverts will be replaced and a third will be modified as part of local highway improvements. The new structures have been designed to restore fish passage and be compatible with the stream restoration design.

In addition to reducing high flow impacts, baseflow will be improved by phasing out several older municipal well fields within the watershed. An analysis of regional water supplies has indicated that water needs can be met more efficiently by investing in a better regional transmission line network.

Significant water quality improvements will result from the new deicer management plan at Baltimore Washington International Airport. Deicing pads, waste storage tanks, vacuum sweeper trucks, and testing of alternative deicing materials are being implemented. This is one of most extensive deicer management plans thus far at an operating US airport. Monitoring and management plans are also being developed to deal with leaking underground storage tanks at two local industrial facilities.

A number of the restoration practices described for Muddy Bridge Branch are gradually being implemented in other parts of the watershed. The EPA Rapid Bioassessment Protocols (RBP) are being used to quantify the effectiveness of a stream restoration project on Tributary 9. Post construction habitat scores have improved by 60 % within the first growing season. We expect that the habitat scores will continue to improve as the riparian plantings develop into a mature forest buffer. Nine species of fish have been stocked in this stream segment which only supported one species before the restoration project. The team is also working on plans to remove a downstream fish blockage.

Conclusion

The Sawmill Creek project is a good example of how a multi-disciplinary team can develop an ecologically sound watershed management project. The key to success was the use of quantifiable measures of biological health and stream stability to guide the integration of a wide variety of best management practices. This approach can be used for both restoration and

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Managing the Mandates: Baltimore County, Maryland's Experience in Applying the Watershed Approach

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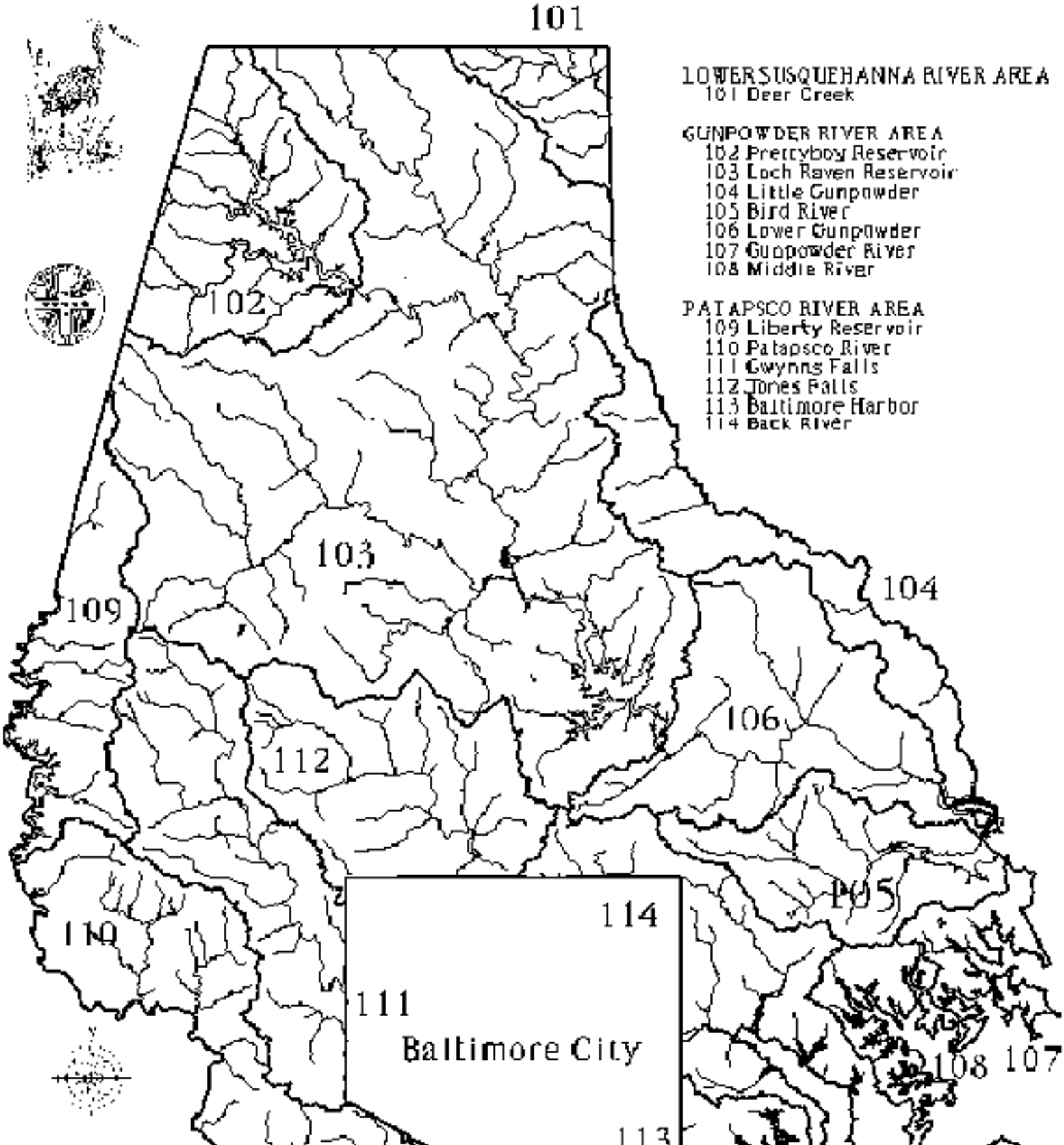
Baltimore County, Maryland has developed a watershed management program to address federal nonpoint source pollution control mandates, State of Maryland initiatives for restoration of the Chesapeake Bay, and special cooperative water quality projects. The County's watershed approach allows for consideration of different geographic scales and management objectives. Characterization of watershed resources and problems, and prioritization of restoration opportunities, are accomplished through the preparation of watershed management plans, which are implemented through capital and operating programs. This paper describes the development of the watershed approach in Baltimore County and components of a successful program.

Geographic Context

Baltimore County is located in north-central Maryland and straddles the Fall line separating the Appalachian Piedmont and Atlantic Coastal Plain physiographic provinces. With a land area of approximately 610 square miles and a 1995 population estimate of 710,000, it is the third largest in area and population of Maryland's 23 counties and the independent City of Baltimore. The County surrounds the majority of Baltimore City and contains no incorporated municipalities. Land use composition is rather evenly-divided among forest, agricultural, and urban uses.

With respect to water resources, the County includes more than 2,100 miles of streams and rivers. About 46 percent of the land area drains to 3 reservoirs, 2 of which (Loch Raven and Prettyboy) are located

wholly in the County, with the third (Liberty) located on the western boundary with Carroll County. These 3 reservoirs are owned and managed by the City of Baltimore as the drinking water source for 1.6 million citizens in the metropolitan region, including the City, about 90 percent of Baltimore County, and small portions of 3 other counties. Baltimore County's streams and rivers ultimately drain to the Chesapeake Bay, and the County has 175 miles of shoreline along the Patapsco, Back, Middle, and Gunpowder Rivers and other smaller creeks which are sub-estuaries of the Bay (Figure 1).



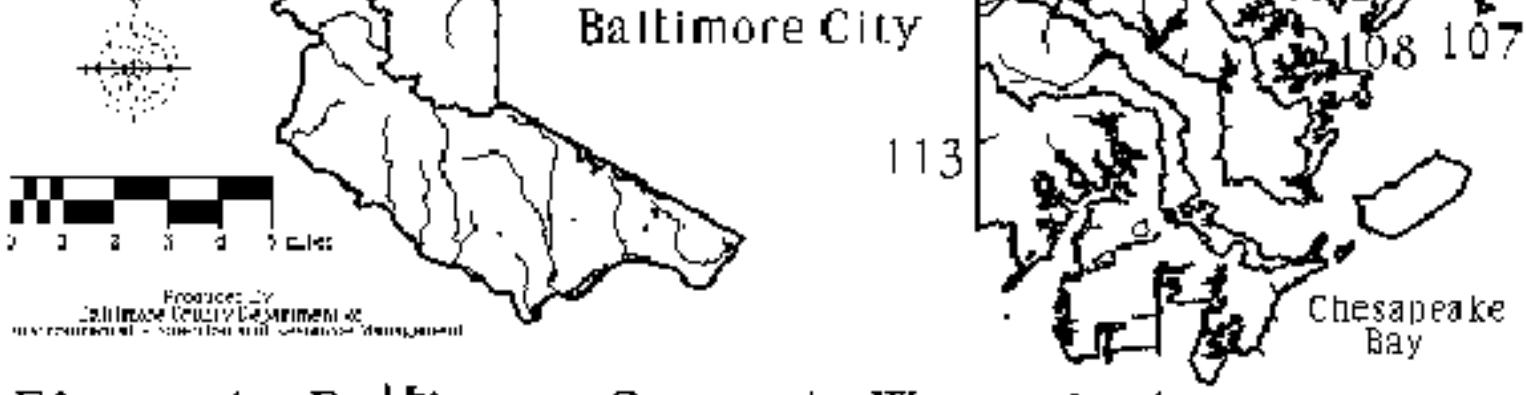


Figure 1: Baltimore County's Watersheds

Watershed Culture

The adoption of a watershed framework to meet recent federal and state mandates and initiatives is not a revolutionary approach for Baltimore County, but rather a new application. As part of the State of Maryland's program pursuant to the 1972 Federal Water Pollution Control Act Amendments, Baltimore County participated in the preparation of the Patapsco/Back River Basin and Gunpowder River Basin Water Quality Management Plans in 1974 and 1977, respectively. These primarily point source efforts were followed by individual plans for extension of sewerage facilities to development in local watersheds. Other watershed plans were prepared by state and county agencies for flood hazard analysis in the 1970s, particularly following the devastation caused by Hurricane Agnes in 1972. Baltimore County later participated in preparation of the Water Quality Management Plan for the Baltimore Metropolitan Region from 1978 to 1980 as part of the section 208 program of the Clean Water Act.

Watersheds were also the focus of a cooperative regional effort following the identification of nuisance algae in the early 1970s in the Loch Raven Reservoir. A Reservoir Watershed Management Agreement was signed in 1979 by the City and Baltimore and Carroll Counties to recommend actions, and was expanded and strengthened in 1984 to establish a continuing program to implement phosphorus reduction measures. The Agreement, which then included the local Soil Conservation Districts and several State agencies, was further expanded and re-affirmed in 1990.

A tradition of response to issues using a watershed framework, or a "watershed culture," also was evident in Baltimore County's growth management efforts. Suburban expansion from the City contributed to an increase in the County's population of about 130 percent from 1950 to 1970. Facing the prospect of development across much of the County and projections of a 1990s population of nearly 1 million, the County embarked on an aggressive growth management program beginning in the late 1960s. The County evaluated its planning and zoning to provide for concentrated, planned growth centers and preservation of the rural expanse across the northern half of the County. In 1975, more than 240,000 acres or 65 percent of the County was down-zoned into four Resource Conservation (RC) Zones. The RC zones account for 87 percent of the 3 reservoir watersheds. The RC-4 Watershed Protection Zone, which includes more than 71,000 acres, has a development density of 1 unit per 5 acres and contains performance standards that limit the amount of clearing for a lot to 25 percent and limit impervious cover

to 10 percent. The watershed culture of the County, focused on protection of the regional water supply reservoirs during the decades of rapid suburbanization, set the stage for more comprehensive initiatives in the following decades.

Early DEPRM Initiatives

In 1987 Baltimore County created the Department of Environmental Protection and Resource Management (DEPRM) to consolidate environmental functions from four departments and initiate enhanced resource management. The watershed approach was developed within DEPRM's Bureau of Water Quality and Resource Management. One early initiative for forested stream buffer regulations was implemented in 1989 and 1991. Codified as "Regulations for the Protection of Water Quality, Streams, Wetlands, and Floodplains," the regulations were enacted to provide protection of the County's streams during the development process, particularly headwater streams.

A second initiative was the creation of a Capital Improvement Program (CIP) for environmental restoration in 1987. With a fiscal year 1988-1993 budget of $6.2 million, the "Waterway Improvement Program" was established to fund the design and construction of shore erosion control projects, stormwater retrofits, and waterway dredging to restore recreational boating access. These latter projects were typically localized and involved the assessment of sediment and nutrient loading to dredged channels and permit conditions for construction of stormwater retrofits or wetlands to help reduce continuing sedimentation of tidal waterways. For the first few years of DEPRM's CIP, primarily local priorities were addressed.

The restoration program especially addressed the fact that 95 percent of the County's population growth, which slowed dramatically to only 11.5 percent from 1970 to 1990, occurred prior to Maryland's programs in the 1980s for storm water management or the protection of resources such as non-tidal wetlands, forests, and the Chesapeake Bay Critical Area. The cumulative result of population growth trends and its growth management program was that Baltimore County protected two-thirds of its land from urban density development, but concentrated some 600,000 people in the remaining one-third of its area. For this area, some of the watersheds were reduced to only 10 to 20 percent forest cover, and many first and second-order stream systems were virtually eliminated. The CIP was an opportunity to begin prioritized restoration of important resource functions.

The Impetus for County-wide Watershed Management

Baltimore County adopted a watershed management framework in the early 1990s in response to federal and State of Maryland water quality mandates and initiatives, each with differing scales of treatment, resource objectives, and time-frames. In 1991 and 1992 the County prepared for implementation of the federally-mandated National Pollutant Discharge Elimination System (NPDES) Storm Water permit program, which applies to all urbanized watersheds of the County. DEPRM also became aware of potential management initiatives under section 6217 of the Coastal Zone Management program, which would have covered the NPDES watersheds as well as rural watersheds due to nonpoint management

measures for agriculture, forestry, and septic systems.

At the same time that the County was applying for its NPDES permit, the State of Maryland launched a major Chesapeake Bay program initiative in 1993, the Tributary Strategies for Nutrient Reduction. This program focuses on reduction of the controllable 1985 loading of nitrogen and phosphorus by 40 percent by the year 2000 and maintenance of nutrient caps for 10 large river basins. Baltimore County comprises part of two of the State's 10 tributaries under this effort, which arose from the 1992 Amendments to the Chesapeake Bay Agreement. After Maryland's counties signed a Partnership Agreement with the State for the Tributary Strategies program, participation was added as a special condition of the local NPDES Storm Water permits issued in 1995.

The County is also participating in special watershed restoration projects, including the Army Corps of Engineers' Baltimore Metropolitan Water Resources Study and the US Forest Service's Revitalizing Baltimore project, both for the Gwynns Falls watershed. These projects involve the participation of federal agencies, State agencies, the City of Baltimore, and citizen group partners. Even smaller watershed restoration efforts, such as that of the Herring Run Watershed Association in the County's Back River watershed, are accommodated by providing some technical assistance, potential capital project funding, and computerized resource management information.

Watershed Management Program Components

An important part of DEPRM's watershed management program involves the use of Geographic Information System (GIS) technology to perform analysis and mapping for environmental data layers. Student interns are routinely used to help build the GIS database. Of special note, stream systems were digitized from 1"=200' photogrammetric maps, allowing scale flexibility through the hierarchical classification of stream segments and watersheds. Fourteen major fifth-order or larger watersheds and about 200 third-order or larger watersheds were delineated. The GIS's capability is enhanced through use of MIPS, Idrisi, MapInfo, and ARC-Info programs. It is accompanied by database tracking of projects and implementation progress for the NPDES, Tributary Strategies, and special watershed partnership projects.

Using selected information about land use, storm water outfalls, and management facilities, the County's 14 watersheds were prioritized for the NPDES Storm Water permit program. The County's program involves preparation of watershed management plans for 3 priority watersheds every two years. For 1995-1996, watershed management plans are to be prepared for the Loch Raven, Back River, and Jones Falls watersheds. The prioritization and two-year cycle were selected to acknowledge the need to implement the program at a scale appropriate for making capital project decisions. For each watershed plan, sub-area assessments and prioritization are conducted by consultant firms. The assessments include water quality conditions, calibrated runs of the Storm Water Management Model (SWMM) to develop sub-area pollutant loadings, and Rosgen-based stream assessments to identify unstable stream reaches and restoration needs. This management plan structure was adapted from a special study of the Bird River watershed completed in 1995. Water quality monitoring is also conducted for the NPDES permit and to

evaluate project effectiveness.

The watershed plans result in prioritized needs for stream restoration and for storm water facilities. Preparation and implementation of watershed management plans are funded through DEPRM's CIP, which was re-structured in 1993 to provide funds for the 14 major watersheds, following the phase-in scheduling. The existing fiscal year 1996-2001 CIP is $23.5 million. Baltimore County's capital program is supported primarily (75 percent) by County General Obligation bonds, with the remaining funds from Maryland General Assembly bond bills for the County and State of Maryland cost share programs. These programs include the Waterway Improvement Fund and the Storm Water Pollution Control and Small Creeks and Estuaries cost-share programs. To date, assessments and project implementation are underway in 8 of the County's 14 major watersheds.

County operating programs, including storm drain inlet cleaning with 3 special vacuum trucks, are also coordinated through the watershed program and help address specific management requirements for NPDES. Citizen involvement programs, including participation in the Tree-Mendous Maryland reforestation program and ambient stream biomonitoring as part of a continuing Citizen's for Stream Restoration Campaign in partnership with Maryland Save Our Streams, are further coordinated through the watershed program.

Summary

Baltimore County's watershed management program illustrates a successful application of the watershed approach for implementing multiple resource management mandates and initiatives. The program is comprehensive and flexible, due to the combined use of regulation, restoration, and education/participation; an established watershed culture; the ability to attract cost-share funding and to enter partnership projects through CIP funding; an agency with an inter-disciplinary "team" structure; integrated GIS capability; and a commitment to fostering effective citizen participation.

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Historical Vegetation Changes On The Edwards Plateau of Texas and The Effects Upon Watersheds

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Spanish Explorations-1675 to 1723

The early Spanish explorers of the Southwest were required by the Crown to keep diaries of their travels (1) Many had more than one diarist accompanying their expeditions to record "the leagues traveled, the mountains, streams, prairies, and woodlands crossed, and the chief characteristics of these natural features of the land (2)" Fortunately for historians and others interested in the early history, geography and natural history of Texas many of these early explorers accurately described the vegetation and wildlife which was found in Texas during early Spanish colonial times.

"The first European explorers of Mexico and Texas came themselves from the high arid plains of Spain where water was more precious than gold." (3) Texas was mapped in 1519 by Capt. Alonso Alvarez de Pineda and one of his unnamed rivers was the San Antonio River. It is unsure as to which Spaniard first camped at the headwaters of the river at the San Antonio springs. Many historians believe that Cabeza de Vaca was the first in the 1520's when he wrote of his shipwrecked adventures and first described the buffalo in writing. Other historians credit Alonso de Leon as the first in 1670. In 1691 the first governor of Texas, Domingo Teran de Los Rios and Fray Damian Massanet, a Franciscan missionary, camped at or near the present day San Antonio springs alongside a village of friendly Indians. Some authors interpret Massanet's diary to actually describe Leon Springs as what he named "San Antonio de Padua" whereas others are sure that they first camped at San Pedro Springs, which are much nearer to the river's headwaters (1) The flag of Spain was raised and the expedition marched eastward on "The King's Road" to the boundary of French Louisiana to expel all foreigners and lay claim to the lands for the King of

Spain. (3)

Thus, San Antonio with its clear, cool, flowing springs and lush river became the most important stopping point for all future expeditions. Spanish expeditions began from various points, but most eventually travelled to San Antonio, known in early days as San Antonio de Bexar. In 1718, nine years after his quest for the establishment of a mission in San Antonio, Father Antonio de Olivares, broke ground for mission San Antonio de Valero. Days later Governor Alarcon of the Province of Tejas founded the Presidio de Bejar (Bexar) and its Villa (3) The first Mission San Antonio was located west of San Pedro Springs, which forms a tributary of the San Antonio River. A year later the mission was moved to a site near its present location, where it remained until destroyed by hurricane floods in 1724 and then moved to its final location on Alamo Plaza. In 1801 the mission was renamed "Alamo" after a Spanish cavalry company from the town of Alamo (which means cottonwood) in Mexico. (3)

Manzannet, diarist on the Teran expedition, described the area explored as very beautiful, having hills with large oaks and easy for travel. He describes a region well-grassed with few oaks and mesquites on the hills and along streams. There were many fish in the streams, chickens (prairie) on the highlands and buffaloes roamed the region. (1)

The Espinosa-Olivaris-Aguirre expedition of 1709 traveled into the present Bexar County through a well-watered route with only the arroyos and creeks being timbered with oaks, mesquites, walnuts, poplars, elms and mulberries. (1) "Espinosa reports on the Ramon expedition of 1716, of travel through hills and dales covered with lush pasturage of very green grama-grass." Only sparse mesquites and some oaks were reported until reaching the various springs, creeks and rivers near San Antonio (1) The Aguayo Expedition of 1720, as reported by Pena, also rode across a " beautiful treeless plain with fertile valleys until reaching San Antonio." Leaving Bexar in 1722, Aguayo traveled thru "a beautiful level country sparsely covered with evergreen oaks." (1)

The Edwards Plateau Region of Texas

The Edwards Plateau region of central and west-central Texas is locally known as "the Hill Country." It is bounded on the east and on the south by the Balcones Fault, which caused a geological uplift known as the Balcones Escarpment. The Plateau's northern edge grades into the Cross Timbers Oak, the Llano Uplift and the north Plains Regions. On the west, the Plateau is bounded by the Rio Grande and Pecos Rivers. The Edwards Plateau consists of 31,000 square miles and ranges in elevation from 1000' msl to over 3,000' msl. Precipitation is 33 inches at Austin in the east down to 15 inches in the west(4). The Plateau is composed of Edwards and Glen Rose limestones with large areas exposed at the surface of this predominantly rangeland region. The shallow calcareous soils are dissected by many canyons along the southern boundary with steep grades and exposed geological strata. Several river systems flow from the region with the Nueces, San Antonio and Guadalupe River basins being the most important. The well known Edwards Aquifer is fed by precipitation and streamflow from the 4,400 square mile Drainage Area which is in 13 counties lying north of the Edwards Recharge Zone (ERZ).

Water entering from the ERZ percolates by gravity through the exposed limestone fractures and pore spaces into the aquifer flowing generally to the southeast. Aquifer flows are from areas where the water levels are at higher elevations to areas where the water levels are at lower elevations (near the major springs.) Caves and sinkholes are very common in this area. The complex geology of the aquifer has produced estimated flow rates ranging from two to 31 feet per day, but local transmission rates of as much as 1,000 feet per day have been recorded. In the Artesian or Reservoir Area of the aquifer, the Edwards limestone is buried between confining formations. The Edwards formation is about 500' thick in this area and slopes downward to about 1000' below the land surface at the southern edge of this zone. The Edwards Aquifer contains many pore spaces and huge underground pools which have often produced wells from 6000 to 7000 gals/min. Prior to well drilling and pumping, there existed a natural balance in the aquifer between recharge and spring flow. Of the five major springs in the region: the Leona (Uvalde), San Antonio and San Pedro (San Antonio), Comal (New Braunfels) and San Marcos, only the later two are now of any significance. Many small springs and creeks in the region are now dry or only flow during very wet years (5).

Early Vegetation of the Edwards Plateau

Some of the common grasses first identified on the Plateau's upland sites were little and big bluestem, Indiangrass, sideoats grama, Canada wildrye, Texas wintergrass, buffalograss, etc. Riparian area grasses included switchgrass, eastern gamagrass, Virginia wildrye, dropseeds and the smaller bluestems. The drier western section grew shorter grasses such as: tabossa, curly mesquite and threeawns, etc.

Trees and shrubs on the Plateau include: many oaks such as live oak, Spanish, burr, shin, blackjack and post oaks; hackberrys and elm; mesquite; junipers ("cedars"--two species), catclaw, yucca, cacti, bumelia, cenizia, mountain laurel and sumacs. The cooler and more moist bottomlands and canyons also contain many eastern species mixed with western plants. Found in these less xeric environments were: pecan, ash, bald cypress, walnut, mulberry, maple, willow, sycamore and cottonwood(6,8).

In scattered sites across the region were found less common plants such as: Texas madrone, hickory and even pinyon pine on many southwestern hill tops. The drier and hotter western Edwards Plateau was home to numerous genera including: opuntia, cholla, ocotillo, saltbush, snakeweeds, acacias, prunus, sacahuista, ephedras, lechuguilla and agarita (9)

The Vegetation Changes-Causes and Results

By 1930, heavy, continuous grazing combined with range fencing and the control of wildfire, greatly reduced growth of the more desirable grasses allowing many shrubs and trees to invade the uplands. What early Texas explorers once had described as "a waving sea of grass, often stirrup-high on a horse or high as a cow's back" deteriorated into the present shortgrass, rock, shrub, cactus and tree dominated landscape. (10) Soil conservation experts estimate that between 1930 and 1995, many tons per acre of valuable top soil have been lost, especially from the steeper and more shallow soiled hillsides and from overgrazed riparian areas. We know from rancher's quotes, historical records and maps that many springs

have dried up, numerous perennial creeks now only flow intermittently and grassland productivity has been drastically lowered. Ranges which once supported from 300-500 cattle per section (640 acres) in the 1860's often are presently recommended to carry no more than 50 animal units per section. (6)

As the more palatable grasses and forbs decreased or even disappeared, many ranchers on the Plateau switched to cattle, sheep and Angora goat operations, often grazing all three types of livestock to better utilize the now dominant shrubby vegetation (6) Unfortunately, little attention was given, and less was known until decades later, concerning desirable proportions of each type of livestock pastured together. This factor, combined with the steady climb of deer herd numbers on the Edwards has caused further range deterioration on much of the region. Range and wildlife management is now often complicated by free-ranging herds of exotic big game animals, which are commonly found across much of the Plateau. Many ranches have several species of exotics-either within game fences or free-ranging (11).

On the Plateau the most prominent and widespread brush invaders are junipers, primarily ashe juniper; liveoak, mesquite, shinoak, and cactus. Ashe juniper, also called cedar, is by far the most common shrub invading the southern and central Plateau. Cedar, a water hog, is very susceptible to killing and long-term control by fire (12, 13, 16). Prior to the brush invasion, dense mid and tallgrass stands slowed runoff, organic matter in the soil enhanced water infiltration allowing rains to rapidly replenish not only the Edwards but other local aquifers as well. Today, runoff erodes bare areas around cedars, biomass intercepts moisture, while dominating the grasses and forbs for space, sunlight and soil nutrients. Many of these evergreen plants transpire year-around, which increases soil water losses. The most valuable product of rangelands is water!! Ideally, rangelands should be managed not only to provide livestock forage, wildlife habitat, and recreational opportunities-but, primarily, to produce sufficient quantities of clean water throughout watersheds. This water maintains creek and river flows and recharges aquifers. If watersheds become infested with heavy water utilizing shrubs and trees, they soon lose the beneficial characteristics so desired by hydrologists (15).

One of the principal net effects of this woody plant invasion coupled with the decrease in herbaceous vegetation, is that less water is available to replenish the Edwards Aquifer--especially during dry years, when little rain runoff is available for groundwater recharge. This is the effect which should be of most concern to not only to the urban users and industry, but also to irrigators, ranchers, wildlife biologists, downstream water users and to the federal courts which are now protecting the Endangered Species in the Comal and San Marcos Springs. Complicating the serious concerns about the Edwards Aquifer's quality and quantity of water, are the 1990 Texas Water Development Board's projections for state's municipal and industrial water demands to increase by 186% by the year 2040 (5).

Texas Research and Demonstrations

While many Texas researchers, agency personnel and ranchers have long been aware of the hydrologic benefits of cedar management upon watersheds of the Edwards Plateau, few definitive studies are available. Research and extension policy has long been slanted towards animal science goals. Now, with renewed emphasis and concerns in the Edwards Aquifer region on aquifer production and quality, new

research is being designed and implemented to address many of the concerns and unknowns affecting watershed management in this area.(14) Some concerns are more urban in nature, such as city zoning, planning and developmental regulations. The San Antonio Water System (SAWS) is directly involved in aquifer recharge zone regulation, as well as in research. New studies have been funded with the USGS to both depict and investigate the surface geology of this critical zone. Another is designed to calculate and predict pollutant loadings of runoff water from selected types of development. Other SAWS studies monitor stormwater quantity and quality across the city and groundwater quality.

Watershed, range and agricultural researchers have also made great advances in recent years. Recent research has shown water savings varying from 30,000 to 160,000 gals/acre/yr. resulting from differing levels of ashe juniper control. Research scientists and extension specialists from the Texas A & M University System at College Station and from the Uvalde, Temple and Sonora Research Centers have improved criteria for watershed management methods with resulting benefits. Ranchers in the region continue to be assisted by Range Specialists with the USDA's Natural Resources Conservation Service (former SCS) in planning and implementing range management alternatives accomplishing the desired livestock or wildlife objectives and improving watershed characteristics as well.

Several large rangeland watershed projects on Texas ranches have aptly shown the hydrologic benefits of planned brush control. One noted example involving the infamous mesquite tree, was the Rocky Creek site near San Angelo. While results were unquantified, springs feeding a long-dry creek resumed flow following shrub management on several ranches in the upper watershed.(14) The author has had identical results from cedar control on the Beal Ranch in the same area, where following control, unknown springs and seeps developed into flows maintaining numerous small ponds. The Bamberger Ranch north of San Antonio had identical results from a planned rangeland recovery utilizing the NRCS's Great Plains Program funding. The Kerr Wildlife Management Area near Hunt, Texas has describedthe mutual benefits of selected brush management using prescribed fire and livestock to improve wildlife habitat, increase Endangered Species numbers and to expand their cattle herd (16).

Texas Tech University scientists evaluated cedar control on several research projects and highly recommended fire as an effective tool (17). On the Annandale Ranch near Uvalde, researchers found water savings of 160,000 Gal/Ac/Yr when all cedar was removed from small watersheds (12). The famous Seco Creek Water Quality Demonstration Project, which lies west of Bexar County astradle the EARZ, has produced excellent results in several water conservation areas including spring development (19). This project typlifies a multiple agency approach to problem solving. The Sonora Center has assessed the impacts of juniper management on water yield (12) with data indicating a major increase.

Summary

- Site hydrology greatly affected by vegetation changes
- Juniper significantly reduces amount and distribution of water reaching the soil
- Juniper out competes herbaceous plants, potentially uses more water
- Combined effects of juniper invasion on rangelands is reduced water yields and herbaceous plant

production, plus wildlife habitat losses (14)

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Implementation of a Watershed Management Plan for Drinking Water Source Protection: A Case Study

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Introduction

The purpose of this paper is to present a "utility perspective" on the value of implementing a Watershed Management Program for drinking water source protection. It is intended to demonstrate the importance of a Watershed Management Program in managing a raw water supply and in determining methods to protect and enhance the quality of water produced in the watershed area for drinking water purposes by developing a baseline of water quality data that will serve as a standard with which to compare future water quality and by addressing the management of natural, cultural and biological resources of the watershed area and its 6.0 billion gallon reservoir. Regulatory agencies have set finished water standards at levels that utilities may find difficult and expensive to meet. This problem could worsen in the near future if these standards are tightly sharpened. A reservoir-watershed monitoring program is essential to the proper operation of a surface drinking water supply, even if no finished water quality problems are presently perceived. Therefore, it is the thesis of this paper that reservoir/watershed protection and restorative methods can provide a valuable supplement to in-plant operations. A policy for the management of the watershed and reservoir area, established by a thorough and regular stream and reservoir monitoring program to assess the reservoir's condition, anticipating timely and appropriate watershed and in-reservoir management and restorative strategies, will enable water plant operators to predict changes in reservoir water quality. If raw water quality is improved, then the costs of in-plant treatments may be reduced and their effectiveness increased.

Background

The Harrisburg Water Treatment Facility (HWTF) receives source water from an impoundment reservoir supplied by water from Clark's Creek and 23 minor tributaries, and from the Susquehanna River. The system consists primarily of the DeHart Reservoir, the impoundment which provides water via a 42" transmission line to the Robert E. Young Water Filtration Facility. In addition, an intake located in the Susquehanna River is connected to a pumping station, which pumps river water to the filtration facility. In the recent past, the HWTF completed construction of the 20 MGD Water Filtration Facility in an effort to meet the filtration requirements of the Safe Drinking Water Act (SDWA) and to meet anticipated increases in demand for drinking water in the City of Harrisburg area.

Prior to 1994, the source of the system consisted solely of the DeHart Reservoir and treatment facility. Concerns that led to the construction of the new facility in 1994, included the fact that the DeHart source was unfiltered and that demands on this supply may exceed its yield. In addition, low alkalinity and low pH in the DeHart source resulted in aggressive water creating elevated iron and manganese levels at dead ends in the distribution system. Infrequent algae on the reservoir may have contributed to taste and odor complaints, however, the source of the complaints and the type of algae was not documented. Operators simply added approximately 8 pounds per year of copper sulfate to the reservoir in anticipation of the growth of algae.

In 1994, the DeHart Superintendent's responsibilities were modified to include Watershed /Reservoir Management. Up until this time, there was not a watershed protection plan in place other than protection of the water resource by routinely patrolling the reservoir and restricting the area to trespassers.

Description of the DeHart Reservoir and Watershed

The DeHart Reservoir and Watershed area (refer to Figure 1 (343K)) is located 20 miles northeast of the City of Harrisburg on PA Route 325 and impounds water flowing through the valley in Clark's Creek and twenty-three (23) smaller tributaries producing an impoundment of water that when full is 4.55 miles long and contains about 23,000 acre feet of water, or approximately 6 billion gallons of water. The reservoir drains an area

of 21.62 square miles of which 90% is forested, 5% is residential and 5% is owned and managed by the PA State Game Commission. The Harrisburg Authority owns 8,600 acres of the watershed area. The DeHart Reservoir is closed to the public and used solely as a source of drinking water. The watershed area is open to hunting and receives heavy pressure from fisherman, however, no other recreational uses are allowed. In 1994, a Forest Management Plan was prepared for 1/2 of the watershed area, which reported stands of timber that included valuable species of oak. The watershed lies in an area surrounded by 43,000 acres of State Game Lands and is one of the few unbroken tracts of forestland remaining in the central area of Pennsylvania.

Preliminary analysis of the water quality in DeHart Reservoir and Clark's Creek, along with investigation into historical water quality information shows the source tends to be acidic with very low alkalinity. Stratification occurs near the intake area at a depth of approximately 30 feet in late summer. There seems to be little observable species diversity, i.e., zooplankton, fish, aquatic plants, and algae; although Clark's Creek has shown the capability of supporting stocked species of brown trout that grow to a reported weight of 9 pounds. Heavy metals appear to be concentrated in the hypolimnion and the sampling has shown the reservoir to have acceptable levels of transparency, hence the reservoir does not appear to be highly productive.

Water Quality Protection Planning Approach

The development of a source protection plan for the DeHart Reservoir and Watershed Area consists of five principal component parts: (1) scoping, (2) watershed analysis, (3) a monitoring program for the reservoir and watershed, (4) selection of appropriate control measures to protect water quality, and (5) source protection plan implementation. These are briefly described as follows:

1. Scoping: Scoping establishes the breadth and depth of problems that may result from certain types of land uses. This takes into consideration the concerns of the utility in providing a safe drinking water source. Perhaps no issue has been of greater concern to the drinking water treatment industry than the issue of the generation of trihalomethanes (THMs). THMs appear in the water when chlorine is added to the raw drinking water that includes certain organic molecules, primarily humics. These organic molecules, called THM precursors, appear to originate mainly from terrestrial and aquatic vegetation. (Reference 1). Some of the other concerns that needed to be addressed include: iron and manganese control, algae control, the cause of apparent lack of biodiversity, timber resource management, the trophic (productivity) state of the reservoir and protection of the watershed from human activities in an effort to prevent contamination.

2. Watershed Analysis: A Watershed Analysis is used to inventory and characterize the watershed area in terms of its physical characteristics, land uses, ownership and water quality. In addition, potential contaminants of concern, their sources and their rates of generation are identified in this stage.

3. Monitoring: A monitoring program for the reservoir and watershed area has been established to begin to provide a database for the analysis of water quality in the reservoir. This analysis is used to address concerns listed in the Scoping stage and to develop the Watershed Management Plan. Once the Watershed Management Plan is implemented, the data is used to monitor and evaluate the effectiveness of the source protection program.

   A description of the monitoring program developed and initiated for the DeHart Reservoir and Watershed Area is listed in Table 1. Results of monitoring of temperature and dissolved oxygen for the first year are listed in Table 2. In addition, treatment plant records were examined to determine historical and current levels of treatment chemical use as an estimate of long term changes in water quality and the costs of maintaining water quality standards. Future plans include collecting data on those inorganic and organic chemicals for which monitoring is required under the SDWA and its amendments. The monitoring program described here is fairly representative of most diagnostic programs with some adaptations made to target the particular concerns of the HWTF. The information is loaded into a computer program such as Microsoft Excel or Lotus 1,2,3 in an effort to record, analyze and display the information. The monitoring program is an ongoing part of the Source Protection Plan. Information from this program is used to make operational adjustments, and once enough data has been collected, to develop source management strategies.

Table 1. Database development for DeHart Reservoir

Reservoir Ñ 4 Sampling Sites Ñ Frequency Ñ 2 Times per Month (as conditions allow)

One per Station	Sampled Every Meter	Sampled at Top, Bottom and Middle Depths		Sampled at 4 Times/Year Station
Air temperature Transparency Vegetation Weather	Dissolved Oxygen Profile Temperature Profile	Total Dissolved Solids pH Conductivity Alkalinity Ammonia Total Organic Carbon Orthophosphorus Total Phosphorus	Nitrite Nitrate Ferrous Iron Manganese Copper Aluminum Hardness Bacteria	Algae Identification & Quantification Chlorophyll a Zooplankton

Daily Readings (at DeHart Facility)

Rainfall (inches)
Precipitation pH
Weather
Air Temperature
Total Water Delivered
USGS Gaging Station Level
Reservoir Level
Chemicals Used
Time
Date

Watershed Sampling Program

Location: Clark Ds Creek, 6 stations
Frequency: One sample per station per week
(as weather conditions allow)

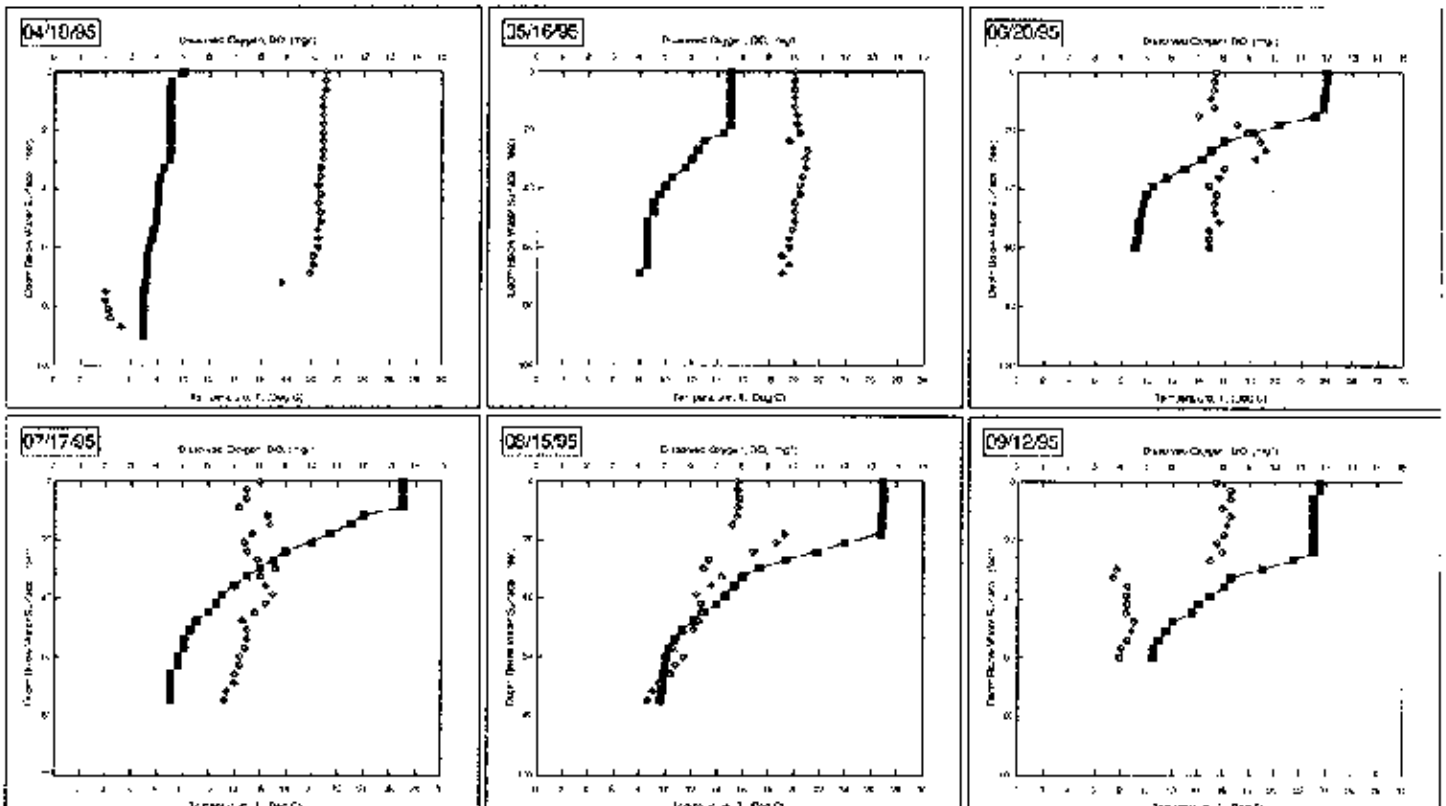
Stream Velocity
pH
Total Dissolved Solids
Conductivity
Dissolved Oxygen
Air Temperature
Water Temperature
Nitrates

Total Phosphorus
Ammonia
Fecal Coliform

Exhibit

CITY OF HARRISBURG
WATER TREATMENT FACILITY

Temperature and Dissolved Oxygen at Various Depths in the DeHart Reservoir
Station 1



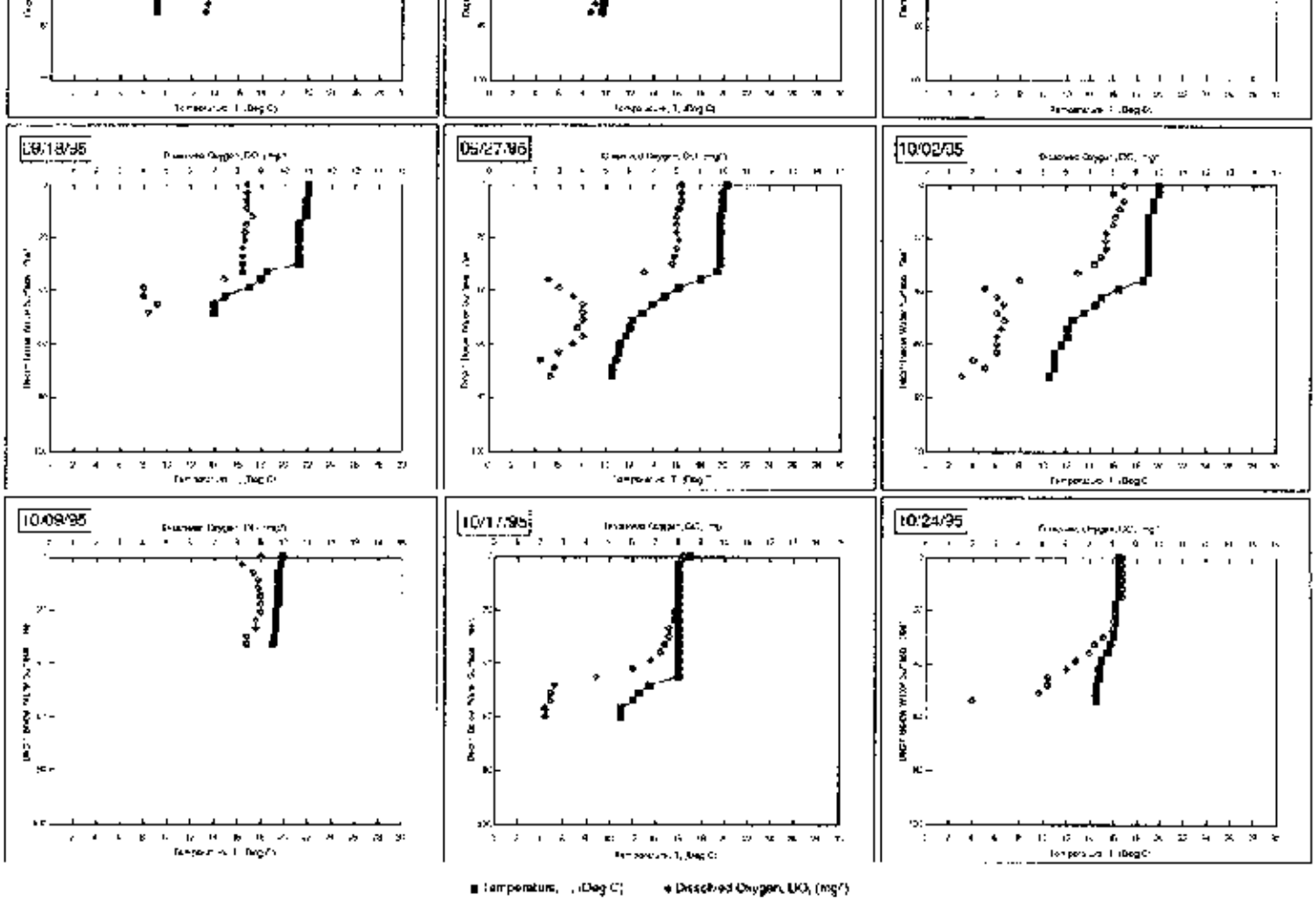


Table 2. Temperature and dissolved oxygen at various depths in the DeHart Reservoir (Station 1).

4. Select appropriate control measures to protect water quality: In the case of the DeHart Watershed area, land use and ownership are optimal in that the majority of the land is owned by either The Harrisburg Authority and managed by the City's Water Bureau, or by the State Game Commission, allowing for either direct control by HWTF or control measures implemented through cooperative agreement with the State's Game and Fish Commission's. The majority of the land is forested which, compared to other land uses, contributes the least amount of potential contaminants. Some contaminants are associated with forestry practices such as: turbidity, sediment, nutrients (which can lead to algae production), bacteria, THM precursors, pesticides and the presence of iron and manganese.

   One of the several control measures being explored to address the potential of pollution from these contaminants is the preparation of timber harvest management plans that considers the timber harvest sales to increase the quantity of water in the watershed area while preserving or, possibly, enhancing the water quality of the reservoir. Timber harvest sales are set up by a forestry consultant through the preparation of a timber harvest plan and include the preparation of erosion and sedimentation control plans, the proper location of skid trails and water bars, the selection of trees to be harvested, including the removal of lower value timber in an effort to enhance the growth of more desirable timber that is allowed to remain, and post-timbering inspections to ensure the regeneration of the forest stand and the maintenance of erosion control measures. In addition, timber harvest sales, if properly planned, provide potential revenue to The Harrisburg Authority and increase the value of the timber resource in the watershed area.

   The potential benefits of other control measures that may be considered include examples such as: pH control in the watershed area by stream dosing with lime, bioremediation, improved communications with cooperating agencies, and sediment removal to increase reservoir capacity. One control measure, reservoir depth selection, has already been successfully utilized in the first year to completely eliminate the use of copper sulfate by lowering the raw water intake level to below the uppermost stratified area, reducing the intake of algae and lowering the turbidity of the raw water delivered to the treatment plant. This has already shown a decrease in the cost of chemicals such as copper sulfate, alum, and disinfection, which can lead to the formation of THM precursors.

   In the future, capability will be developed to use "real time" water quality information to make determinations as to times, zones and depths of optimal water quality within the reservoir. This information will also help to control taste and odor problems associated with algae by predicting blooms and, as a result, manipulation of the water intake depth rather than rely solely on the application of copper sulfate to the reservoir. Drawing off of these depths will then help reduce the costs of chemical treatment at the Harrisburg Water Treatment Facility while still meeting water quality standards.

5. Source Protection Plan Implementation: As shown above, some parts of the DeHart Watershed Management Plan are already in the stages of implementation. With further monitoring and data analysis, areas of improvement of the water quality will be identified and control measures will be evaluated to meet water quality standards. In addition, the information gathered will be used to evaluate existing controls and to propose new controls. For example, one possible aspect that could be explored is policy decisions such as public use or land acquisition. The Plan is flexible in that it allows for re-evaluation based on data gathered and on any new circumstances that may arise.

Conclusions

A water quality protection plan should provide feasible and effective solutions to managing the quality of reservoirs. The concepts used to develop the Watershed Management Plan for the DeHart Reservoir are directly applicable to other lakes and reservoirs. As it becomes more difficult to develop new sources, and as SDWA restrictions become more stringent and demands for existing supplies increase, it will become imperative to manage and protect our existing raw water supplies more intensively. A source protection plan should be considered a basic reservoir management tool, and an essential part of the surface drinking water treatment process.

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Reservoir Watershed Protection: A Voluntary Interagency Agreement to Protect Sources of Drinking Water for Metropolitan Baltimore

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Few resources are as important as our sources of drinking water. The Baltimore Region has been fortunate in having an excellent metropolitan water supply system. Protection of our source of drinking water is vital to the future of the Baltimore region. The Reservoir Watershed Protection Program is a voluntary, interagency partnership established by the 1984 Watershed Management Agreement. The purpose of the Program is to improve the quality of water feeding into the reservoirs. This paper traces the history of this program, highlights its accomplishments and future challenges, and offers a few tips for other communities considering voluntary reservoir watershed management programs.

Reservoir Watersheds

Three reservoirs_Loch Raven, Prettyboy and Liberty_and their watersheds provide water for over 1.6 million people living in Baltimore City and five suburban counties. Baltimore City owns and manages the reservoirs and is responsible for the quality of water delivered to customers. Reservoir drainage areas extend over 466 square miles and include large portions of Baltimore County and Carroll County. (See Figure 1.) Land within the watersheds is used for a wide variety of purposes ranging from farmland and rural residential communities, to small towns and villages, to intensive commercial and office development. Over 60,000 homes, thousands of businesses, and hundreds of farms are located in the watersheds. About half of the homes in the watershed depend on individual wells and septic systems. The other half are served by public water systems and sewerage infrastructure_including pipes and pumping stations. Baltimore City-owned municipal watersheds and reservoirs cover 38 square miles_only 8 pecent of the total watershed. Streams feeding the reservoirs include some of the best trout streams on the East Coast, and others that have been severely degraded by streambank erosion, sediment, and runoff.

Pollution problems in the watersheds became apparent during the 1970s and early 80s. In the early 70s all three reservoirs were found to be in various states of eutrophication. Algal blooms associated with eutrophication were causing water treatment problems and were adversely affecting the taste and odor of the drinking water. In the late 1970s, studies conducted by the Johns Hopkins University concluded that, like parts of the Chesapeake Bay, algae in the reservoir are phosphorus limited. Phosphorus from sewage treatment plants, agriculture and urban development was causing excessive growth of algae. Sedimentation rates were high. Coordinated action had to be taken to correct the problems and to establish the basis for continual, long-term improvement in water quality in the reservoirs.

Reservoir Watershed Management Agreement

These concerns led to the first Reservoir Agreement in 1979. In 1984, a strengthened Reservoir Watershed Management Agreement was agreed upon. It has two goals:

1. ...prevent increased phosphorus and sediment loadings in all three reservoirs, and
2. ...reduce phosphorus loadings in Loch Raven, Liberty and Prettyboy Reservoirs to acceptable levels as soon as possible (...to levels that are not likely to cause algal blooms)

The Agreement and its related "Action Strategy" have provided a cooperative framework for improving the quality of waters feeding into the reservoirs. Signatories are:

- Baltimore City
- Baltimore County
- Carroll County
- Maryland Department of Agriculture
- Maryland Department of the Environment
- Baltimore County Soil Conservation District
- Carroll Soil Conservation District
- Baltimore Metropolitan Council (BMC)
- Water Quality Coordinating Committee

Most of the reservoirs' drainage area is located in Baltimore and Carroll Counties. The Maryland Departments of the Environment and Agriculture administer state regulatory and assistance programs critical to watershed improvement. Two soil conservation districts provide direct water quality and soil conservation services to farmers and residents in the watersheds. Although not signatories to the Agreement, Anne Arundel, Harford and Howard Counties have agreed to participate in the Program because, as users of reservoir water, they also are stakeholders in its quality.

Reservoir Watershed Protection Program

The Agreement put in place the Reservoir Watershed Protection Program, a voluntary partnership among

participating organizations. Each organization exercises its own authority and leadership in implementing components of an agreed-upon "Action Strategy." Top Executives approved the Agreement and related Action Strategy. Oversight and policy guidance is the responsibility of the Reservoir Watershed Protection Subcommittee. The Reservoir Technical Group of water quality staff from participating organizations coordinates implementation of the Action Strategy and guides technical work in support of the Program. Each year the Subcommittee reviews progress in implementing the Action Strategy and, pursuant to the Agreement, issues an Annual Report which describes reservoir conditions and trends, and summarizes progress in implementing each item in the Action Strategy. The Baltimore Metropolitan Council serves as convener and facilitator of the process, provides technical support, coordinates preparation of the draft Annual Report, and conducts public awareness efforts in support of the Reservoir Watershed Protection Program. BMC's work is funded by contributions from each of the six participating jurisdictions. The amount is determined by how much water from the system is used by each jurisdiction.

Action Strategy

The Action Strategy includes specific management actions in the following categories:

Water Quality Monitoring. Water quality monitoring is a critical component of the Action Strategy. Beginning in 1981, the Baltimore City Water Quality Management Office (WQMO) initiated stormwater monitoring at key tributaries feeding the reservoirs. The resulting data are used to estimate phosphorus loadings and their sources, and to relate these to conditions in the reservoirs. The WQMO also monitors in-lake conditions within the three reservoirs. A large body of water quality data has been collected and is being used to monitor conditions and analyze trends, and to focus management efforts on critical issues and practices. Periodically, the WQMO issues a Water Quality Progress Report summarizing current findings which is included in the Action Report for the Reservoir Watersheds.

Point Source Management. Point Sources (effluent from pipes) are regulated mainly by the Maryland Department of the Environment.

Nonpoint Source Management. Nonpoint sources of pollution are extremely complex and very difficult to control. The Action Strategy has identified specific action items in the following areas: agricultural practices, stormwater and sewerage infrastructure, septic systems, planning, zoning and development, municipal watersheds, and resource conservation.

Reservoir Watershed Protection Program Coordination and Support. This category includes the work of the Subcommittee and Reservoir Technical Group, technical support by BMC, and coordination with related watershed program by state and local governments. Members of the Reservoir Technical Group are active on two of Maryland's tributary strategy teams formed to implement the Chesapeake Bay nutrient reduction and tributary strategy goals.

Public Awareness. Realizing the critical importance of voluntary efforts of individuals in improving_or degrading_waters feeding into the reservoirs, we recently initiated a public awareness campaign in

support of reservoir watershed protection. The campaign was designed by Save Our Streams under contract to BMC. The first step was a telephone survey of reservoir watershed residents done in collaboration with the Schaefer Center for Public Policy. Planned in consultation with the Reservoir Technical Group, the survey provides a wealth of information on the current state of awareness, attitudes and behavior of watershed residents in matters affecting reservoir water quality. In collaboration with Baltimore and Carroll County Public Schools, a Reservoir Watershed Protection is being developed. Designed by and for teachers, it includes field studies at reservoir sites, staff development, and is now being used in middle and high schools in these two large school districts. We have piloted public workshops and displays on reservoir watershed protection in collaboration with Save Our Streams and others. We are continually working to determine how best to reach and motivate individuals to take responsible actions in reducing pollution in the watershed. We are very grateful to the Chesapeake Bay Trust and EPA's Environmental Education Program for assistance in funding these efforts.

Results and Future Challenges

The Agreement and related "Action Strategy" has provided a sound framework for improving the quality of waters feeding into the reservoirs. Numerous actions, taken by signatory agencies and summarized in annual Action Reports, have reduced pollutants entering the reservoirs. Some projects have been completed, many point sources eliminated, and some nonpoint sources reduced. Other projects are ongoing. Water quality trends in streams feeding the reservoirs, despite the inherent variability associated with hydrological phenomena, show that the trend in total phosphorus loads into Liberty Reservoir is downward. No clear downward trend is evident in streams feeding Loch Raven and Prettyboy Reservoirs. Nitrate concentrations, however, are trending upward_a disturbing trend. Future challenges include the continuing suburbanization in the watersheds; maintaining sewerage infrastructure; implementing management practices that are more effective in controlling eutrophication in the reservoirs; giving more attention to issues related to toxics, pathogens and disinfectant by-products; securing funds for implementation; and expanding our public awareness efforts.

Tips for Other Organizations Considering Reservoir Watershed Protection

Work with top executives in State and local government when putting a program together. Make sure they have a key role in the Program. Include elected officials. Make sure to involve the key public agencies. Carefully identify and involve key stakeholders in your program. Form partnerships and alliances with other organizations. Work toward a culture of cooperation. Establish clear long-term goals. Work toward those goals by accomplishing short-term tasks. Establish an open process and involve the public. Develop a public awareness marketing plan and use survey research to determine target audiences. Piggy-back on fairs and other public gatherings with displays and information on reservoir watershed protection. Take a comprehensive approach in developing your "action strategy." Establish an agreed-upon funding mechanism to provide program and technical support. Make sure you have a high-quality ongoing monitoring program in place. It is crucial in focusing your program on relevant issues.

Take the first step! The future health of your source of drinking water depends on

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Point-Nonpoint Pollutant Trading Study

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In the spring of 1993, the New England Interstate Water Pollution Control Commission through a grant from EPA, together with the City of Stamford, Connecticut, and CH2M HILL funded a two-part study of nitrogen reduction techniques in Stamford, Connecticut, as part of the Long Island Sound Action Plan Demonstration Project. The City of Stamford is located in the southwestern corner of Connecticut, on the northern bank of Long Island Sound. The first part of the study involved the operation of a 0.3-million-gallon-per-day biological fluid-bed denitrification reactor to reduce the total effluent nitrogen at the Stamford, Connecticut, Water Pollution Control Facility (WPCF) to very low levels, 3 to 5 milligrams per liter. The second part of the study involved assessing point-nonpoint source trading potential in the Stamford area by comparing the effectiveness of reducing nonpoint source nitrogen loads with point source nitrogen loads to Long Island Sound. The subject of this paper is the second part of the study, the assessment of point-nonpoint source nitrogen trading.

The study area, shown in Figure 1, consists of the urban coastal area of Stamford and two watersheds, the Rippowam River Watershed and the Noroton River Watershed. All areas drain to Long Island Sound. The Stamford coastal area encompasses approximately 7 square miles of 100 percent sewered area. The watersheds encompass 35 square miles and cross political boundaries, intersecting the towns of Stamford, Darien, and New Canaan, Connecticut, and Westchester County, New York. Land cover in the watersheds is approximately 50 percent urban and 50 percent wooded and includes a small amount of agricultural terrain. Approximately 20 percent of the watershed area has sewers.

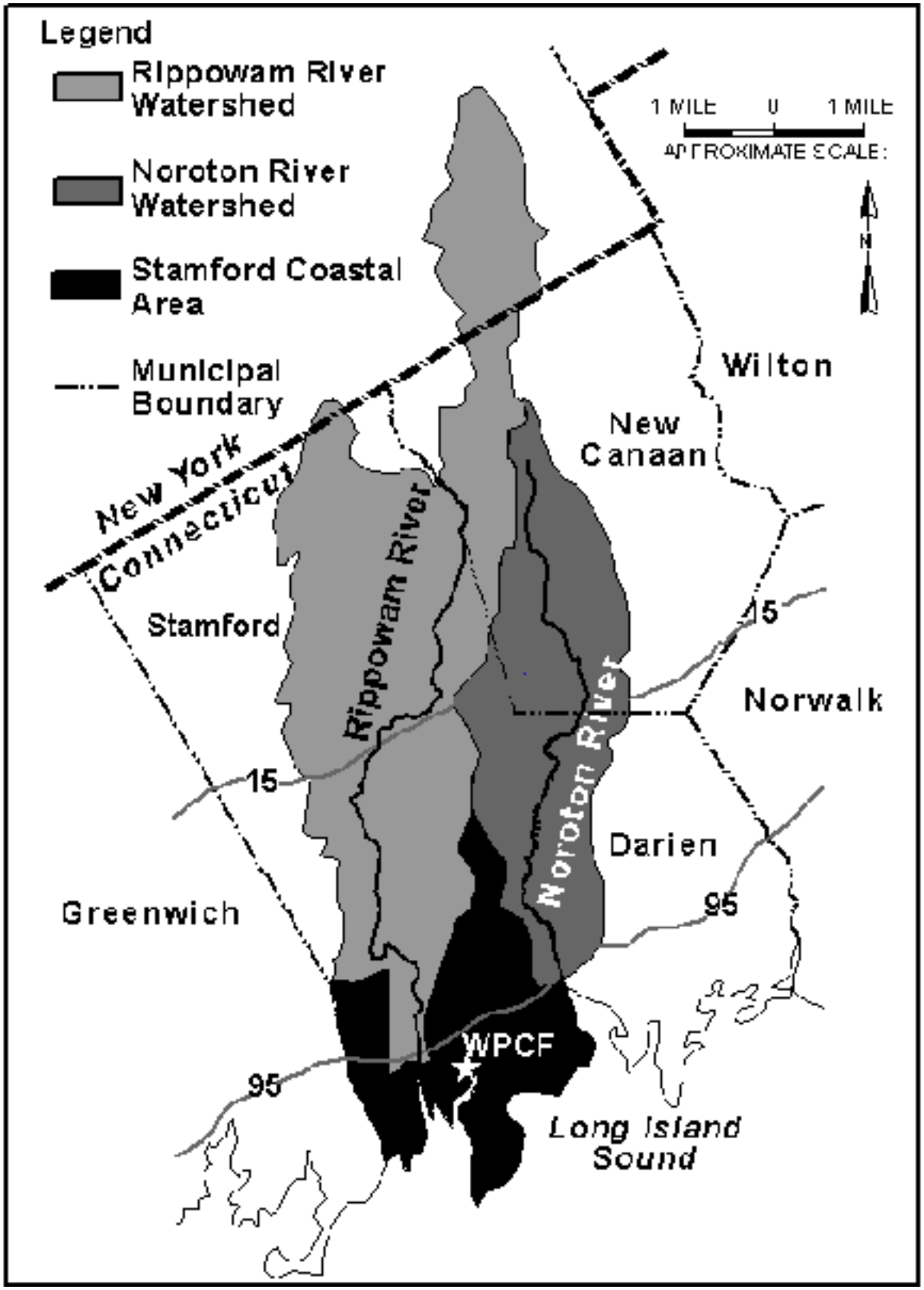

Figure 1. Study area.

The trading concept in the context of the study focused on the cost-effectiveness of reducing nitrogen loads through nonpoint source controls versus point source controls within the study area. As part of the study, nitrogen loads from various towns in the watersheds were also identified to demonstrate a potential for a town to pursue nitrogen controls for the watershed and to receive "credit" for reducing the nitrogen load above its contribution.

The assessment of point-nonpoint nitrogen trading included the following approach:

- Identification of point and nonpoint nitrogen sources.
- Development of point and nonpoint source nitrogen loads.
- Comparison of point and nonpoint source loads.
- Comparison of strategies for point and nonpoint source control.

Identification of Point and Nonpoint Nitrogen Sources

Nitrogen is introduced and transported through the watersheds and to the Rippowam and Noroton Rivers through a variety of sources that can be principally categorized as follows:

- Surface nonpoint sources related to land cover and land use.
- Groundwater and soil nonpoint sources related to septic systems.
- Point sources (direct discharges).

Data on nitrogen sources in the study area were obtained from the City of Stamford and from the Connecticut Department of Environmental Protection's Geographic Information System (GIS) database.

Development of Point and Nonpoint Source Nitrogen Loads

Nitrogen export coefficients for Long Island Sound (lbs/acre/year) were previously estimated (Frink, 1991) by measuring concentrations of nitrogen in 33 lakes in Connecticut and relating the measurements to the land use in their watersheds. These coefficients included both the surface and subsurface nitrogen load. Therefore, in unsewered areas nitrogen loads were developed by applying mean annual nitrogen export coefficients, as developed by Frink, to acreage's of urban/suburban, wooded/parkland, and agricultural land cover.

Nitrogen loads in sewered areas were developed by subtracting the septic load from the mean annual nitrogen export coefficient developed by Frink. The nitrogen load from septic tanks was based on extensive groundwater sampling data available from the City of Stamford and USGS baseflow data for the Rippowam and Noroton Rivers. The river baseflow data were multiplied by the groundwater nitrogen concentrations to calculate the groundwater nitrogen contribution to the surface water. New mean annual nitrogen export coefficients were developed for sewered areas.

Information on potential point sources of nitrogen was obtained from the GIS database, including the location, a short description of the site, and whether the site is an active or inactive discharge location. Potential nitrogen loads were developed directly from site data or, if no data were available, from values in the literature (Lu et al., 1985).

Data on future development that may affect the loading rates from both nonpoint and point sources were also integrated but found to be not significant.

Comparison of Point and Nonpoint Source Loads

A spreadsheet model was developed to calculate and compare the nitrogen loadings from the various sources in the Rippowam and Noroton River watersheds. As a result, the most significant contribution, approximately 134,000 lbs/year of nitrogen, is from nonpoint sources in the watershed. Of that total, approximately 108,000 lbs/year were estimated from unsewered areas (i.e., septic systems) and the remaining 26,000 lbs/year were estimated from sewered areas, predominantly surface runoff. Only 520 lbs/year were estimated from point sources in the watershed. The effects of future development were not significant.

The loads for the two watersheds were then compared with the point source nitrogen load of the Stamford WPCF and the nonpoint source nitrogen load of the urban coastal area surrounding the plant. The comparison of the nitrogen load from the Stamford coastal area and by town within the watersheds is provided in Table 1.

Table 1. Comparison of Nitrogen Load by Town.
Nitrogen Load (lbs/yr)

Rippowam and Noroton River Watersheds						
Nitrogen Load Source	**Stamford**	**Darien**	**New Canaan**	**Westchester Co.**	**Stamford Coastal Area**	**Total**
Nonpoint Surface Groundwater/Soil Unsewered	67,700	5,010	28,900	6,700	29,800	138,000
Nonpoint Surface Groundwater/Soil Sewered	18,800	4,850	1,970	0	--	25,600
Point Source	520	--	--	5	473,270 (1)	473,800
Total	**87,000**	**9,860**	**30,900**	**6,700**	**503,100**	**637,500**
Percent of Total Load (2)	14%	2%	5%	1%	79%	--
Acres	12,820	1,740	5,260	2,305	4,610	26,735
Percent of Total Area	48%	6%	20%	9%	17%	--

(1)The significant component of this load is the Stamford WPCF, which receives wastewater from the towns of Stamford and Darien.

(2)Percent of total load > 100 percent because of rounding.

As shown in Table 1, the Stamford WPCF under its current operation by far contributes the greatest nitrogen load within the study area to Long Island Sound, approximately 470,000 lbs/year. The nonpoint source nitrogen load from the urban coastal area was estimated to be approximately 30,000 lbs/year.

Comparison of Strategies for Point and Nonpoint Source Control

Control strategies for nonpoint sources were evaluated to compare the costs of reducing nitrogen from nonpoint sources with the strategy being developed under the second part of the study for reducing nitrogen at the WPCF.

Controls for groundwater nonpoint sources of nitrogen (i.e., septic systems in the study area) were reviewed. Nitrogen removal efficiencies of an anaerobic upflow filter, recirculating sand filter, and constructed wetlands vary in the literature from 60, 65, and 90 percent nitrogen removal, respectively (U.S. EPA, 1993). Costs for the various controls varied from $10 to $55 per pound of nitrogen removed. Although it is unlikely each unsewered household would retrofit an existing septic system to provide additional nitrogen removal, it is possible that some existing and new developments could provide additional treatment. At the time of the study, the nitrogen removal potential related to reduction of the subsurface nitrogen load was unknown.

Surface controls for nonpoint sources that were reviewed included pollution prevention programs and detention basins and infiltration areas with and without vegetation. Although information was collected related to the types of pollution prevention programs in place in the various communities, no information was available to quantify the cost-effectiveness of the pollution prevention programs or to determine the amount of nitrogen reduction achieved by the programs. Pollution prevention programs implemented in the various towns included street sweeping, catch basin cleaning, erosion control, and litter control. As a result, the surface nonpoint source controls focused on the potential application of detention basins and infiltration areas.

The GIS database was used to identify potential sites for nonpoint source controls and to develop estimates of nitrogen reduction for the various control sites. Nitrogen removal effectiveness of these controls varied in the literature from 10 to 90 percent depending on the quality of the site selection for the particular technology application (Griffin, 1993). Costs for the detention and infiltration basins ranged from approximately $110 to $130 per pound of nitrogen removed. Assuming a few sites are potentially suitable for surface nitrogen removal results in about a 5 percent reduction in the total nitrogen load of the watersheds.

The cost-effectiveness of pollution prevention programs for nitrogen control requires further study. Pollution prevention programs may be the most appropriate nitrogen controls in areas where land is scarce or unsuitable for other controls.

Under the second part of the study, strategies to reduce the nitrogen load in the WPCF discharge to long Island Sound were being pilot-tested. At the time of the study, it was estimated that approximately 50 percent of the nitrogen load could be removed at a cost of $1 per pound of nitrogen removed, resulting in the most cost-effective method for reducing the nitrogen load to Long Island Sound within the study area (CH2M HILL, 1993).

Conclusion

Through this study, a methodology was developed to identify nitrogen sources, develop nitrogen loads, and identify nitrogen control strategies within the study area. The methodology can be easily expanded to include other watersheds and towns and is best used to identify where nitrogen control may be cost-effective. Conclusions from the study follow:

- The study identified the WPCF, septic systems, and urban surface runoff as the most significant sources of nitrogen pollution in the study area.
- The effectiveness and cost of nitrogen controls is very site-specific.
- Controlling nitrogen at the WPCF is a cost-effective alternative for the study area.
- Appropriate siting, operation, and maintenance of a nonpoint source control alternative in an ideal setting can provide significant removals.
- Pollution prevention programs need to be documented and monitored to determine their cost-effectiveness in reducing nonpoint source pollution.
- Pollutant trading credits could be available for collecting and treating a significant percentage of the nitrogen pollutant load of the study area.
- Study area boundaries need to be expanded to investigate the potential for pollutant trading among towns.

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European Experience with Decision Support Systems for Watershed and Basin Managers with Implications for the U.S.

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The Danube Emissions Management Decision Support System (DEMDESS) is an approach to managing water quality that centers on a PC-based data integration and modeling tool. The U.S. Agency for International Development (USAID) has sponsored DEMDESS development and institutionalization in the Danubian countries of Bulgaria, Hungary, Romania, and Slovakia since the winter of 1991. Figure 1 shows a map of the region. Assistance to Poland began in 1993. USAID's goal was to assist countries in Central and Eastern Europe (CEE) with water quality and pollution management decision making.

DEMDESS started with experience gained in the U.S., especially lessons from the success of the U.S. EPA's STORET and Reach Files. The first phase emphasized the development of an "Initial DEMDESS" and building of the institutional support. The second phase emphasized training and technical development. The third phase was targeted at strengthening specific aspects of the decision process within DEMDESS, in direct response to host country needs.

My work in Central and Eastern Europe provided a unique laboratory for development of a systematic approach to integrated decision support systems for basin planning. The CEE countries are in a unique position in history. They are undergoing complete political and institutional change, which opens them up to new ideas and approaches. Also, they have excellent basic technical capabilities in engineering and science. The major problem has been a "disconnect" between decision making and technical capabilities; decisions have emanated primarily from high-level political positions often without regard for technical merit.

Figure 1. Danube Basin.

Based on these experiences, I would like to highlight five major lessons that are applicable to watershed planning and management programs in the U.S.:

- *Place equal emphasis on institutional and technical issues.* The best approach is to work the institutional and technical factors in parallel, letting the technical solutions support the institutional considerations. This is accomplished by including the following elements in the program:
    - *Engage the decision makers* in the process from the beginning. Seek their advice, support, and guidelines throughout the process. Be sure to keep them engaged!
    - *Include training and institutional capacity-building* in the program. Training should start early on, and be sure the institutions have the capacity to use and support the system.
    - *Regular system "marketing" and outreach activities* (demonstrations, meetings, etc.) will build and maintain support for the program.
    - *A multi-disciplinary team approach* works very well at properly addressing the many objectives of a watershed management system. The first phase of DEMDESS was carried out by such a team, which included engineers, an institutional analyst, a training expert, an economist, and myself, a systems analyst/modeler.
- *Build the DSS "on top" of the existing routine administrative systems.* There are three "layers" of DEMDESS functions. The first layer is the central data bases, drawn from the existing systems

and models. The second layer is integrated applications, for example an Emissions Policy Model and a Scenario Manager. The third layer is called "Executive Interfaces," which provide concise, clear graphical presentations for decision makers, nontechnical stakeholders, etc.

DEMDESS does not need to change the underlying systems, such as ambient water quality and discharger monitoring data bases. Further, DEMDESS is designed to work with existing models, such as Qual2e, as they are currently being used. Putting DEMDESS on top of existing systems has several advantages. First, nobody has to change the way they are currently doing business; there is a minimum of disruption. Second, you take full advantage of the good, hard work that the experts have already invested to solve their problems. Third, there is great flexibility in adding "new" components as needed (especially if the next two lessons are followed). Fourth, effort is focused on the decision-support issues rather than the routine administrative programs.

- Use a data-based approach to integration as opposed to a software-based approach. Modern data base management systems have tremendous power for quickly and efficiently integrating a wide variety of data. Figure 2 illustrates this approach. A "data-based" approach means that the core of the system is a set of data bases surrounded by various individual data systems and models. The individual systems are linked to the core data bases through customized "gateways." This means that the DSS is composed of many diverse, individual data and software systems tied together by one DSS data system. For example, DEMDESS currently uses the stand-alone Qual2e water quality model; another water quality model could be used and only the "gateway" would need to change. Think of this approach as a "plug and play" system.

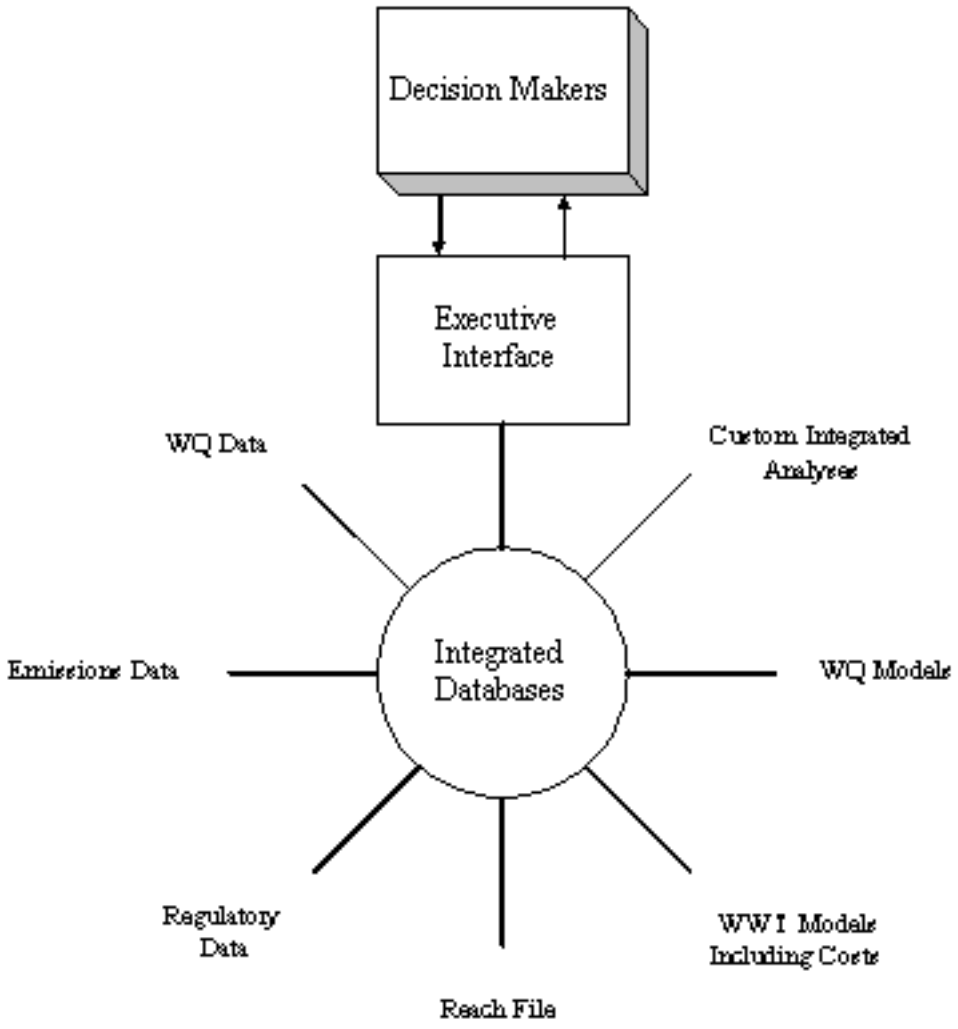

Figure 2. The data-based approach to decision support systems.

A software-based approach would incorporate all of the DSS elements into one software package. This necessarily leads to numerous complications and extra costs. The system would have to be quite large, with many reprogrammed elements (e.g., water quality modeling). Adding and changing components can become complex, with changes and additions having a ripple effect through the system.

- *Careful design of central organizing constructs is critical.* One very powerful construct is the Reach File. Reach Files are central to DEMDESS. A Reach File has been built and used to integrate the water data in every country in which DEMDESS is implemented. Dr. Ilya Natchkov, the Danube Programme Coordinator for Bulgaria, said "The most important thing DEMDESS has brought to us is the Reach File philosophy." The Reach File philosophy is obviously readily transferable to the U.S. through Reach File Version 3 (RF3). Other central organizing constructs are important, such as a single unified parameter code table, economic sector table, etc.

- *Bring in costing, financing, and economics as integral components*, preferably at the beginning of the program. Cost-benefit analyses and justifying expenditures to the public are going to have to

be the norm in U.S. basin management. The countries in CEE are severely strapped for cash, and getting the biggest bang for the buck is essential. Therefore, DEMDESS has as much emphasis on the financial side as on the technical side. By bringing these financial factors into the system at the beginning, we can achieve quite dynamic interactions between water quality changes, costs, and economic benefits.

Application of these five lessons will lead to a technical system that is matched to institutional requirements and capacity. The system will be well-placed for ongoing use over many years and be able to adapt and grow as the issues and technologies change.

DEMDESS Implementation

DEMDESS is an entirely PC-based system. The core DEMDESS system is implemented in Paradoxr for DOS. The Executive Interfaces are implemented in Quattro Pror for Windows. The underlying databases are built for each country's routine administrative systems, most often X-Base files. Linked models are implemented in a variety of languages, including Visual Basic, Fortran, and Paradox Application Language. The Polish implementation includes links to their MapInfo Geographic Information System. Our Polish counterparts have also implemented ground-water and water supply systems using the principles learned from DEMDESS.

DEMDESS has been implemented in Bulgaria, Hungary, Romania, Slovakia, and Poland. In each case, DEMDESS is translated into the host language and customized to work with the local data bases. We are continuing work in Poland this year. We have also begun work on a greatly expanded DEMDESS implementation, with major hydrologic and water supply components. This most recent work is for the Aral Sea program at USAID.

DEMDESS Presentation

This presentation highlights the use of DEMDESS for prefeasibility studies using the city of Sevlievo, Bulgaria, as the case study. The interactions of several core data components and models are shown, especially analysis of existing conditions and wastewater treatment alternatives analyses. Tradeoffs between costs and ambient water quality improvements are illustrated with

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The Role of Pollution Prevention in the Watershed Management Approach to Toxics Control

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The watershed management concept is fast becoming established as the logical envelope for implementing water quality improvements in accordance with the natural physical divisions of aquatic ecosystems. Similarly, pollution prevention is favored by EPA and many wastewater dischargers as the preferred approach to minimizing pollutant loading to receiving waters. These concepts are fundamentally tied to one another because watershed management helps to define two notorious questions surrounding pollution prevention programs: "Who should be required to do pollution prevention?" and "To what extent should pollution prevention be carried out?" The coordination and implementation of these two broad-based concepts is not always clearly defined, particularly where technical, financial, or regulatory obstacles hinder a rapid switch-over to a watershed management approach.

In the Spring of 1994, members of Tri-TAC, a technical advisory committee which is jointly sponsored by the League of California Cities, the California Association of Sanitation Agencies, and the California Water Environment Association, analyzed the role of pollution prevention within the watershed management approach to toxics control. This paper discusses Tri-TAC's recommended approach to integrating these concepts, and suggests some interim steps that may be taken where the watershed approach to pollutant management has not yet been established.

A Holistic View of Pollution Prevention

The pollution prevention agenda was far simpler in the past when water quality degradation was primarily the result of point source discharges, and improvements to our waterways could most quickly and cost-effectively be implemented by upgrading treatment systems at industrial dischargers and publicly-owned treatment works (POTWs). With significant advancements in treatment technology and widespread implementation of pretreatment programs, the balance of pollution sources in California (and many other states around the country) has shifted; the traditional industries and POTWs are generally contributing a smaller percentage of the pollutants entering US waterways. While there continues to be a need for effective pollution prevention at large point sources, it is clear that we must increasingly focus on the more diffuse, broad-based pollutant sources such as agricultural and urban runoff, commercial businesses, and household toxics. These sources are not as easily identifiable or controllable as the industrial or POTW discharge pipe, but in many cases they represent more cost-effective targets for pollutant reductions.

Numerous POTWs across the country have instituted pollution prevention programs in an effort to meet stringent permit limits. For example, POTWs discharging to San Francisco Bay have been particularly aggressive establishing programs aimed at reducing the loadings of heavy metals such as copper, silver, nickel, and mercury to sewer systems due to extremely low NPDES permit limits (e.g., a 4.9 µg/L copper limit where tap water concentrations average 30 to 40 µg/L). In the face of potential permit violations, enforcement measures, and/or citizen lawsuits, these pollution prevention program measures have appeared cost-effective for POTWs when compared to the more costly end-of-pipe options such as reverse osmosis. However, were the receiving water body to be examined as a whole, it may be that more cost-effective pollutant reductions would be obtained elsewhere within the watershed. It is inappropriate, therefore, to limit the comparison of these pollution prevention programs being implemented by POTWs only to alternative POTW treatment measures. Ideally, the pollution prevention measures of each contributing source (whether discharging directly to a water body or to a POTW's sewer system) would be compared to all of the potential control measures within the watershed on a pollutant-by-pollutant basis. Without such a holistic view, gross ineconomies can result as point sources face diminishing returns on their pollution prevention investments.

Integrating Pollution Prevention into the Watershed Management Approach

Tri-TAC's approach to integrating pollution prevention and watershed management uses a modified version of EPA's existing Total Maximum Daily Loading (TMDL) process. It utilizes the predicted impacts of pollution prevention strategies on pollutant sources to determine the appropriate allocations of pollutant loadings among the key sources contributing to a watershed. This approach calls for a review of available historical data and other pertinent information on pollution prevention options and the associated potential reductions for each key source. In light of the maximum pollutant loadings allowed to enter the watershed to meet water quality standards, and the expected loadings reductions to be obtained from each source through pollution prevention, an appropriate pollutant loading is allocated to each source. This approach dictates that certain priority sources will be targeted for strict reductions,

whereas other sources must merely comply with baseline measures, or "minimum standards of operation" (MSOs) in order to meet their pollutant loading allocation. Selection of the priority sources for pollution prevention is thus determined through watershed management.

If water quality standards are not achieved following subsequent implementation of control actions and monitoring, then the process could be repeated with more site-specific information and a better idea of the expected impacts of pollution prevention measures. However, in some cases, low-cost pollution prevention measures alone may not be sufficient to attain water quality standards. In these cases, end-of-pipe treatment, or other more capital intensive structural measures, should be employed as necessary where the most significant reductions in pollutant loadings can be attained.

Targeting Pollutant Reductions

A cost-efficient watershed management program relies on a clearly defined methodology for targeting which watershed sources should implement extensive pollutant reduction measures, and which should merely employ baseline measures, or "minimum standards of operation" (MSOs). This determination relies on a two-step process being conducted for each pollutant of concern:

- Identify and assess the cost effectiveness of pollutant reduction options, watershed-wide
- Rank the options in the order of cost-effectiveness, and identify the minimum number of targeted control measures to achieve the cumulative reductions necessary to meet water quality standards

A ranking process for pollution prevention measures could be incorporated into the watershed approach to cost-effectively reduce toxic loadings. Feasible pollution prevention and end-of-pipe treatment measures would be identified, evaluated, and ranked for comparison purposes on the basis of expected dollars to be spent per pound of pollutant expected to be removed ($/lb). Pollution prevention measures can take the form of educational/outreach measures (e.g., storm drain stenciling, leaflet distribution, public meetings) or more structural solutions such as building stormwater catch basins or implementing wastewater recycling programs at POTWs. Although extensive cost-effectiveness information is not currently available for ranking many of these control measures, development of a consistent protocols (e.g., the watershed management approach) through which such information can be employed, would allow the appropriate data to eventually be gathered to facilitate this ranking procedure.

The ranking of the watershed management pollutant reduction measures by expected cost effectiveness would allow selection of high-priority control measures, and a prediction of the expected implementation cost to reduce the overall watershed mass loadings to levels below the water quality standards. The cost-effectiveness of pollution prevention measures would be ranked side-by-side along with end-of-pipe treatment measures to determine which should be selected for implementation. In one case where such ranking was applied, the annual pollutant loadings to the watershed exceeded the water quality standards (WQSs) by 280 lb/yr. In order to meet these WQSs, the five most cost effective reduction measures (pollution prevention and end-of-pipe treatment measures) would need to be implemented at a total cost of $40 million. By applying this approach to pollution prevention, there is a clearly defined purpose and

endpoint for each reduction measure. Each source targeted for extensive reduction measures would know why they are expected to perform the measures, and to what extent they must be carried out. The remaining sources would initiate MSOs (e.g., regular monitoring, public education materials, staff training) such that no easily controllable copper loadings would be contributed to the water body.

It is noteworthy that in addition to the two-tiered system of targeted and baseline programs described above, special consideration (e.g., a separate ranking procedure) may be necessary to address high-risk discharges that pose an imminent threat to public health or sensitive ecosystems. Also note that the dollars-per-pound ranking approach does not account for the impacts of flow alone on river and stream systems. Scouring and other high-flow impacts can often be more significant for habitat loss than the long-term impacts of chemical pollutants. Thus, a ranking of flow-oriented habitat improvement measures also may be necessary to supplement the above methodologies.

Interim Approaches to Watershed Management

The watershed management process described above depends upon three key pieces of information, each of which can prove extremely difficult to finalize:

- the water quality standards must be determined.
- a predictive water quality model must be available.
- the cost per pound of pollutant for the potential control measures must be known.

In many geographic areas, water quality standards for metals are being re-evaluated to incorporate new data, to move to a dissolved basis, and/or to develop site specific water quality standards (objectives). In a number of areas this reanalysis is not complete and new standards are therefore not finalized. Predictive water quality models are more available for rivers and traditional pollutants and decidedly less well developed for estuaries and for low level toxics. Contributions from air deposition and resuspended sediments have been especially difficult to model. Finally, the cost of source control measures has not yet received the research attention that the cost of end-of-pipe treatment has received. For example, despite the fact that 35 percent of the copper loading to the lower South San Francisco Bay has been attributed to automobile brake pads (a greater contribution than point sources), no cost estimate for brake pad reductions is available. In contrast, costs of further end of pipe treatment in this same area are well established (at several thousand dollars per pound of copper removed).

As a result of these and other shortcomings, it will often not be possible to immediately conduct the most desirable form of watershed planning in many geographic areas. Recognizing this dilemma, Tri-TAC, industrial, and regulatory agency representatives recently developed a set of recommendations for permitting point sources in the near term; either in lieu of, or until a more scientifically satisfying analysis can be performed.

Task Force Recommendations

In 1995 the California State Water Resources Control Board (SWRCB) convened eight Task Forces to provide recommendations for creating new water quality plans for California. One of the task forces, the Permitting and Compliance Issues (P&CI) Task Force, developed recommendations for permitting point source dischargers when a "scientifically constructed" watershed management plan is not available.

Lacking one or more of the three key information pieces (listed above) for a comprehensive watershed management plan need not be fatal. A key recommendation of the P&CI Task Force is to convene stakeholder groups and initiate a collaborative watershed planning process despite information gaps. It may be possible for the stakeholders to negotiate a set of agreements and control measures which can be approved by regulatory agencies as an Interim TMDL and Waste Load Allocation (WLA). If environmental advocacy groups and the regulatory agencies are partners in the process, there should be no barriers to approval of a negotiated agreement as the Interim TMDL and WLA.

While less scientifically satisfying than a modeled and a calculated TMDL and WLA, it must be remembered that even with full data availability, neither science or economics can necessarily provide an implementable WLA. Economic theory can tell us which control measures to pick to minimize overall costs to society. But economic theory cannot tell us who should bear those costs or where the money should come from to implement the chosen control measures. In the end, regulatory agencies must either require implementation or facilitate negotiation among stakeholders.

In California, it is becoming increasingly true that no single regulatory agency can require implementation of all, or even most, of the needed control measures. Again taking copper as an example, it is now clear that the San Francisco Bay Regional Water Quality Control Board (Regional Board) has the regulatory authority to control only a small fraction of the copper entering the Bay. Pesticides (regulated by the Department of Pesticide Regulation), erosion and abandoned mines (regulated to some extent by other water and resource conservation agencies), and vehicle emissions (regulated to some extent by the California Air Resources Board and US EPA) contribute the vast majority of the copper. Therefore an approach which depends alone upon the Regional Board requiring people to do things is doomed to failure. Thus we should not be bashful about moving immediately to an arena of negotiated agreements.

Definition of "TMDL"

The P&CI Task Force recommended using an expanded definition of TMDL developed by SWRCB staff to facilitate the negotiation process. It will often be difficult to express the TMDL as originally envisioned; the total pounds of a pollutant that the water body can accept. Large, complicated water bodies will present particularly challenging technical problems. Therefore, the TMDL could be expressed as a "Quantifiable Target" of something other than pollutant loading. It could be a percentage reduction of a pollutant, a measure of ecosystem improvement (a specific increase in fish population), or a specific degree of implementation of a control measure. Committing to and implementing pollution prevention measures could thus become a direct measure of success.

Negotiated Agreements Also Take Time

But what if attempts to negotiate agreements don't produce immediate results? If certainty on water quality standards is lacking, it should be no surprise that stakeholders will be reluctant to make commitments. They, in fact, would only make commitments if they believed either 1) that they will have to do even more if they wait, or 2) that they will be subject to undesirable public criticism for not agreeing. When agreements on TMDLs and WLAs are not reached, regulators still need to issue NPDES permits for point source discharges. The P&CI Task Force made a number of recommendations for this case.

If it has not been demonstrated that the discharger has a reasonable potential of causing a water quality standard to be violated, no interim water quality based effluent limit would be imposed. Neither would new source control or pollution prevention requirements be imposed for that pollutant. But if a reasonable potential of a standard violation was demonstrated, then interim limits and/or requirements to implement source control or pollution prevention requirements would be imposed.

Regulatory agencies will generally need to have an enforceable limit in the permit. Dischargers will resist enforceable limits when the TMDL/WLA process is incomplete. The compromise recommended by the P&CI Task Force is to have two limits--a trigger effluent concentration (TEC) and an interim limit (IL). The IL would be the enforceable limit and the TEC would be a somewhat lower value that would trigger further monitoring, investigation, and analysis by the discharger. The TEC would be based on statistical methods developed by EPA for estimating maximum concentrations from past performance data. The IL would be calculated by multiplying the TEC times an uncertainty factor developed by the regulatory agency. The uncertainty factor would account for unforeseen and uncontrollable circumstances that may cause future increases.

Conclusion

Watershed management planning should be the driving force to determine which pollution prevention measures will be implemented. Minimizing overall costs to society should be the guiding light. Stakeholder involvement in the planning process should be used to avoid unacceptable impacts to particular sectors of the economy, and can be initiated despite information gaps. The types and degree of pollution prevention determined to be needed will depend on the availability of good data and degree to which stakeholders can come to agreement. The role of regulatory agencies should be to insure needed information is developed and to facilitate agreements among stakeholders.

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Watershed Protection Verses Housing in the Germantown Master Plan

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Introduction

In the late 1980s, the Montgomery County Planning Board was confronted with two conflicting needs when revising the older 1974 master plan for the Germantown area: (1) the need to protect environmentally sensitive stream systems that exist within the planning area; and (2) the need for additional housing near an important employment and transportation corridor.

The Germantown planning area in Montgomery County, Maryland, encompasses approximately 10,350 acres (16 square miles) and is located approximately 25 miles northwest of Washington, D.C. It is bisected by Interstate-270, a primary transportation route and high employment corridor in the county. The Germantown planning area lies within the Seneca Creek basin, the largest watershed in the county. The Seneca Creek basin has a total drainage area of approximately 82,000 acres (128 square miles), and includes three significant subbasins: the Great Seneca Creek, the Little Seneca Creek, and the Dry Seneca

Creek. The entire Seneca Creek basin drains to the Potomac River, which in turn drains to the Chesapeake Bay. The Little Seneca Creek in the Germantown area is one of the most environmentally sensitive portions within the Seneca Creek basin, supporting a naturally-reproducing population of brown trout.

In the face of increasing residential development, the protection of water resources in a watershed can be reinforced by applying low-impact land use policies in combination with environmentally sensitive best management practices. Low density development is generally less damaging to the existing natural resources as it typically produces less storm water runoff, less impervious surfaces, and less nonpoint source pollution than high density development. Yet low density residential development patterns, especially those near important employment and transportation corridors, tend to conflict with the need to accommodate the rapid population growth and rising demand for affordable housing in the county. Furthermore, the general development plan for the county envisions higher density residential and commercial development in close proximity to the major transportation "corridors", and a series of lower density residential developments in combination with agricultural areas in the "wedges" between the corridors.

In the initial stages of updating the Germantown master plan, planning staff identified specific areas adjacent to the Little Seneca Creek trout stream as the most environmentally sensitive areas of concern. Typical zoning recommendations in the revised master plan called for increasing the base zoning densities throughout the planning area from agriculture and rural residential to medium density and high density residential and commercial patterns. It was recognized that those high density development patterns near the Little Seneca Creek could potentially induce substantial degradation of the existing stream habitat, hydrology, and water quality which support the naturally-reproducing brown trout population. As a means to reduce the threat of degradation, a series of requirements were introduced into the revised master plan to promote stream protection in specific portions of the planning area.

Discussion

The revised 1989 Germantown master plan envisions the Germantown area as a group of six interconnected villages or communities. For planning purposes, the villages are divided into analysis areas. The KI-2 analysis area of the Kingsview village and the NE-1 analysis area of the Neelsville village were scheduled to be the last significant developable tracts within the planning area. The KI-2 analysis area lies downstream of the Little Seneca Lake, a drinking water reservoir, and is adjacent to a segment of Little Seneca Creek. The NE-1 analysis area drains directly into Little Seneca Lake. Both analysis areas have streams with existing high quality ecosystems based on agency surveys.

Planning staff initially recommended low residential densities in the KI-2 and NE-1 analysis areas as a means to protect the trout stream and the reservoir from potential impacts of high density development. In the 1988 preliminary draft master plan, planning staff recommended that the maximum residential base densities in these two areas be set at one dwelling unit per acre, and that no public water/sewer pipelines be constructed in the stream valleys of both areas to serve the proposed developments. However, given the county-wide demand for more housing and Germantown's status as a future corridor city, the County Planning Board and the County Council decided to retain a more intense base density of two dwelling units per acre in these two analysis areas with options to increase these densities even further. In addition, two alternative alignments for new arterial roads were included in the master plan for the KI-2 and NE-1 analysis areas, further compounding the potential for impacts to the nearby water resources. The recommended densities initially proposed by staff in these two analysis areas as a means to protect the water quality and stream habitat were believed by the political leaders at the time to be too low to support corridor city development.

Planning staff recognized that residential development patterns of two or more dwelling units per acre would result in detrimental increases of nonpoint source pollution and peak storm water flows to the nearby streams, and could potentially jeopardize the long-term survival of existing brown trout populations and the water quality of the reservoir. These impacts could also potentially violate state

regulations on permissible water temperature and nonpoint source pollution loadings for trout waterbodies. As a result, the Planning Board and planning staff agreed that special protective measures for development projects in the NE-1 and KI-2 analysis areas should be specified in the new master plan to offset the more intense land use recommendations.

The protective measures outlined in the 1989 Germantown Master Plan require development projects within the KI-2 and NE-1 analysis areas of Germantown to conform to the following conditions.

- Prepare an environmental impact analysis to assess the potential impacts of a proposed development project.
- Document the existing conditions of adjacent stream ecosystems and track the short-term and long-term trends in those conditions.
- Utilize enhanced development standards and innovative site designs to promote stream protection.
- Utilize enhanced best management practices, storm water management systems, and sediment control measures.
- Implement special mitigative measures to offset potential impacts to nearby streams.
- Establish binding, long-term inspection and maintenance agreements for various structural and non-structural best management practices.

These protective measures aim to: (1) prevent the excessive degradation and contamination of streams through innovative site design and enhanced best management practices; (2) provide increased control of sediment and storm water runoff through the application of enhanced management systems; (3) minimize disturbances within stream valleys (such as road crossings and water/sewer pipelines); (4) provide timely feedback on the effects of development activity on neighboring stream ecosystems; and (5) protect existing forested areas, especially in stream valleys, and promote reforestation.

The environmental impact analysis requires the collection of detailed information to characterize the existing topography, soils and geology, vegetation, stream

ecosystem, hydrology, and water quality associated with the site. The impact analysis evaluates a number of aspects such as the size and location of proposed development, the proposed storm water management plan, the proposed sewer and water system plan, and the proposed best management practices to estimate the potential impacts to existing environmental conditions, stream valleys, wetlands, aquatic organisms, and water quality. Also, the environmental impact analysis is required to estimate the potential for violations of the state's water quality criteria for trout streams, which include: coliform bacteria, dissolved oxygen, temperature, pH, turbidity, total residual chlorine, and a number of inorganic substances (mainly metals) and organic substances (mainly herbicides and pesticides). Specific storm water management performance criteria were developed for the KI-2 and NE-1 analysis areas to encourage conformance with these state water quality criteria.

To tract the impacts of construction activity and the performance of storm water management systems, developers are required to monitor the condition of the stream ecosystem(s) adjacent to the development site for a minimum period of eight months prior to construction, throughout the construction period, and 18 months following the construction period. After this period, the county will continue long-term monitoring, but at a less intense frequency of sampling. The stream monitoring required by the developer includes: (1) assessing benthic macroinvertebrate communities and stream habitat conditions three times per year following modified EPA Rapid Bioassessment Protocol III methods; (2) examining changes in stream channel cross-sections at specific locations once every three months; (3) assessing of the performance of water quality and quantity control of the storm water management facilities following construction activity; (4) collecting local rainfall information to aid in correlating bank-full storm event frequency before and after construction; (5) measuring nutrient loadings and selected chemical water quality constituents before and after construction; (6) routinely measuring physical water quality attributes; (7) measuring monthly fluctuations of sediment loadings in pools and riffles; (8) monitoring water and air temperatures hourly during the summer; and (9) photographing the condition of the site and the monitoring stations during monitoring events.

The enhanced development standards require the use of certain site configurations and best management practices to encourage the protection of nearby streams. For instance, one site design standard limits the maximum impervious surface over the developable portion of the site to 20 percent. The results of recent imperviousness studies document serious stream impacts when drainage areas approach 15 to 20 percent impervious cover for most piedmont ecoregion watersheds (Klein, 1979 and CWP, 1994). Separation of larger expanses of impervious surfaces into smaller, interconnected areas with shading and vegetated spaces is encouraged. Other site design criteria expand the normal 100 feet minimum stream buffer to 150 feet from the edge of each stream bank, and restrict all construction activity within this buffer area. Stream buffers are required to be placed in a conservation easement or dedicated to the county park system. A similar approach applies to existing wetlands. Stream buffer reforestation is required in areas were the stream side forest or natural vegetation was previously removed. Development activity is to be avoided, or minimized as much as possible, on slopes which exceed 15 percent. Further site design measures call for reducing allowable densities near stream valleys, wetlands and other environmentally sensitive areas and transferring or clustering those allowable units to more suitable areas of the site. Development activity is encouraged in areas which are already cleared as a result of past agricultural activity rather than in areas of existing forest and steep slopes. The importance of maintaining forests in the stream buffers and stream valleys is stressed as a critical component to ensuring the success of the protective measures. A high priority is placed on situating infrastructure facilities away from environmentally sensitive areas such as stream valleys, high quality forests, and steep slopes. If intrusion into these sensitive areas are unavoidable, then measures are taken to permit only the footprint of structures to be disturbed. For roads, the use of bridges instead of closed culverts for stream crossings is strongly encouraged. The use of pumping stations to connect with existing gravity sewers and existing water lines is also encouraged, rather than constructing new gravity sewers and water lines in stream valleys.

The use of enhanced best management practices (BMPs) is another protective measure required on development projects within the KI-2 and NE-1 analysis

areas of Germantown. These BMPs are designed to strengthen efforts to reduce sediment, storm water, and nonpoint source pollution loadings to nearby streams above and beyond the typical strategies required by state and county regulations. For instance, infiltration is the preferred method of storm water management, followed by dry ponds with extended detention. Permanent wet ponds are discouraged due to their propensity for discharging high temperature water into receiving streams and infringing on existing wetlands and forests in stream valleys (Galli, 1993). The use of both vegetative shading and created wetlands are strongly encouraged as part of storm water management concepts. Areas with highly pervious soils are recommended for use as open space or storm water facility sites due to their natural capability for infiltration. Other BMPs require more stringent sediment and erosion control standards during construction, such as use of oversized sediment traps, use of redundant control systems, timely vegetative stabilization after grading activity, and increases in fines for violations. Routine site inspections by county enforcement staff are scheduled more frequently than normal.

Long-term storm water management facility inspection and maintenance agreements are required as part development plan approval in the KI-2 and NE-1 areas of Germantown to ensure that the guidelines specified in the master plan are followed. Developers and/or homeowner associations are required to enter into binding agreements with the county to guarantee that storm water facilities are constructed, inspected and maintained in accordance with the guidance specified in the master plan. An escrow fund is established by the developer or homeowners association to finance the various inspection and maintenance activities and any needed repairs or improvements to a storm water management facility. If the developer or homeowners association fails to inspect and maintain storm water management facilities in a timely fashion and in accordance with the agreement, then the county would perform the necessary repair and/or maintenance activity and assess the developer or homeowners association for the costs of this work along with any applicable penalties.

Conclusion

The discussion surrounding the use of enhanced environmental protection strategies in the KI-2 and NE-1 analysis areas of Germantown convinced the County Planning Board and the County Council to adopt new philosophies and approaches to deal with balancing the impacts of development on natural resources and the need to sustain growth in areas near important transportation corridors and employment centers. Indeed, planning for the future to ensure a relatively health quality of life for the community is greatly dependent on maintaining the health of the natural resources (e.g., healthy air, water, soils, etc.). The maintenance of these natural resources must be carefully balanced and integrated with economic growth and population growth so that all are sustainable.

The special protective measures established in the Germantown master plan for the KI-2 and NE-1 analysis areas were compromises between the need for maintaining and protecting the natural resources of Little Seneca Creek and the need for more residential housing in this area of planned growth. By applying these special protective measures, the probability that Little Seneca Creek will retain its exceptional ecological health is enhanced. The success of this master plan approach to stream protection and the offshoots of these original philosophies have led to many new master plan strategies and policies for improving the environmental sensitivity of land use planning throughout the county. These policies have helped to establish a regulatory framework through master plans for promoting the protection of stream ecosystems in a more comprehensive, watershed-based manner that more equitably balances county growth needs with natural resource protection needs so that both can be sustained into the future.

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Ground Water Nitrogen Contributions to Coastal Waters of Virginia's Eastern Shore: Identification of High-Risk Discharge Regions and Remediation Strategies

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Introduction

The shallow, unconfined aquifers of the mid-Atlantic Coastal Plain display characteristics that are conducive to ground water contamination and its subsequent transport into aquatic habitats. Ground water contributions of nitrogen, both in the form of base flow and direct discharge to tidal waters, have been implicated in nitrogen enrichment of surface waters of Virginia's Eastern Shore. Therefore, detailed information regarding the coupling of surface and ground water resources is a primary requirement for rational watershed management and water quality protection. Efforts within Cherrystone Inlet watershed, a Bay-side watershed located on the southern tip of the Delmarva Peninsula, have concentrated on defining ground water discharge patterns and associated nitrogen flux and developing and initiating watershed management strategies.

Study Site Description

Cherrystone Inlet watershed, approximately 20 km2 in upland area, is located on the Chesapeake Bay side of the southern Delmarva Peninsula. Average annual rainfall is 108 centimeters (Virginia Agricultural Extension Service, Painter, Va.). Agriculture is a dominant land use within the watershed accounting for approximately 50 percent of the land cover. Surface relief is generally low, with slopes ranging from 0-2 percent over the main portion of the watershed; greater slopes are associated with regions adjacent to perennial and intermittent streams. Upland soils are dominated by well drained fine-sandy to sandy loams with moderate to rapid (0.4-3.7 m . day-1) saturated infiltration rates. The unconfined aquifer, the Columbia, is underlain by the Yorktown-Eastover confining unit at a depth ranging from 8 to 20 meters below ground elevation.

With narrow channels flanked by broad shoal regions, Cherrystone Inlet is representative of Bay-side inlets. Maximum depth within the main stem channel is 4 meters and the nearshore and tidal creeks display mean depths of 1 meter or less. Mean semidiurnal tidal range is 0.7 meters with salinities ranging from 14-23 % (Reay et al., 1995). Intertidal and nearshore sediments within Cherrystone Inlet are predominantly sandy substrates, whereas sediments in the more protected coves and upper creek reaches are dominated by finer grained sediments. Deeper main stem channel regions are represented by both silt-

clay and sandy sediment types.

Methodology

Ground Water Flow Analysis

Over 130 monitoring wells have been established within Cherrystone Inlet watershed to determine lateral and vertical hydraulic head variations, aquifer media characteristics, and collect water samples for nitrogen analysis. In addition, water level staffs have been installed within selected non-tidal impoundments. Shallow monitoring wells penetrated one meter into the unconfined aquifer and deeper wells were up to 18.9 meters in depth. Saturated hydraulic conductivities (Ksat) of upland substratum were determined at selected wells using a slug test method. Samples for chemical analysis were collected with a peristaltic pump following purging of three well volumes of water. Standard methods were used for the analysis of ammonium (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-). Total dissolved inorganic nitrogen (DIN) is the sum of NH_4^+, NO_2^-, and NO_3^-.

Hydrologic modeling efforts have concentrated on both field and watershed scales. A two-dimensional profile model (FEMCoast), developed at VPI&SU, was used to simulate density-dependent nearshore ground water flow patterns. MODFLOW, a USGS three dimensional ground water flow model, was used to investigate upland freshwater ground water flow patterns to first-order streams and impoundments. The use of conventional flow models provided a better understanding of ground water dynamics which were incorporated into a geographical information systems (GIS) approach. The GIS model incorporated hydrologic, geologic, and land use base data layers to prioritize shorelines with respect to nitrogen loadings to surface waters.

Results and Discussion

Ground Water Quality

NO_3^- comprised greater than 95 percent of DIN in shallow ground water underlying cultivated, woody, and grasslands; contributions of NH_4^+ were greater for developed land. DIN concentrations of shallow ground water as related to upland land-cover are summarized in Figure 1. These results are comparable with reported values within the mid-Atlantic Coastal Plain and indicated that shallow ground water quality is reflective of overlying land use. Upland land-cover determinations were assigned according to NOAA C-CAP (NOAA, 1995) land-cover classification system. Land cover classified as "developed" consisted of low intensity single-family housing utilizing on-site wastewater disposal systems. Grasslands consisted primarily of managed herbaceous cover which included road/railroad right-of-ways, lawns, and wastewater irrigated fields.

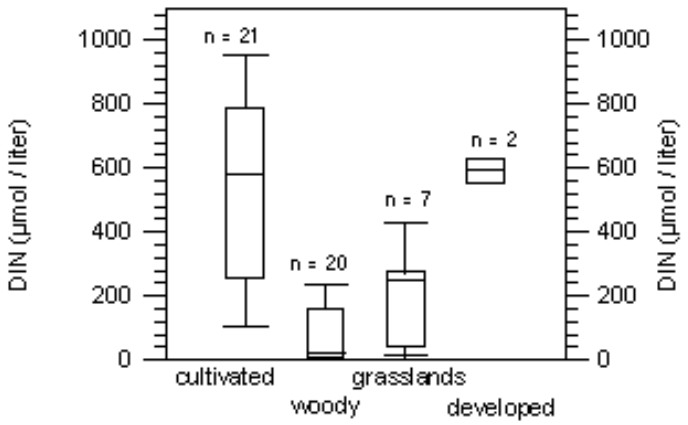

Figure 1. Boxplot of shallow ground water DIN quality in relation to land cover within the Cherrystone Inlet watershed.

A Kruskal-Wallis analysis of variance by ranks test demonstrated significant differences in shallow ground water DIN concentrations as related to land cover ($p<0.01$). Based on nonparametric multiple comparison test ($a = 0.05$), DIN levels for

cultivated lands were not significantly greater than levels associated with developed or grasslands, but were significantly greater than woody lands. Plant uptake, microbial mediated processes (denitrification), soil adsorption and storage, and potential dilution with low nitrogen sources of water result in low NO3- levels in ground water underlying forested land. Elevated ground water NO3- levels can be observed if deeper ground water flow from upgradient regions is nitrogen enriched, and if the water table is located below the forest's biologically active zone or an underlying local confining units restricts interaction with the biological active zone.

Elevated NO3- concentrations also occurred in deeper portions of the unconfined aquifer down-gradient from distant nitrogen sources. NO3- concentrations on the order of 700 a)r-1 were measured at 8.4 meters below the water table (12.1 meters below the lands surface). Samples taken near the base of the unconfined aquifer showed a relatively consistent pattern of moderate NH4+ concentrations (40 1.r-1) and low (~1 (a)r-1) to non-detectable levels of NO3-.

Ground Water Flow

In general, sediments comprising the upper portion of the unconfined aquifer ranged from silty-sands to coarse clean sands with moderate to rapid (0.2-9.0 m . day-1) hydraulic conductivities. Sediments graded into a finer texture near the Yorktown-Eastover confining unit. Interbedded, thin and discontinuous silt-clay and peat layers have been observed in specific regions. Guidelines are being developed to estimate Ksat of major soil series for use in GIS analysis. Methods to estimate Ksat based on soil texture for well drained sandy-loam soils are in relative agreement with in situ measurements (root mean square error = 1.9 m.day-1). The final guidelines to estimate Ksat values of major soil series, as classified by county soil surveys, will be determined following analysis of the moderately well-drained and poorly drained soils.

Water table elevations at the topographic divide are over 8 meters above mean local sea level. Depth to the water table varied between near surface to 3.7 meters below ground level. Water table fluctuations varied from 0.5 to 1.5 meters and were dependent on depth to the water table, land cover, and general hydrogeologic setting. Elevated water tables were associated with late winter/early spring recharge periods, whereas the lowest water table elevations occurred in fall. Tidal variations associated with shoreline wells were 0.1 to 0.2 meters.

Contours of water table elevation for Cherrystone Inlet watershed are shown in Figure 2. Water table contours were relatively uniform near the topographic divide and converged along tidal inlet headwaters and perennial streams and impoundments. Hydraulic gradients along the upland regions adjacent to Cherrystone Inlet shorelines were between 0.001-0.002 m . m-1 and increased to 0.004 mday-1 in upland regions adjacent to Cherrystone Inlet shorelines and 0.01-0.15 m . day-1 in upland regions near tidal creek headwaters.

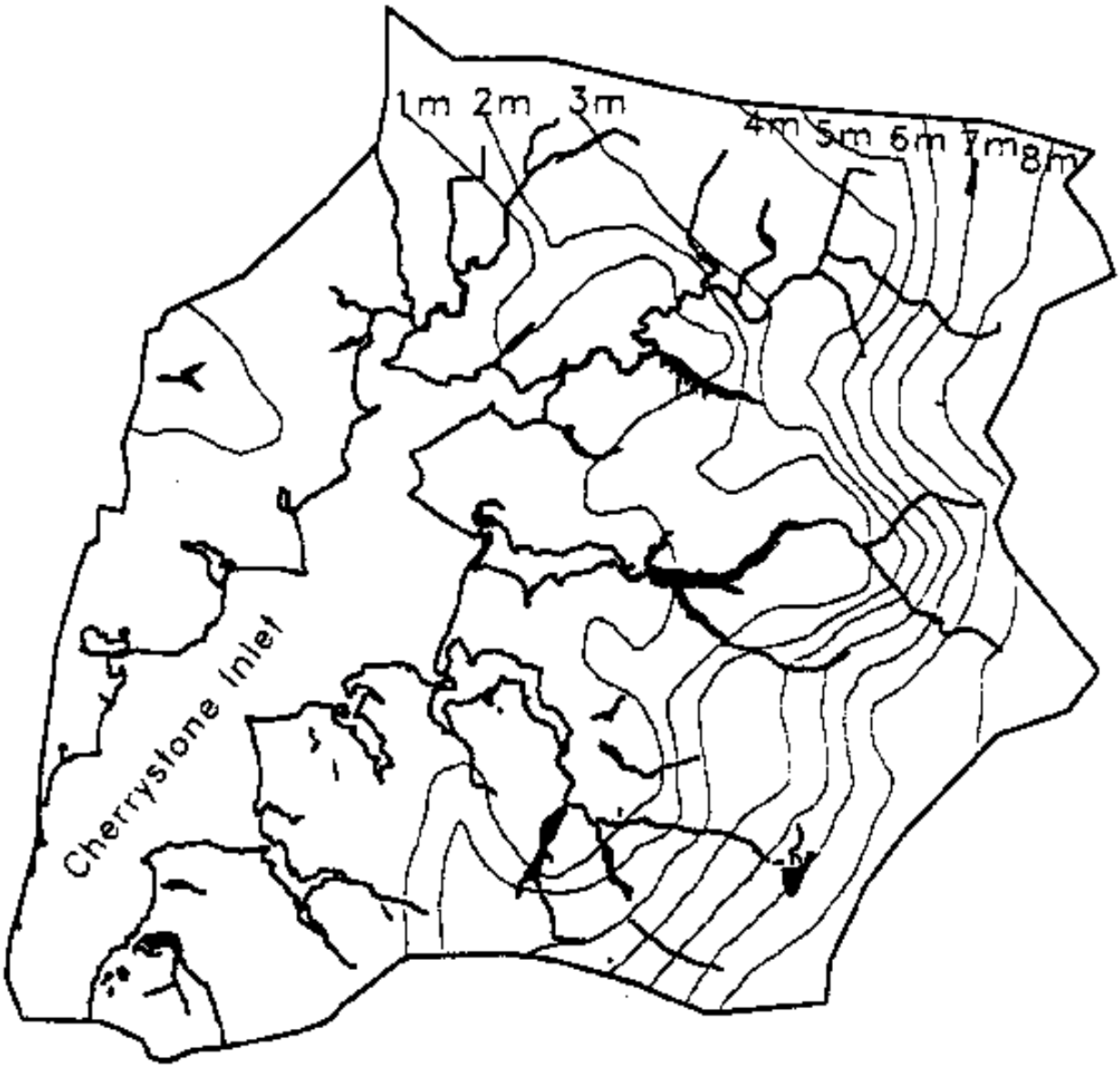

Figure 2. Contours of water table elevation for Cherrystone Inlet watershed. Sample period: February 1995.

The discharge of ground water into coastal environments is a nearshore process with daily and seasonal variations in discharge patterns and rates. Discharge of water across the sediment-water interface is a mixture of fresh ground water and interstitial seawater. Measured discharge rates ranged from 0 to 3.7 l . m-2 . hr-1 for sandy sediments. Fresh water contributions to measured discharge were on the order of 10 percent. Figure 3 depicts a vertical profile of modeled discharge patterns across the sediment-water interface and interstitial water salinity ratios relative to ambient Cherrystone Inlet waters. Ground water flow is sharply forced upward near the shoreline along the dispersive interface between the fresh ground water and interstitial salt water.

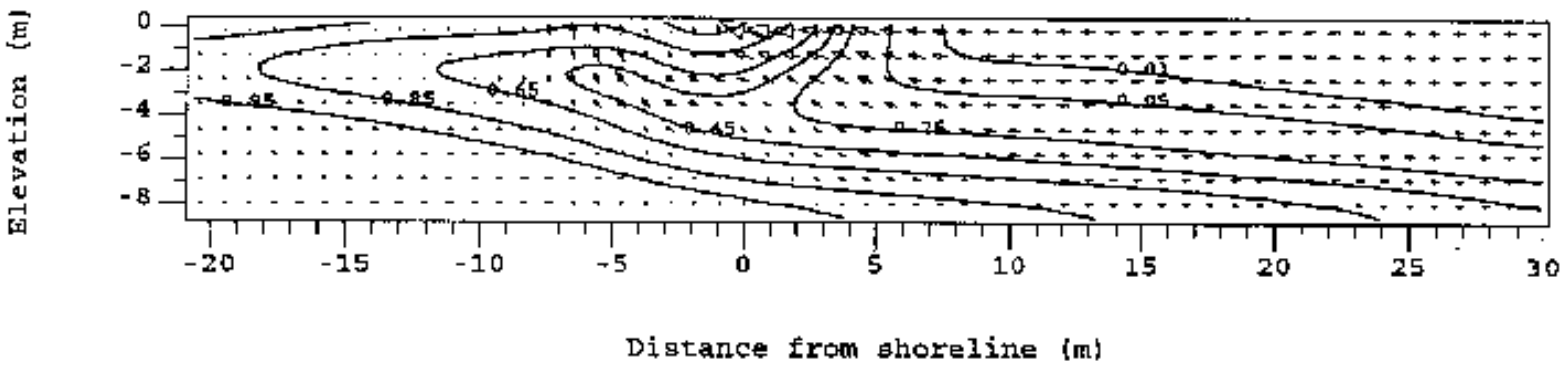

Figure 3. Vertical profile of modeled (FEMCoast) ground water movement and interstitial water salinity ratios relative to ambient Cherrystone Inlet waters for a representative sandy shoreline with homogeneous geologic parameters.

Sediment nitrogen fluxes are a function of physical, chemical, and biological processes. In nearshore sandy sediment, nitrogen fluxes were dependent on freshwater discharge rates and upland ground water quality. Elevated sediment NO3- flux rates, greater than 2000 a) . hr-1, were measured adjacent to upland agricultural land uses (Simmons et al., 1992; Reay et al., 1992; Gallagher et al., 1996). Such elevated fluxes can have an measurable impact on estuarine water quality. DIN levels within main stem Cherrystone Inlet are approximately two orders of magnitude less than ground water impacted by cultivated or developed land uses.

Ground water discharge couples land use activity and the quality of surface water in aquatic environments. Conventional modeling and field efforts have been used to assess contamination risk and potential nutrient loadings to surface water resources. GIS efforts have concentrated on determining high-risk landscapes, based on geohydrologic setting and land use patterns. Based on initial findings, development and implementation of best management practices designed to reduce ground water nitrogen loadings to surface waters have begun within the watershed. Efforts have concentrated on determination of optimal locations for vegetative buffers and the development/assessment of deep-rooted native warm season grass buffers. Findings of this research are directly applicable to similar coastal plain watersheds.

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Enhancement and Application of HSPF for Stream Temperature Simulation in Upper Grande Ronde Watershed, Oregon

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Reduction or removal of streamside vegetation by logging and grazing can alter stream temperatures by reducing riparian shading. In the Pacific Northwest and other parts of the United States, elevated stream temperatures in summer are a major fish habitat degradation problem that affects coldwater species such as salmon and trout. For example, the lethal temperature for Chinook Salmon is approximately 26oC, and sublethal effects on juveniles can occur at significantly lower temperatures. Projects to restore riparian forest cover are often intended to reestablish shading and reduce stream temperatures to levels that can support coldwater communities. To provide guidance for riparian vegetation restoration activities, comprehensive and dynamic information about stream temperature regimes can be cost-effectively generated by watershed-scale, continuous stream temperature modeling. The Hydrologic Simulation Program - FORTRAN (HSPF), a major EPA and USGS watershed modeling tool, together with its supporting data management programs and expert system software for model calibration, form a comprehensive watershed hydrology and water quality modeling system that may be used to conduct

hydrologic/hydraulic and stream temperature simulations (Bicknell et al., 1993).

In recognition of the limitations of HSPF for simulating temperatures of forest streams, enhancements were made to improve the model's applicability and accuracy. The enhanced HSPF modeling system with a new stand-alone program called SHADE was applied to the Upper Grande Ronde watershed in northeast Oregon (Figure 1). This paper presents a brief summary of the methodologies and algorithms for HSPF enhancements and the modeling results of the application study in the watershed. A complete and detailed report of this study is given by Chen (1996).

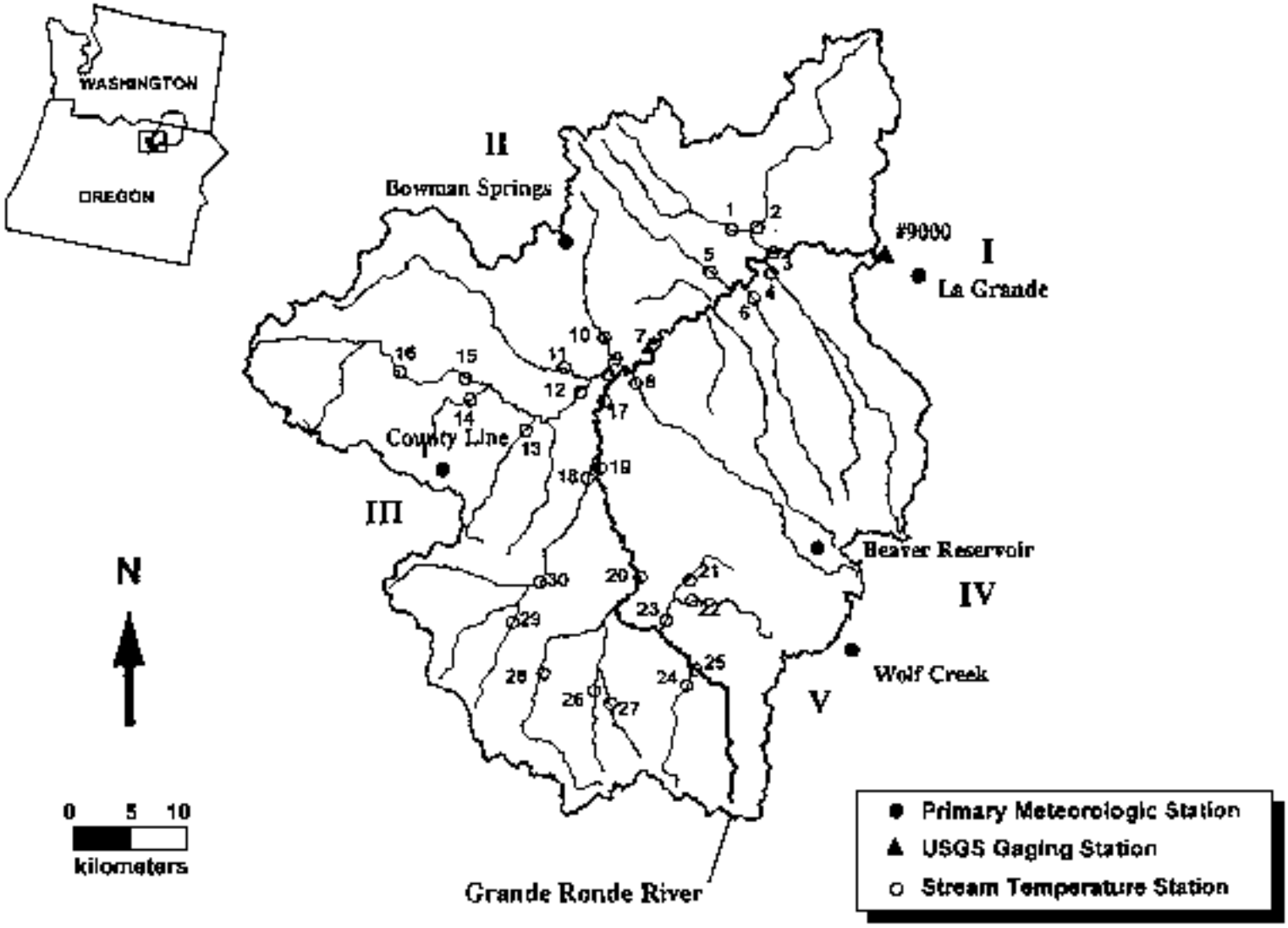

Figure 1. Upper Grande Ronde watershed and location of stations.

Model Enhancements

SHADE Program

The module section HTRCH in HSPF is a one-dimensional code for simulating water temperature of reaches (called RCHRES) in a stream network. In HTRCH, the energy budget analysis technique is

employed to determine the net heat exchange for simulating stream temperature dynamics. However, HTRCH does not have the capability to realistically estimate the amount of incoming solar radiation that actually enters stream water, due to the lack of adequate algorithms for vegetation and topographic shading computations. Therefore, a stand-alone program called SHADE was developed for dynamically estimating the contribution of riparian vegetation buffers and topography to stream surface shade.

Stream shading dynamics are controlled by the spatial relationships among sun position, location and orientation of a RCHRES, hillslope topography, and riparian vegetation buffers. For each hourly time interval, SHADE computes the riparian shading and thus adjusts the incoming global solar radiation to the amount of radiation which is effective for stream heating. Shade computations are made at stream sample points located at 100 meter intervals throughout a RCHRES. The average solar radiation for that RCHRES is then estimated. Model inputs for SHADE include: (1) watershed location and number of RCHRESs to be simulated; (2) incoming daily global solar radiation (RADG); (3) hourly values of stream wetted width (TWID) computed by the hydraulic module section HYDR in HSPF; (4) stream sample point location in UTM coordinates and topographic shade angles (TSA) in the 12 directions whose azimuth angles are 0o, 30o, 60o, ..., 330o (clockwise from due north); and (5) vegetation shading characteristics specifying the location (left or right bank), nature (forest/shrub or gap), and dimensions of each vegetation polygon mapped as homogeneous stands. The required geometric features are: (1) distance from the edge of stream wetted perimeter to the near-stream polygon boundary (DIS); (2) width of polygon (WID); (3) average height of vegetation polygon in absolute value (HABS); (4) average height of vegetation polygon in reference to the elevation of stream surface (HDEM), which is the sum of HABS and the difference between the ground elevation and the stream channel elevation; and (5) average canopy density of vegetation polygon (DEN). These topographic and vegetation shading characteristics can be effectively created and processed using remote sensing data sets with geographic information systems (see also Norton et al., 1996, in this proceedings).

The input data of global solar radiation are disaggregated into two components, beam and diffuse, which are reduced differently by the topographic and vegetation shading effects. For beam radiation, the solar path is defined by two angles, the zenith angle Z or its complement, the solar altitude ALT, and the azimuth AZ. When ALT TSA, no sun beam can enter the stream valley, and there is no vegetation shading effect. When ALT > TSA, the vegetation buffer (if existent) provides the only obstruction to the sun beam. The effective length and density of shadows of single or multiple vegetation polygons on stream surface are estimated. The amount of incoming beam radiation that actually reaches the stream surface is then approximated based on the fraction of unshaded stream surface. In contrast to the dynamic shading effects on the beam radiation, the blockage to the diffuse radiation is assumed to be controlled only by the sky openness of the stream valley and does not change over time.

The SHADE program generates two output files of hourly time series data for each RCHRES. One is the solar radiation adjusted to account for the riparian shading effects. The other is the solar radiation factor (SRF, the ratio of radiation effective for stream heating divided by the incoming radiation before any reduction by shading) values that can be used to characterize the dynamic shading conditions. SHADE was coded in FORTRAN 77 programming language and its application program can be run in a DOS environment on any IBM compatible PC computer. The input and output data files for SHADE and its

integration with the HSPF modeling system (within the dotted box) are illustrated in Figure 2.

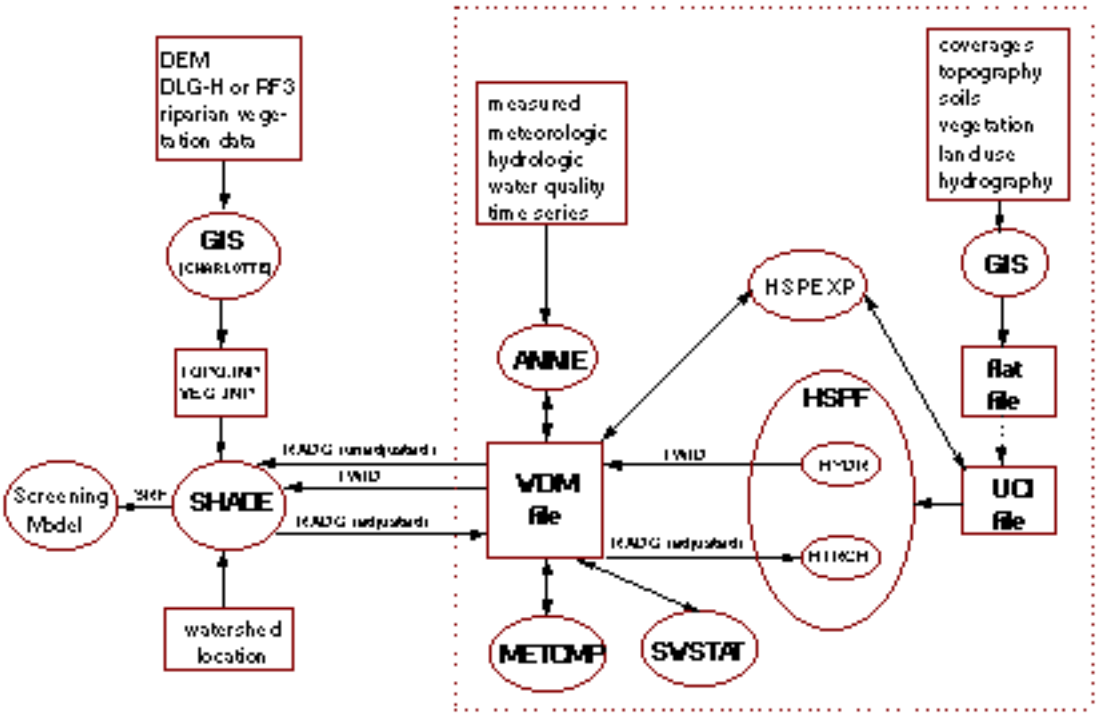

Figure 2. Enhanced HSPF modeling system with SHADE program for forest stream temperature dimulation (expanded from A.M. Lumb of USGS, personal communication, 1994).

Heat Exchange Between Water and Streambed

The heat flux between water and streambed is neglected in HTRCH. However, the importance of this energy component has been recognized in water temperature simulation studies for rivers and streams and even for shallow lakes. The bed conduction becomes even more important in small shallow streams (e.g., the low order forest streams in the Upper Grande Ronde) as the diurnal variation in water temperature increases. Therefore, a methodology for computing the heat flux between water and streambed was selected, evaluated, implemented, and coded into HTRCH in HSPF.

Literature review indicated that the algorithms developed by Jobson (1977) are appropriate for direct computation of the heat flux which can easily be added into HTRCH for a complete heat budget analysis. Jobson's method was evaluated using the recorded hourly temperature data at two monitoring sites in the watershed, indicating the reliability of heat conduction estimates and the importance of this energy component in stream temperature simulation. Watershed Segmentation and Database Development

Applying a semi-distributed parameter model like HSPF requires division of the watershed into relatively homogeneous land and stream segments. Maps and digital databases of various land and stream characteristics within the Upper Grande Ronde were assembled and processed with ARC/INFO GIS for watershed characterization and segmentation. Overlaying of three data layers (topography, vegetation types and soil characteristics, and locations of meteorologic stations) resulted in 19 pervious land

segments (PERLNDs) in 5 groups and 51 stream reaches (RCHRESs) in 51 sub-basins.

Weather conditions in each of the five PERLND groups were represented by one of the five primary meteorologic stations. Six other stations near the watershed were selected as secondary stations to provide supplemental and reference data for developing the meteorologic database. There is only one long-term USGS gaging station (#9000) at the watershed outlet which has mean daily streamflow records. Observed hourly stream temperatures were available at 30 monitoring sites for the summers of 1991 and 1992 (Bohle, 1994). See Figure 1 for the locations of various stations. Based on the availability of time series data, hydrologic simulations were conducted for eleven calendar years (1984 to 1989 for calibration, and 1981 to 1983 for calibration) and stream temperature simulations for two calendar years (1991 for calibration and 1992 for validation). The time step for all simulations was one hour. The time series and spatial data described above were used to develop the WDM (watershed data management) and UCI (user control input) files for HSPF and SHADE simulations. Pre- and post-processing of input and output time series data sets in the WDM file were undertaken using ANNIE, METCMP, and SWSTAT (also see Figure 2).

Simulation Results and Conclusions

The enhanced HSPF modeling system with the new SHADE model was applied to simulate the watershed hydrology and stream temperatures in the Upper Grande Ronde. The hydrologic simulation results are presented in Chen et al (1995). Stream temperature simulation confirmed the accuracy and robustness of the modeling system. To identify the possible causes for reducing the high summer stream temperatures, the impacts of hydroclimatic shifts and hypothetical riparian vegetation buffers were evaluated. Simulations demonstrate that natural weather cycles of ñ10% or ñ20% in air temperature, solar radiation, and precipitation can not sufficiently moderate the stream temperature regimes for the survival and reproduction of salmon. Therefore, riparian vegetation is the only critical factor that can be managed to significantly alleviate the lethal and sub-lethal stream temperatures. Stream temperature forecasts for restored riparian buffers demonstrate that 44 out of 51 reaches in the watershed can achieve the standards which include the maximum summer temperature of 16oC and average 7-day maximum temperature of 14.5oC. Downstream reaches on the mainstem Grande Ronde River are too wide to be sufficiently shaded by the restored buffers to meet the standards. The creation of thermal refugia or other management practices may be required if studies of the threatened salmon species show that the mainstem is a critical habitat.

Simulated maximum values of stream temperature, on which the riparian restoration forecasts are based, are accurate to 2.6 to 3.0oC. Hourly simulations have approximately the same accuracy and precision. The phase, diurnal fluctuations, and day-to-day trends in stream temperature simulations are very good, confirming the validity of shading computations and the observed air temperatures. Occasionally, the model conservatively oversimulated, especially in localized areas where cool ground-water in-flow may dominate. The difference in the spatial resolution between the reach-averaged simulations and the point measurements of stream temperature, together with other data uncertainties such as the limited precision and accuracy of riparian shading characteristics and the lack of extensive channel morphological data,

caused some systematic simulation errors for 13 of the 27 calibration sites which have valid data.

In summary, the application study demonstrated the validity and usefulness of the SHADE-HSPF modeling system. With the SHADE-generated solar radiation data, the enhanced HSPF modeling system can accurately simulate reach-averaged stream temperatures at the watershed scale by accounting for the riparian shading characteristics and the thermal impacts of basin-wide land cover on the runoff temperatures. Compared to the 8 to 10oC violations of the temperature standards under the present riparian vegetation conditions in the Upper Grande Ronde, the model accuracy of 2.8oC is more than adequate to assess riparian restoration scenarios. The calibrated and validated HSPF modeling system will be used to target critical temperature-impaired reaches for riparian restoration and to predict the effectiveness of various hypothetical restoration alternatives in supporting of the development of the nation's first stream temperature TMDL (Total Maximum Daily Load).

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Evaluation and Use of Fertilizer and Pesticide Fate and Transport Models At Golf Courses

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Pesticide fate and transport to receiving waterbodies near golf courses have become important issues to the regulatory and scientific community. Unfortunately, few if any studies are available that rigorously evaluate existing models for their applicability and accuracy of prediction under the soil and turf profiles typically found at golf courses. EPA and other regulatory agencies are currently formulating policy designed to minimize the impacts of pesticides on receiving streams based on expected toxic effects of pesticides to plants and wildlife. However, the analytical tools needed to predict actual instream concentrations of pesticides under standard application rates have not been tested or validated for golf course conditions. In particular, many existing models are designed at the "micro-scale", requiring complex information on soil profiles, hydrology, rate constants, and other hydro-geographic information which is typically not available at most golf course locations. In most regulatory applications, models developed at the "macro-scale" may be more applicable and require much less information to run.

This presentation contains results of an intensive study funded by the U.S. Golf Association to evaluate the universe of potential fate and transport models. The study consisted of the following phases: (1) identification of candidate models; (2) review of all models with respect to data requirements, applicability to regulatory settings, ease of use, and expected prediction accuracy and precision; (3)

selection of the best 2 or 3 models for rigorous evaluation; (4) quantitative testing and validation of the best models with actual monitoring information typically collected by golf courses; and (5) statistical analysis of the models' accuracy and prediction under a variety of conditions.

An eight-step process was initiated to determine the suite of applicable models for macro-scale analysis of pesticide and nutrient runoff from golf courses. Thirty models were evaluated. Models were selected based on criteria that included the following characteristics: resolution, hydrology requirements and handling, sediment transport requirements and handling, pesticide and nutrient management flexibility, and total amount of input data required. Based on the established criteria, SWAT and SWRRBWQ were selected. Two screening models were also selected: CHEMRANK and NPURG. These models represent the most basic level of models in terms of assumptions, information needs, and output.

In addition, we developed and evaluated simple Tier I-level risk assessment procedures for determining the potential risk of pesticides and nutrients to receiving streams.

At our presentation, we will present the final results of the analyses including the following:

1. An analysis of the of the precision and accuracy of SWAT and SWRRBWQ in predicting runoff from golf courses will be presented. Model predictions will be compared with actual measurements taken at operating golf courses.

2. Methods appropriate for Tier I risk assessment will be presented. These include cost-effective procedures for evaluating the impacts of pesticide runoff on receiving streams near golf courses.

3. We will present an analysis of the differing environmental management decisions that a golf course could possibly make based on the results from various assessment approaches, including screening-level approaches and exposure modeling procedures. We will evaluate the associated costs with each approach.

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A Visual/Interactive Method for Examining the National Stream Quality Accounting Network (NASQAN) Data

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The U.S. Geological Survey's National Stream Quality Accounting Network (NASQAN) program started in 1973 and was designed to describe the water quality of the Nation's streams and rivers on a systematic basis and to identify temporal trends in the concentration of measured constituents. There have been as many as 500 sampling stations, and samples have been collected as frequently as monthly in the history of the program. Samples were analyzed for a wide range of chemical constituents and properties. The interpretation of NASQAN data on a regional scale has been limited.

This paper discusses the use of multimedia software on a personal computer to visualize and analyze NASQAN data output generated using geographic information system and scientific visualization system techniques in a way that can be accessed and understood by the general public and scientists. This technique allows the user to interact with NASQAN data and visually examine a portion of the data base. The discussion in this paper focuses on NASQAN sites in the Mississippi River Basin and selected water quality parameters.

Introduction

This paper describes how an integrated system consisting of a large historical database, a geographic information system (GIS), a scientific visualization system (SVS), and multimedia software are used to produce an interactive data analysis tool that is useful to both the scientific community and the general public. The integrated system allows users to analyze the vast amount of three-dimensional data

contained in the NASQAN database in an intuitive manner, from both a scientific and a management perspective. Visual representations of water quality constituent concentrations across space and over time are used to facilitate data verification and interpretation. This paper briefly describes the: (1) NASQAN database; (2) study area; (3) software components; and (4) interactive data analysis tool that is produced.

NASQAN Data Base

The National Stream Quality Accounting Network (NASQAN) program began periodic collection of water quality and sediment samples at selected fixed sites in 1973. The number of sites in the network increased from less than 100 in 1973-1974 to 518 during 1978-1986, then decreased to 284 by 1994. At most sites, samples were collected monthly until the early 1980's when financial constraints resulted in a decrease in sampling frequency to bimonthly or quarterly. The water quality characteristics measured at NASQAN stations include water temperature and pH; common dissolved constituents such as calcium and silica; major nutrients such as phosphorus and nitrogen; trace elements such as lead and zinc; organics and biota such as organic carbon and phytoplankton; and suspended sediment (Ficke and Hawkinson, 1975). The original objective of NASQAN was to account for the quantity and quality of river water within and leaving the United States. In the 1980's the objectives of NASQAN were broadened and efforts were made to identify trends in the concentration of measured constituents. Declining availability of resources for the NASQAN program resulted in a decrease in sampling frequency, limitations in the number and types of constituents measured, and limitations in the interpretation of the data. Still, more than 65,000 samples have been collected and analyzed by the NASQAN program. Currently (1996) the NASQAN program is undergoing a major redesign (NASQAN II). In NASQAN II, fewer sites (80 or less) will be sampled. At these sites sampling will occur more frequently (12-15 times annually) and more constituents (including pesticides) will be measured. Results will be used to evaluate water quality conditions and constituent fluxes at selected locations on large rivers in the Nation's largest river basins.

The example presented in this paper uses data collected at 221 NASQAN sites in the Mississippi River Basin between 1971 (at some sites data were collected prior to the official start of NASQAN) and 1993. These data were retrieved from a centralized database maintained on a computer in Reston, Va. (Kathleen Fitzgerald, USGS, written commun., 1995). The bulk of the NASQAN data base soon will be released on CDROM (Richard Alexander, USGS, oral commun., 1996). NASQAN data also have been published by the USGS in annual state hydrologic data reports.

Study Area

The Mississippi River Basin (MRB) was selected as the study area for this paper because the MRB is the largest river basin in North America (3,237,500 square kilometers) and the third largest basin in the world (the Amazon and Congo River Basins are larger) (van der Leeden and others, 1990). The MRB drains about 40 percent of the conterminous United States. The average MRB discharge (about 17,300 cubic meters per second) is the seventh largest among world rivers. The MRB is home to more than 72 million people (about 30 percent of the total U.S. population), and includes the majority of the Nation's cropland

and livestock. For example, about 80 percent of the corn and soybeans and 60 percent of the cattle and calves in the U.S. are produced in the MRB (U.S. Department of Commerce, 1989; Battaglin and Goolsby, 1994). The application of agricultural chemicals (pesticides and fertilizers), tillage practices, land irrigation or drainage, and urbanization of farm land affect surface water quality. Runoff from both agricultural and non-agricultural land in the MRB contains sediment, naturally occurring chemicals weathered from soils and rocks, and contaminants from human activities. These contaminants can have significant effects on the quality of water in the MRB and the Gulf of Mexico (Justic and others, 1992). The spatial and temporal variability of several contaminants that are affected by agricultural land management practices have been monitored at NASQAN sites.

GIS, SVS and Multimedia Software

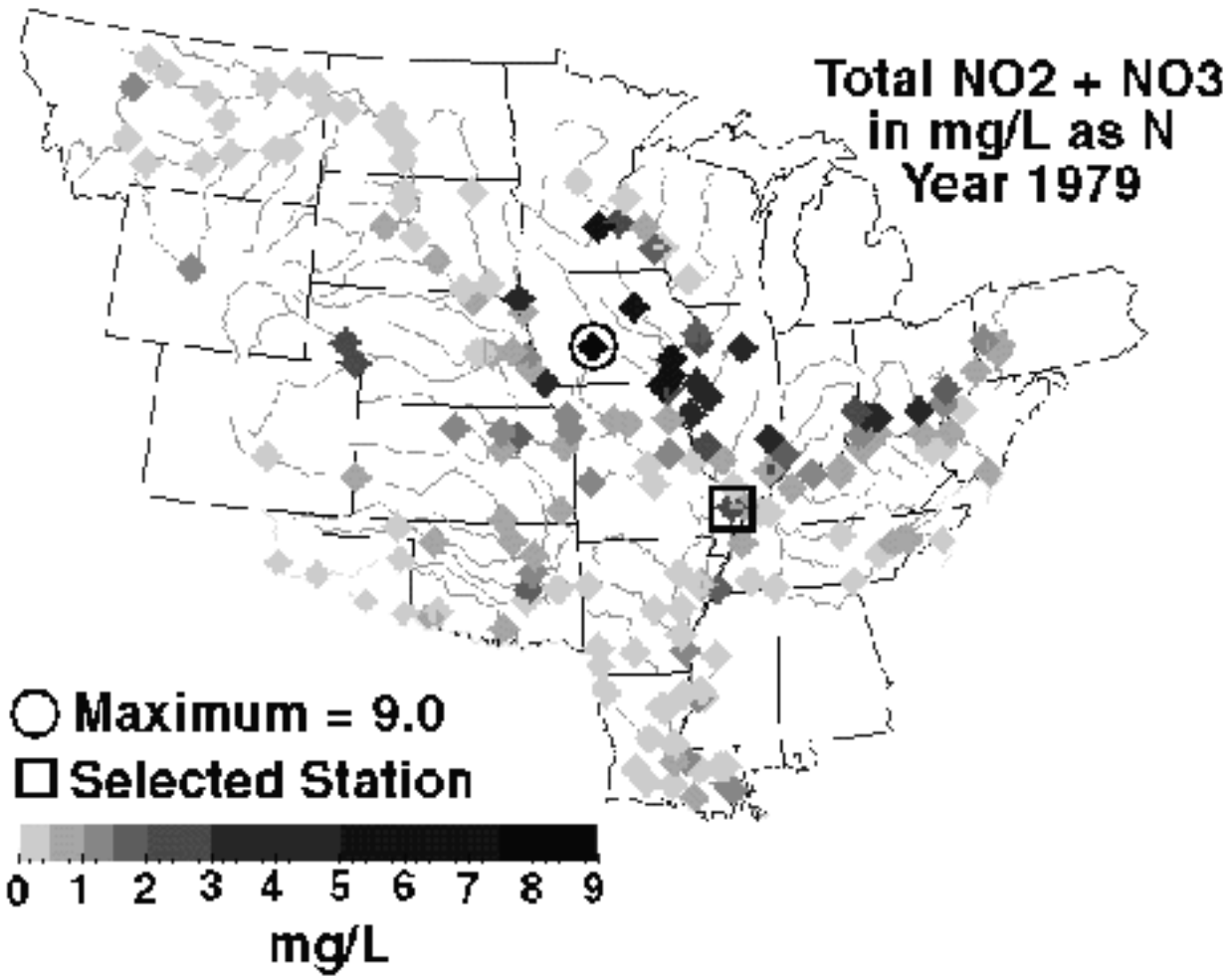
Geographic Information Systems (GISs) are useful to perform spatial analyses but commonly only used to analyze two-dimensional data. GIS tools are integral to the understanding or modeling of geographic phenomena because they provide easy data access and the ability to develop flexible methods for quantifying spatial variables over discrete areas (Hay and Knapp, 1996). Analysis of spatially-distributed data through time is tedious and time consuming as each time period is treated as a separate spatial layer. Many hydrologic models use three-dimensional and/or time-variant data. A visual representation of three-dimensional model output in two-dimensional space does not give the full representation of the data.

Scientific Visualization Systems (SVSs) can be used to generate interactive, multidimensional displays of data, but lack data management facilities and the capability to perform complex spatial operations. The objective of SVS software, to provide an interactive environment for visually exploring data, results in a wider array of visualization techniques than those found in most GISs. SVS permit the manipulation and display of data which have three spatial dimensions and are time variant. SVS also provides a variety of techniques to present data including maps, animated maps, plots, cross-sections, glyphs, dynamic glyphs, and statistical graphs. Incorporating SVS techniques into a geographic problem-solving environment can greatly enhance data interpretation because both spatial and temporal dimensions can be explored, large complex data sets can be viewed interactively, and multiple data images can be presented to accommodate a variety of scientific and management perspectives.

Multimedia software (MS) is useful to produce stand-alone projectors (movies on a personal computer) that are built from images produced using other software (such as GIS and SVS). Projectors with sound incorporated can be distributed to other parties and viewed on a compatible personal computer.

GIS, SVS, and MS are individually strong in specific aspects of spatial data analysis and display, but are inadequate in cross-functional analysis of complex problems. The software components of the integrated system presented here consist of ESRI's GIS tool ARC/INFO (use of trade names does not constitute endorsement by the USGS and is for identification purposes only), IBM's SVS tool Data Explorer (DX) and Macromedia's MS tool Director.

Example


Total NO2 + NO3
in mg/L as N
Year 1979
Maximum = 9.0
Selected Station
0 1 2 3 4 5 6 7 8 9
mg/L

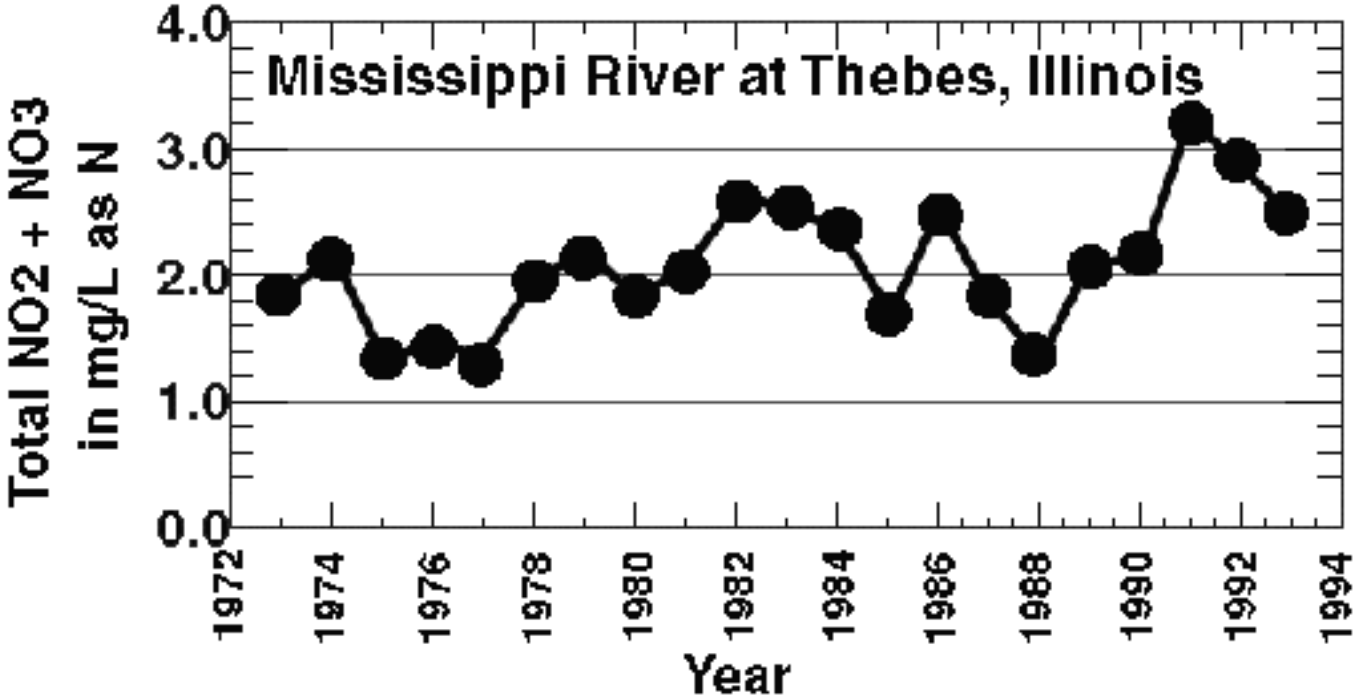

Mississippi River at Thebes, Illinois
Total NO2 + NO3
in mg/L as N
4.0
3.0
2.0
1.0
0.0
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
Year

Figure 1. Sample output from the data analysis tool.

The water quality constituents selected for display in this example are concentrations of total NO2 + NO3 as N, total phosphorus as P, and total dissolved solids, dissolved oxygen as a percentage of saturation, fecal coliform count, and suspended sediment concentration.

In this example, the user is able to select: (1) a constituent; (2) a seasonal or annual time frame; and (3) a station. For example, figure 1 shows total NO2 + NO3 as N on an annual average basis at all sites, and at a selected station: Mississippi River at Thebes, Ill.. The selected station appears with a black box around it on the map. The maximum annual average concentration for that year appears highlighted with a circle around the station. During the analysis, the station's marker symbol changes color as the annual average concentration changes over time. The graph shows the annual average concentration at the selected station for the period of record.

Each of the software components contributed to the making of the final data analysis tool. GIS provided all the background coverages (rivers, state outlines, and station locations). SVS produced the actual images utilizing the GIS information and sequencing through time. These images were saved and transferred to the MS where sound, additional text, and interactive buttons were incorporated, producing a stand alone projector.

Discussion and Conclusions

A method for viewing selected data from the NASQAN data base for the Mississippi River Basin is described in this paper. In this method, the user is able to select a water quality parameter and observe seasonal or annual concentration time series over space and time, in both spatial and graphical forms. GIS, SVS, and MS were all used in the production of this data analysis tool which is transferrable to compatible personal computers for interactive use. Interpretation of the NASQAN data using visualization and statistical analysis provides a basis for the further understanding of water quality conditions in the Mississippi River Basin.

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Introduction

The Environmental Protection Agency's Office of Water has begun to re-engineer its primary marine and freshwater ambient water quality and biological monitoring and information systems, the STOrage and RETrieval System (STORET), Biological Information System (BIOS), and the Ocean Data Evaluation System (ODES). This project, begun in 1992, and scheduled for completion in mid 1997 will represent a first for the Agency in the area of large systems re-engineering. STORET, BIOS, and ODES contain over 250 million parametric observations from over 850,000 sampling stations nationwide. These data, collected primarily by States, represent an investment of over $2.2 billion. These systems serve as the Agency's primary sources of point and non-point source ambient water quality and biological monitoring data and their analytical tools support a wide range of EPA water quality and ecosystem health assessment activities.

This new system will better meet the emerging data and information needs associated with watershed level environmental protection. This new system will also facilitate the data sharing activities and spatial assessment requirements necessary for successful local watershed protection programs.

Implementation of new system will begin in mid 1997, initially in a client/server architecture probably using a UNIX/Oracle server and a PC-based Oracle client workstation configuration. Additionally, we may offer a version which will operate in a stand-alone mode on a 32-bit PC workstation. Final

determination of our implementation architecture will be made in late 1996. We expect to precede our implementation and roll-out with a period of "Beta" testing in selected EPA Regional Offices. For these tests, we will install the new system in the Region, and conduct hands-on training in its use. Feedback from these tests will help determine the actual configuration of the new systems first release.

Background

The features of the new system are being carefully engineered to meet the information requirements of our federal, state, and local clients engaged in ambient water quality and biological monitoring activities of all kinds. The process of identifying the functions which make up these activities, and identifying information generated by, and needed to, conduct them is known as Information Engineering (IE).

IE employs a common repository of analytical tools to construct models of data relationships and process flows to efficiently design an information system to store data for an organization. To support the IE approach the project team is using the Texas Instruments I-CASE tool set, Information Engineering FacilityÖ to capture detailed data requirements.

This project began in early 1992 with a series of system requirements gathering workshops. EPA conducted over 15 Joint Requirement Planning Sessions (JRPS) nationally involving well over 600 current STORET, BIOS, and ODES users, as well as their middle and senior managers. These workshops were attended by many State and local governments, and several environmental organizations. From the results of these workshops the Agency generated a high level data architecture, and formulated five critical success factors for the new system:

1. It must be easy to get data in to and out of the system,

2. The system must have a menu access and browse capability,

3. The system must support the storage of quality assurance and quality control (QA/QC) information on a project basis,

4. The system must be flexible and able to change with the changing needs of its users,

5. The system must provide a wide range of standard output formats, i.e., dBase, Lotus, ASCII... including the GIS environment.

The immediate next steps conducted during 1993 and 1994 included the completion of the business area analysis, construction of logical data model, and the prototyping of system functional requirements. User testing of portions of the new system began in late 1994. Users were formally introduced to the new system during a National Workshop held in Dallas in February 1995. At this workshop attendees began the testing and validation of user requirements, a process which is crucial to user acceptance of the new system. At the next National Workshop, tentatively scheduled for September 1996, users will begin

testing the complete system prototype. Roll-out of Production Version 1.0 of the new system for use by the federal, state, and local users is planned for mid 1997.

Database Design

The new system, designated STORET X for development purposes, has been divided into 5 primary business areas, each one representing a closely related set of activities and their associated data. These are:

1. Identify and describe organizations which conduct ambient water quality and biological monitoring activities.

2. Identify and describe the projects or surveys within which these activities are carried out.

3. Identify and describe the physical locations (sites, areas) at which monitoring occurs.

4. Identify and describe water quality sampling, observation, and measurement activities which occur at these sites.

5. Record the results of sample analyses and field measurement.

The STORET X prototype embodies these five business areas. As mentioned earlier we will be demonstrating this new system to current and future clients beginning in September 1996.

The following discussion highlights the key features of the new system, with an emphasis on areas in which it differs from the legacy systems it will re-place.

Organizations

In STORET X, organizations will be the primary owners of data, and will control access to it. Organizations will also own metadata, or data describing their data. Organizations will own project descriptions, and lists of organizations and people with whom they work. Organizations will also control a broad set of lists representing their preferences or usual practices associated with their monitoring activities. These lists may include aids to data entry (e.g. substances tracked by monitoring activities, habitat evaluation criteria, and so forth), equipment used in the field, methods used in their labs, bibliographic references they use, and many others.

Projects or Surveys

Monitoring activities are organized by Project or Survey. The descriptions of an organization's projects

will be kept, in summary form, in STORET X. Field activities and their analytical results will be linked directly to all the projects they support. Projects may in turn be linked to programs, and because programs may be defined broadly to include the projects of several organizations, data from any field activity may be easily shared among both organizations and projects.

Project descriptions will permit the linking of data quality objectives and other quality control plan items to a broad spectrum of data. In this way, the needs of users for data quality descriptors can be met with a minimum of data entry effort.

Sites or Areas Monitored

As in the legacy systems, all data concerning field work is keyed to the specific location at which the field work is conducted, so that measurements of water quality obtained can be linked to the place they represent. The concept of "site" in STORET X is broader than it was in these older systems.

Location is very important to EPA, and the EPA standards for locational data are strictly followed in STORET X. In addition, all applicable federal standards (FIPS, NIST, and others) are used wherever possible.

Each STORET X site has a point of reference, whose latitude and longitude are fully defined. In addition, each site may include an area boundary, a field of actual monitoring locations, and the descriptions of any permanent sampling grid or transect found there. For facility sites, additional locational data may be entered for the individual end-of-pipe locations, and for well sites, a field of individual wells may be described.

Sites may participate in external reference schemes, and may carry identifiers from these schemes. For example, a site in STORET X might have an NPDES number, and also be assigned a code to represent it within a state regulatory program. In addition, any site which contributes data to a project may be assigned a project-specific identifier to assist project staff in easily identifying it.

Once a site has a defined reference point, with a latitude and longitude consistent with EPA policies for locational data, it may be assigned to one or more projects, and begin collecting samples. This assures that all results are place-based.

Site Visits, Cruises or Trips

The collection of environmental data is always linked to a specific site visit, to relate it to both space and time. Site visits are treated as events on a trip (or cruise), and activities which are related to multiple site visits are linked to the trip. Trip descriptions will include the names of key participants, cooperating organizations, and the sites to be visited. Certain Quality Control (QC) activities such as the preparation and handling of trip level, as well as, site and sample level QC samples are linked directly to the trip and

associated with their corresponding individual(s) samples.

Each site visit on the trip becomes an opportunity to make field measurements, record observations about both the site and the environment at the site during the visit, and to collect samples. Single sites may be visited more than once during a trip, and sample collection may occur repeatedly during each visit. Samples collected may include biological catches/traps, sediment grabs, water, or air samples.

Field Monitoring Activity

Field monitoring activity may consist of water, air, or sediment sample collection, biological specimen catch/trap events, and any measurements or observations obtained while at the site. Each of these field activities is linked to those analytical results it generates.

Measurements and Observations

Information gathered in the field through the process of measuring or observing the environment during the site visit is recorded in STORET X as part of the site visit description. These data may include physical conditions of the site itself, status of any equipment permanently located at the site, biological habitat assessments, weather observations, and simple field-determined physical or chemical data.

Samples

Samples are described according to the medium sampled, and the intent for which they were collected. Methods and equipment used to collect samples are fully described, by linkage to lists of methods and equipment. These lists will be available from EPA, or client organizations may choose to supply their own lists.

STORET X will accept descriptions of the sample collection process which address the complete spectrum of water monitoring and sampling of the biological community. For large area samples, such as trawls, details such as the lat/long of its end points, the gear deployment depth, the bottom conditions under the trawl, and others can all be recorded.

Samples can be created from other samples, by compositing, splitting, or subsampling. Each new sample is linked to its "parents", so that it can be traced back to all the events which might influence its results. A sample which is generated by a trawl (a "catch") might be the parent of a sample which is an individual fish. The fish in turn might be the parent of a sample which is a specimen of liver tissue, and chemical results for this liver specimen can thus be traced back to the spatial coordinates of the original trawl.

Results

Each result is attached to a field monitoring activity. If the activity was the collection of a water sample,

the results are qualified by all the methods used to collect, handle, store, and process that sample. The results may be further qualified by the identity of the lab performing the analytical work, and equipment and methods used in this process. Statistical information concerning confidence intervals may be supplied, and for results which are not quantified, detection status and quantitation status may be stored. Results which are counts or percentages may be qualified by the range of some size or weight variable which they represent.

Biological results are handled in different ways. For a "catch", the biota may be grouped and regrouped repeatedly for counting, weighing, or measuring. For example, one grouping might be by taxon, and the counts recorded for purposes of computing taxonomic diversity and richness. Another grouping might be a user-defined histogram or class frequency table of fish lengths within a species, and yet another might be to record counts and weights of only adults, or only gravid females, or any other category the analyst might request. A catch might be divided so that a group contains only 1 individual, and a detailed description of it recorded.

Planned Outputs

STORET X will emphasize the delivery of data to the end user, in the form most compatible with the intended analysis. A variety of data delivery formats is envisioned which will facilitate the export of STORET X data onto the local workstation, from which it may be portrayed statistically or graphically, or imported into a Geographic Information System (GIS). Users will have broad latitude in defining these export formats. In addition, certain aids to data interpretation will be available on our server, to enable data browsing and to provide data summaries.

Summary

STORET X is the first major change to EPA's immensely popular STORET System since its inception in 1964. With this new system, the water monitoring community will have access to information and data structures which accurately reflect the current and future way they do their jobs, and which can be effectively used by decision makers to both plan and evaluate the effectiveness of pollution prevention and abatement programs.

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Characterizing Drinking Water Quality In the Watershed: Do We Have The Tools?

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Characterizing Drinking Water Quality-Data Management vs. Data Availability

Our ability as State and EPA regulators to characterize the drinking water quality in the watershed is in most cases poor. Even the data available to the water systems on their own water supply sources is limited in scope and sporadic. Yet despite the data gap, source water management has emerged at the national and state levels as an attractive alternative to the existing drinking water regulatory framework. EPA has taken advantage of its limited statutory discretion to build such options into its current regulatory program. Under EPA's Surface Water Treatment Rule over 150 water systems were allowed to avoid filtration treatment (and save millions of dollars in capital costs) because they were able to show their source water was protected from contamination. Many thousands of water systems also were granted monitoring waivers for selected chemicals where the data showed that the source water was not susceptible to contamination. Such incentives are likely to increase in the future: Source water protection will likely find its way in one form or another into the Safe Drinking Water Act reauthorizatrion proposals now under consideration in Congress.

Are we as regulators able to take advantage of the source water alternative to the traditional "monitor, then treat" drinking water regulatory structure? Do we have an adequate information base to know which source waters are impaired and what potential risks to drinking water supplies are on the horizon? The short answer is NO! Although there is plenty of water quality monitoring data available from several

different programs, we have been unable to effectively collect, integrate, and manage the existing data to systematically show which source waters are at risk and which are not.

What can we do to improve data management to support our source water initiatives? At least at EPA and most states, launching a new data collection initiative is not on the horizon. The challenge is to make effective use of the tools already in place on the existing data bases to better characterize drinking water quality in the watershed.

This paper will focus on two data management tools that could help states build a source water quality data base. First, Section 305(b) of the Clean Water Act requires the states to prepare on a biennial basis an assessment of which water bodies are meeting the designated uses defined under State Water Quality standards, including for drinking water use. The guidelines sent to the states for the 1996 305(b) report included for the first time a detailed technical approach to assembling available Clean Water and Safe Drinking Water Act data to make the assessment. Second, EPA is beginning the installation of the new Safe Drinking Water Information System (SDWIS) in selected states, which will give the states capability (at their option) to merge analytical results data through Electronic Data Interchange (EDI) with locational data on water sources, flow, and treatment.

The 1996 Guidelines for the CWA 305(b) Report and Drinking Water Assessments

The 1996 305(b) Guidelines provide a framework for characterizing drinking water quality in the watershed. States are asked to assess whether water bodies can support their use as water supplies and then to group each water body into one of five categories, based on an objective look at available monitoring and other data: fully supporting, threatened, partially supporting , non-supporting, or unassessed. States are asked to focus their drinking water use assessments on those contaminants with State Water Quality Standards under the Clean Water Act that also are regulated under the Safe Drinking Water Act.

The Guidelines lay out three different data sources for use in the state assessment of drinking water use support:

- Ambient Water Quality Monitoring Data available at the state from the water quality management program for rivers, lakes, and reservoirs used as drinking water supplies by public water systems.

- Drinking Water Use Restrictions set by the state or local government for a specific source, including closures, other restrictions (e.g., boil water notices), or requirements for treatment based on source water quality.

- Public Water System (PWS) Compliance Monitoring Data required to be submitted to the state under the drinking water regulatory program.

Ambient water quality monitoring data, including raw water data collected at the water intakes, is clearly the best data source. But availability of such ambient monitoring data is sharply limited for most source waters. Data on use restrictions is even more limited. These data limitations in the past have resulted in a relatively small percentage of water bodies with drinking water use assessments. EPA proposed new guidelines that the states use the compliance monitoring data base where other data is not available or inconclusive. By broadening the data base to monitoring data taken at the water system itself, EPA hoped to increase the percentage of water bodies assessed for drinking water use.

This recommended new protocol is fraught with risk if not used carefully. First, much of the water system data is collected after treatment, and may not properly represent the source water quality. Second, the drinking water data base may be managed by a separate Division or Agency in the state and the integration of data sources may not be feasible. The Guidelines address how such risks can be avoided through a front end screening of available data before use in the water body assessment.

Safe Drinking Water Information System (SDWIS)

SDWIS offers the states a data base structure to store, retrieve, analyze, and report on data needed to complete the drinking water portion of the 305(b) report. SDWIS contains information on over 200,000 public water systems. The potential for its use to support 305(b) assessments is great, but tailoring such a use for SDWIS will be a long undertaking and require considerable resources.

EPA initiated the modernization of its previous drinking water data base (i.e., the Federal Reporting Data System (FRDS)) in 1992 to address existing drinking water data deficiencies and to respond to an emerging Agency priority to integrate data bases around "places" rather than programs. The objective was to improve the accessability and quality of drinking water data to a broader range of stakeholders, including the states. EPA published an Information Strategy Plan (ISP) in December, 1992 that defined the components of the data base structure and the technical architecture of the system itself.

The SDWIS data base structure laid out in the ISP covered all aspects of the drinking water business, from traditional drinking water elements-such as inventory, sampling, monitoring schedules, and enforcement-to program tools such as automatic compliance determinations and monitoring schedule adjustments.

The technical architecture envisioned two systems: a national EPA data base (converted from FRDS) residing on DB2 on the EPA Mainframe (called SDWIS/FED) and a State-level Oracle-data base operating in a network environment using either Novell or IBM's OS/2 LAN manager (called SDWIS/LAN). The two systems would use the same data model and data element encyclopedia. Upload of selected data fields to the EPA SDWIS/FED data base from the State SDWIS/LAN would be part of the system design.

SDWIS is being developed in a modular fashion, with each successive module integrated into an upgraded version offered to the states for installation. The current version of SDWIS includes four core

business systems (inventory, sampling and analytical results, compliance schedules, and automatic non-compliance determinations for selected rules). SDWIS/FED replaced FRDS as the EPA data base of record last August. The SDWIS/LAN software has been installed in nine states and two Regional Indian Land programs. We will shortly offer the states the capability to electronically transfer sampling data directly from the analytical lab to the SDWIS data base, using an Electronic Data Interchange (EDI) standard approved by ANSI. Eventually, we expect over 30 states to adopt SDWIS/LAN as their drinking water data base of record.

The potential for use of the SDWIS data base to support the states' 305(b) assessment is great. The SDWIS/LAN data base can be used, at the state's option, to store analytical results for both regulated and unregulated contaminants, linked to each water source and treatment facility. The data base includes common identifiers, including HUC code and lat/long, that could give a spacial dimension to the data and link it with related data used in the 305(b) assessment. Special fields in SDWIS will allow data sharing with STORET and other state data bases to better characterize the water quality in selected watersheds.

The Challenge-Taking Steps Now that Make a Difference in the Future

The two data management tools outlined here are of most use to the states, who have the most to gain from better management of the available data to characterize drinking water quality in their watersheds. The 1996 305(b) Guidelines define a protocol for States to collect and evaluate data from several sources to make a reasoned assessment of whether water bodies meet their drinking water designated uses. The emergence of SDWIS as the State drinking water data base provides a vehicle that supports the state use of this 305(b) protocol. Although only 9 States and two Regional offices currently have the SDWIS application installed locally, there are close to 25 additional states who are interested in pursuing SDWIS over the next several years.

The integration of SDWA information into what has traditionally been a CWA program is no small undertaking. The benefits of such integration for building a drinking water source water protection program could be substantial, but the resource investment at the state level is significant. States interested in using the 305(b) process for the drinking water assessment, in conjunction with SDWIS implementation, should work closely with both the water quality and drinking water staff at EPA to devise a multi-year strategy to bring the various pieces together.

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Application of Agricultural Nonpoint Source Models to Predict Surface Water Quality Resulting From Golf Course Management Practices

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Abstract

Pesticide use on golf courses within the State of New Jersey is presently being examined as a major contributor to the degradation of surface and ground water quality. In April of 1991, as part of an effort to determine pesticide use in New Jersey, a survey was sent to all 219 courses within the state by the New Jersey Department of Environmental Protection_Pesticide Control Program (NJDEP-PCP). Of the 219 golf courses surveyed, 204 responded to the survey (93%). From these completed surveys, it was determined that fungicides are the most widely used pesticide within the state, accounting for 63% of all pesticides utilized.

The goal of this survey was to address public concerns, establish monitoring programs for pesticide use, and develop guidelines for golf course management. In 1993, the NJDEP draft manual entitled a "Guidance Manual for Siting, Design and Maintenance of Golf Courses" recommended the use of computer models to predict the impact of pesticides on surface water. In conjunction with the NJDEP-PCP, Stevens Institute of Technology examined the use of several agricultural nonpoint source models to determine their applicability to a golf course management. This paper presents the use of an existing agricultural water quality model to predict surface water quality resulting from different golf course management practices.

Modeling a Golf Course

Participation in the NJDEP-PCP golf course survey was strictly voluntary. The courses which participated provided all chemical application information for 1993, 1994 and 1995. As part of a continuing investigation by the NJDEP-PCP, several golf courses granted permission to the NJDEP-PCP to obtain surface water and soil samples periodically throughout the year. These samples were used to validate the computer model.

The course selected for the initial modeling began operation in June of 1993. Prior to its development as a luxury 18-hole course, the land was part of the New Jersey Pine Barrens, and most likely not subjected to chemical applications. As a result, any chemicals found in the surface water and soil samples were assumed to be related to current golf course management practices. The course covers approximately 80 acres and is located within the southern coastal plain of the state (Atlantic County). The soils in this region are generally a sandy loam and classified as hydrologic soil group B. The surface water within the course is collected by four detention basins. Surface water and soil samples were taken by the NJDEP-PCP in May, July, August, September and November of 1994. The water samples were taken from the surface of each pond, and soil samples taken along the banks. These sample locations were chosen because they represented the low point within each drainage area.

The computer model selected for the analysis was Groundwater Loading Effects of Agricultural Management Systems (GLEAMS). It is an extension of the Chemical Runoff, and Erosion from Agricultural Management Systems Model (CREAMS). These models were developed by the United States Department of Agriculture_Agricultural Research Service (USDA-ARS) Southeast Watershed Research Lab. The GLEAMS model consists of four input files, hydrology, erosion, pesticide and nutrient. Since the golf course survey indicated that pesticides where the most commonly used chemical, the nutrient component of the GLEAMS model was not considered.

The GLEAMS model was chosen for several reasons: (1) It was recommended by the NJDEP in it's draft golf course design guidance manual, (2) It is a very user friendly model and (3) The data necessary to run the GLEAMS can be obtained from construction drawings of the course, chemical application records, the county soil survey, minimal soil samples, and sound engineering judgment.

The GLEAMS model was used to predict the fate of pesticides in surface water for 1993 and 1994 on the

Atlantic County course. Input files were created for each of the four drainage areas, the required Hydrology, Erosion and Pesticide input for the GLEAMS simulation were as follows:

Hydrology

The drainage area, hydraulic slope and the ratio of the field length to width were obtained using the construction drawings of the course. A Soil Conservation Curve Number (SCS-CN) of 80 was selected due to the extremely dense nature of the surface of a golf course. The root zone for the course was chosen to be 6-inches. This was determined from soil samples and available data on the turf. Two soil horizons were determined to exist within the 6-inch root zone. The top 2-inches were found to consist of a very sandy soil and the 4-inches immediately below consisted of a sandy loam. The parameters required for these two soil layers were obtained from laboratory tests, the United States Geological Survey (USGS) Soil Survey for Atlantic County, New Jersey, and other available data. Other hydraulic parameters including porosity, field capacity, wilting point, saturated conductivity, organic matter content, and the percent of silt and clay were also required. Environmental input parameters including the mean monthly maximum and minimum temperatures, and monthly solar radiation for each year within the simulation period are also necessary.

Erosion

The erosion component of GLEAMS accounts for the surface conditions of the drainage areas. An overland flow profile was determined from the construction drawings of the golf course. A site visit was also performed to verify the path. This overland flow profile was entered in segments of uniform slope. The soil erodibility of the surface profile was entered in segments of uniform erodibility. The path should best represent how the soil erodibility changes within the drainage area. For a golf course there are several different land surfaces, turf grass, sand traps, rough areas and sometimes a natural border of woods, each which can have a different erodibility. The overland flow path is further described by parameters which include the soil loss ratio, contouring factor and the roughness coefficient (Manning's "n"), for each segment. The overland flow path for the area was chosen to best represent the drainage area.

Pesticide

Ten separate pesticides can be simulated in a single run of GLEAMS. The Atlantic County golf course uses many different chemicals. The three most frequently used were Chlorothalonil, Iprodione and Metalaxyl. These are all fungicides and were applied frequently throughout the season. The pesticide input data included the water solubility of each pesticide, the half-life of the chemical within the soil, upon the foliage and the partitioning coefficient. These values are all readily available, either from the chemical manufacturer, or in applicable agricultural literature (Balough, 1992 and Meister, 1992). Along with the chemical specific parameters, other input values included the concentration of pesticide residue on the foliage and in the soil when the simulation began, the fraction of pesticide on the foliage available

for washoff by rainfall and the coefficient of pesticide uptake by the plants.

Following the chemical specific input, the pesticide application information was entered. The application rates were entered according to the Julian date of the application, the pesticide being applied, the depth of incorporation, and the fraction of pesticide applied to the soil and the foliage. These values were entered for each day of application within the simulation period.

Results of the GLEAMS Simulation

The GLEAMS model was used to simulate the four separate drainage areas within the Atlantic County course. The results of each area were analyzed separately and compared to the field samples obtained from the respective areas. Since the results of the four areas was determined to be similar, only one of the four areas will be presented for discussion. Also, since Metalaxyl was the only pesticide consistently detected in the field samples, further analysis of Chlorothalonil and Iprodione was discontinued.

The output from the GLEAMS model gave the predicted pesticide concentration in the runoff water, sediment and percolation water. Since this study was directly concerned with the contamination of surface water, only the concentrations in the runoff water were examined. The predicted concentrations of Metalaxyl in the runoff water for a single drainage area are presented in Figure 1.

The initial predicted concentrations of Metalaxyl did not correlate well with the actual surface water samples taken by the NJDEP-PCP. It was determined that GLEAMS was not accounting for the dilution and degradation of the pesticides in the ponds. The GLEAMS model was modified to account for these processes. The final predicted concentrations of Metalaxyl compared to the actual sample results are presented in, Figure 2.

Figure 2 shows the initial levels of Metalaxyl in one of the ponds and the degradation which then takes place. The three points represent the samples taken by the NJDEP-PCP on August 24, September 15, and November 4, 1994. As can be seen from this figure, the final predicted concentrations of Metalaxyl were in close agreement with the actual surface water samples.

Conclusions

The modified GLEAMS model can be a very useful and effective tool in predicting the movement of pesticides on the surface of a golf course. The GLEAMS model was developed in order to predict the fate of agricultural chemicals and determine the best management practices for agricultural land use. Unlike farmland, golf courses are not flat and uniformly planted or maintained. With some modifications to the program and the input parameters, GLEAMS can predict the movement of pesticides into the water system of a golf course and which chemicals may pose a direct threat to the quality of surface waters.

The State of New Jersey presently has 219 USGA approved 18 hole courses. This number is expected to

double by the year 2000. A predictive tool such as the modified GLEAMS model can be a valuable asset to the golf course industry in order to preserve the quality of surface waters within the state. When the construction of a course is proposed, the input requirements can be easily obtained through soil testing and site plans. The GLEAMS model could be used to determine the best management practices for the course, the best locations of ponds, and the most effective grading of the land. Using GLEAMS to model an existing course can assist golf course managers in choosing the best management practices in order to preserve surface water quality.

Future research on this subject should include the use of the GLEAMS model in conjunction with additional program modifications/extensions to further refine the model's applicability for golf course management .

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Urban Forest Management of Community-Owned Open Spaces

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Trees and forests are essential components of our communities that make a community more livable. Studies show that trees and shrubs improve a community's appearance, improve energy efficiency and air quality, and increase property values. Trees are also a factor in retaining and attracting residents, which promotes community stability. More and more businesses are locating their offices and industrial complexes in wooded settings because they present a desirable aesthetic atmosphere for their employees and customers. But aesthetic benefits of a forested environment is only one of many provided by forests. The economic and environmental benefits that forests provide are also part of the explanation for the increasing value of forested real estate.

Nationally, 75% of the population lives in the urban/suburban environment and these areas are expanding at a rate of 3500 acres per day.1 Therefore, the need for our communities to develop a plan to manage our remaining natural resources is becoming increasingly important. The remaining fragments of undeveloped open space, parkland and street trees comprise the urban forest. Overall, our community forests are declining from poor management and surveys indicate the rate of tree removal exceeds those being planted.2 So it is important to properly mange these tracts to maintain their health in order to derive the maximum benefit for both human and animal life.

Currently, a comprehensive guidance document for the owners of these tracts; homeowners associations, community associations, or property management companies, is unavailable. Management is either performed on an as needed basis, possibly incorrectly or not at all. To address this issue, COG staff in coordination with the Community Forestry Network has developed the Community Forestry

Management Handbook. This handbook was inspired by a concern for the care of these urban forest lands, and also to foster an appreciation for this valuable resource. Another goal of this handbook is to guide the forester/urban forestry professional to better understand the needs of the community in the management of their urban forests. Together, all of these communities and their urban forest tracts are "linked". By providing a consistent management philosophy, it is the hope that the outcome will be a healthier forest, wildlife and human community.

The most important aspect of Community Forestry, as presented in this handbook, is promoting the idea of stewardship of the environment. Whether the issue is water quality, soil erosion, or forest land management, these aspects of the environment are so closely connected that an affect on one influences them all. Stewardship of the environment must always be the first consideration whenever an activity may affect any one of these environmental components. This applies to the largest of community projects to the smallest homeowner project.

The focus of the program should be to re-establish woodlands removed during construction, landscaping new areas for beautification, and preserving and maintaining the existing community forest. Activities can range from creating a forested buffer along a stream, improving water quality in local streams, to providing wildlife habitat for forest mammals and birds.

The key to growing and maintaining a healthy community forest is to involve the community and to pursue those individuals or groups that will help attain these goals. This handbook is designed to provide the basic information needed to begin to manage your community's forest.

Who Practices Community Forestry?

Community Forestry is the act of caring for our natural environment through the planting and management of trees in our parks, open spaces, common lands, yards and streets. Supporters of community forestry include private citizens, professionals, and governmental agencies. Private and governmental professionals are also involved in community forestry, with backgrounds from the fields of forestry, arboriculture, horticulture, wildlife, biology, natural resource conservation, and urban or environmental planning. Also, citizens groups and grassroots organizations devoted to terrestrial and/or watershed protection, community outreach and education and other civic-minded activities. Citizens active in their communities promote community forestry through their attention, energy and time to actively care for their surroundings.

How Does Community Forestry Begin?

Community Forest Management Programs can begin in different ways. The impetus may be a concerned resident or group that promotes a community beautification project, or the influence of the environmental quality of a neighboring community. Whatever the reason, everyone in the community has the opportunity to make a personal contribution. The success of the forest management program will be

determined by the cooperation of everyone involved.

This handbook presents a logical, step-by-step process on how to establish and continue a community forestry program. The ultimate goal of a successful community forestry program is to create a sustainable natural resource that provides a continual benefit to both the human and wildlife community. All community members have a vested interest in the trees and other natural resources of the community. The chapters in this handbook are organized so that they include the essential components of a comprehensive Community Forestry Program. The following are the topics covered in the chapters of this handbook.

Handbook Chapters

Chapter I - Establishing a Program

Chapter II - Conducting Forest Inventories

Chapter III - Creating A Community Forest Plan

Chapter IV - Tree Planting

Chapter V - Community Forest Maintenance

Appendices included cover information needed to execute the inventory and to aid in understanding the management of the urban ecosystem. Among the most notable sections are: Sources of Technical Assistance, Funding a Community Forestry Program, Pruning Standards, How to Hire an Urban Forestry Professional, Contracting.

Forest Inventories

The core of this handbook is the nuts and bolts of how to implement an inventory of forest resources within the framework of the existing community. The level of inventory conducted for the community will be contingent upon the needs and resources of the community. Typically, a community has street trees and landscaping, and in some cases larger tracts of urban forest. To evaluate these different types of forest cover, the following two methodologies are discussed to inventory woody vegetation:

- Forest Tract Sampling_This method refers to the process of collecting data from representative plots of a forest stand or other vegetation type, and then using this data to estimate the content of the entire tract. This eliminates the laborious task of locating and plotting each tree in a forest stand.

- Individual Tree Inventory_This method examines the entire tree population by gathering

information on individual trees. The complete inventory is the most appropriate for street trees, landscaped areas and "pocket" forest tracts. The data collection for these areas will concentrate on exact location, health, size, species, and surrounding conditions. The identification of hazardous trees is especially important in high traffic areas i.e. street trees, sidewalks, recreation areas etc.. This method is an intensive community forest assessment that clarifies maintenance needs, maintenance budgets, and prioritizes management activities. The individual tree inventory does require a thorough use of resources, however it does provide the best representation of forest health for the community.

Conducting the Field Survey

Once the community has determined the most appropriate inventory method for their purposed, the field work can begin. The field survey portion of the forest inventory process combines all of the map overlays to date and uses them to conduct the actual field survey work. Included in the handbook are field data worksheets, instructions and examples of their application. For individual tree inventories, criteria are listed on a field sheet to use in the evaluation of each tree. When the data is compiled for each inventory method, it is transferred to a forest resource map overlay so that it may be viewed with other community infrastructure. Figure 1 demonstrates how the resulting maps are compiled to provide a "picture" of how all of the communities features are linked to aid in forest management decisions.

Step A. Compile MAPS 1,2, &3 overlays to create a composite of the community
Step B. Use the resulting compostie map to identify the areas to conduct field inventory using Forest Tract Sampling and/or Individual Tree Inventory
Step C. Update Map 3 with field data retrieved during the field inventory (Step B).

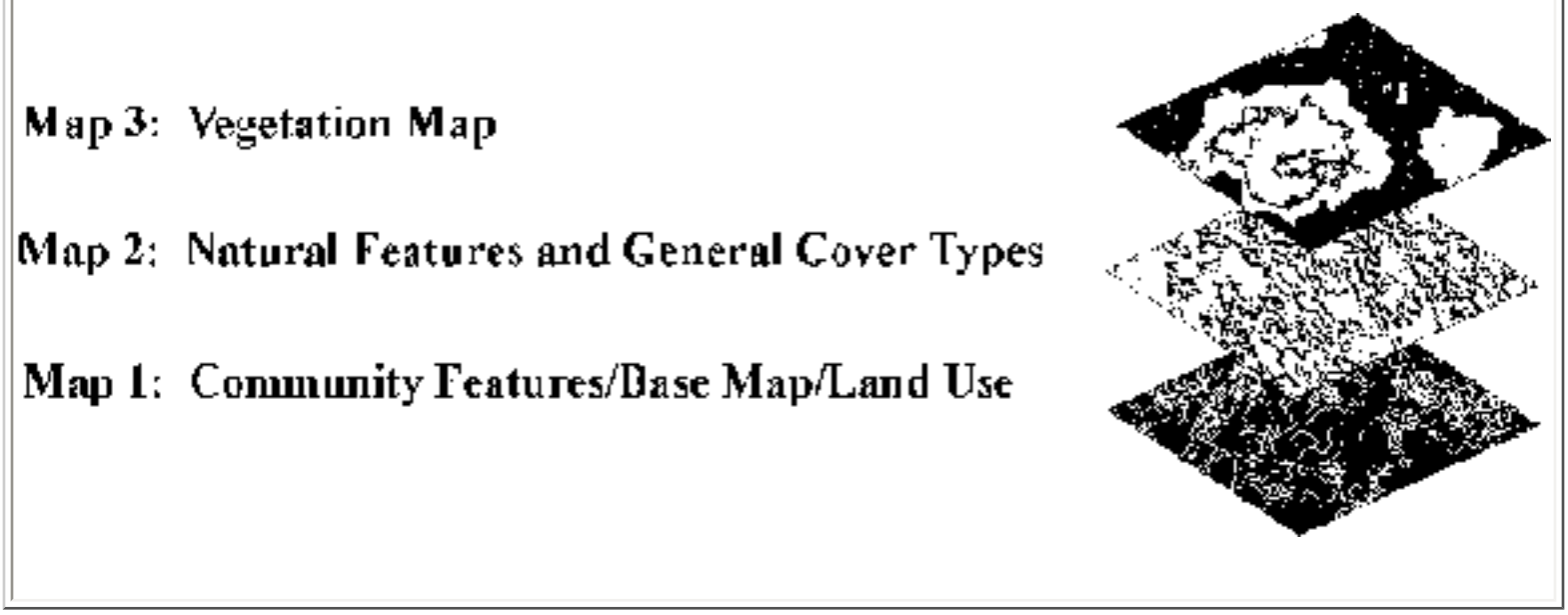

Figure 1. Forest Resource Map Overlay.

Community Forest Plan

The forest inventory is the key to developing a long-range community forest plan. Derived from the plotting of the inventory data are two basic components:

- A Resource Map developed from the community forest inventory depicting the existing and future planting patterns and other natural features for the entire community.

- A Forest Plan report that puts forth recommendations, actions and schedules to achieve the community's stated goals for the program. The report should also include how the stated goals will be achieved within the confines of the budget, available resources, related community ordinances and policies and a list of program priorities for the long-term management of the community forest.

A strategy is typically a combination of actions necessary to achieve a set of related goals and objectives. For example, a goal may be to protect the community's water resources from nonpoint source pollution in order to improve water-related recreation opportunities for the community. An effective strategy to achieve this goal is to identify those areas from the inventory data that will provide the most benefit for water quality through reforestation; evaluation of the quantity and quality of piped drainage that is impacting the watershed and determine ways to improve that delivery system; and the implementation of a community-wide education program on the use of pesticides, herbicides, fertilizers, and petroleum products that find their way into streams. In doing this, other benefits derived will be an improvement of wildlife habitat, aquatic habitat, community awareness and aesthetics. In turn, the resulting benefits will include increased property values from the community-wide improvement and recreational benefits.

The final plan should be ecologically-based, economically feasible, dynamic and flexible enough to allow updates in response to any changes in environmental conditions and community needs. Of course, the achievement of these goals will require time to plan, implement within the confines of the budget. A primary realization in situations where watershed degradation is the focus of the forest management plan is that the direct benefits are only effective when performed in conjunction with other specific rehabilitative techniques. An important period of convalescence for the watershed is coupled with a realization that indications of improvement in the health of the watershed will occur as gradual as the degradation.

Tree Planting

Planting street trees, landscaping reforestation or riparian restoration projects_all require some knowledge of what to plant, where to buy, and how to plant them. A Tree Planting Plan establishes a program for planning and creating a community that is attractive and is environmentally functional. The planting plan is necessary to establish a logical schedule to achieve the community's tree planting goals. A planting plan can be implemented in one season or in phases depending upon community priorities and the available resources and is divided into two sections: Landscaping/Street Trees and Reforestation.

Trees are an important community asset in that they play a key role in determining the "livability" of a community by softening the sometimes stark atmosphere of the urban/suburban environment. A healthy community forest or forested commercial or residential property has been documented to increase property values. Forested communities also contribute to a healthy ecosystem, and water quality benefits through interception and absorption of rainfall over non-forested properties.

A Tree Planting Plan enhances the community benefits of trees by providing:

- Improved Long-Term Tree Health
- Reduced Maintenance Costs
- Improved Aesthetic Character
- Reduced Liability from Hazardous Trees

This chapter also provides guidance on how to select and purchase the right tree for the right place_matrices and tables of desirable characteristics for specific planting situations_specifications for reforestation projects and wildlife habitat planning.

Community Forest Maintenance

Frequently, maintenance of anything that requires it, receives large helpings of neglect. Natural systems possibly suffer more as a result of an idea that if something is after all, natural, what kind of maintenance could it possibly need? Well, the answer is...Plenty. When the forest exists without human interaction, it does function well without maintenance. However, in the case of community forests, we are placing humans and infrastructure into an environment where human interaction affects the performance of the natural environment. The maintenance section provides guidance for developing a tree health monitoring plan for watering, fertilization, pruning, pest identification and control measures. Timing of these needs are summarized in a landscape maintenance calendar for the Mid-Atlantic region.

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Best Management Practices and Integrated Pest Management Strategies for Protection of Natural Resources on Golf Course Watersheds

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Introduction

Golf course management for the 21st century must be different than now. Whatever the futuristic plans for the year 2000 might include, add three factors concerning the environment to those other golf course management decisions which will affect how golf courses are managed-credibility, accountability and defensibility. Why? Because the public does influence environmental law. Because the public will insist that drinking water supplies be protected. Because of the link between water resources and watersheds, management of water resources must include the watershed. Incorporation of Best Management Practices (BMPs) to protect water resources should be part of the golf course's overall environmental management program.

Golf course management decisions must be made based on the principles of Sustainable Resource Management. This can be defined as a pattern of human activity that can be supported indefinitely. This means it must be synonymous with progress. It also means becoming less dependent on non-renewable

resources and that activities associated with golf course management must not create a negative impact environmentally. In many people's eyes, golf courses have an image as an energy waster and polluter. Those knowledgeable about turfgrasses can offer many positive environmental impacts such as the following: oxygen production; cooling of the atmosphere; absorption of sound and glare; preventing erosion; and effective filtering of natural and synthetic contaminants. Equally, a second list could be offered which touches on the positive impacts dealing with our quality of life including the following: providing areas for popular recreational activities; increasing property values; providing greenspace and wildlife habitats in urban areas; and economics-jobs! Less informed individuals, and those whose agendas are anti-development and anti-golf would list the following as negative impacts: destruction of wildlife habitat; sedimentation of wetlands; fertilizer and pesticide pollution; and wasting of valuable water resources.

Environmental quality has many aspects. Public perception and attitude is often influenced by the popular press. Consider the following article on the Neuse River which flows through Raleigh, North Carolina to the coast:

> "City sewage, industrial wastewater, farm fertilizers, livestock manure and lawn and golf course chemicals are changing the Neuse (River), choking it with nitrogen and phosphorus."
>
> _Julie Powers Rives
> *Raleigh News and Observer*

Upon inquiring as the types of studies into the problems associated with environmental quality and the Neuse River which focussed specifically on lawn and golf course problems, it was determined that there were none. The reporter admitted that she was just making a "generalization." The danger here is obvious. The public does not know what is a "generalization". Since fertilizers and pesticides are used on lawns and golf courses they must create a pollution problem. What is lacking is good, scientifically valid data which identifies a specific problem which must be corrected.

The response to these problems from the golf course perspective is clear. The industry must be proactive and not only just point out the positive benefits, but must also address situations where golf course management intersects with environmentally sensitive areas and develop management strategies which will protect these areas. To protect natural resources within the watershed a threefold approach should be taken as follows: 1) Preventative measures; 2) Control measures; and 3) Detection. This proactive approach stresses incorporating Best Management Practices (BMPs) into the design as a preventative strategy; protecting water quality through removal, filtration, detention or rerouting potential contaminants before they enter surface waters; using Integrated Pest Management (IPM) to achieve BMP goals; a Risk Assessment, including developing strategies for protection of environmentally sensitive areas and guidelines for pesticide selection based on this assessment; and detection through an environmental monitoring program that provides feedback to the golf course superintendent as to conditions and movement of materials.

Management Program

A well developed management plan will be well documented and structured. While some of the types of information may at first seem elementary, to someone who is not scientifically astute it will lend credibility to one's intentions to manage the golf course in a responsible way rather than making instantaneous decisions. This plan should include, but not necessarily be limited to, the following:

Site Description and Evaluation-This will include a detailed description of the physical setting, preferably hole-by-hole with the surrounding environment with drawings and/or aerial photographs as available to delineate where concerns must be focussed. The description should also include details of the topography and how it intersects with natural areas and interacts with management practices. The general soils mapping should be included which classifies the native soils and gives an indication of fertility, percolation, depth to bedrock and/or groundwater. Surface water features should be described and located. Data on the climate should summarize conditions which relate to growth of turfgrasses at the course and impact pest management strategies such as temperature, rainfall, potential evapotranspiration, length of growing season, and mean first and last frost dates.

Golf Course Cultural Practices-Mowing affects playability, turf performance, stress tolerance, pest problems and evapotranspiration. Mowing factors to consider include species, cultivars, and golfer's expectations. Mowing objectives during optimum and stress situations should be described. Irrigation factors such as slope, type of grass, height of cut, rooting depth, weather factors, soil types and irrigation system performance should also be documented. Fertilization factors to be addressed should include soil and plant tissue testing, objectives for growth, choice of materials, and environmental consequences. Supplemental practices such as aerification (which could affect pesticide/nutrient loss due to runoff), topdressing/vertical mowing (which affects thatch control and pesticide/nutrient response) and others are also important.

Safety-Details on storage, handling, disposal and record keeping of pesticides related to worker protection, employee right-to-know, OSHA, should be provided.

Best Management Practices-Developing the plan should rely heavily on use of (BMPs). There are several goals of BMPs which are as follows:

- Reduce the off-site transport of sediment, nutrients and pesticides;
- Control the rate, method and type of chemicals being applied;
- Reduce the total chemical loads by use of IPM, economic thresholds, alternative pest control and fertility testing

Examples of BMPs which can be put into place include:

- use of vegetative buffers for filtering runoff or sub-surface drainage

- planting more pest resistant or stress tolerant cultivars
- culturally or biologically controlling pests
- using soil testing and plant tissue analysis to help determine nutritional requirements

There are many more examples which are intent on meeting the goals of BMPs as stated above (Balogh and Walker, 1992; USEPA, 1993).

Integrated Pest Management-IPM is a BMP whose strategies have been applied in agriculture for over 30 years. Recently, the US Department of Agriculture has launched an initiative which has a goal to implement IPM methods on 75% of the total crop acreage by the year 2000. The EPA supports this effort and the Office of Pesticide Programs has been instrumental in helping golf course superintendents find ways to incorporate IPM strategies into their programs. The definition of IPM as put forward by the Responsible Industry for a Sound Environment (RISE) is as follows:

"A system of controlling pests in which pests are identified, action thresholds are considered, all possible control options are evaluated and selected controls are implemented. Control options-which include biological, chemical, cultural, manual and mechanical methods-are used to prevent or remedy unacceptable pest activity or damage."

The choice of control options then is based on:

- effectiveness
- environmental impact
- site characteristics
- worker/public health and safety
- economics

The basic components of IPM are 1) monitoring of potential pest populations and their environment; 2) determining pest injury levels; 3) decision making-developing and integrating all biological, cultural and chemical control strategies; 4) educating personnel on all biological and chemical control strategies; 5) timing and spot treatment utilizing either the chemical, biological or cultural methods; 6) evaluating the results an on-going process. This necessitates that the turf manager and people involved in the IPM program have a thorough knowledge of turf and its pest problems, that there be a structured monitoring or scouting program the intensity of which is determined by the value of the area and a knowledge of pest life cycles and that detailed records are kept to measure the effectiveness of the program and record information on which to make future decisions.

There are six basic approaches for turf protection using IPM as follows: 1) regulatory using certified seed, sod, and sprigs; 2) genetic selecting the best adapted species/cultivars for the location; 3) cultural-a healthy grass means fewer problems; 4) physical-isolating areas where pests are a problem; 5) biological-favoring natural competition; and 6) chemical-which is selective, but may be necessary. One of the critical strategies to an IPM approach is to set thresholds for pest problems and try to only use chemical

treatments when they are exceeded. This requires vigilant daily scouting for pests by qualified personnel who are trained to recognize the pest problem even at an early stage.

These are also largely determined by the value of the area and the recuperative capacity of the turf (Watschke et al., 1994). Information on the biology of insect problems common to the area should also be included in an IPM plan. For example, there is a degree day model on billbug larvae and adults that uses climatic information on which to base the scouting program and plan the most effective treatment schedule.

Thresholds for fungal and bacterial diseases are less well defined and depend to a great extent on the turfgrass species, prevailing environmental conditions, economic or aesthetic value of the site, and the cost of chemical treatment versus renovation of damaged turf sites. Thresholds may also be based on previous history of infection at the site, particularly for problems such as Spring Dead Spot, Take-All Patch and Summer Patch. Similarly, weed problems can be handled with the same objective in mind.

Monitoring programs focus on two objectives as follows: the IPM objective, to determine if pest populations are building to a point they will need some form of control to be implemented; and the environmental objective to determine if any environmental impact is occurring. Monitoring for golf agronomic purposes can be grouped by frequency. There are those items which need to be monitored on a daily basis such as quality of cut, soil moisture, disease incidence, weed infestation and leaf insects; on a weekly basis such as soil temperatures, tissue nitrogen concentrations, algae and moss infestation and the presence of hydrophobic soil problems; on a monthly basis the soil profile should be examined for presence of fungi, compaction, infiltration rate, soil pH should be analyzed, and the irrigation system should be checked for calibration; at least annually a complete soil analysis should be performed, drainage should be evaluated, wind movement and shade should be checked. The determination of timing on these and other factors may vary due to location and the type of soil and turfgrasses in the area. But, some form of structured program should be in place to collect information to help in making management decisions.

IPM is an evolutionary process! Changes will continually be made to the program as information is collected about the golf course, new information on strategies for control and as the options for control change. When starting an IPM program it is important that it be a structured program. The monitoring should be set up to use designated scouts (which should include the superintendent), keep detailed records and continually evaluate the results.

Risk Assessment

Risk Assessment is the process of assigning magnitudes and probabilities of effects to ecosystems resulting from human activities or natural phenomena. The risk assessment protocols include procedures that characterize the source of the risk, the ecological resources at potential risk, the magnitude of the hazard, the exposure potential, and the assessment of risk. A list of pesticides appropriate for use in watershed locations should be developed from this type of analysis. Based on the receptors on the

property, restrictions for use of certain materials should be made where appropriate. Evaluation of materials should start with chemical properties and site conditions. Further evaluation will be based on exposure potential and toxicity and screening models such as GUS, SCS ad PLP can be used. At this point, materials may be accepted for use or require further evaluation. Computer simulations and maximum exposure limitations can further refine the list of those acceptable for use, perhaps with restrictions on locations based on site conditions such as slope, soil texture, proximity to surface water features, etc. This risk assessment procedure will allow development of a list of pesticides which under well managed conditions present the least possible potential for environmental problems.

Cooperative Sanctuary Program

An additional option as part of the overall IPM and monitoring strategy is to consider becoming a part of the Audubon Cooperative Sanctuary Program of Audubon International. The whole approach to the Audubon program is to promote sound land management and conservation of natural resources, incorporating every aspect of the use of BMPs and IPM. Additionally, it encourages the superintendent to take a leadership role in conservation projects and the recognize those golf courses for their efforts. Under this program, everyone should work towards gaining certification in the areas of environmental planning, public involvement, integrated pest management, wildlife food enhancement, wildlife cover enhancement, water conservation and water enhancement. These are not just critical issues from the public relations perspective, but promote and document good stewardship on the golf course.

Summary

The benefits of incorporating BMPs and IPM into golf course management programs are threefold:

- assures more judicious use of pesticides/fertilizers
- an economic savings
- public relations over environmental concerns and less environmental impact

IPM strategies have been successfully employed at thousands of golf courses around the world. By adopting the strategies of prevention, control and detection and using recognized conservation principles, good stewardship and environmental awareness can make golf course management in watershed areas environmentally responsible.

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Hydrologic Methods and Stormwater Management Approaches Applicable to Undeveloped Drainage Areas

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General

In an effort to address area flooding and water quality concerns, Sarasota County has initiated a Basin Master Planning Program. Funded through the Sarasota County Stormwater Environmental Utility, this program was initiated in fiscal year 1991. It is intended to provide a systems approach to the planning of facilities, programs, and management efforts for comprehensive management and use of stormwater. The Sarasota County Comprehensive Plan calls for initiation of basin master plans for all 25 basins in the County by the year 2001. The basin master plan for Forked Creek is a continuation of the master planning program. This master plan has a high priority due to development pressures and the need to establish accurate flood elevations for assessing potential flood hazard and to determine the limitations of existing drainage systems to accommodate future development.

Project Background

The Forked Creek basin is a coastal urbanizing basin within south Sarasota County. It drains approximately 8 square miles. The entire watershed consists of gently sloping terrain which rises from sea level at the outflow in Lemon Bay to just over 10 feet (NGVD) at the headwaters. The basin has an average slope of just over 0.02 percent or a 1.3 foot drop for every mile of distance. The Forked Creek basin is primarily undeveloped with approximately 75 percent in a natural state or being used for agriculture. Over 20 percent of the undeveloped area is wetlands. Historic flooding in the basin has at times been severe. The water quality impacts of stormwater runoff from the basins are also a concern. This is especially important because the state of Florida has designated Lemon Bay as "Outstanding Florida Waters."

Modeling Objectives and Scope

The results of hydrologic and hydraulic modeling provide flood peaks and runoff hydrographs that are used to assess existing conditions and for drainage facility design. The modeling objectives and scope included calibration and verification to provide a degree of certainty to the predicted flood peaks and runoff hydrographs. Calibration and verification of hydrologic and hydraulic models require measured hydrologic data from actual storm events. In the summer of 1991 the USGS, in cooperation with Sarasota County initiated rainfall runoff monitoring stations in seven (7) coastal watersheds in the County. One station was located in the Forked Creek basin. The station is located approximately 1.4 miles upstream from the mouth of the creek. It consisted of a continuous water level gauge and a rainfall gauge. Numerous discharge measurements were made at the site to develop the stage versus discharge curve. The drainage area to the USGS station is about 2.5 square miles and is 95 percent undeveloped. About 20 percent of this area has been classified as wetlands.

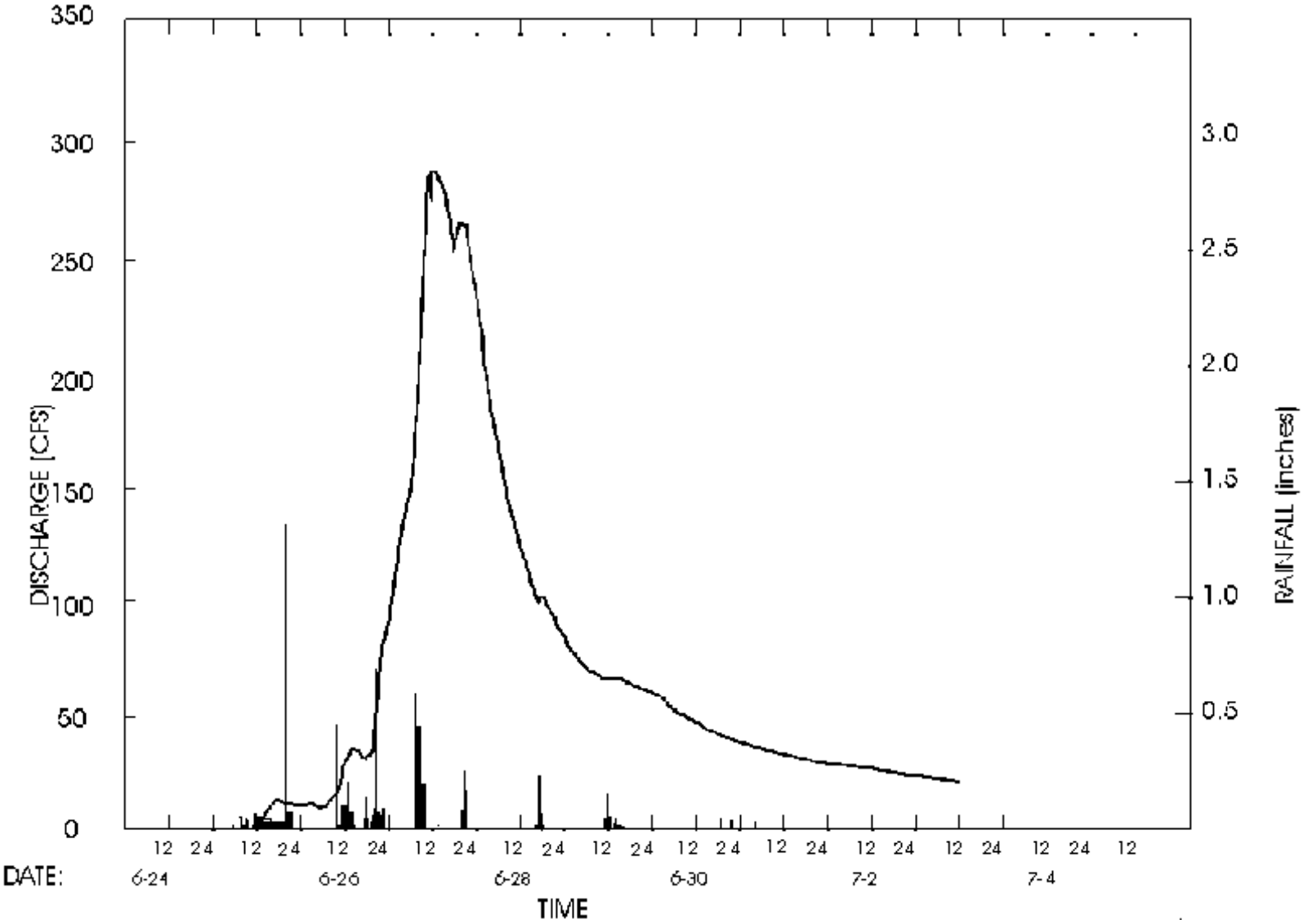
Purpose of this Study

The purpose of this study was to identify the most applicable hydrologic method to simulate basin conditions. The hydrologic model initially selected and specified in the scope of work for the basin master plans was the U.S. Environmental Protection Agency's (EPA)

SWMM/RUNOFF/EXTRAN computer software. Difficulty in calibrating the SWMM/RUNOFF module to recorded data with reasonable parameters prompted consideration of other methods. A variety of modeling methods are available. However, as with SWMM/RUNOFF, standard parameters developed for other areas of the Country have been found to be inappropriate for some areas in Sarasota County and west-central Florida. Because of extremely flat topography, high water-table, and large areas covered by wetlands, applying these techniques requires that empirical relationships be extrapolated beyond tested ranges. As a result, investigating the most adequate hydrologic method for the Forked Creek basin became necessary. All methods investigated herein were based on the unit hydrograph concept. Simulations were conducted using the U.S Army Corps of Engineers HEC-1 Flood Hydrograph Package. Model calibration was conducted using rainfall and streamflow data collected between June 24 and June 29, 1992. Model verification data were obtained between August 9 and 17, 1992. This paper describes the results obtained during the model calibration process.

Calibration Data

The June, 1992, storm resulted in one of the most extreme flooding events on record in Sarasota County. The Forked Creek station recorded about 13 inches of accumulated rainfall. The storm hyetograph is shown in Figure 1. The rainfall depth measured at both the USGS Gottfried Creek station and the NOAA Venice station during that same period was about 11 inches. The Gottfried Creek station is located about 2 miles southwest and the NOAA station is about 7 miles south from the Forked Creek station. This additional information indicated the basinwide characteristics of the storm event. Figure 1 also shows the measured hydrograph used for calibration. This type of hydrograph appears to be typical of the area as it shows similar characteristics of other hydrographs reviewed during this study. The runoff to rainfall ratio is about 70 percent. The initial storage stage is relatively large and results from retention in the existing wetlands as well as in the soil layer above the water table. The total streamflow during this period is small which shows the effects of a high retardance factor. Subsequently, the hydrograph rising stage is characterized by a rapid and substantial increase of the flowrate until the peak is reached. During the June storm, the volume under the hydrograph's rising limb amounted to about 20 percent of the total storm runoff. This also appears to be within a fairly typical range for this area. Finally, the hydrograph recession period is sustained during several days as runoff is released from storage. It should be pointed out that at the gauge station location, Forked Creek has no base flow.



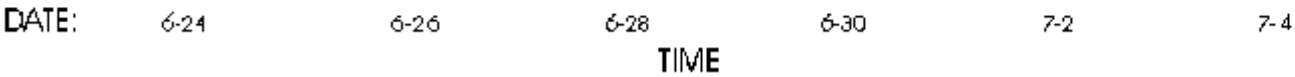


Figure 1. Forked Creek Calibration Hydrograph and Hyetograph

Computer Simulations

The unit hydrographs methods investigated during this study included the Soil Conservation Service (SCS), Snyder's, and Clark's methods. For all simulations, the initial rainfall abstraction was calculated for all subbasins based on available detention/retention capabilities, mainly in wetland areas. The SCS curve number method was used for calculating rainfall loss rates. This method was considered adequate as it allows easy modifications of the input data for model application to expected future conditions. Following is a brief description of each one of the methods investigated in this study and the results obtained from the analyses.

The Soil Conservation Service (SCS) Method

The SCS method is probably the most commonly used hydrologic method in Florida. The time to peak is expressed in terms of the duration of unit precipitation excess and the lag time. The relationship peak discharge to time to peak is:

$$q_p = \frac{K \cdot A}{t_p}$$

where:

q_p = peak discharge

t_p = time to peak

K = Shape factor

A = Area

The hydrograph shape is dependent on the peak factor K which proportions the rising and recession limbs of the hydrograph. For example, the standard SCS unit hydrographs uses a value of the shape factor K= 484 when flow is in cfs, tp in hours and area in square miles. This reflects a unit hydrograph that has 3/8 of its area under the rising limb and 5/8 under the recession limb. In this case, the recession to rising limb area ratio is 1.67. The Hillsborough County Stormwater Management Technical Manual (1) recommends the use of a 256 shape factor, which results in an area ratio of about 4. Studies conducted by the South Florida Water Management District (2) indicate that peak factors as low as 100 may be more applicable to southern Florida conditions as the lower value of the shape factors would account for the high retardance shown by the measured hydrographs. Figure 2 shows the calibration hydrographs obtained by using the SCS method with shape factors of 484, 256, and 150. The unit hydrograph ordinates for the 150 shape factor were obtained by applying the Neidrauer equation (3). In all cases, the parameters initial retention and lag time were manipulated to maximize the calibration fitting. Results show that the best fit is obtained with the 150 shape factor. However, none of the methods account properly for the retardance factor on the rising limb of the hydrograph as well as on its tail.

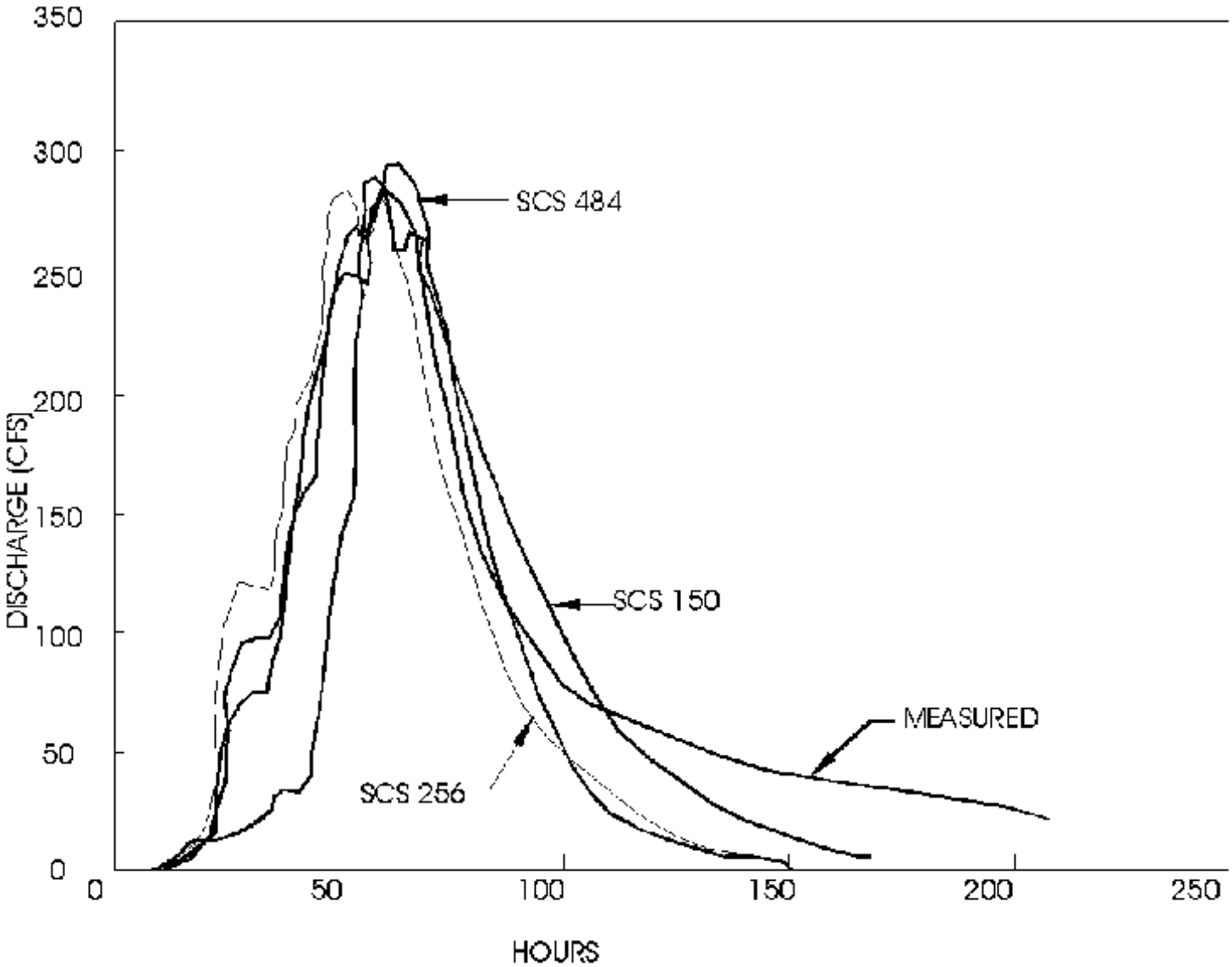


Figure 2. SCS Loss Rate and SCS Unit Hydrograph Methods.

The Snyder's Unit Hydrograph Method

The Snyder's UH method is quite similar to the SCS method. The peak discharge to lag time relationship is expressed as indicated below. The coefficient Cp is the equivalent of the shape factor in the SCS method. Cp is another calibration parameter in addition to the lag time. This could be consider an advantage of the Snyder's method over SCS.

$$q_p = \frac{640 \cdot A \cdot Cp}{t_1}$$

where:

q_p = peak discharge

t_1 = lag time

Cp = Storage Coefficient

A = Area

As shown by the calibration results shown in Figure 3, the resulting hydrograph is similar to that obtained from the SCS method. For the Forked Creek conditions, the value of Cp was found to vary between 0.2 and 0.3 when qp is in cfs, t1 is in hours, and area is in square miles. Increasing the Cp factor tends to increase retardance and decrease the peak. On the other hand, increasing the lag time reduces retardance and increases the peak. As with the SCS method, the application of the Snyder's method resulted in a hydrograph that did not account adequately for the large storage capacity of the basin and the sustained flow at the hydrograph's tail.

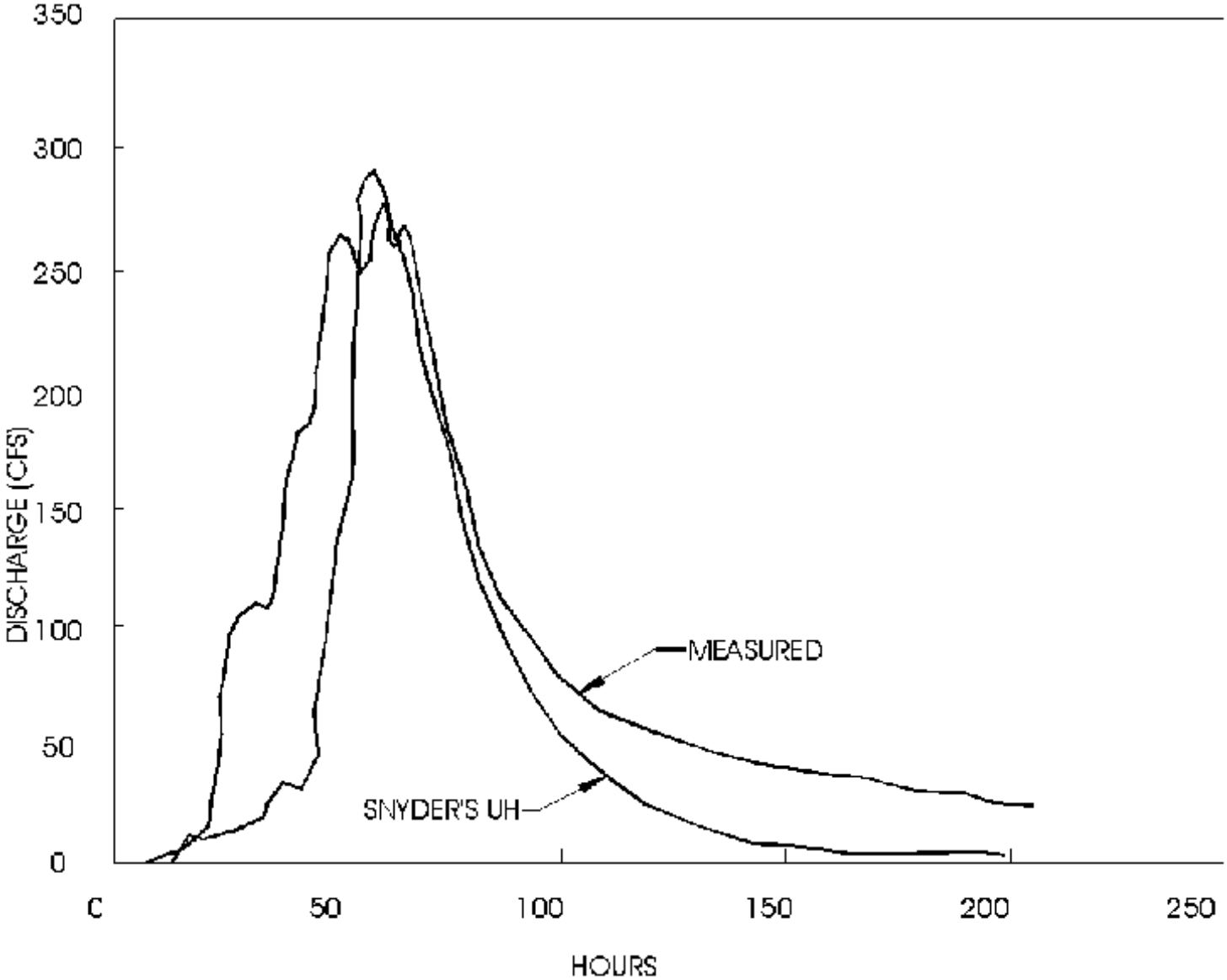


Figure 3. SCS Loss Rate and Snyder's Unit Hydrograph Method.

The Clark's Unit Hydrograph Method

The Clark's UH method requires two input variables, the time of concentration and the storage coefficient R. In addition, the application of this method allows the user to input a time area curve that represents the extent of the watershed contributing to runoff at the basin outlet from the beginning of the storm to the time of concentration. From the calibration standpoint, the Clark's method has one parameter more than the Snyder's method and two parameters more than the SCS method. The main drawback in using this method is the estimation of R. Although Clark defines R as the ratio between the discharge Q and the slope of a tangent at the hydrographs inflection point, estimating this parameter is mostly a judgmental process. Intuitively R should be related to the time of concentration and the basin slope. Figure 4 shows the results of the calibration using this method. By computing the deviation from the measured hydrograph, this method showed the best calibration fit. However, the calibration fit is not exact. For this application, the value of R was found to approximate the following relationship:

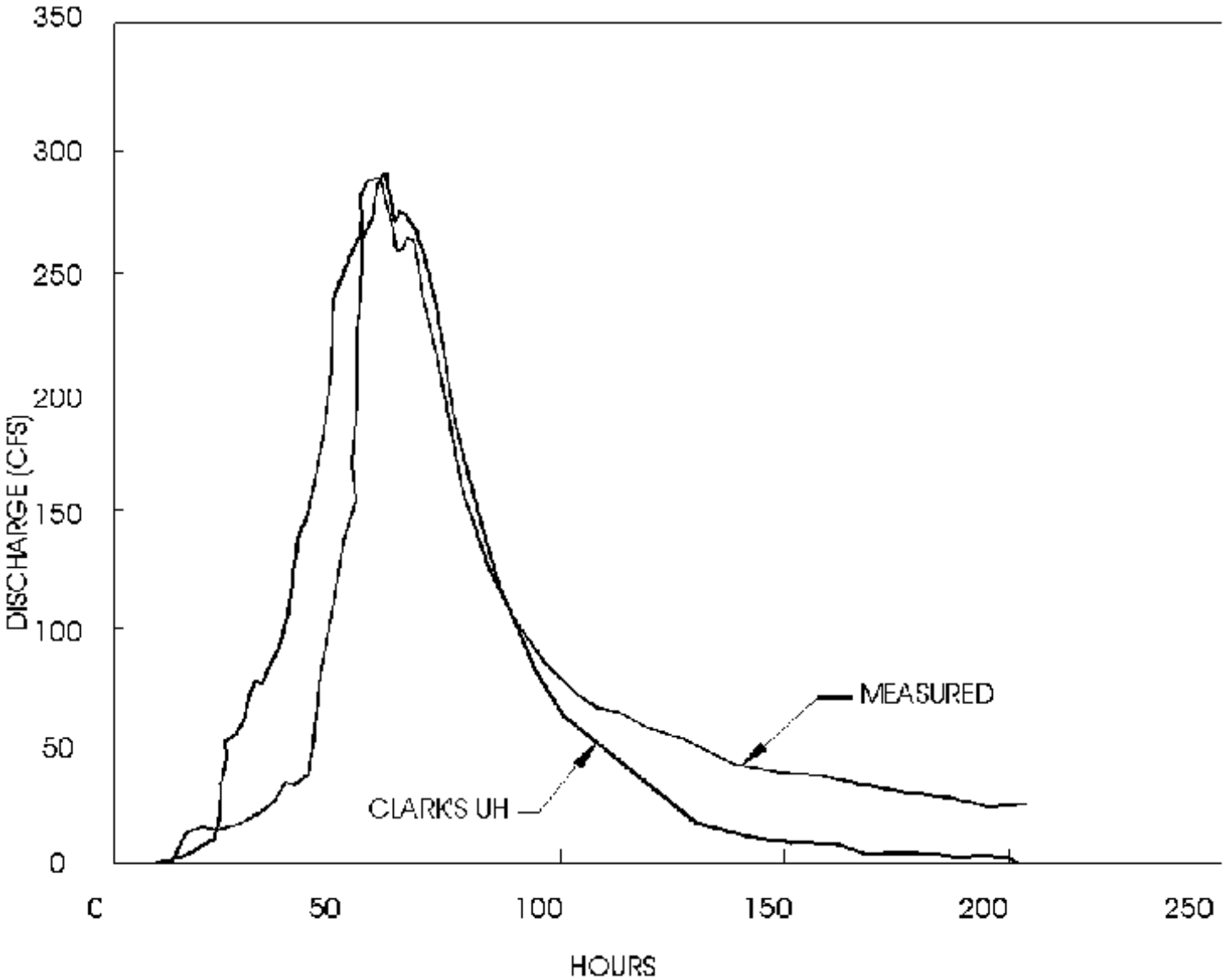


Figure 4. SCS Loss Rate and Clark's Unit Hydrograph Method

$$R + t_c = 0.57 L^{0.45} S^{-0.35}$$

where:

R = Storage coefficient (hours)

= time of concentration (hours)

L = basin length (ft.)

S = Basin slope (ft/ft)

Conclusions and Recommendations

In the present study, the Clark's unit hydrograph method and the SCS method with a shape factor equal to 150 seem to be the most appropriate for calibrating hydrologic models for undeveloped basins in southwest Florida. However, none of the methods investigated resulted in an exact replication of the measured hydrograph. Sarasota County elected to use the SCS method when developing the Stormwater Management Plan for Forked Creek because of the method's wide use in central and south Florida. The SCS and others are continuing investigations to determine the appropriate parameters for application of the SCS method to the low-gradient watersheds of west-central Florida. Parameters developed through this study are comparable to those of others for similar areas and will add to the data base being developed for use in Sarasota County and other similar areas. It is recommended that additional studies be conducted to develop unit

hydrographs more applicable to central and south Florida.

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An Overview of Washington State's Watershed Approach to Water Quality Management

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In July 1993, the Washington State Department of Ecology initiated a new managerial framework to improve the protection of water quality. Ecology began a five year transition to a comprehensive Watershed Approach to Water Quality Management. In this approach, both point and nonpoint source problems and needs are addressed for all parts of the state.

As a management approach, the design was formulated to guide the organization toward improving coordination of water quality activities, service delivery, protection and prevention activities, and finally improved water quality statewide.

The cornerstones of the approach are the designation of water quality management areas (WQMA), the appointment of staff "leads" for each WQMA, and a five step process for systematically issuing permits, assessing water quality conditions, focusing staff effort, and developing an improved basis for decision making in each WQMA. This management model was necessitated by the need to increase protection using fewer resources. The objective is to develop more precise information so that managers can allocate scarce resources to where they are most needed and to better schedule workload over time. Since 1993, the watershed approach management model has provided a consistent and sequential internal structure for improving water quality, it is nationally recognized, and it is a prime example within EPA's Statewide Watershed Management Course as a planning and priority setting system.

The watershed approach synchronizes water quality monitoring, inspections and permitting and supports water protection activities on a geographic basis. It is a coordinated and integrated method to link science, permits, and other water pollution control and prevention activities to meet state water quality standards. As a management tool, the watershed approach focuses resources by matrixing staff through time into a variety of tasks and areas of the state. Each step of the process addresses specific evaluation, planning, and implementation needs. A strong public involvement process insures that the state continues to support and validate local watershed efforts. Local priorities strongly influence state planning and grant/loan funding priorities.

The State of Washington has been divided into 23 water quality management areas (WQMA's). Ecology has four regional offices located throughout the state. Each region has approximately five WQMA's with its boundaries with the exception of Eastern Regional Office has eight WQMA (total is 23). The WQMA's have been named and an identified staff "lead" has been assigned to coordinate watershed processes and activities within the area (see attached map).

Other water quality technicians and research staff are also targeted to these 23 WQMA's across the state. Point source permits for municipal and industrial facilities are scheduled within individual watersheds to be issued during the same year to ensure equity, consistency, and predictability (see attached schedule). Nonpoint source pollution controls along with technical and financial assistance programs are being integrated to complete the comprehensive system.

Five Step_Five Year Cycle

Each year, approximately four or five WQMAs are scheduled into a cycle. Within each cycle, there are five steps with each step consuming one year. The steps are:

- Year 1: SCOPING: Identify and prioritize known and suspected water quality issues within the WQMA by assembling input from extensive community involvement and internal Ecology staff. Produce a Needs Assessment.

- Year 2/3: DATA COLLECTION/ANALYSIS: Conduct water quality TMDL's, monitoring, special studies, class II inspections and general research to discern which of the issues identified in scoping are in fact problems.

- Year 4: TECHNICAL REPORT: Develop a report in coordination with the community that addresses the problems identified above and other areas of concern. Also, outline strategies and management activities needed to reissue permits, to form partnerships, and to solidify nonpoint partnerships with grants/loans.

- Year 5: IMPLEMENTATION: Issue/reissue waste water discharge permits and work with local programs and partners to implement nonpoint pollution prevention and control activities that respond to priority water quality problems.

Approximately five WQMA's are scheduled each year to enter the process. The attached schedule shows the WQMA names in the left-hand column organized into year groups. These groups are moved through the five step, five year process outlined above. In this way, the entire state will be covered within a period of five years. It is important to note that statewide coverage is ensured by scheduling WQMA's rather than prioritizing them. Scheduling avoids the priority trap, that is, placing all assets into one area only to find too much work leading to excluding other areas for treatment.

The above process will be repeated on a five-year rotating cycle. By focusing on smaller geographical areas, Ecology closely scrutinize the sources and effects of pollution within each watershed (WQMA) and can take positive action to dramatically improve the water quality over time.

Unlike permitting which is mostly a scheduling effort, nonpoint problems must be addressed through cooperative relationships with local partners. In order to facilitate these activities, issues must be targeted, partners identified and cultivated, and funding sources must be coordinated and focused to address mutually agreed upon priority needs. Financial support systems are key and critical to a strong nonpoint effort. In its third year, the watershed approach model is now ready to create, innovate, and incorporate funding frameworks.

State of Washington
Water Quality Management Areas

Lessons Learned to Date

- Targeting issues for treatment each cycle provides focus.
- Building relationships with partners is essential to nonpoint progress.
- Help and facilitate those who want to help themselves.
- Watershed teams are key to obtaining comprehensive information.
- Ecology staff act as brokers to facilitate multiple activities.
- Community involvement is essential for continued improvement.

Activities Schedule for Watersheds Under 5-year Cycle (lower case letters denote transition activities)	
	State Fiscal Year (July 1 through June 30)

Water Quality Management Areas	FY94	FY95	FY96	FY97	FY98	FY99	FY01	FY02
Skagit/Stillaguamish, Columbia Gorge, Horseheaven/Klickitat, Upper Columbia, Pend Oreille	S	D	A	R	I	S	D	A
Island/Snohomish, South Puget Sound, Okanogan, Crab Creek, Esquatzel		S	D	A	R	I	S	D
Nooksack/San Juan, Western Olympic, Wenatchee, Upper Snake, Lower Snake			S	D	A	R	I	S
Kitsap, Lower Columbia, Upper Yakima, Mid Columbia				S	D	A	R	I
Cedar/Green, Eastern Olympic, Lower Yakima, Spokane					S	D	A	R

I = Permits Issued; Other Actions Started
S = Scoping
D = Data Collection
A = Data Analysis
R = Technical Report

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Texas' Strategy for a Watershed Management Approach

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Texas Natural Resource Conservation Commission, Austin, TX

Introduction

The planning and management of water resources in Texas rely on a host of local, state, and federal programs and participants to manage, protect, and enhance public health and the environment. However, planning and management activities for the state's water resources are often fragmented due to multiple jurisdictional boundaries, statutory limitations, and the distinct classification of surface and ground waters into separate resources. Furthermore, due to program-centered objectives and funding, and statewide regulations which do not accommodate geographic differences, water resource programs often lack flexibility and coordination necessary to effectively address water resource issues. While Texas has made significant progress to protect and improve water resources, water resource managers and other interested parties continue to face complex public health and water resource issues. To address these issues, the Texas Natural Resource Conservation Commission (TNRCC) is implementing a comprehensive approach to better coordinate and integrate water resource management activities geographically by river basin or watershed.

Existing Building Blocks to Support a Statewide Watershed Management Approach

To implement a comprehensive watershed approach for water resource management in Texas, the TNRCC had to determine the goals and boundaries of the approach and identify existing programs or tools which support watershed management. The primary goal of Texas' statewide watershed management approach (WMA) is to maintain and improve the designated uses of water resources within

each river basin. The WMA identifies and evaluates water quality issues, establishes priorities for corrective action, and initiates the work necessary to implement those actions. When considering whether to coordinate both water quality and water quantity programs, the TNRCC determined the approach needed to concentrate on water quality management programs consistently before dealing with water quantity programs. Guided by this decision, the TNRCC then began to identify all of the existing water quality programs which could be used as building blocks to support a WMA.

For its WMA, the TNRCC established a planning process through which it sought to organize programs, funding, public participation, and ultimately the implementation of solutions to water quality issues at the watershed level (Figure 1). Using watershed management as an organizing principle for water quality programs was based in part on the premise that water resource protection and restoration are best addressed through integrated efforts within hydrologically defined watersheds or river basins. Driven by these two basic tenets, the TNRCC recognized it already possessed some of the major components of an effective WMA. The major components the TNRCC has in place are the Texas Clean Rivers Program (CRP) and the Permit-by-Basin Rule. The CRP was established by the Texas Clean Rivers Act in 1991 to provide an initial framework for water resource management statewide. The goal of the CRP is to maintain and improve the quality of water resources within each river basin in Texas through an ongoing partnership involving the TNRCC, other agencies, river authorities, regional entities, local governments, industry and citizens. The program uses a watershed management approach to coordinate public participation, target water quality monitoring to identify and evaluate water quality issues, and assess the data to establish priorities within each river basin.

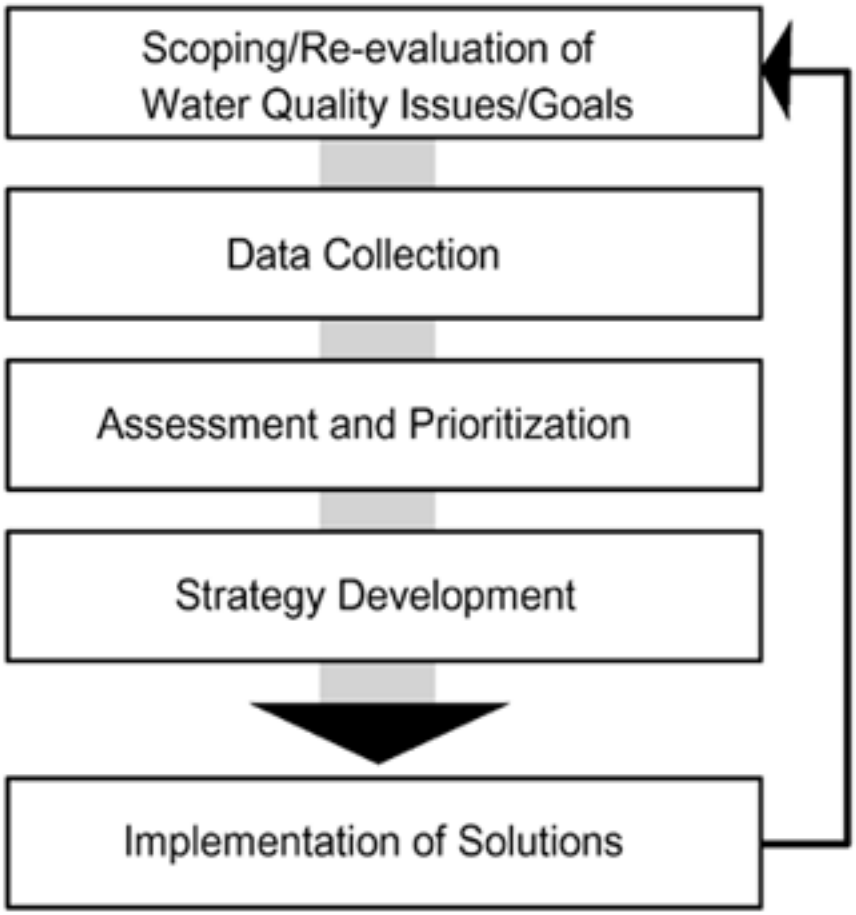

Figure 1. Texas' Watershed Management Planning Process.

The Permit-by-Basin Rule states the TNRCC shall to the greatest practicable extent, require all permits for the discharge of wastewater within a single watershed or river basin to have the same expiration date. By requiring a comprehensive evaluation of the combined effects of permitted discharges, the TNRCC has initiated the long-term watershed management process necessary to better understand the overall water quality of a river basin or watershed. The Permit-by-Basin Rule also allows the TNRCC to better balance its permit work load and provides consistency to the permitting process.

While these two major components provide a solid foundation for a statewide watershed management approach, the TNRCC and other water resource management partners recognized other components necessary to support the Watershed Management Planning Process were not fully in place. Other water resource management partners include agencies, organizations, or individuals at the local, regional, state, or federal level with an interest in water resource management. Despite having a well-organized watershed monitoring program, public participation through river basin steering committees, a water quality assessment component, and schedules for issuing wastewater permits by river basin, certain components were still missing and additional coordination was needed. Specifically these include activities and resources associated with Strategy Development and Implementation of Solutions.

Building a Better Mouse Trap

To develop additional components and identify the coordination necessary to support a WMA, the TNRCC and other water resource management partners determined which existing water quality management programs fulfilled the objectives of each phase of the Watershed Management Planning Process. The programs evaluated included: water quality monitoring, modeling, toxicity, water quality standards, Clean Rivers Program, nonpoint source, and wastewater permitting. Where existing programs and resources were not designed to fulfill the roles, responsibilities, and objectives of the five phases of the Watershed Management Planning Process, an internal work group was selected to develop the components and coordination necessary to ensure a comprehensive approach. Highlights of this evaluation are presented below.

With respect to the first three phases, Scoping/Re-evaluation, Data Collection, and Assessment and Prioritization, the Clean Rivers Program and other existing water quality management programs provide the framework and resources necessary to achieve the objectives and needs of a comprehensive WMA. Some adjustments between the programs involved in these phases were identified which could strengthen each phase, most of which centered around better coordination and timeliness of deliverables.

With respect to the last two phases, Strategy Development and Implementation of Solutions, an effective process was not in place to address the priority issues identified through public participation, monitoring, and assessment. As a result, the TNRCC developed a list of activities necessary to implement these phases of the process. These activities are outlined as follows:

Strategy Development

1. Coordinate participants and target priority issues by watershed.
    - Incorporate public participation.
    - Identify scale at which issue needs to be addressed (site, segment, reservoir, aquifer, watershed, basin, etc.).
    - Identify and predict the targeted loading in each priority watershed (total maximum daily loads).
    - Identify the roles, capabilities, and authorities of key partners to solve priority issues.
    - Identify new opportunities for leveraging resources of partners.
    - Establish specific management objectives for each issue.
    - Select indicators which link management options to objectives.
    - Identify range of feasible management options and establish potential combinations of management options.
    - Develop most promising scenarios, identify funding alternatives, and evaluate the degree to which each scenario achieves the objectives.
    - Reach consensus on optimal management strategies to be implemented.
    - Specify methods, funding, roles, and time tables for implementation of management strategies.

2. Document management strategies.
    - Establish a format for a written document which can serve as the reference for all partners.
    - Describe the methods, funding, roles, and time tables for implementation of management strategies in the document.
    - Coordinate and seek public input on the draft document.

Implementation of Solutions

1. Implementing management strategies.
    - After revisions to the draft document, the partners adopt the management strategies as their action plan.
    - Partners initiate the actions (permit effluent limits, best management practices, stream standard revisions, public education, etc.), resources, and funding per the action plan.
    - Conduct outreach to increase stakeholder awareness of, and participation in, implementing management strategies.

2. Initiate evaluation of progress made in implementing solutions.

Making the Transition

Having defined what needs to be done under a watershed management approach, the TNRCC and other partners are in the process of identifying the coordination, resources (management, technical, funding), and commitments necessary to support the five phases. Some of the preliminary recommendations which are being considered as necessary to support the five phases are listed below.

1. Strengthening participation in the existing river basin steering committees.

2. Augmenting the existing river basin steering committees with a technical advisory committee.

3. Obtaining commitment of resources from partners to develop and document management strategies.

4. Sequencing activities across basins to balance workloads of key partners who operate in more than one basin.

5. Consolidating various state reporting requirements to allow staff more time for data collection, assessment, and strategy development.

6. Designating basin coordinators to oversee the coordination of multiple programs and resources in specific areas of the state.

7. Improving existing information management systems to allow partners to share raw and interpreted data better.

To effectively communicate the components, activities, responsibilities, and coordination associated with Texas' WMA, the TNRCC will prepare a guidance document for programs to follow as they make the transition to a watershed approach. Based on the guidance document, the TNRCC will then begin to develop a two-year work plan to guide the location and timing of the activities and funding for the following TNRCC teams: surface water quality; modeling; toxicity evaluation; water quality standards; Clean Rivers Program; nonpoint source; and, wastewater permitting.

Lessons Learned

The development and implementation of a statewide watershed management approach have been an arduous yet beneficial process for the TNRCC. In conclusion, some of the important lessons the TNRCC learned along the way include:

- Developing a statewide watershed management approach requires commitment from the leadership of the lead water resource management agency.

- Enlisting partners to educate others about the watershed management approach is essential to statewide acceptance.

- Strive for flexibility in the approach; work with other partners and the EPA to achieve this flexibility at all levels.

- Work to achieve the highest level of internal understanding and support of the watershed approach before implementation is initiated.

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Integrating Water Resources Management: An Evolving Approach for Wisconsin

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Wisconsin is moving toward a new phase in water resources management. The impetus for the shift stems from the need to better protect and preserve the state's highly valued natural resources, which include 15,000 lakes, nearly 60,000 miles of rivers and streams, the Great Lakes Michigan and Superior, the Mississippi River, groundwater, and associated bird, fish and wildlife habitats. More and more, resource managers and citizens in Wisconsin are realizing that effective resource management must include cooperation among agencies, active stakeholder involvement and an agency structure which supports interaction and coordination. The Wisconsin Department of Natural Resources (WDNR) is in the midst of better accommodating these needs through a departmental reorganization and an evolving interest and belief in watershed and ecosystem management approaches. Wisconsin is making strides toward more integrated water resources management.

As part of the learning process, WDNR has initiated a series of seven "pilot" projects to shed light on current and future challenges associated with integrated management, including: defining a specific role for stakeholders, determining pollutant load allocations, and developing a mechanism for trading between point and nonpoint sources of pollution. Several other issues also remain unresolved. These include: deciding how to adapt our current basin management plans to the new structure and the new approach; determining how to target efforts among and within the state's basins; and understanding more completely

how these plans will fit with broader resource management goals.

This paper briefly outlines a "working" model of Wisconsin's new watershed approach. For context, both the old and new WDNR organizational structures and their relationship to approach development and implementation are briefly explained. The main emphasis is on the approach and the pilot projects. A final synthesis ties together our experiences and how WDNR is moving towards a goal of integration.

Outlining the Goal: Clarifying a Watershed Approach

Wisconsin's watershed approach emphasizes integrating management through two main concepts: first, stakeholders are central to decision making and implementation, and second, solutions are geographically-based and reflect an array of factors affecting an area. In part, Wisconsin's concept mirrors a characterization of integrated environmental management made by Born and Sonzogni (1995) who suggest integrated management efforts begin with an holistic conceptualization of issues affecting the resource with a realization of interconnections between issues. A specific management strategy emerges out of the initial conceptualization by reducing the issues into an implementable plan. The whole process includes a variety of participants and hinges on the degree of interaction and coordination among them. WDNR's eventual goal is to integrate land and water resource management activities; first by integrating water management.

Stakeholder involvement will be part of the process at multiple levels: state, basin, and watershed. Involving stakeholders in a meaningful way adds unique insights into resource management needs and opportunities including valuable knowledge of resource use histories and creative methods to meet resource goals. Stakeholder roles will include identifying issues, setting and prioritizing goals, and assisting with implementation. At the state level, a dormant statewide water quality advisory committee may be reactivated to coordinate efforts under the watershed approach. This committee would include members from academic, industrial, agricultural, development, local government, user, and regulatory communities who will lend unique perspectives, strengthen acceptance for pilot projects, and help coordinate pilot projects and implementation efforts. Stakeholder groups will also be created to advise WDNR resource management teams in each of 23 newly delineated geographical management units (GMUs) (Figure 1). These units are a blend of basin, terrestrial management, and county boundaries; two of the 23 GMUs coordinate activities related to the Mississippi River and Lake Michigan. Wisconsin is further divided into 333 watershed management units. Stakeholders from these watersheds will form the core of GMU stakeholder groups.

Wisconsin's watershed approach builds on several ideas which have long been part of the state's water management package. A set of 25 water quality management plans has been guiding several water resource activities for nearly three decades. These plans guide monitoring needs, identify point sources of pollution, provide an inventory of water quality in steams and lakes, and determine eligibility for priority watershed projects. Priority watershed projects alone represent a significant history of targeted watershed-based management programs aimed at reducing nonpoint sources. Over the past 18 years, nearly 20 percent of the 333 watersheds have been selected for nonpoint source pollution treatment under the state's priority watershed program. Priority watershed projects are planned and implemented jointly with local

governments, WDNR, and the Wisconsin Department of Agriculture, Trade, and Consumer Protection. The projects encourage integrated resource management and strong roles for stakeholders, both through their involvement in citizen advisory committees and in implementation of best management practices.

The new approach has a central emphasis on broad stakeholder involvement and incorporating multiple water resource needs into management strategies. Whereas past efforts have focused separately on point sources or nonpoint sources of surface water pollution, groundwater protection, site remediation, or fisheries management, this approach considers the combined impacts of these and of other resource management actions. The continuum in Figure 2 illustrates several degrees of integration. Currently, most WDNR activities are located at the left end of this continuum. WDNR's goal is to move along a continuum toward integration within water resource activities and eventually with all other resource management programs.

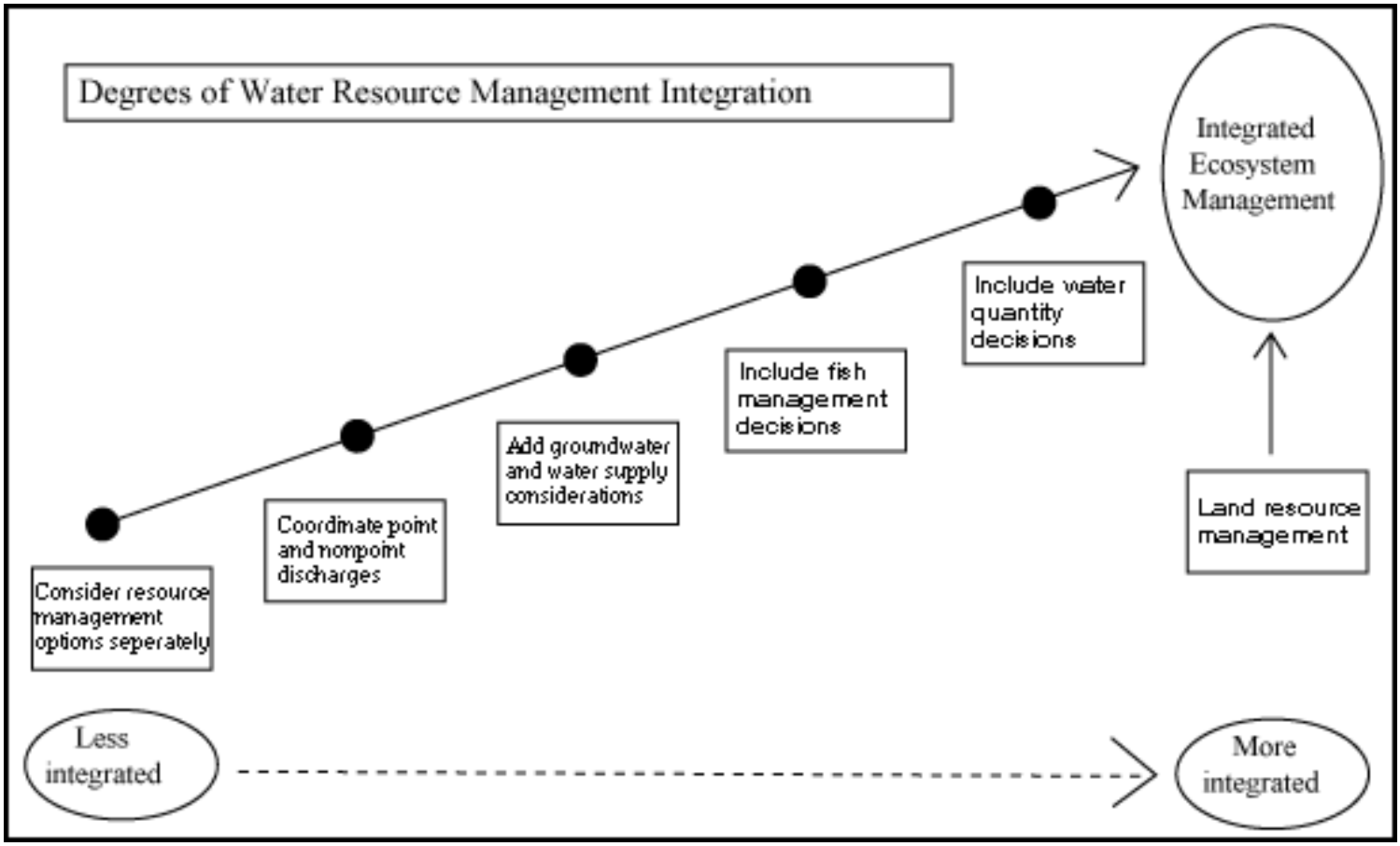

Figure 2. Degrees of Water Resource Management Integration.

Pilot Projects: Seeking Answers to Implementation Issues

WDNR has initiated a series of pilot projects to add insights into practical aspects of integrating water resources management activities. At this stage, these projects are focused on gaining stakeholder involvement in waste load allocation among point and nonpoint pollution sources. Concepts explored through these projects include developing new tools for working with permittees, empowering stakeholders in targeted geographic areas, sharing responsibilities for monitoring and some management

decisions, promoting intergovernmental partnerships, and developing mechanisms for financial assistance to support cooperative management through a watershed approach. These projects are funded through a mix of EPA 104(b)(3) grants and state and local government funds. There are currently seven pilot projects in place. A description of three of them will help illustrate where we are with Wisconsin's approach.

Red Cedar River Basin Project: Phosphorus Management & Defining the Role of the Public

This project incorporates stakeholders in a phosphorus management scheme for an eight-watershed sub-basin covering 1900 square miles and parts of eight counties in west-central Wisconsin. The willingness of stakeholders to interact and develop a scheme for wasteload allocation, the potential of developing new tools to work with point discharge permittees and nonpoint sources, and how to develop a strategy for implementing tradeoffs will be studied. The largely rural area includes several villages, the City of Menomonie, and several impoundments. This project will also develop stakeholder involvement in local watershed management activities. One of the early discoveries has been the lack of identity (and occasional animosity) among stakeholders in this relatively large area. Whereas stakeholders do see local benefits, little enthusiasm exists for improving downstream water quality. There has also been initial confusion over the differences between this project and the Department's priority watershed efforts. These issues may change as a core group of stakeholders emerges to work on the region as a whole. An overall action plan for this project area will be developed by September 1997.

Upper Sugar River Integrated Management Initiative: Grassroots Partnerships

A second project involves developing a watershed management strategy based on joint WDNR and external partner issue identification and prioritization. Rather than respond to a specific issue identified by resource managers, stakeholders and resource managers are working as partners to identify water resource priorities for this area. This project is limited to a single 90 square mile watershed southwest of Madison, in central Wisconsin, a rolling rural area experiencing rapid conversion from agricultural to urban land uses. Preliminary discussions indicate a general concern with the effects of this urbanization. Some of the major issues already identified include groundwater contamination and groundwater diversion due to pumping for municipal water supplies, continued agricultural discharges, urban storm water discharges, loss of wetlands and recreational space, concerns over aging dams, and coordination problems among the several local governments in the watershed. At the end of this eighteen month project the resource manager/stakeholder partnership should have an implementable management plan focused on the key water resource issues in the watershed.

Yahara River Project: Integrating Point and Nonpoint Sources

A third project deals with innovative approaches to managing phosphorus in a 500 square mile, five

watershed sub-basin of the Yahara River. This project, adjacent to the Upper Sugar Watershed Project, involves numerous institutional issues also addressed in the Red Cedar River Basin Project. The major interest is in estimating the costs and cost effectiveness of point versus nonpoint source reductions and exploring pollutant trade-offs between stakeholders. Issues include: the willingness of various groups to trade phosphorus, possible implementation scenarios, successful incentives for financial transfers likely needed to implement the allocation, and responsibility for the attainment of phosphorus reduction goals.

Changing Departmental Structure: Complementing a Watershed Approach

An ongoing departmental reorganization has introduced a fundamental shift in WDNR management structure. Wisconsin created the nation's first "super-agency" for natural resource management in 1969 by combining environmental quality and resource management functions into a single Department of Natural Resources; the original agency structure included separate divisions of Environmental Quality and Resource Management with several additional divisions for enforcement and management support. Over the past year and a half, WDNR has gone through a comprehensive self-assessment and restructuring. The new structure, which is expected to be fully in place this fall, organizes the Department by media. All water resource management activities will be joined into a single Water Division. The Water Division will include the Bureaus of Watershed Management, Fisheries and Surface Waters, and Drinking Water and Groundwater, all of which will be coordinated by a Water Division Integration Team.

In addition to reorganizing the central office, the new structure divides the state into five regions and 23 geographic management units (GMUs) (Figure 1). Each region contains the greater portion of four to six GMUs and will be staffed by interdisciplinary land and water resource management teams. Under this arrangement, the central office will continue to provide policy guidance and certain types of technical support, but specific resource management efforts and projects will have regional leadership and local stakeholder partnerships. These changes are intended to facilitate integrated approaches to resource management and enhance the role of citizens as stakeholders.

Synthesis: Continued Evolution

In summary, WDNR has set a goal of integrated water resource management and continues to move towards this goal. Currently, we are in the midst of refining our vision of a watershed approach, how that approach fits in with other Department management schemes, and how to implement this integrated approach to include targeted efforts and broad stakeholder involvement. We have spent a lot of time sorting through institutional relationships and are currently working through a reorganization and a series of pilot projects aimed at addressing several continuing challenges. Challenges include developing new tools for working with permittees, empowering stakeholders in targeted geographic areas, sharing responsibilities for monitoring and management decisions, promoting intergovernmental partnerships, and developing mechanisms for financial assistance to support interactive management through a watershed approach.

WDNR is moving away from its programmatic emphasis on either point or nonpoint sources and its separate treatment of water resource management activities and towards an integrated management approach encompassing both land and water resources. WDNR's new approach places great emphasis the stakeholder role in identifying and prioritizing goals and in implementing management strategies. Sustained protection of Wisconsin's aquatic resources depends on our ability to move forward in this direction.

Reference

Born, S. M. and W. C. Sonzogni. (1995). "Integrated Environmental Management: Strengthening the Conceptualization." Envir. Management. Vol. 19, No. 12, Pp. 167-182.

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Implementation of the Watershed Approach in Massachusetts

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The watershed approach to resource management is the centerpiece of the Department's "Clean Water Strategy", and as such, the river basin has been designated as the fundamental planning unit upon which the integrated water quality management activities of the Bureau of Resource Protection's Office of Watershed Management (OWM) watershed teams are based. In fact, this model is the foundation upon which the OWM was established, allowing the Department to synchronize five functions according to a watershed-oriented regimen that had previously been performed in isolation. These were: water quality monitoring and assessment, water withdrawal permitting, nonpoint source pollution control, awarding of water quality related grants, and wastewater permitting under the National Pollutant Discharge Elimination System (NPDES). By coordinating these programs, and focusing their activities in a particular watershed, the relationship between water quality and water quantity, and point and nonpoint source pollution are better understood and more effectively communicated to the public.

OWM has established river basin work groups or "teams" for the twenty-seven river basins in Massachusetts for the purpose of implementing its watershed-based resource assessment, surface water permitting, and non-point pollution control programs. The use of teams allows staff to pool their knowledge and skills and is gaining wide acceptance as a project management strategy in both public agencies and in the private sector, and is built on the premise that, when functioning properly, the synergy created by pooling individual areas of expertise and the mutual support gained by group members, produces energy and creativity that greatly exceeds the sum of its parts.

A phased program for watershed-based assessment, permitting, and nonpoint pollution control has been adopted by the OWM. Water quality and biomonitoring surveys are carried out by the river basin teams two years prior to the year in which NPDES and water-withdrawal permits are to be issued for the entire basin. The scope of the field assessments varies depending upon the resources available and the important water quality issues within each watershed. Input from outside agencies and the general public is actively solicited by the OWM basin team in order to gain further insight with respect to water quality goals and use-objectives for Massachusetts surface waters, and to build partnerships with "stake-holders" who will play an increasingly important role in protecting these waters as the focus of water pollution abatement continues to shift to nonpoint source control measures.

Resource assessment information, including, where applicable, the determination of site-specific water quality criteria, calculation of total maximum daily loads (TMDL), and the derivation of load/wasteload allocations and instream flow requirements are completed during the year prior to permit issuance. Finally, the third phase involves meeting with the permittees and issuing final wastewater and water withdrawal permits. In addition, this phase includes the targeting of priority waterbodies exhibiting nonpoint pollution problems for the implementation of Best Management Practices (BMP) or other control strategies. Implementation will be realized, in part, by the awarding of Nonpoint Source Pollution competitive grants in accordance with the requirements of Section 319 of the Clean Water Act. Because the entire OWM watershed management process is implemented over a period of three years on a rotating basis, a period of five years is required to complete one cycle of assessment, planning, and implementation for all twenty-seven Massachusetts river basins, and not all river basin teams are active at the same time.

The successful completion for a particular river basin of each of the phases described above is now the responsibility of the respective river basin team.

To enable the Commonwealth to understand the relationship between point and non point pollution, land use and water withdrawals the Department is using an EPA 104(b)(3) grant to support the development of a GIS based computer model. The model is being piloted in the Neponset River Basin, and will enable managers to consider different scenarios for pollution abatement. The model will provide predictions regarding changes in water quality from different strategies, allowing targeting of those efforts which promise the greatest environmental and economic return. While the model will be transportable to other basins, the Neponset will be the basis for the development as it is the pilot basin for coordinated activity between the Executive Office of Environmental Affairs, the Neponset River Watershed Association, EPA and the general public.

Massachusetts' twenty seven watersheds vary dramatically with respect to size, hydrology, land use, geography, available data, water management institutions and their resources and capabilities, public priorities, water body characteristics, and numerous other factors. Watershed management must tailor its planning approaches to the unique characteristics of each watershed. Existing water quantity and quality models utilize past water quality and flow data to allow users to predict the response of a watershed and river system to various control programs, to assess the consequences of future development and land use

changes, and to prioritize the control and management options based on benefits and costs.

In embarking on a comprehensive watershed planning and management initiative over the next decade it is imperative that the modeling and analytical approaches be appropriate for the watershed characteristics, data availability, regulatory requirements (e.g. permitting, water quality standards setting, partial use of determinations, etc.), and water use goals and problems of a particular watershed. Modeling approaches must also be scientifically valid, technically defensible, affordable, and responsive to schedule requirements. Inappropriate selection and/or use of models often results in misdirected plans, inefficient or inappropriate use of data, substantial waste of human and fiscal sources and loss of opportunity to improve water quality and beneficial uses. Most importantly, results of analytical work must clearly answer specific, critical water management questions and must be understandable to the public-those responsible for implementing necessary programs.

The goals of the modelling project are to facilitate watershed planning statewide by organizing and making available modeling technology and user guidance that will result in cost-effective, technically sound analytical approaches that make best use of data that are now or will soon be available and produce results that are understandable to informed but non-technical individuals. The project will have three phases. The first will be the development and selection of a methodology useful in Massachusetts. The second phase will be application of the model in the Neponset Basin. The third phase will be the development of a plan to expand the use of the methodology throughout the Commonwealth.

The project involves the development of computer modeling capability and user guidance necessary for implementation of the statewide watershed management initiative in Massachusetts. The products of this three phase project will be:

- A suite or "menu" of watershed runoff models (or analytical methods) and receiving water quality models suitable for application to a range of requirements for watershed and receiving water quality analysis.
- Set up and application of several of these models or analytical methods in the Neponset River Basin or its subwatersheds.
- Guidance to users regarding the selection and use of runoff and receiving water models tailored to the particular conditions of each watershed and planning program, and
- A plan for use of the analytical (modeling) tools and application guidance through the state.

It is anticipated that the models utilized will be those developed by EPA and other federal agencies over the last 25 years and available in the public domain. These water quality and land based pollutant loading models will be linked with one another and, after piloting in the Neponset, be used to develop relationships between land use, point and non-point sources, water withdrawal, and water quality in rivers and estuaries throughout the state. The models will generally be GIS (land use) based and will be adaptable to the level of data available in each watershed. The models will provide predictions regarding changes in water quality from different pollution control strategies, allowing targeting of those efforts which promise the greatest environmental benefit and economic return. While the models will be useful

in all basins, depending upon goals of the specific watershed programs, the Neponset will be the basis for the development and prototyping, as it is the pilot basin for coordinated activity between the Executive Office of Environmental Affairs, the Neponset River Watershed Association, EPA and the general public under the Massachusetts Watershed Initiative. A key objective of the proposed project is to develop DEP staff technical capability to support watershed planning statewide on a long-term basis. DEP staff will be assigned to work with the selected consultant as a means of developing internal staff capabilities.

Additional 104(b)(3) funding is being sought to support the development of a complimentary economics model that will assist in the evaluation of the relative costs of the options for water quality improvement. The Commonwealth's ability to cost effectively improve water quality has to be guided by a more thorough understanding of the relative costs and benefits of the different strategies revealed by the water quality analysis. Funding of this final component of the modelling project will provide a framework from which a discussion of the optimal option can be conducted.

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Talking to the Stone-The Art and Science of Querying Watersheds in Washington State Watershed Analysis

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Since antiquity man has searched for more and more powerful ways to interrogate nature to learn her secrets. Francis Bacon, a principal architect of the scientific method, argued for natura vexata, vexing/agitating nature so that she would give up her secrets. More recently Ludwig Von Bertalanffy and other systems theorists have argued for interrogation of natural systems using a biological, interdisciplinary model of how physical processes interact to create stability, balance, and resilience.

Washington State Watershed Analysis, a four-year-old management system, embraces aspects of these and other natural philosophies in a pioneering effort to practice systems ecology and management. It does this in an interdisciplinary manner, with hydrologists, biologists, geomorphologists, and managers working as a team to evaluate watershed processes, risks to resources, and appropriate management prescriptions.

Origins

Washington State Watershed Analysis originated in the late 1980s in a crucible of imminent litigation over the cumulative effects of forest practices on salmon. At issue were declining fish production and demonstrable impacts on fish habitat coincident with increased harvest rates.

After lengthy negotiations in 1987, industry, tribes, environmental groups and other cooperators signed a mediated agreement committing signatories to work together to find cooperative solutions to problems on the forest landscape. The principal mechanism for this would be an organization known as TFW (timber, fish, and wildlife group) with administrative, policy and scientific arms.

Despite initial successes, TFW came under increasing pressure to find a mutually agreeable scientific approach to managing cumulative effects, in particular, the effects of high sediment yield on fish habitat. This eventually led to a 1991 commitment to develop watershed analysis, an interdisciplinary, watershed-level assessment method.

A prototype methodology was developed by the Pacific Watershed Institute in 1992, with field applications quick to follow. Since then, watershed analysis has been considerably refined and widely practiced throughout the state.

Elements of Watershed Analysis

Watershed analysis is really watershed analysis and management (WAM), an integration of assessment, management, and monitoring at the watershed level (See Figure 1). It is the linkage between policy and technical elements that most distinguishes it from other analytical or management approaches.

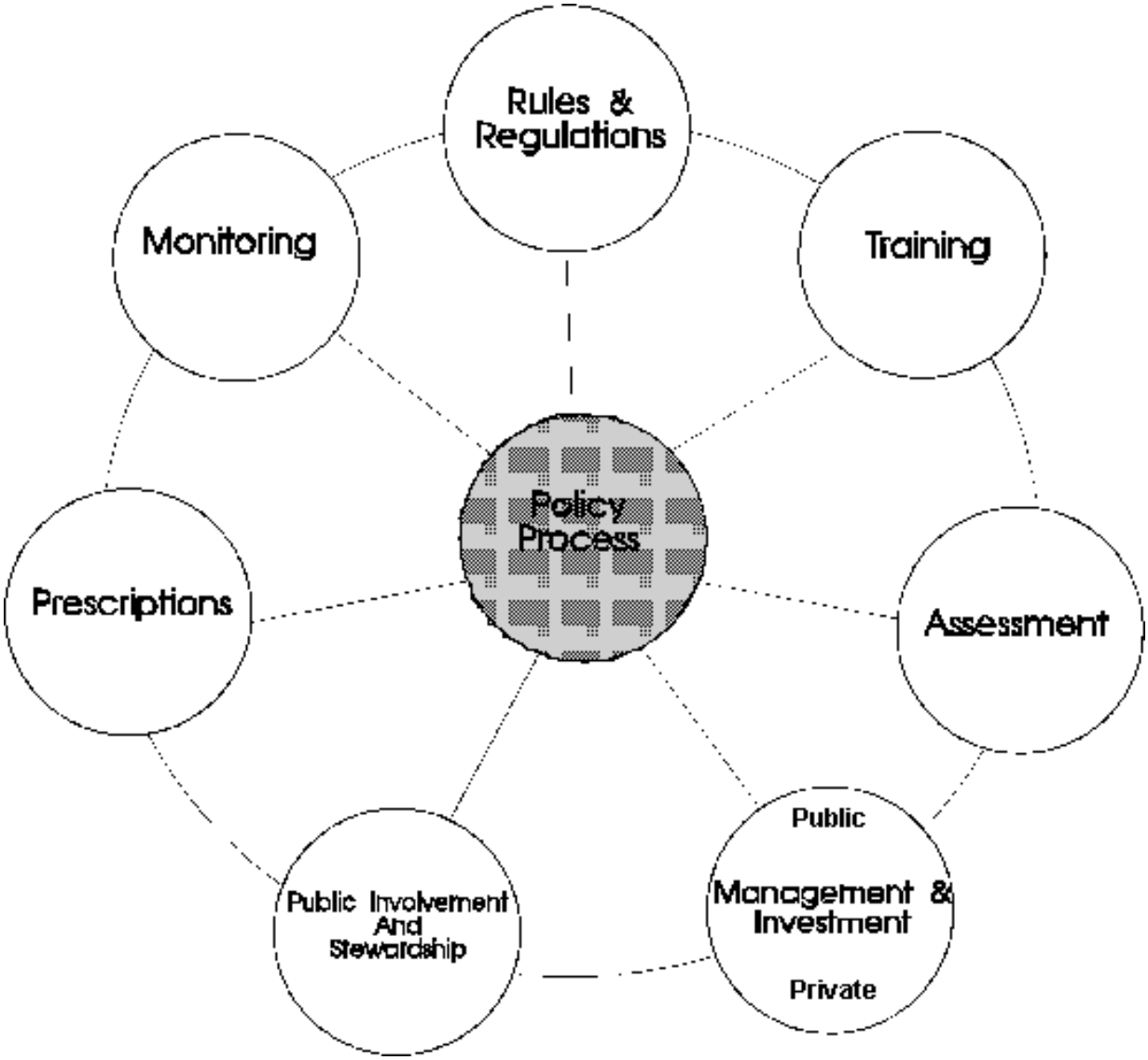

Figure 1. Components of Waterhsed Analysis and Management.

Policy Process

A stakeholder policy group (i.e., TFW) is the hub of the overall system. The effectiveness of a WAM system is largely based upon the fact that values and objectives of stakeholders are treated in an explicit manner. The Washington system recognizes that critical value judgments commonly enter into problem scoping, issue definition, effort allocation in assessment, treatment of uncertainty, and other analytical-technical steps.

Consensus decisions made by the TFW policy group ensure that products, including assessments and prescriptions, will be implemented. The TFW policy group also presents a common front to the state legislature in seeking program funding.

Assessment

Assessment is the system component for interdisciplinary analysis of watershed conditions, sensitivities and risks. Analysts, using repeatable assessment methods set forth in a state-approved manual, must define sensitivity of stream resources to

changes in the flows of wood, water, energy/temperature, sediment, nutrients and pollutants. Landscape analyses of these processes establish the presence of hazards, while a delivery or routing method establishes the connection to sensitive resources and overall risks.

Prescriptions

Management prescriptions are the remedies for problems and risks defined by analysis. Prescription for hazardous areas may include buffer protection, land treatment measures, scheduling to mitigate impacts, and a host of other commonly employed BMP's. WAM prescription-setting always attempts to tailor practices to site sensitivities and risks, rather than rely on "one-size-fits-all" BMP's.

Rules and Regulations

Washington State Watershed Analysis is integrated with rules and regulations through revisions of the State Forest Practices Act. As a result of TFW-sponsored changes, the act conditions the approval of site permits on the consistency between planned actions and watershed analysis prescriptions.

Revised rules and regulations also set forth the bounds and structure for prescription-setting. Three categories of risks are defined by law which dictate the severity-stringency of prescriptions for different plots of ground. Forest land managers are thereby provided with a valuable planning tool: they know in advance of a planned harvest what issues must be addressed, the severity of resource risks, and the kinds of conditions that are likely to be attached to permits.

Targeted Investment and Business Planning

This is an embryonic but promising element of an overall WAM system. Business plans involve a clear identification of goals, products, priorities, timelines, investment streams, strategies, and measures of effectiveness. Under a business planning approach to environmental management, public agencies would align programs for maximum leverage and efficiency. They would also reorient protection, prevention and restoration efforts toward end-products, such as clean water, fish, clean air, sustainable resource flows, rather than toward indirect (and more conventional program objectives) such as activity levels, dollars spent, enforcement actions taken, numbers of people involved in programs, etc.

Recently Weyerhaeuser and Critical Path Productions of Seattle developed a concept paper for implementing such an approach in conjunction with Watershed Analysis and Management. The paper describes how business plans could take advantage of watershed analyses to build strategies for effective watershed management.

Diagnostics features of the Assessment Method

Original design standards for the assessment method called for a repeatable methodology with explicit treatment of uncertainty, variable levels of resolution and discrimination, and a capability of linking physical processes (e.g., surface erosion) to resource sensitivities (e.g., the sensitivity of salmon to sedimentation).

Early attempts floundered over questions of analytical rigor, the merits of individual methods, and questions of scale and resolution. A major breakthrough occurred when a core team headed by Dr. Kate Sullivan of Weyerhaeuser decided that the overall method should pivot on risk-related questions that would be addressed in all analyses. The questions would be linked to various methods, more or less quantitative and rigorous depending upon desired resolution and confidence levels.

Critical questions and alternative methods for answering them were subsequently defined for both physical processes and potentially affected beneficial uses. Process questions probe the sources, magnitude, and variability of surface erosion, mass wasting, hydrology, riparian processes, and channel dynamics. Beneficial use questions interrogate the sensitivities of

aquatic resources, water quality, cultural resources, and public capital improvements to changes in the flows of water, wood, heat energy, sediment, and pollutants.

The questions are hierarchical and, in most cases, holarchical in design. High order questions generally capture interconnections between processes and habitat or beneficial uses. For example, a high-order stream channel question would be:

What is the channel sensitivity to changes in flood frequency and magnitude?

Foundational, lower-order questions probe spatial and temporal variability, interrogating different channel reaches to establish current conditions, departures from the historical record, indicators of disturbance and disequilibrium, and triggering/causative factors.

The product of such guided questioning is a series of "situations sentences" (or problem statements) contained in a "causal mechanism report". In developing these problem statements, analysts are cautioned to avoid overly reductionist, near-sighted analysis. They are encouraged to look for "a big picture" that may transcend the guiding menu of questions and methods and data used to answer them.

Correspondingly, each team is called upon to define "the watershed story" which requires group dialog to probe for dominant historical phenomena, contextual issues, and signature features of adjustment, balance, resilience, and homeostasis. It is also recognized that many of the relevant processes in a watershed cannot be readily evaluated with the recommended watershed-scale methods. In these cases, team members are expected to record "indeterminate" findings that may lead to more detailed evaluation using more powerful methods and detailed site analysis.

Results and Prognosis

As of late January 1996, 50 watershed analyses have been completed with plans for over 300 more in the next several years.

A related effort has been mounted to conduct watershed analysis on federally owned lands. The federal method, however, is much less structured and has prompted criticisms about reliability, repeatability, and unrecognized value judgments implicit in analyses. These are all problems anticipated and planned for in the development of the Washington system.

Nationally, the Pacific Watershed Institute is involved in a project sponsored by EPA to explore application of WAM to other ecological provinces and settings. The institute is currently working on a guide to be used for inventorying and characterizing processes on and off tribal lands in diverse ecological provinces. The guide will also define design considerations for prescription-setting, watershed monitoring, and the training of practitioners. Demonstrations on tribal lands are expected in the coming year.

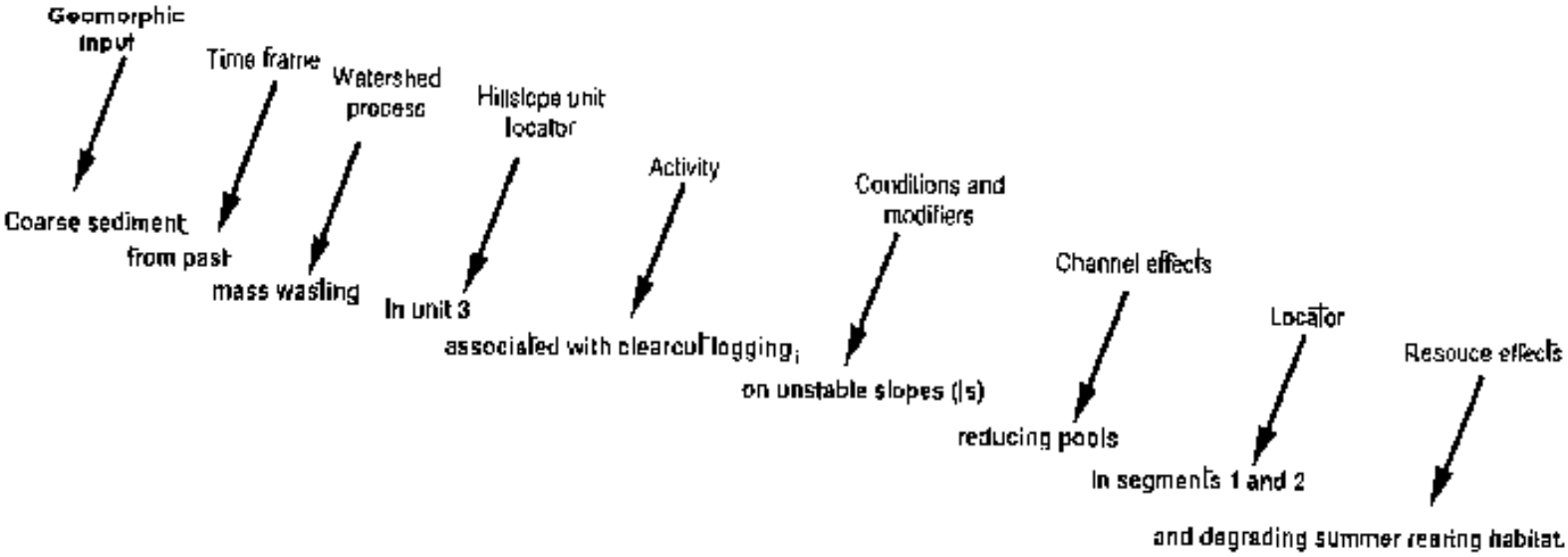

Figure 2. Situation Sentence Syntax.

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The Environmental Protection Agency's Tribal Watershed Assessment and Planning Process

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Over the past two years, the U.S. Environmental Protection Agency (EPA) has made a concerted effort to strengthen its Indian Program and fulfill its trust responsibilities to tribes. As two significant and visible components of the EPA's commitment to advance tribal environmental and resource management, Administrator Carol Browner established the American Indian Environmental Office (AIEO) and a Tribal Operations Committee (TOC), composed of nineteen tribal representatives in 1994. The Administrator also reaffirmed the Agency's 1984 Indian Policy which stresses that tribes are clearly the appropriate government to design and implement environmental management programs for their reservations. Where tribes do not have adequate programmatic resources to establish such systems, the EPA provides assistance to tribal governments in building tribal capacity to manage reservation environments, and directly implements environmental programs on reservations until tribal governments can assume these responsibilities.

As the EPA strengthens its Indian program, the Agency recognizes the fundamental needs both to better understand past and present tribal environmental conditions, problems, and capacity and also to address the future environmental expectations, objectives, and priorities of tribes. This gap in information is not a new problem and over the years the Agency and tribal organizations have tried to obtain this information in various ways. These past efforts have had varying success and failure in building a baseline of data on tribal environmental conditions and needs.

On July 14, 1994, the Administrator issued an action memorandum directing her management team and all EPA employees to take prompt action to enhance EPA-tribal programs. The cornerstone of this Action Directive is a recommendation that tribes and EPA jointly develop Tribal/EPA Environmental

Agreements (TEAs). EPA developed the concept for TEAs working with the TOC and other tribal leaders. The purpose of the TEAs is to ensure that the EPA and a tribe work toward the tribe's environmental and public health goals. The agreements are meant to describe the current condition of a tribe's health and environment, the tribe's vision for their environmental future, and the near-term steps the EPA and the tribe will take to meet the tribe's long-term goals. The EPA and the TOC envision the TEAs as planning strategies that include a careful review of all tribal resources, including cultural, and an identification of the tribal needs necessary to build an appropriate management and resource preservation program. If designed properly, TEAs can provide a comprehensive strategy for managing and preserving tribal resources while still maintaining maximum flexibility to support an effective government-to-government partnership. TEAs are not a requirement, however, EPA's goal is to develop a TEA with every tribe that wants one.

The EPA and the TOC recognize that to be successful, TEAs must respect the government-to-government partnership between the EPA and tribes. Thus the EPA and the TOC identified some key principles for the TEAs. First, the information generated for the TEAs had to come from the tribes, not from the EPA. Second, the method had to account for the varying levels of environmental capacity among the tribes, so that every tribe could participate whether or not the tribe already had an environmental program in place. Third, the method needed to generate not only information about existing environmental conditions and needs, but also the expectations, goals, objectives, and priorities of individual tribes. Fourth, this information needed to be generated so that it could then later be aggregated into regional and national program workplans to support Agency resource decisions. Finally, the method needed to be more than an information gathering process; it needed to be the first step in an ongoing process of developing tribal environmental capacity, developing EPA-tribal partnerships, and addressing tribal environmental concerns.

Good TEAs depend on good information. As one effort to ensure that tribes have sound data to use in setting environmental priorities, the EPA's AIEO is developing a watershed evaluation technique which is called the Watershed Analysis and Management (WAM) approach. Through the WAM approach, tribes can categorically survey and assess their resources using defensible and reproducible scientific procedures. These results then become integrated into TEAs as part of the decision-making process and as an environmental strategy for implementation. Therefore, TEAs in concert with the WAM recommendations and data, provide tribes with a long-term, comprehensive and defensible management plan. A technical discussion and overview of the WAM framework entitled, "Talking to the Stone-the Art and Science of Querying in Watersheds" is being presented at this conference by Jim Currie from the Pacific Watershed Institute.

TEAs and the WAM approach are intended to support effective management of: (1) tribal subsistence lifestyle opportunities, and (2) traditional food and vegetation (e.g., grasses, medicine plants). For example, overgrazing by livestock and the subsequent erosion may result in impacts to native grasses which are a critical cultural resource to basket-weaving tribes. Also, the application of certain pesticides may result in contamination of the grasses such that they become a health hazard to basket weavers using the traditional methods for basket weaving. Traditional basket weaving involves many techniques including the splitting of the reeds by hand and mouth by the basket weaver. This traditional art form is

one of many tribal activities which are an integral part of tribal lifestyles, economy and traditional culture.

Another cultural resource is fish consumption which in many tribes has both religious as well as a direct connection to tribal traditions celebrating family. One impact to the cultural practice of fish consumption is bioacculmulation of toxins (especially organic) in fish fatty tissue thus preventing certain tribal members or possibly any member from consuming their native fish resources. Toxic pollutants may also result in fish population depletion and species diversity impacts. Cultural fish resources can also be impacted by timber harvesting, grazing and other activities that, if mismanaged, may contribute to changes in stream structure, temperature modifications and turbidity increases.

To develop the WAM approach, the EPA is coordinating with tribes to implement four pilot demonstrations of the watershed analysis and management framework on reservations. These pilot demonstrations are critical steps toward validating the framework for wide tribal use. The framework is designed to be a very powerful tool. For example, the framework might support a persuasive cumulative effects analysis under NEPA showing that erosion caused by grazing or other activities on off-reservation lands would adversely impact tribal watersheds and, therefore, harm a tribe's ability to sustain its cultural, religious and subsistence resources. Thus, the use of the WAM approach and the implementation of the resulting TEAs fulfills many of the principles in the TEAs guidance, including the principle that tribal culture and non-traditional values are sustained.

The AIEO recognizes that the WAM framework by itself addresses only part of the information needs for comprehensive environmental decision-making. Thus, the AIEO is also developing a multi-faceted decision-making and management "toolbox" to enable tribes to accurately assess environmental impacts, to make well-informed decisions about tribal priorities, and to respond quickly to activities that pose serious threats to tribal health, cultural and natural resources. Among other components, the tool box may include:

- Models of tribal environmental policy, acts, and guidance to assist tribes that want a larger role under the National Environmental Policy Act (NEPA) in reviewing actions that effect tribal resources.

- A geographic information system that tribes could use to map their resources and develop overlays that show the various activities contributing to tribal health risks and natural resource degradation (e.g., air emissions, discharges to surface waters, septic fields).

- A decision guide that would help a tribal environmental program manager assess and weigh various environmental risks, incorporating, for example, watershed analyses and the results of radon and lead paint screening procedures.

As comprehensive TEAs are implemented and several WAM modules are developed, tribal experts certified for the WAM approach will be able to transfer the WAM approach to other tribes thus

expanding the base of successful watershed management across tribal watersheds. Tribal managers will also be able to share quality watershed data and have access to a wealth of information on potential watershed management strategies. In order for tribal watersheds and critical tribal resources to be appropriately managed and sustained, there needs to be national coordination and implementation of repeatable and sound WAM techniques. When these national objectives are achieved, tribal cultural and natural resources, tribal watersheds, and tribal economic benefits that depend on managing and preserving these resources are more likely to be sustained for the use of current and future generations.

Acronym Key List:

AIEO American Indian Environmental Office

EPA Environmental Protection Agency

TEAs Tribal Environmental Agreements

TOC Tribal Operations Committee

WAM Watershed Analysis and Management

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An Approach To Selecting A Watershed For Rehabilitation Developed For The Zuni Reservation, New Mexico

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The physical restoration and maintenance of watersheds on the Zuni Reservation, New Mexico, are essential to the Zuni Tribe's economic and social well being. Soil erosion on the Zuni Reservation has been a continuing problem since the early part of the 20th century. Active gullying (arroyo incision), a major part of this erosion, is affecting the sustainability of various natural and cultural resources, such as farmland and grazing areas, wildlife habitats, and roads, within watersheds on the reservation. The Zuni Land Conservation Act of 1990 authorized the Zuni Tribe to formulate a Resource Development Plan that includes a program of watershed rehabilitation. The tribe's approach for selecting a watershed for rehabilitation was to prioritize the watersheds by integrating data on physical elements and anthropogenic features in the watersheds and by incorporating community input.

Methods

Watershed rehabilitation is a mechanism to improve and maintain the physical and socioeconomic quality of watersheds that have been degraded by a combination of natural causes and anthropogenic activities. A major part of watershed rehabilitation is erosion control. Erosion control may involve structural treatments in the channel (gully rehabilitation) or nonstructural treatments in the watershed outside the channel (reseeding). To develop an integrated approach for selecting a watershed for rehabilitation, the Zuni Tribe instituted the Zuni Conservation Project, which included several work groups: geographic information system (GIS), hydrology and erosion, fish and wildlife, range science, forestry, and agriculture.

Selection of a Watershed for Rehabilitation

Because of the size of the Zuni Reservation (1,653 km2) (Figure 1), rehabilitating the watersheds within the Zuni Reservation in one project phase is not feasible. Instead, watershed rehabilitation efforts may be more effective if started in smaller subbasins. Therefore, a basin for rehabilitation was selected in two stages. In the first stage the reservation was divided into eight major watersheds; delineated from major drainages on topographic maps (Figure 1). After a major watershed was selected for rehabilitation, this major watershed was divided into subbasins in the second stage.

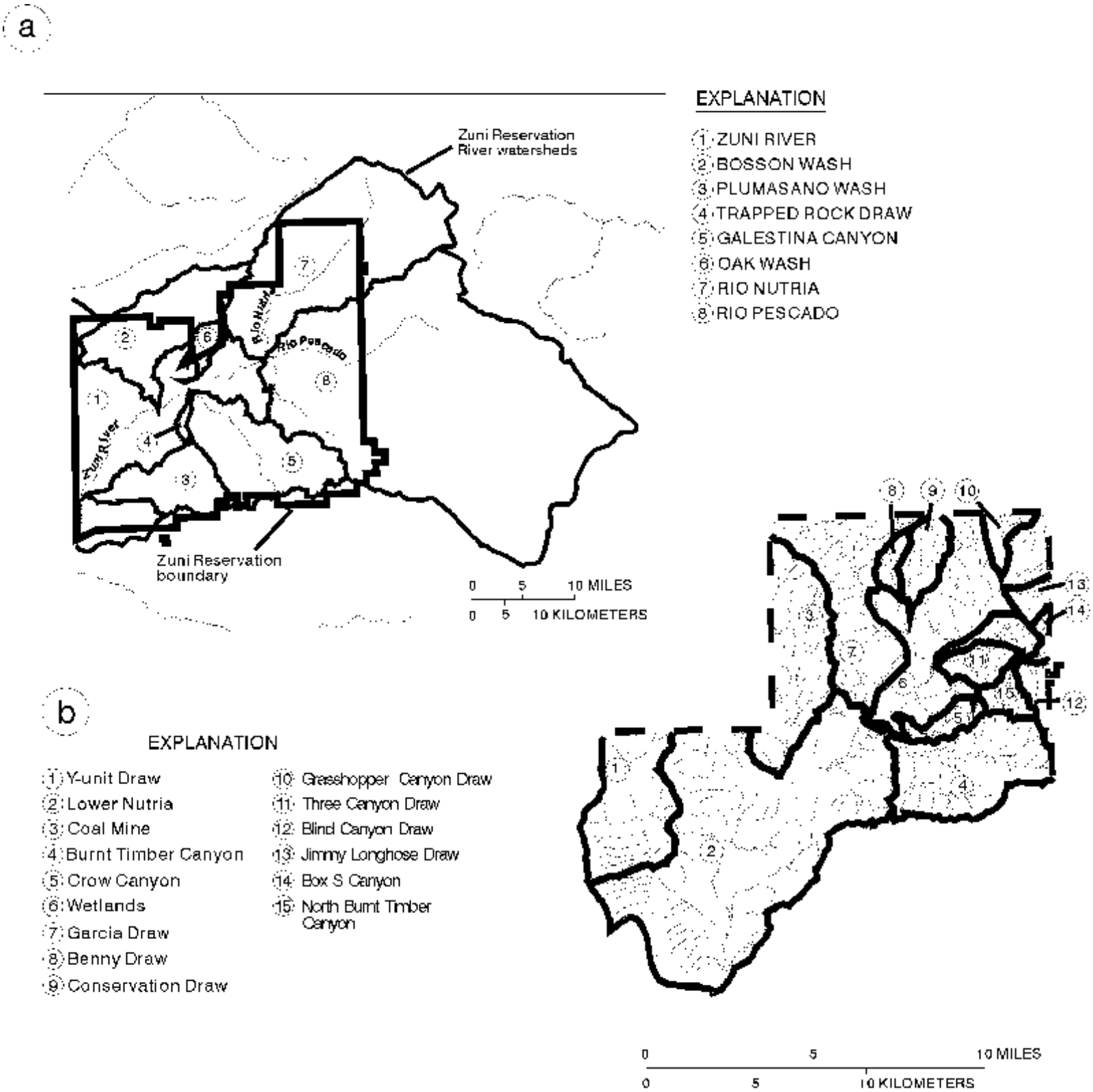

Figure 1. (a)location of major watersheds of the Zuni River basin on the Zuni Reservation, New Mexico, and (b) location of subbasins in te Rio Nutria Watershed.

Data Collection for Selection of a Major Watershed for Rehabilitation

Table 1. Factors considered in the selection of a major watershed for rehabilitation.

Quantitative and qualitative information on natural and anthropogenic

factors in each major watershed on the Zuni Reservation (Table 1) was collected and assessed to select a watershed for rehabilitation. Quantitative data included headcut density and vegetative characteristics such as percentage of bare ground and percentage of chained areas. Headcuts are vertical drops in the bed of the gully. They are important indicators of erosion because they represent baselevel lowering of the channel and channel downcutting. Headcuts were identified from color aerial photographs available for 1988 at a scale of 1:15,840; and some headcuts were verified in the field. Percentage of bare ground, tabulated by the range science work group of the Zuni Conservation Project, was based on plot studies for each soil type and extrapolated to unmeasured areas. Areas of bare ground may be natural, due to the chemical nature of the soil, or anthropogenic, due to clearing activities, such as in chained areas. Chained areas are those areas where vegetative cover was removed for the purposes of improving grass cover.

I. Physical Features
    a. Headcut density (headcuts/km2)
II. Qualitative Physical Features
    a. Average value of main channel erosion
    b. Average value of tributary erosion
    c. Visual estimate of watershed erosion
III. Vegetative Cover
    a. Bare ground (percent)
    b. Chained area (percent)
IV. Roads
    a. Density of dirt roads (m/km2)
V. Structures
    a. Number of failed dams
VI. Weighting Factor
    a. Agriculture (hectares)
    b. Results of community survey

Qualitative information also included a relative ranking of main channel erosion, tributary erosion, and an estimate of erosion for the entire watershed. A scale of 1 to 10 was used in this ranking, 10 representing the potential for the most erosion, 1 representing the potential for the least erosion. Similar qualitative rankings for erosion were used in the Pacific Southwest Inter-Agency Committee (1968).

Data collected on anthropogenic features in major watersheds included the density of dirt roads and the number of failed dams. Both features were obtained from aerial photographs and digitized into a GIS. Dirt roads can channel runoff and may cause gullying (Gellis, 1996). Structures such as earthen dams used for erosion control were examined from aerial photographs to discern if the structures had failed. The failed structures have ceased to retard sediment and because some have failed by headcutting may cause a new cycle of erosion in the watershed.

The percentage of agricultural acreage in each basin and the results of a community survey were used as weighting factors in the selection of a watershed for rehabilitation (Table 1). Agriculture is an important socioeconomic factor to consider. For example, two major watersheds may have an equal potential for erosion, a watershed used heavily for agriculture may be of more socioeconomic value to rehabilitate. The community was surveyed about its interpretation of the most appropriate watershed for rehabilitation. A map depicting the eight major watersheds on the reservation was handed out at a land user meeting where participants were asked, "Which area of the reservation do you think needs to have erosion-control work first, second, third, and so on?".

After all data were collected, the watersheds were ranked on a scale of 1 to 8, with 8 representing the watershed with the potential for the most erosion. The ratings were summed and the highest total value indicated the most appropriate watershed for rehabilitation. The first ranking which assumed all variables to be equally weighted, indicated the main stem Zuni River as the most appropriate major watershed for rehabilitation, followed by Trapped Rock Draw and Rio Nutria. A weighted value was assigned to select factors listed in Table 1 based on their significance in characterizing erosion. For example, weights were given as follows: headcut density, 1.5; percentage of bare ground, 2.5; number of failed dams, 2; agricultural acreage, 1.5; and results of community survey, 4. The use of these weighted values indicated Rio Nutria watershed as the most appropriate watershed for rehabilitation followed by Trapped Rock Draw and the main stem Zuni River.

The Rio Nutria watershed was selected by the Zuni Tribe as the first watershed for rehabilitation. Selection of this basin was based on the weighted values, with special regard to its selection as the most appropriate watershed for rehabilitation by the community survey (weighted value of 4). Rio Nutria was also a pilot project basin.

Data Collection for Selection of a Subbasin for Rehabilitation

As the major watershed selected for rehabilitation, the Rio Nutria watershed was divided into 15 subbasins (Figure 1), and physical and anthropogenic information was collected for each subbasin (Table 2). Physical information included quantitative information on (1) headcut density, (2) change in gully lengths between 1934 and 1988, (3) gully density in 1988, (4) width-to-depth ratios of gullies, (5) sheetwash erosion rates, and (6) the percentage of chained areas (Table 2). Physical information also included a qualitative ranking of main channel erosion, tributary erosion, and an estimate of entire subbasin erosion. Anthropogenic data included information on dirt roads and erosion-control structures.

Increases in gully length over time may indicate subbasins with

Table 2. Factors considered in the selection of a subbasin for

greater rates of erosion. Gully density was used in the subbasin assessment process. Gully density is the total length of gullies in a subbasin divided by subbasin area (Table 2). Narrow, deep channels are more erodible; therefore, width-to-depth ratio is a variable that can be used to describe erosion in a channel. Width-to-depth ratios of incised channels in Mississippi were used as part of a geomorphic approach developed to aid engineers in rehabilitation efforts (Schumm et al., 1984). In the assessment of a subbasin for rehabilitation, width-to-depth measurements were made in select channels (Table 2). An average of all width-to-depth measurements for a gully were used in the assessment.

Sheetwash erosion is the erosion and transport of soil from a hillslope by tiny streams that move back and forth across the hillslope during a rainstorm (Dunne and Leopold, 1978). Sheetwash together with rainsplash are responsible for most hillslope erosion. In a study conducted on sheetwash erosion in the Rio Nutria watershed on selected land-cover sites using sediment traps, the highest total sediment concentrations were measured at chained areas and in two of the three grazed pastures. Due to the nature of chaining, vegetation may not have recolonized these areas effectively, resulting in large areas of bare ground. The lowest sediment concentrations were measured in woodland areas (pinyon and juniper, sage and ponderosa pine) and may be due to high vegetative cover and leaf litter.

rehabilitation.

I. Physical Features
   a. Headcut density (headcuts/km2)
   b. Change in gully length 1934-88 (m/km2)
   c. Gully density in 1988, (m/km2)
   d. Width-to-depth ratios (m/m)
   e. Average sheetwash erosion rates (grams sediment/ grams runoff)
II. Qualitative Physical Features
   a. Average value of main channel erosion
   b. Average value of tributary erosion
   c. Visual estimate of subbasin erosion
III. Vegetative Cover
   a. Chained area (percent)
IV. Roads
   a. 1988 density of dirt roads (m/km2)
   b. Change in dirt road length 1934-88, (m/km2)
V. Structures
   a. Number of failed dams
   b. Number of structures more than 50% filled
   c. Number of dams with headcuts downgradient
VI. Weighting Factor
   a. Agriculture (hectare)

Average sheetwash erosion rates were obtained from the sediment trap data using total sediment concentration per unit area (g/g/hectare). The concentration per unit area for a select land cover type was extrapolated to similar land-cover types in each subbasin of the Rio Nutria Basin.

Qualitative information collected for the assessment of subbasins was similar to that collected for the assessment of a major watershed. A relative interpretation of main channel erosion and tributary erosion was made by assigning a value of 1 to 10; 10 indicates the channel having the most potential for erosion.

A map of dirt roads in the Rio Nutria Basin in 1934 was created from aerial photographs (scale 1:28,000), and a map of dirt roads in 1988 was created from aerial photographs (scale 1:15,840). An increase in the lengths of dirt roads per unit area between 1934 and 1988 is an indicator of the potential for increased erosion.

Three characteristics useful in the assessment of erosion-control structures in the Rio Nutria watershed were: (1) number of failed dams in each subbasin, (2) number of structures more than 50 percent silted, and (3) number of structures with headcuts downgradient (Table 2) (Gellis et al., 1995). Agriculture acreage in each subbasin was obtained from a coverage created in GIS (Graham, 1990).

After all data on physical and anthropogenic factors were collected, the data were entered onto a spreadsheet. All factors were ranked on a scale of 1 to 15, with a value of 15 given to the factor with the most potential for erosion. The values were summed and the highest value indicated the subbasin with the most potential for erosion. Various scenarios using various weighted values were presented to rank the watersheds. In almost all scenarios the three most appropriate watersheds for rehabilitation were Coal Mine Canyon, Garcia Draw, and Benny Draw.

Monitoring Erosion Control

A monitoring program was established to determine if erosion control is successful over an extended period of time. Monitoring in the Zuni watersheds is carried out by the Zuni Tribe at the watershed and gully (arroyo) scale. The watershed scale incorporates an area greater than 26 km2 and encompasses 3rd-order drainages or greater. Both structural and nonstructural controls used in erosion control are monitored. A check dam is considered a structural control, whereas reseeding is considered a nonstructural control. The gully scale typically refers to 1st to 3rd order drainage systems. Monitoring is conducted by the collection of streamflow and suspended-sediment data at the mouth of the basin. At the gully scale, monitoring includes but is not limited to resurveys of cross sections and inspections and surveys on erosion-control structures.

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Sustainability through Restoration: Experiences of the White Mountain Apache Tribe

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The White Mountain Apache Tribe has launched a many-pronged effort to achieve its goals for sustainable development. This approach is guided by the understanding that sustainability has four cornerstones, which are mutually reinforcing and interdependent:

1. People, with knowledge, awareness, faith, and energy to promote sound resource management.

2. Ecosystems, that are currently in, or can be restored to, healthy and productive conditions.

3. Culture, instilling strong values that bind communities, that facilitate long-range planning based on traditional knowledge and experience, and that encourage promotion of healthy ecosystems.

4. Sovereignty, including the power to make unfettered decisions about tribal resources.

The Tribe recognizes these four forms of social and natural capital as essential to its existence. All have been attacked and diminished by federal and state policies ever since the US first sought to control Apache lands. Many people unfamiliar with tribes question the inclusion of sovereignty as an essential component of sustainability. The experience of White Mountain reveals that threats to tribal sovereignty constrain the Tribe's ability to make decisions that best promote sustainable development. Sovereignty in this context includes self-government, cultural and religious freedom, and economic power derived from control of resources. All of these factors empower tribes to manage their lands as they wish, and thereby pursue their visions of sustainable development.

No one can define sustainability within the White Mountain Apache Reservation better than the Tribe itself. Their aboriginal lands and waters not only provide tremendous natural resources, such as ponderosa pine, trophy elk, native trout and rich rangelands, but also play a critical role in sustaining the Tribe's culture, health and values. Western approaches to management of these resources may conflict with Apache perspectives. For example, many Apaches believe that it is presumptuous for humans to try to dictate where and whether other creatures should live; therefore, both critical habitat and species reintroduction may be viewed as unnatural. Other Apache belief

systems, such as the cyclical nature of the world, do provide a solid foundation for concepts such as ecosystem management, sustainable yield and land restoration. Particularized knowledge and values, such as historical conditions and significance of certain waters, are invaluable resources for ecosystem management. Despite the attention given by outsiders to biological diversity, this ecological knowledge acquired by the Tribe over millennia is the most vulnerable aspect of sustainable development, as each year buries more knowledge of the elders.

Sovereignty

The White Mountain Apache Tribe has a long and storied history of defending its lands and freedom while pursuing economic development, extending back to its success in retaining much of its ancestral lands within the boundaries of the Reservation. Other highlights include an armed confrontation with the State of Arizona over the building of a reservoir on its lands, the development of a ski resort, a 9th Circuit Court of Appeals case supporting the Tribe's exclusive right to regulate hunting and fishing, and long battles with Phoenix and the Salt River Project over water flows.

One of the more recent conflicts occurred when the US Fish and Wildlife Service sought to impose Endangered Species Act regulations on the Tribe. This conflict was resolved through the adoption of a Statement of Relationship between the Tribe and the Service in 1994. At the heart of this declaration was the Tribe's objective of developing ecosystem management plans with technical assistance from the Service. The agreement has led to numerous creative solutions to ecosystem management challenges on the Reservation, and off it as well. The Tribe has adopted ecosystem management plans that safeguard sensitive species such as the Mexican Spotted Owl and Arizona Willow, and it has initiated stream restoration projects with assistance from the Service. Both parties recognize that far more ecosystem protection has been accomplished through this effort than through a legal battle over federal regulations.

The Tribe and the Service are planning to take their relationship into a new phase, by developing an Ecosystem Management and Research Project for a large portion of the Reservation. Dubbed the Medicine Ecosystem Project, it will bring together individuals with varied talents. Scientists will address native fishes, birds, plants, and watershed health, cultural advisors will identify significant cultural resources to be protected, and resource planners will mitigate the impacts of development.

People

The comprehensive Medicine Project will build upon the Tribe's numerous smaller programs to target particular elements of sustainable development (see Figure 1). A Tribal Watershed Planning Program, funded by the EPA and the Tribe for two years now, conducts stream monitoring with assistance from Forest Service researchers and develops integrated resource plans to reconcile multiple uses and promote ecosystem health. The Tribe has operated an environmental restoration program for two years that employs young persons while informing them about ecosystem management issues on their lands. This program is being extended to include a Youth Training Camp, where college and high school students are being trained in stream monitoring and restoration. The youth programs serve to demonstrate that people can make a good living by taking care of their land.

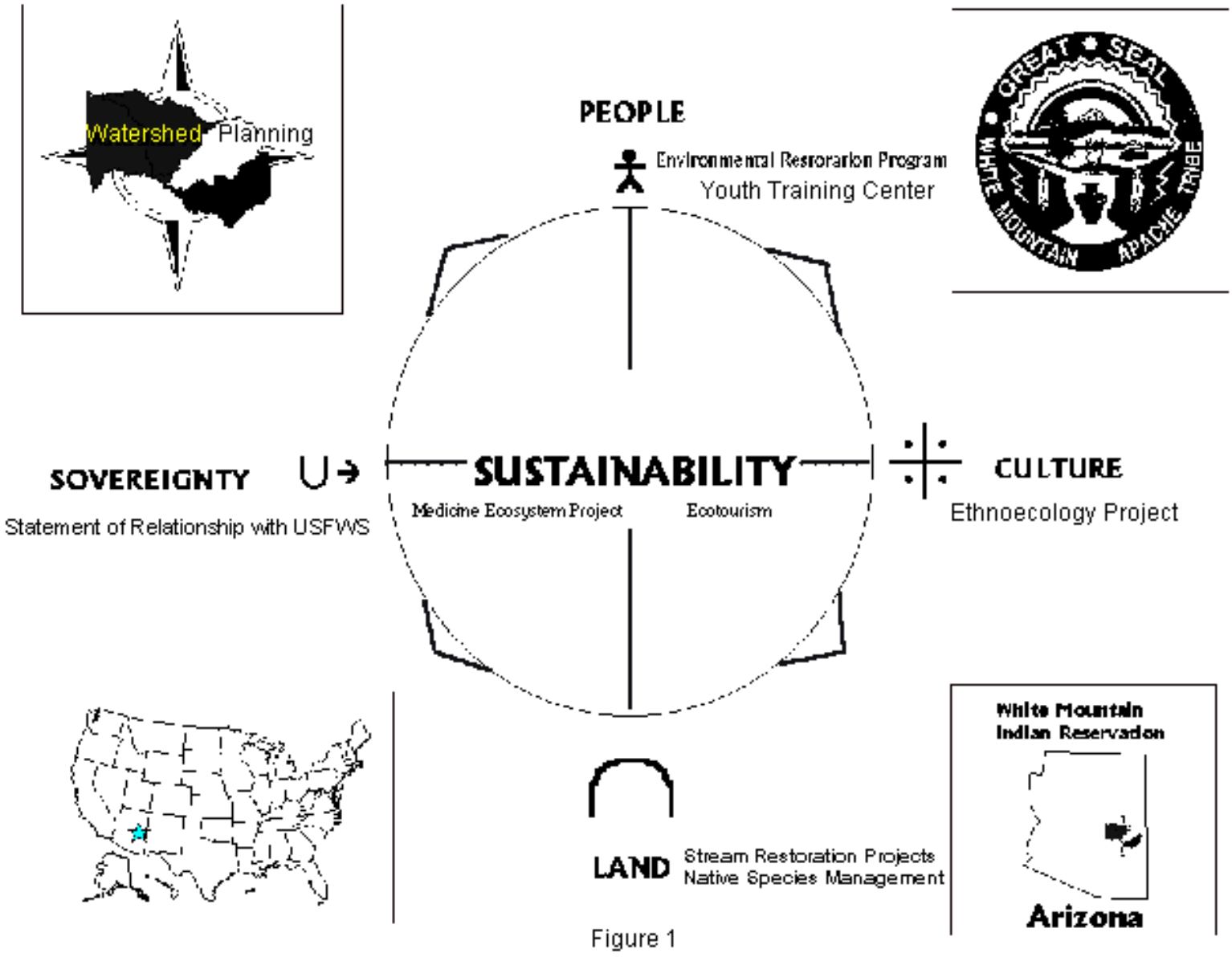

Figure 1.

Ecosystems

The land restoration program has focused on high-elevation streams, home of the Apache Trout and dominated by highly productive mountain meadows. The lessons learned in the mountains are now being extended to the more arid low country. One of the most important of these lessons has been that non-woody vegetation such as sedges, rushes, reeds, and bulrushes play a critical role in maintaining stream structure and function. These plants have been severely depleted due to historic overgrazing, vegetation eradication, and channel manipulations_activities that were sponsored by the federal government. These findings support the need to promote natural recovery of systems and to research undisturbed conditions. The focus on recovering plants and streams has been well-received by tribal leaders and elders, who remember how their lands have been damaged by outsiders.

Culture

The cultural dimension of restoration will be directly addressed through the establishment of an Ethnoecology Project, in which elders will be enlisted in recording and applying traditional knowledge of places, plants, and animals. This information will guide resource management and educational programs. The Tribe is working to encourage eco-tourism ventures by tribal members, while instituting plans to ensure that such development is compatible with cultural and environmental concerns.

Unifying Strategy: Restoration

At the heart of the Tribe's sustainable development program is the strategy of restoration, in all four areas of people, culture, land, and sovereignty. The youth programs are rebuilding human capital, the stream projects are restoring waters, fisheries and riparian zones, and the cultural programs are revitalizing traditional language and knowledge. Providing impetus for these efforts has been the Statement of Relationship, which in essence, was a restoration of the Tribe's way of dealing with external entities. This affirmation of tribal sovereignty reinforced an assertiveness that permeates tribal natural resources management and policy. While the Tribe has sometimes been insular and reactive, it now seeks out contacts and opportunities to address challenges. The most important step to guarantee long-term success of this effort is to prepare enough skilled tribal members to lead at all levels. This goal has been promoted through regular Natural Resource Workshops that bring leaders and resource managers together. Tribal members have led most of the presentations, many of which are conducted in Apache. Development of tribal managers is also being promoted through apprenticeship-like positions under the supervision and training of experienced managers. The Tribal Council made a powerful statement in support of the restoration strategy in deciding the fate of a $4 million portion of the settlement of its claim against the United States for damage to its lands prior to 1946. In November 1995, the Council recommended that the Tribe establish a permanent fund to assist students of natural resources management and support ecosystem restoration projects. This resolution emphasizes the Tribe's role as the dominant investor in its own sustainable development.

Integrating Management

Concurrent with this astounding growth, the structure of natural resources management is becoming better integrated. Programs and projects bring together experts from different fields, such as law, science, education, health, and public policy. Such achievements seem simple, but are not easy due to the alien statutes, confining grant programs, bifurcated management, and entrenched mindsets that have been typical contributions of the federal government. These conditions do not create incentives or resources for integrated management. Nevertheless, the Tribe has pieced together funding, projects, and staff to work in a common direction. Several steps were helpful in integrating management:

- Focus on field work: to train young persons and to show the real challenges and potential of restoration.
- Informal interdisciplinary teams: to encourage brainstorming from many perspectives.
- Joint funding and projects: to encourage communication and a shared mission.
- Speaking with elders: to promote awareness of the history and purpose of management.

Lessons for Non-tribal Entities

The experience of White Mountain brings important lessons to people and agencies outside the Tribe. One of them is to facilitate tribes in building integrated programs that draw upon the resources and expertise of all governmental agencies that offer valuable resources and appreciate their responsibilities to tribes. A second lesson is that developing strong local relations greatly encourages cooperation, as the Fish and Wildlife Service has demonstrated by establishing a new position in the local Fisheries Resources Office to serve as a liaison to the Tribe on endangered species issues.

Integrating management and localizing relationships are helpful steps, but for sustainable development to be realized, tribes must have the power to make decisions free of imposed constraints. Non-Indian society must acknowledge its responsibility for the precarious conditions in Indian Country that are products of the numerous long- and still-standing policies that erode tribal sovereignty, ecosystems, and culture. No one who has either a sense of justice or a hope for sustainability can fairly argue that these historical disparities can be passed over as we move forward. Many advocates of sustainable development and ecosystem protection express support for their notions of tribal management based on traditional values, but these same individuals may be circumspect, if not outright confrontational, when tribes take steps that do not mesh with their romanticized views. There are many constraints that are unavoidable, including degraded lands and waters, lack of education, and economic resources. But these constraints are not immutable, and other ones, such as the violation of water rights and abdication of treaty responsibilities, are matters of policy that can be righted. Therefore, any effort that seeks to promote sustainability within Indian Country should help to remedy these conditions rather than dismiss them as intractable or irrelevant.

Promoting self-determination is not only morally justified, it is also the only strategy likely to succeed. Non-Indian laws, regulations, and priorities will not solve the complex ecosystem problems in Indian Country. Consider the issue of the federally endangered salmon runs: even from a narrow view of sustainability, it is irrelevant who has the right to take the last salmon, because at that point the salmon is already lost. We should accept a broader view, which recognizes that the same forces that have jeopardized our nation's ecosystems, have also threatened tribal peoples, political systems, economies, and cultures. Then we can see that steps to restore ecosystems and ensure sustainable development should harness the tremendous power and knowledge that tribes possess, by supporting tribes in their efforts to restore their worlds.

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Every River Has Its People

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A tribal saying is that "Every River Has Its People" and in the Dungeness watershed of Washington State an unusual mix of committed groups and individuals have been working together for the last few years to address the deteriorating condition of the Dungeness River ecosystem. The Dungeness has always been the primary river of the Jamestown Band of S'Klallam people, who pooled $500 in gold coin in 1874 and purchased 200 acres near the river to remain in their traditional territory. Unfortunately, the Dungeness is not the abundant source of fisheries that it was in the last century with chinook and fall pink salmon now identified as critically depressed (Washington State Salmon and Steelhead Stock Inventory, 1992), meaning the runs are now so small that permanent damage to the stock is likely or has already occurred. A number of interrelated factors have led to this decline including logging practices from decades past, past water withdrawals for irrigation, shoreline development, bridge construction, and diking. The Jamestown S'Klallam Tribe participated in a series of separate planning processes that each addressed a piece of the watershed puzzle, i.e. water quality, flood management, water quantity, and fisheries restoration. The Tribe served as the coordinating entity for the successful development of a water resource management plan under the auspices of the "Chelan Agreement," a locally-based consensus process that sought to avoid water rights litigation through regional negotiations.

The result of all this planning has been the advancement of the "three R's" in the Dungeness watershed: (1) improved technical knowledge through research; (2) better management of watershed resources through consensus-based recommendations; and (3) the building of lasting relationships among the people with a stake in the watershed. Clallam County and the Jamestown S'Klallam Tribe passed a joint resolution in 1995 to form a Dungeness River Management Team that is comprised of representatives from the Tribe, County, state, and federal agencies, riparian property owners, farmers, environmentalists, and scientists. These veterans of watershed planning processes and a few new recruits have stated the

purpose of exchanging information, implementing watershed plans, coordinating staff and funding, and promoting public education on watershed processes. It is hoped that the Team will continue the positive direction that emerged from endless hours of meetings, careful analysis, and learning to listen to each other. In the words of the Jamestown S'Klallam Tribal Chairman, Ron Allen: "We have chosen to manage the water resources of the Dungeness watershed with the residents of this community, rather then seek solutions in the distant courts. Whether this will remain possible in the long run is up to the people of the river."

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Chesapeake Bay Community Action Guide: A Step-by-Step Guide to Improving the Environment in Your Neighborhood

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In 1987, the Chesapeake Bay restoration effort was heightened by the signing of the Anacostia River Restoration Agreement, by the Governor of Maryland, Mayor of the District of Columbia and the County Executives of Prince Georges and Montgomery Counties. And, in 1991, as a signatory in this multi-jurisdictional agreement, the Metropolitan Washington Council of Governments developed a Six-Point Action Plan for the restoration activities for this highly degraded tributary of the Potomac River.

The Anacostia Watershed Restoration Committee (AWRC), comprised of state and local government officials from the District of Columbia, Prince Georges County, Montgomery County and the State of Maryland, was established to ensure that the objectives of the 1987 Agreement were met. The Metropolitan Washington Council of Governments (COG) has the responsibility of providing staff support to the AWRC as well as providing the Committee with recommendations on new initiatives to be undertaken by the AWRC in support of the 1987 Agreement. The AWRC has been actively involved in the restoration effort, having committed to over 50 restoration initiatives in 1990 alone.

Since the signing of these agreements, there has been a dramatic increase in the number of resource restoration projects within the Chesapeake Bay watershed. Many of these projects are initiated at the public and private levels and are supported by citizen volunteers. Two initiatives were spawned within the Anacostia Watershed as this environmental restoration effort proceeded: 1) an effort to coordinate groups interested in participating in the restoration activities, and 2) technical guidance to assist citizens

in overcoming the hurdles organizing and implementing these projects successfully.

The first initiative was accomplished through the establishment of the "Small Habitat Improvement Program" (SHIP), whose primary purpose is to assist implementation of a series of small scale restoration projects by citizen groups and others. The second initiative was The Chesapeake Bay Community Action Guide which is a publication specifically targeted at those groups both public and private that want to improve the environment of the Bay watershed. Published in final form in May of 1994, the Community Action Guide is designed to provide step-by-step instructions on environmental restoration projects for those interested in participating in these efforts. These citizens groups and volunteers to governmental efforts are increasingly important as financial resources devoted to such activities shrink.

This handbook-style document has aided many community groups, teachers and other school groups, as well as individuals to implement Chesapeake Bay Cleanup activities in their communities. Included in the Handbook, are case studies of continuing restoration projects in the Anacostia River Watershed.

Projects which involve a volunteer labor force require a considerable amount of time in planning, executing and follow-up activities. Although numerous projects of this type have occurred, little information is available on how to ensure a successful project. Consequently many project organizers have to continually reinvent the wheel, expending valuable time and resources. It is the intent of this document to provide volunteer project organizers a concise, step-by-step approach to organize a resource restoration project.

Also, by providing concise, up-to-date information, as well as step-by-step guidance from project organizers who have had experience with volunteer projects, the chances of implementing a successful project are enhanced. Not only does this save valuable time, but it also saves valuable resources and ensures that the money spent on a volunteer project is money well spent.

The Guide is a handy reference guide to be used by educators, public agencies and environmental groups. This should encourage groups or agencies to sponsor mere volunteer projects. It may also encourage other groups that do not normally sponsor volunteer projects, to become involved due to the reduction in the time involved in project organization. By conducting mere volunteer restoration projects, it is anticipated more people living within the Bay watershed will be able to take an active role in the Bay clean-up effort.

Guide Content

The Guide has provided guidance in the following types of environmental projects:

- Storm Drain Stenciling
- Wetlands Plantings

- Stream Cleanups
- Reforestation and Tree Care

Although the Guide has been developed based on the Anacostia restoration effort, the nature of the document will allow its adaptation throughout the Bay watershed. Information on project contacts, checklists have been written at a generic level, allowing for their use on the eastern shore of Maryland as well as in the western portion of the state, with mock project plans as well as educational materials.

The most important part of any environmental/community project are the volunteers. This Guidebook highlights the importance of volunteer involvement and support as well as methods on how to organize restoration events and how to maximize the benefit to the volunteers and organization resulting in a 100% positive experience.

- Checklists for each specific type of project which will guide a project organizer through project development, execution, and identify critical follow-up activities to ensure project success;
- Mock Project Plans for each type of project, including project location; project description; sources of labor, materials and funds; location map(s) and schematics of the project; cost estimates; and a time line for project implementation;
- Generic Educational Material for each type of project, to be used as is or adapted as needed; this material will explain project importance and will be distributed not only to project volunteers, but also to the surrounding project community;

This Guide is currently being distributed free of charge throughout the Chesapeake Bay region and beyond. It has been used as a model to develop similar programs in other watersheds outside of the Bay region.

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Backyard Actions for a Cleaner Chesapeake Bay: A Cooperative Outreach Program

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Public Education and Water Quality

Increasingly we realize that the key to restoring the health of Chesapeake Bay lies in the hands of individual citizens. Reaching those citizens, however, represents a daunting challenge, one we have addressed through a multi-media public information campaign described below.

Restoration of Water Quality in Chesapeake Bay

Water quality in the Chesapeake Bay has been on the decline for nearly 40 years-that decline has been especially evident in oxygen-depleted bottom waters, in widespread losses of submerged aquatic vegetation and in periodic fish kills. We have known for some time now that good water quality begins with land practices-how we use the land, how we eliminate and change its natural topography (e.g., forests and grasslands to farms and suburban development), and how we protect its connections with the water, for instance, the direct discharges from sewage treatment and commercial plants, the indirect loading through runoff and groundwater seepage, and the airborne pollutants released from smokestacks and automobiles.

Years of scientific research have shown that much of the Bay's degradation is the result of excessive

nutrients that overwhelm the ecosystem's assimilative capacity. Overenrichment of nitrogen and phosphorus sets into motion processes that feed massive growths of algae, much of which sinks unconsumed through Bay waters to fuel bacterial growth among the end results is depletion of oxygen, elimination of habitat and deterioration of a healthy ecological infrastructure.

A major goal of the Chesapeake Bay Program-a compact of state and federal governments to restore Bay water quality-is to slash nutrient flow to the Bay. In 1985, the states of Maryland, Virginia and Pennsylvania, the District of Columbia, and the Environmental Protection Agency set a goal of reducing nutrient releases to the Bay 40 percent by the year 2000.

A Cleaner Chesapeake: The Need for Educated Citizens

Notable achievements towards meeting the 40 percent reduction have been made, for instance, through such actions as the banning of phosphorus detergents and through the upgrading of sewage treatment plants to remove phosphorus and, more selectively, nitrogen. In addition, the federal Clean Water and Clean Air Acts have led to significant reductions in direct discharges of contaminants from industrial processes as well. As direct discharges of pollutants come under greater control, primarily through regulatory efforts, diffuse, or non-point, sources of pollutants loom as a larger problem to water quality: runoff from highways and streets, farms, and urban and suburban development are not as amenable to regulatory control and enforcement.

The Chesapeake Bay Program has developed a Tributary Strategy that sets goals for nutrient reductions in major river basins that make up the Bay ecosystem. To meet those goals, nutrient and toxic runoff will have to be severely curtailed from many sources. While farms constitute a major source of nutrients to the Bay, through runoff and groundwater seepage, state programs, Cooperative Extension Service agencies, and soil conservation districts in the Chesapeake Bay watershed are working with farmers in numerous programs to encourage voluntary reduction of fertilizer and pesticide use and control of soil erosion.

Related efforts are not in place for curtailing nutrient and pesticide runoff from residential areas: few educational programs reach out to citizens. In Backyard Actions for a Cleaner Chesapeake Bay-a public education outreach program-the Maryland Department of Agriculture, the Maryland Sea Grant College Program, the University of Maryland Cooperative Extension Service, and Maryland farmers joined together in a program in Spring and Summer 1995 to begin educating citizens on practical actions they could take on their lawns and gardens to help protect the Chesapeake Bay.

Backyard Actions for a Cleaner Chesapeake Bay: The Outreach Program

Goals

Called Backyard Actions for a Cleaner Chesapeake Bay, the goals of the education program were three-fold: (1) to inform citizens that their personal actions, even on small plots of land, can impact the health of Chesapeake Bay, (2) to provide hands-on information on gardening and lawn maintenance practices and (3) to show city dwellers and suburbanites that farmers are stewards of the land and what they are doing to protect the Bay.

The educational focus was on wise fertilizer use, alternatives to pesticides and controlling soil erosion. According to a recent public attitudes survey on the Chesapeake Bay, citizens are still not aware that nonpoint sources of pollution play a major role in the Bay's health: 32 percent of those interviewed said that industries were the major cause of pollution in the Bay and 8 percent that farmers were-7 percent identified individuals (Chesapeake Bay Attitudes Survey 1994).

Strategy

Three, 30-second video public service announcements (PSAs) and radio scripts, produced by the University of Maryland Sea Grant College, formed the centerpiece of the outreach program to disseminate the conservation message. The outreach strategy included important and related elements:

- Take It from Maryland Farmers Bay-Wise Guides designed to give easily accessible advice on gardening and lawn practices. By phoning the 800 number at the Maryland Cooperative Extension Service's Home and Garden Information Center, callers received copies of Use Fertilizers Wisely; Control Soil Erosion Around Your Home; Try Pesticide Alternatives.

- Take It From Maryland Farmers posters advertising the availability of the Bay-Wise Guides by calling the 800 number. These were distributed to libraries, schools and public office buildings.

- Maryland Farmers Partners With the Bay stickers. Handed out at special events.

- Take It From Maryland Farmers table top exhibit for use at special events such as home and flower shows, National Soil Stewardship Week, Earth Day, Governor's Bay Bridge Walk, Maryland State Fair, Chesapeake Appreciation Days.

- Cooperative Extension Service outreach education programs.

- Chesapeake Regional Information Service (CRIS), Soil Conservation district outreach programs.

- Television and radio appearances with farmers, among them, Martha Clarke, Central Maryland; Don Spickler, Western Maryland; Martha Daughdrill, Southern Maryland; Marty Rice, Frederick County. Other spokesmen were interviewed, including Maryland Department of Agriculture head, Lou Riley.

Backyard Actions for a Cleaner Chesapeake Bay: The Results

The Maryland Department of Agriculture was responsible for marketing the PSAs, arranging television and radio interviews, and contacting print journalists for stories on the Backyard Actions campaign. The Maryland Cooperative Extension Service provided the 800 number and distributed materials-they recived more than 3500 calls. In addition, Cooperative Extension Service agents used the fact sheets in educational programs in their counties. While the campaign was slated to run from April to June 1995, television stations are still running the PSAs in winter 1996. Channel 2 in Baltimore, for example, reported that PSAs were shown four times in December 1995, representing a broadcast value of $850. The data below are as of October 1995-the estimated value of public service announcements and print media during this time totaled more than $62,000.

Public Service Announcements

The Public Service Announcements were run on at least 44 outlets (15 television and 29 radio) with an average of at least five runs per station: 2,200 hits for a total estimated value of $22,000. The channels included commercial stations WJLA-7, WBAL-11, WMAR-2, WUSA-9; Maryland Public Television; and cable stations. Radio stations (throughout Maryland and the Washington metropolitan area) read or adapted PSA scripts, among them, WRC-980, WTOP-1500, WMAL-63.0, WBAL-1090, and National Public Radio.

Television and Radio Interviews

Between April 3 and July 9, ten radio and television on-the-air interviews were placed: they included a WJZ-TV Bob Turk Interview and WBAL-TV Dave Durlen Interview. WBOC-TV ran programs on the evening and morning news. Longer programs on television included two 30-minute programs on WJFK (Trish Mahoney) and WLIF (Sloane Brown). The dollar value of these interviews are estimated at $7,300.

Print Media

Articles or mentions of the Backyard Actions campaign appeared in at least 20 different publications, and ranged from large newspapers such as The Washington Post to more regional newspapers such as the Daily Banner, Maryland Independent, and the Star-Democrat to specialist newspapers such as Delmarva Farmer. The estimated dollar value of these articles or mentions is $27,884.

Additional Marketing Outlets

While the media outreach markets played a major role in public education, the Bay-Wise Guides were delivered to other outlets for educational programming. A total of 5,000 guides were delivered to 24 Soil Conservation Districts and to Cooperative Extension Service Offices, Pennsylvania and Virginia Departments of Agriculture and Natural Resources, Maryland Farm Bureau, local government agencies, various homeowners and condominium associations, teachers, Save Our Streams, and Federated Garden Clubs of Maryland.

The 1996 Outreach Campaign and the Future

During spring and summer 1996, we will repeat the Take It From Maryland Farmers campaign; this will include updating the PSAs and adding a 10- or 20-second version on preventing soil erosion. We have also begun planning a public education effort on the prevention of soil erosion during winter.

We are developing a survey questionnaire for interviews with callers who requested Bay-Wise Guides. Our aim is to evaluate the effectiveness of PSAs and the value of the guides in gardening and lawn practices.

Using the Backyard Actions campaign as a model, we will explore the potential with other state agencies for extending the campaign throughout the Chesapeake Bay watershed.

References

Chesapeake Bay Attitudes Survey. (1994). Chesapeake Bay Program Communications Subcommittee. U.S. Environmental Protection Agency for the Chesapeake Bay Program.

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Multi-Faceted Extension Education Program to Reduce Residential Nonpoint Source Pollution

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Introduction

The Water Wise Gardener Program, developed by Virginia Cooperative Extension (VCE) with funding from the Cooperative State Research, Education, and Extension Service (CSREES) at the U.S. Department of Agriculture (USDA), is an educational program aimed at reducing nonpoint source pollution from suburban residential areas. Targeted pollutants include: (1) nutrients, especially nitrogen and phosphorus from residential fertilizer use and pet wastes; (2) sediments, primarily due to erosion from poor landscape or site development practices; and (3) toxics, such as pesticides and household chemicals.

The program seeks to reduce pollution to area water ways through the following objectives:

- Education on various lawn, landscape, septic system, and well-water best management practices;
- Implementation by homeowners of recommended practices;
- Partner Master Gardener volunteers with homeowners to achieve the first two objectives listed.

Specific working goals of the program that have been met include:

- 85 percent of participants complete one-year Water Wise Gardener program; this includes attendance at a series of spring and fall seminars, implementing at least five recommended

practices, keeping accurate records of lawn and landscape activities, and meeting at least once with a Master Gardener;

- Documentation of a 40 percent reduction in nitrogen applied, and a 25 percent reduction in yard waste sent off-site, pesticides applied, and water used in the landscape.

The following discussion will identify and describe some key aspects and lessons learned from conducting the Water Wise Gardener to date.

Who is the Audience?

Before planning or conducting a water quality education program, one should ask the question: "Who is the intended audience?" There are a number of ways to classify the publics (people) served by a public education program. The physical area served by an Extension office or agency, e.g. a small community, a big city, a rapidly developing suburban area, will play a large part in audience determination. An inner-city program will be different from a suburban program or a rural program. Discovering which water quality issues are important from a community, social, and political perspective is a key element of the program planning process.

Some generalizations about audiences and their interests in water quality education can be made. For example, in rural areas, the quality of well water and septic system maintenance will likely be of major interest to both residents and local government. In suburban areas, lawn and yard care is popular with residents and commercial landscapers, neighborhood appearance is a great concern to homeowner associations, and storm-water management is emerging as an issue localities must deal with. Inner-city audiences may be concerned about urban stream restoration, river clean-up, or municipal water quality problems.

What is Public Education Anyway?

Cooperative Extension programs incorporate a combination of informational, developmental, and implementational components. Informational programs are focused on distributing and sharing information. Speakers, brochures, videos, news releases, seminars, and, field days generally fall into this category. Stand alone informational activities such as a seminar or brochure generally provide a "one shot" approach to education. The impact of such an approach is difficult to quantify, other than to specify how many people attended or received a publication. What people do as a result of the event, e.g., did participants change their behaviors, or did they go on doing what they were doing before, is hard to determine. Nonetheless, such informational opportunities certainly have a place in educational programs; they are effective in raising awareness and encouraging people to a deeper level of involvement.

In most areas, Cooperative Extension programs are getting away from a purely informational approach to education in favor of a more developmental approach. The aim of a developmental program is to move a targeted audience confronted with a problem (poor water quality, a bad lawn, overuse of fertilizer),

through an educational process that leads to implementation of desired behaviors. Developmental programs work best with objectives that are sequenced and aimed towards accomplishment of program goals, and, an evaluation of program results.

The Five Level Program Involvement Model for Water Quality Education

The heart of the Water Wise Gardener Program is the Five level program involvement model for water quality education shown in Table 1. In the first level of the program, suburban homeowners and renters participate in a series of seminars designed to educate them on various lawn and landscape topics that also impact water quality. Examples include fertilization, integrated pest management, plant selection and care, and composting. The seminars feature speakers and actual demonstrations. Plenty of time is allowed for questions, and publications on the topic are available. The seminars also serve to interest individuals in participating in the volunteer lawn component of the program (level two). Many Cooperative Extension offices are already conducting these types of programs with existing resources. If available, additional funding can be sought to purchase or design publications, promotional items, or pay for speakers.

Level two recognizes that while seminars and workshops are great places to begin public education on water quality issues, developmental programs should challenge people to a deeper level of personal involvement. One of the most successful methods of developmental education related to lawn care and water quality is the volunteer lawn. In this part of the program, homeowners volunteer to implement the recommended practices they have learned in the seminars. The homeowner signs an agreement stating his or her intention to implement at least five best management practices, as well as keep track of lawn and yard care activities and amounts of fertilizer and pesticides applied on a record form. The homeowner is assigned a personal Master Gardener (Cooperative Extension volunteers trained in many aspects of horticulture), with whom the homeowner can consult about the implementation of the recommended practices. The Master Gardener conducts at least one personal visit with the homeowner and establishes regular phone hours when he or she can be contacted with questions. While by no means essential, additional funding at this point can allow a part time professional to be hired for managing and tracking the individual volunteer lawns.

Table 1. Five level program involvement model for water quality education.

Level # and Name	**Program Objective**	**Time & Funds Needed**
#1 workshop, seminar, field day	awareness, provide written material, opportunity to hear speaker and ask questions, recruitment for next level	one year $0 - $500 (supplies and promotion)

#2 volunteer lawn	adoption of best management practices, data collection, one-on-one interaction with volunteers	two years, $0 - $5000 (above plus wages for technician)
#3 demonstration lawn term data	program publicity, long term	three years, $0 - $10,000 (above plus more wages)
#4 master gardner training	train new volunteers already familiar with the program	three years, $0 - $25,000 (above plus more wages)
#5 transfer to community	bring program to closure, refocus based on new priorities	four + years, $0 - ?

It is generally a good idea to start out with a small number of volunteer lawns the first year, perhaps 10, and see how it goes before committing to greater numbers of lawns. Some homeowners can require a big time commitment, especially if their yards need a great deal of work and they are counting on you to answer all their questions! In many cases, a lack of trained Master Gardeners is the primary factor limiting the number of volunteer lawns that can be initiated at one time. A minimum of a one-year commitment by the volunteer lawn homeowner is essential to learn and implement the recommended practices as well as collect data. It's okay to have a homeowner in the program longer than one year.

Demonstration lawns are the third level in the Water Wise Gardener Program. The purpose of a demonstration lawn is to signify achievement, mastery, and knowledge gained. Once homeowners have been in volunteer lawn status for a year or more, they are knowledge about how water quality relates to lawn care, and hopefully the educational role of Cooperative Extension. Their lawns are probably looking good as well! This is the time to reward them by highlighting their efforts to the community with some type of yard sign. This not only emphasizes the "grassroots" nature of your program, but is also an effective marketing strategy. Demonstration lawns can also provide you with a source of long term data, i.e., did participants follow the recommendations beyond the one year period, beyond two years? A realistic goal is to have about 20 percent of the volunteer lawns continue on as a demonstration lawn. Here again, additional funds can provide more personnel to help you manage an expanding program.

Master Gardener training is the fourth level of the program. Here, the idea here is to encourage volunteers who are already familiar with the Water Wise Gardener Program, by virtue of having participated as a volunteer or demonstration lawn themselves, to become Master Gardeners. This brings the volunteer effort full circle, as the volunteer who has received training in levels one through three now makes a commitment to share his or her knowledge with others in the community. At this point, additional funds can support an expanded training effort.

Level five is evaluation of the program. Evaluation of some sort should occur every year. This is covered in more detail in the following section. In addition to yearly evaluation, every three to four years, decisions about future program direction should be made. Perhaps the original goals have not been met

and either more time or goal redefinition is needed. If the program goals have been achieved in one particular community, perhaps resources can now be focused on other community. It may be that the program focus changes to some other water quality aspect, such as well-water testing or septic system maintenance, and the community takes on the lawn and landscape part. It is not an easy task to get a community to feel invested enough in a program to continue it without the time and money resources of your agency. You may find it helpful to adopt such a attitude as you go about conducting your program.

Don't Forget Evaluation

Assessing the impacts and outcomes of water quality public education programs is important for many reasons. Increasingly, limited funds for such programs means that managers will be required to show that the education efforts are producing desired impacts and outcomes. Recall that developmental programs are designed to assist participants in both learning new information and changing behaviors. A common approach to evaluating these types of changes is the administration of a before and after survey that asks the same questions. Such a survey can assess changes in before and after behaviors or practices (usually expressed as a percent) addressed in the educational program. Besides obtaining data on homeowner behaviors and practices, a well designed survey can provide demographic information such as age, race, income level, and voting district. Such a survey, administered before the homeowner attends the first seminar or event, can also supply specifics on amounts of fertilizer, pesticide, and water being used. Similarly, a survey completed after the homeowner has been participating in the program for at least a year will show what the person has learned, attitude changes, and quantitative data on fertilizer, pesticide, and water usage. Comparison of the surveys will enable you to evaluate whether or not program goals are being met. Use of a computer software spreadsheet or database manager facilitates keeping track of, analyzing, and reporting of this type of data.

Once data has been collected and analyzed, it is essential that you use it to improve your program, not just to see how good or bad you did. If your goals are not being met, ask yourself why. Could it be that another year is needed, or were the goals perhaps too unrealistic? It may take a few years until the program is running as it should. Be sure to prepare_and widely distribute_an easy-to-read summary or impact sheet showing your more positive results. Such information helps to demonstrate that public education is indeed effective in reducing nonpoint sources of pollution by changing peoples attitudes and practices in and around their homes and yards.

What's Next?

With funding from the CSREES at the USDA, and Extension specialist support from Virginia Tech, a program guide on the Water Wise Gardener has been developed. The program is currently being expanded to Cooperative Extension offices in the Chesapeake Bay watershed. Further expansion on a national level is hopeful.

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Blue Thumb-An Urban Watershed Success Story

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Oklahoma Conservation Commission

Blue Thumb, a nationwide effort to educate citizens about nonpoint source pollution was begun by the American Waterworks Association (AWWA). When our state began an Environmental Protection Agency (EPA) 319 project to teach our citizens how to protect their watersheds, we adopted the Blue Thumb logo with AWWA's permission. As you can see from the long list of authors, we had several agencies involved. The Blue Thumb logo was just the ticket to packaging a public relations program to teach folks to care about their storm sewer system in urban areas.

Blue Thumb is Oklahoma's statewide, volunteer based, water quality education project. It began in 1992 with an EPA grant to a dedicated group of agencies: Oklahoma Conservation Commission, Conservation District offices in Tulsa and Oklahoma Counties, Oklahoma Cooperative Extension Service, and the Natural Resources Conservation Service (formerly Soil Conservation Service).

This is the story of how all of these agencies cooperatively worked to get the message out that "We all live downstream."

The Blue Thumb logo was selected for the project as an eye-appealing way to present the water quality message. It has been loaned to us by the AWWA and is, indeed, part of a nationwide campaign. Our mission is to teach citizens in urban areas of Oklahoma that they are part of a watershed that needs protection from nonpoint source pollutants. If we are good gardeners, we are said to have a green thumb. The Blue Thumb indicates that we also are good to our environment and that we care about water running downstream from our homes.

Having water quality awareness takes us to a greater depth of understanding of the following areas of the urban environment: stormwater drainage, urban erosion and sediment control on construction sites, and groundwater protection, and proper choices of fertilizers and pesticides for our homes, yards, and golf courses.

These facets of urban activity affect all of us, downstream. Blue Thumb's job has been to convey to people just how important they are in maintaining healthy aquatic ecosystems in the cities.

We have educated people about storm water drainage by starting the first storm drain stenciling project in Oklahoma. Volunteers can come to the Blue Thumb office, check out a stenciling kit, and spend a few hours labeling drains and explaining to the public that these are direct conveyances to local water resources. Stencils read: "Dump No Waste--Drains to River." The stenciling project has taken off in Tulsa and Owasso. It will soon be expanding to other cities in Oklahoma as well.

Construction projects are infamous for clearing land and choking downstream waters with sediment. To address this, Blue Thumb has teamed up with local Builders Associations, the Oklahoma State University Biosystems and Agricultural Engineering Department, the City of Tulsa, and the Oklahoma Department of Transportation to teach a series of erosion control seminars and an engineering design short course. These are now a routine part of continuing education for engineers and field operators in the construction industry.

Groundwater protection is a serious concern. Small pump houses behind urban homes are often used for pesticide storage. Blue Thumb in Oklahoma City has worked hard to convince homeowners that spilled or leaking lawn and garden products in the area of wellheads spell trouble for groundwater. This problem is nearly impossible to clean up once the damage is done.

In the Oklahoma City metro area, Blue Thumb provides helpful messages to the public through "The Environment Guide", a voice mail system accessible through the information pages of the phone book. Recorded messages tell listeners where their drinking water comes from, how it is protected, and what they can do to protect the environment.

Fleas, weeds, household pests, and other problems often prompt the use of pesticides. Blue Thumb has strived to give the public sound advice on proper selection and use of such pesticides. Oklahoma County Blue Thumb equipped lawn and garden centers with brochures on proper pesticide selection to provide to their customers. We have worked closely with small municipalities, such as the City of Norman, to provide flea control information. Tips on environmentally responsible flea control were broadcast to the general public. People were especially urged never to dump pesticides down storm drains or into the sanitary sewer system via sinks and toilets. As a result, the City of Norman Wastewater Treatment Plant was able to reduce discharge of the pesticide diazinon in the Little River. EPA standards at that location were previously exceeded. The educational efforts of Blue Thumb are now being shared with other cities around the State of Oklahoma via the "Oklahoma Clean!" campaign to keep pesticides out of the wastewater system.

Our program is gaining momentum and continues to be used as a model for the region in successful environmental education for the people.

Acronyms

EPA Environmental Protection Agency

AWWA American Waterworks Association

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Lessons Learned from Preparation of the Mill Creek Special Area Management Plan

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Since the first inquires in 1988, the development of the Mill Creek Special Area Management Plan (SAMP) in the lower Green River Valley, King County, Washington has presented a significant challenge bringing together agency, environmental and development interests. The Mill Creek Basin contains the last large (greater than 2,500 acres), fairly contiguous wetland system in southern King County. The basin wetlands are also one of the last large blocks of land suitable for industrial development in King County. The Mill Creek SAMP was initiated to address the conflict between resource protection and the need for land for development. Under the present system of case by case permit review, outcomes of permit decisions were unpredictable, and lead to increasing fragmentation of the existing system. The long term cumulative impacts of projects were not evaluated in the context of broad ecosystem needs. In addition, mitigation efforts were not coordinated, missing opportunities to capture benefits of combining areas where wetland were being restored, created or enhanced as compensatory mitigation for development projects.

To address these problems, the Corps of Engineers, the Environmental Protection Agency, King County, and the city of Auburn, and the city of Kent entered into an agreement in August 1990 to develop a SAMP to better manage and protect the wetland resources of the Mill Creek Basin, while allowing for some development of the basin wetlands. The 1980 amendments to the Coastal Zone Management Act established the Special Area Management Plan mechanism. The Corps of Engineers adopted this mechanism for wetland planning as described in the Regulatory Guidance Letter Number 92-03 on SAMPs (U.S. Army Corps of Engineers, 1992).

Goals of the Mill Creek SAMP

Six general goals were presented in the Plan of Study to guide the development of the Mill Creek SAMP:

- Provide for a balance between wetlands protection and economic development in the Basin,
- Ensure that wetland functions and values continue to be equal to or greater than those currently existing in the Mill Creek Basin,
- Reflect the needs and interests of the federal, state, and local regulatory and resource agencies and contribute to consistency among federal, state and local efforts for wetlands protection and management,
- Provide detailed information (including watershed information) to agencies and all interested parties for resource management and protection and for assessment of cumulative impacts,
- Provide greater predictability for both developmental and environmental interests, and
- Provide an abbreviated Corps of Engineers and local government permit process for projects meeting certain conditions and located in appropriate areas of the Basin.

Development of Wetland Management Alternatives for the Mill Creek SAMP

The first step in developing alternatives for SAMP was to inventory and characterize the wetlands of the basin. The Mill Creek Basin is approximately 22 square miles in size. Mill Creek and Mullen Slough are the major tributaries in the basin, and despite degraded water quality conditions, still support significant coho rearing habitat. The wetland inventory identified 128 wetland systems covering over 2,500 acres. The majority of the wetlands identified are emergent systems, either actively farmed or in various stages of reversion from cultivation to a more natural state. Approximately 360 acres of forested systems with large areas of open water also exist in the basin.

After the inventory was completed, a wetlands functions and values assessment was conducted using the Wetland Evaluation Technique (WET), and the Washington State Department of Ecology rating system. The result of this characterization was the realization that while the basin's wetlands might appear to be highly degraded, they still are providing significant fish and wildlife habitat, flood water storage, and water quality improvement.

The "performance" of functions by wetlands in the SAMP area was then quantified using the Indicator Value Assessment (IVA) methodology developed by Dr. Thomas Hruby (1995), Washington State Department of Ecology. This method provides a relative estimate of the performance of wetland functions based on specific indicators. The IVA does not provide generic models for measuring performance, but rather a framework for developing local models. Thus, the specific quantitative models needed to evaluate performance in the Mill Creek basin were developed by a local committee of wetland experts, and reflect conditions and factors known to affect performance in this area. The wetland with the highest performance in the basin is scored at 100 and the rest are scored relative to this. Wetland performance was characterized according to Fish habitat, Wildlife Habitat, Floodflow Alteration, and Water Quality Improvement.

Information on the relative value of basin wetlands' performance, combined with an analysis of landscape position were used to identify wetlands in the basin which were of higher value or had a high restoration/enhancement potential. Wetlands adjacent to Mill Creek or containing mature forested systems were found to have the highest values. Wetlands not in the Mill Creek floodplain were found to have lower values for habitat, floodwater storage, and water quality improvement.

Given this knowledge, the next step was to develop alternatives which balanced wetland preservation and a reasonable level of development while maintaining no net loss of wetland functions and values in the basin. The IVA methodology was used again to identify if there was adequate mitigation land available to compensate for various levels of wetland fills while maintaining and enhancing the basin's highest value wetlands, and preserving a corridor adjacent to Mill Creek. The potential increase in functions through restoration or enhancement actions was scored using the IVA by identifying how wetland indicators would be likely to change. The increases identified over the existing functions could be used in compensating for wetland fills elsewhere in the basin. In evaluating ten alternatives, it was found that enough potential mitigation land exists to allow for development of approximately 300 acres of wetlands which are not in the Mill Creek floodplain. Potential mitigation land consists of both uplands which could be restored to wetlands, or wetlands which could be enhanced.

Status of the Mill Creek SAMP

The SAMP process to date has shown that it is possible to craft a wetland management plan which maintains or increases wetland functions and values in the basin, and maintains a fairly contiguous system, while allowing for some development. At this point in time the ten SAMP alternatives are being reviewed, with a preferred final plan to be selected after extensive public review. Simultaneous with the development of alternatives, a combined agency and citizens group has been developing policy options to allow for an abbreviated permit review process.

Lessons Learned From Development of the Mill Creek SAMP

Because the SAMP process is relatively new and untested, a great deal of time was spent "inventing" the process for developing the plan. Several simple, but important lessons have been learned from this process:

- Be Prepared for the Long Haul. The development of a plan which abbreviates the permit process requires agencies and individuals to give up some of their review responsibilities and control. Trust must be developed. This takes time. To achieve a working level of trust, groups must recognize that they do share some common goals with other affected parties.
- Interact Frequently With Groups That Will be Affected by the Plan. Always remember that without the willing participation of all affected parties, the best plans will fail. In the Mill Creek SAMP planning process, a citizen's group composed of environmental and development interests was formed to solicit public input on a regular basis. The input from the citizen's group provided a useful "reality check" on ideas developed by agency representatives. A continual request from the

citizen's group was , "To insure success of the plan, keep the process simple."

- In Developing a Plan, Work with the Existing Landscape. One of the big challenges of assessing the potential for restoring wetlands in the Mill Creek Basin, was determining what landscape to restore. While a general consensus was to restore the wetland systems of the basin to pre-settlement conditions, this was not technically feasible in many cases. In addition, restoration to pre-settlement conditions would in some cases significantly impact important existing resources such as waterfowl. Shreffler and Thom (1993) have identified five different approaches to restoration of natural systems: 1) restoration to predisturbance conditions, 2) restoration to historic conditions, 3) enhancement of selected attributes, 4) creation of a new ecosystem, and 5) no intervention. All these option s must be considered in developing a basinwide plan.
- Don't Expect Development to Wait for the Process to Conclude. Development pressures will typically not stop while the planning process is ongoing. Use development actions as opportunities to test ideas, and get all involved parties used to the ideas that are being proposed in the plan.
- Be flexible! While your information might be the best available, be prepared to update and change as new information comes on-line. The Mill Creek wetland inventory was only an inventory, and has been at times superseded by field delineations. Any plan must recognize the accuracy of the baseline data, and be flexible to accept new information. The policy section of the Mill Creek SAMP has incorporated yearly review requirements as well as review triggers based on monitoring information. In addition, while the use of mitigation banks is good for the long-term, usually the process cannot wait for a bank to come on-line. Any plans must include processes to address the immediate and near future developments which cannot wait for a bank, not just the long term.

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A Multiobjective Decision Support System for Wetland Mitigation Banking in a Watershed Context

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Introduction

Wetland mitigation banking is a regulatory alternative for protecting and managing wetlands within a watershed-based planning context. Mitigation banking provides a flexible way to achieve "no net loss" of wetland functions and values and to comply with Clean Water Act section 404 permit requirements. Mitigation banks provide not only off-site mitigation opportunities for regulated wetland activities, but also enable small, piecemeal mitigation to be pooled into larger, more ecologically viable compensatory efforts that may be planned within the context of watershed needs.

This paper reviews a computer-based decision support system (DSS) which is being developed by the U.S. Army Corps of Engineers Institute for Water Resources (IWR) to assist regulators and planners in siting mitigation banks as part of a watershed-based approach to wetlands planning. This DSS is essentially a tool which allows planners and decision makers to explicitly address the many goals and objectives involved in mitigation bank siting. Specifically, the DSS has been designed for the task of systematically identifying and selecting suitable land for banks or bank systems in response to a wide range of objectives, including but not limited to cost, location, provision of wetland functions and values, and biogeographic concerns.

Decision Support System Components

The DSS framework contains two types of components, which may be used either individually or in

tandem. The first component is a multiobjective programming (MOP) model, which employs mathematical programming to generate alternative mitigation bank plans. Typically, an MOP model must be formulated for the specific problem at hand, but once formulated can be solved on a computer using commercially available software. The second component is a multicriteria decision making (MCDM) model, used for evaluating alternative bank plans which have been generated either by the MOP model or by some other method. MCDM's are typically "shells" which can be applied to a wide range of problem types. A variety of MCDM methodologies exist, some of which are available in the form of commercial software. A geographic information system (GIS) can also be used in conjunction with the DSS, for both managing data and for compiling maps of alternative plans generated by the DSS.

In order to formulate alternative wetland mitigation bank plans, the MOP model is applied to the problem of selecting one or more wetland sites for a mitigation bank or bank system from among a larger set of available "candidate" sites. The MOP will select the combination of sites which best addresses the planning objectives under consideration. Multiobjective linear programming (Cohon, 1978) is used in this selection process, and economic, ecological, physical, and land use data at the site level are needed as inputs. The MOP can be used to generate a variety of "nondominated" alternatives, each of which optimizes a particular prioritization or weighting of the objectives. Specifically, an alternative is said to be nondominated if one objective can be improved only by sacrificing some other objective. Together, the nondominated plans represent the efficient tradeoffs among the objectives.

Once the MOP has been used to formulate a suitable array of alternative plans, the MCDM model is then used to efficiently evaluate and rank these alternatives. Plans formulated by other methods may also be evaluated by the MCDM. To begin this process, each plan is assessed in terms of its performance or attainment with respect to a range of criteria, as specified by the decision maker. These attainment levels are then used, collectively, to score and rank each plan relative to all other alternatives, along a single metric. As a result of this process, the MCDM identifies the better or more desirable nondominated alternatives so that a smaller and manageable "choice set" of alternatives can be advanced for further consideration.

The criteria used in the MCDM may correspond to the objectives used in the MOP, but may also include additional criteria not incorporated within the MOP. In a practical sense, the MCDM can address more criteria than the MOP since, as more criteria or objectives are added, the computational burden of generating a suitable array of nondominated alternatives in the MOP grows much faster than the burden of evaluating plans in the MCDM. A variety of MCDM methodologies are available, including both parametric (weighting) and nonparametric methods (Hwang and Yoon, 1981). Two MCDMs are currently being developed at IWR for use within a DSS, each of which employs a criteria weighting technique to rank alternatives.

A Decision Support System for Wetland Mitigation Banking

As indicated above, the DSS being developed by IWR addresses the problem of selecting and evaluating combinations of candidate sites for inclusion within a wetland mitigation bank or bank system. It is

assumed that candidate sites are wetlands which can be improved or enhanced, or are areas that can be restored to viable wetland status (e.g., agricultural land), or are nonwetland areas (e.g., uplands) suitable for wetland creation. In some circumstances, high-quality wetland sites in need of preservation might also be considered as candidate sites.

In the MOP component, candidate sites are selected in order to optimize two broad-based or "umbrella" objectives: 1) minimize the total cost of the selected sites, and 2) maximize the amount of ecological improvement that can be realized within the selected sites. In the first objective, site costs are assumed to be based on two components: a) the real-estate cost of obtaining necessary land use rights, which can range from the cost of obtaining conservation easements to the full purchase price; and b) the cost of undertaking a wetland restoration, enhancement, creation, or preservation project at the site, including any additional costs associated with ongoing maintenance and monitoring.

In the second objective, the ecological improvement realizable at a particular site is measured in terms of the number of wetland mitigation "credits" able to be produced by improving the site. Credits are used in the accounting procedures of mitigation banks, and can be quantified in terms of either: a) the amount of acreage restored; or b) measurable improvements in wetland functions, such as fish and wildlife habitat, flood control, and water quality improvement, among others. Improvements in wetland functions can be quantitatively assessed through methods such as the habitat evaluation procedure (HEP) (U.S. Fish and Wildlife Service, 1980) for habitat functions, and other appropriate single- or multi-factor indices for nonhabitat functions. The IWR MOP model has been developed to account for credits based upon any number of quantifiable wetland functions, as specified by the decision maker. In the IWR study (see below), four types of credits were considered, based on four functions: a) flood control; b) fish habitat; c) habitat of nonfish species, including water fowl; and d) water quality improvement.

In addition to objectives, the MOP model also employs "constraints" to ensure that the generated bank plans satisfy any requirements specified by the decision maker. Constraints used in the MOP include bounds placed on the amount of acreage selected in each of four wetland classes: a) emergent; b) forested; c) open water; and d) shrub-scrub. As well, acreage proportions can be established for each class in order to achieve a desirable mix of classes, regardless of the total acreage selected. The MOP can also be used as a mechanism for calculating the attainment levels of additional attributes which do not "drive" the optimization process, but whose values might nevertheless be needed later in the MCDM procedure. In the IWR model, several physical, spatial, and administrative attributes are included in this category: a) the number of pairwise connections or adjacencies between selected sites; b) proximity of selected sites to incompatible land uses such as airports and industrial zones; c) hydrologic connections between selected sites and major bodies of water; d) the amount of acreage selected from each of several ownership categories (e.g, privately- or publicly-owned land); and e) total acreage selected.

Once the objectives and constraints of the MOP have been specified, they are written as mathematical statements (i.e., algebraic equalities or inequalities) and entered into a linear programming (LP) solver. The LP software is run, and the output represents an alternative plan which is both nondominated with respect to the stated objectives and satisfies the model's constraints. Using multiobjective programming techniques, the model's parameters can be varied and the software run many times to generate a range of

nondominated alternatives.

Once a suitable set of alternatives has been formulated, either by the MOP or by some other method, the MCDM model is used to evaluate and rank these alternatives relative to a set of criteria specified by the decision maker. The objectives and/or constraints used in the MOP may be reiterated as MCDM criteria, although new criteria not addressed by the MOP can also be included. The two IWR MCDMs have the ability to evaluate plans based on up to 24 criteria, in contrast to the MOP which utilized just two objectives (minimize cost and maximize credits). Ultimately, the task of the MCDM is to reduce the set of nondominated plans to a smaller and manageable set of preferred alternatives which reflect the decision maker's priorities. In the IWR study, the two MOP objectives were used again as criteria, although each was disaggregated into its component parts, as mentioned above. The other physical, spatial, and administrative attributes mentioned above were also used as criteria.

The two IWR MCDMs are weight-based and require the decision maker to supply a weight for each criterion, reflecting its relative importance in the decision process. Also as input, the MCDM requires a matrix or table of alternatives and their associated criteria attainment levels; these values can be obtained from the MOP output. The MCDM then computes an overall score or relative ranking for each plan. One of the MCDMs computes a numerical ranking for each plan based on the weighted sum of the criteria values. Either single weights or weight ranges can be specified for each criterion; weight ranges can be used to reflect uncertainty in the relative importance of a criterion, or used when the decision maker does not otherwise wish to specify a single weight. In the other MCDM, criteria weights are used to separate the alternatives into those which are "outranked" by other alternatives and those which are not outranked, with the latter representing the "choice set". A third MCDM (MATS-PC), developed by Brown et al. at the Bureau of Reclamation (1986), can also be used in this stage of the DSS.

IWR has applied this DSS to a case study involving 128 candidate wetland sites in a watershed located in the Northwestern United States. Using data abstracted from a Special Area Management Plan (SAMP) study, the MOP was employed to generate 23 nondominated alternative mitigation bank plans under the objectives and constraints mentioned above. The two MCDM's were then used to evaluate and rank the alternatives relative to 16 specific planning criteria, according to weights provided by an "expert" users. Each MCDM was effective in reducing the 23 nondominated plans to a smaller set of three to five preferred plans. All computing was carried out on an IBM 486 personal computer, using commercially available mixed-integer programming software (LINDO) and MCDM software developed at IWR.

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Acronyms

DSS decision support system

GIS geographic information system

HEP habitat evaluation procedure

IWR Institute for Water Resources

LP linear programming

MCDM multicriteria decision making

MOP multiobjective programming

SAMP special area management plan

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Watershed-based Planning For Wetlands Categorization: The Financing Dimension

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Watershed-based planning for wetlands has been advanced as a way to improve scientific determination of wetlands functions for permitting and mitigation decisions, to provide a foundation for ecologically successful commercial mitigation banks and to protect wetlands areas that are not subject to fill regulation (White House Office on Environmental Policy, 1993). For several years watershed-based planning for wetlands has been encouraged within the Corps of Engineers when one met four criteria: (1) an area must be environmentally sensitive and face strong development pressure, (2) the public must be involved in the planning process, (3) there must be a sponsoring local agency, and (4) all parties must agree at the outset that the plan will result in a programmatic general permit (Studt, 1987). The desire to develop a general permit is tied directly to the Corps regulatory mission and its desire to expedite the permit review process. However, the first three criteria are now widely accepted as important considerations for any federal agency to participate in a watershed planning effort (U.S. EPA). In turn, the first two criteria are applied in setting study and planning priorities for non-federal planning efforts.

Corps influenced planning rests on three tasks: (1) mapping or identifying of wetlands and their functions, (2) establishment of wetland evaluation protocols for ranking wetlands, and (3) wetland categorization to allow the design of the programmatic permit. This paper discusses the wetlands categorization component of several Corps influenced watershed-based wetland planning efforts in Hackensack, NJ; Juneau, AK; West Eugene, OR; Dade County, FL; and DuPage County, IL. These five cases were chosen for study because the plans were expected to result in a programmatic general permit and in commercial mitigation venture sales to support no-net-loss goals. Detailed discussion can be found in forthcoming publications (Scodari, Shabman, and White, 1996; White and Shabman, in press). This study was conducted as part of the National Wetland Mitigation Banking Study being conducted by the

Corps of Engineers Institute for Water Resources.

Categorization: One Product of the Plan

The wetland categorization process generally has the outcome of placing a wetlands into one of three groups. A technical evaluation and policy judgment determines whether an individual wetlands area could better contribute to the watershed environment if it were (1) developed with mitigation elsewhere in the watershed, (2) restored, or (3) retained in its current state. These categories are established by consideration of a wetlands parcel's functions in a specific watershed context and by public preferences for the watershed environment in relation to population and economic development pressures. Watershed-based planning efforts to implement categorization under Corps and local leadership do require EPA and state approval.

The purpose of categorization is to reduce regulators' decision making costs and landowner uncertainty by making advanced determination of a parcels desired future state. One approach to categorization is to describe a specific desired future land use at a parcel level. In effect categorization resembles wetlands "zoning"_mapping out in advance the future status for specific wetlands parcels. The West Eugene, Hackensack, and Juneau plans attempted this approach to categorization. A second approach, found in Dade Country, FL, and DuPage County, IL, was to develop general categorization guidelines. With these guidelines as public knowledge wetlands owners would have an indication in advance of both the decision rules that would determine whether a permit would be issued and the compensatory mitigation that might be required. The categorization guidelines create an analytical and reproducible protocol for permit evaluation. Whatever approach is adopted, categorization applies the sequencing logic of individual permits under section 404, but on "watershed-wide" basis and in advance of any specific fill permit request. The West Eugene wetlands plan indicates this purpose of categorization process:

"...Review of the Plan (i.e. results of the categorization process) will determine whether the Plan has identified the least environmentally damaging, practicable alternative for future urban development in West Eugene, as required by section 404 guidelines. If the plan is approved, then the Corps proposes to adopt an alternative permitting procedure for the filling of wetlands within the Plan area under section 404."

Consequences of Parcel Categorization

The first column in Table 1 lists the general wetland categories that result from watershed-based wetlands planning, when the plan includes provisions for a pragmatic permit, mitigation banking and preservation of important wetland sites. Typically advocates for some form of categorization cite the ecological advantages of such watershed-based wetland planning. These advantages are noted in the second column of Table 1. However, some environmental groups do not accept that categorization can have positive effects or that increased local control of wetland fill decisions under a programmatic general permit is desirable. The West Eugene plan has been criticized and environmental opposition at the national level has halted the implementation of watershed-based planning efforts in Juneau. But, it must also be

recognized that the Nature Conservancy has been greatly involved in the development of the West Eugene wetlands plan.

Because environmental support has been mixed, much attention is paid to satisfying the concerns of these groups. However, landowner concerns are also heightened by categorization, especially at the parcel specific level. Unless landowner effects are considered the implementation of the plan may be stymied. The third column of Table 1 describes landowner effects from categorization. The general experience is that categorization is opposed by property owners whose land is designated for preservation by the plan. This opposition arises because development restrictions impose a possible financial loss on the landowner. By contrast when a wetlands is designated for fill with compensation, then most of the development value for the wetland is retained after the plan is implemented and much regulatory uncertainty is removed. In fact, some of the most vigorous advocates for categorization have been landowners who have development ambitions (Brown, 1993).

Table 1. Possible effects from parcel categorization.

Category	**Ecological Effects**	***Landowner Effects***
I. Areas Designated for Compensated Fill	Compensation requirements for granted permits yields no net loss	Returns to development on permitted areas are perserved
II. Areas Designated for Restoration Sites	Mitigation banks are sited in ecologically beneficial locations having high success probability. Restoration funds are targeted to the most promising sites.	Profit potential from commercial mitigation sales. Compensation from public aquisition Certain financial loss
III. Areas designated for Preservation	Unique or high functional value areas are preserved	Certain financial loss

Owners of areas designated for restoration may favor or oppose categorization, depending upon the features of the restoration approach in the plan. If the plan suggests that the restoration will be accomplished with public funds (including compensation payments to landowners) then opposition may be muted. Also, if the restoration sites are designated as mitigation banks then the profit potential from mitigation credit sales could promise a financial return adequate to discourage landowner opposition to a restriction on development. On the other hand, if the restoration sites are simply identified in the plan, then the landowner will perceive a financial loss similar to those whose parcels are designated for preservation.

Financing Landowner Acceptance of Parcel Categorization

If a landowner's parcel is categorized for preservation or uncompensated restoration then the future market price of the land may be less than the owner paid for the parcel and there may be a real financial loss. Even if the land was acquired at a low price there is a denial of possible future speculative gain. This observation is not made to suggest that diminution of land values is legally invalid or politically impractical. Public interest arguments may be accepted as a basis for land use restrictions. However, a categorization that designates a parcel for "preservation" must either get landowners to sacrifice some of the market value of the land willingly or under duress, or must provide financial compensation to the land owner who is asked to limit possible future land uses. This is a practical reality that must be confronted in watershed planning and is the reality that poses the question of financing landowner acceptance.

Financing landowner acceptance means developing a program to acquire the rights to place fill or otherwise alter the wetlands character of land categorized for restoration or preservation. Fee simple purchase of the whole property, with full title and rights to make land use decisions transferring to a public agency, is the most straightforward approach. This would be a voluntary transaction where willing landowners are paid a pre-categorization market value for the land categorized for restoration or preservation. This was the approach used to overcome opposition to categorization in West Eugene, OR. However, the purchase of full rights to the land can be expensive. In West Eugene the federal Land and Water Conservation Fund was used to acquire categorized lands. This type of funding is limited and could not be employed across the nation. Available funds could be stretched by purchasing only the development rights to a categorized parcel. In a Purchase of Development Rights (PDR) program the landowner realizes the value of the development rights by volunteering to sell development potential to the public sector rather than by actually undertaking the development. Such PDR programs have been used widely in state and local efforts to retain land in agricultural use.

Public purchase programs must have access to a source of funds. Possibilities include direct legislative appropriations out of general funds; intergovernmental cost sharing or special taxes and fees, such as a tax imposed on real estate transactions; a dedicated property tax increase; a tourist tax, or a value increment tax levied against the gains realized from the sale of land. Absent adequate funds from these sources owners of categorized land might be offered tax credits as a form of compensation.

From an environmental standpoint the watershed plan is likely to recommend preserving or restoring some parcels that are under development pressure and also recommend that parcels be contiguous and linked to other natural landscape features. However, because of the voluntary nature of the PDR program it is expensive to acquire contiguous tracts of land. There are several reasons for this. The initial purchases increase the development value of adjacent properties, and the properties most beneficial in retaining land often have the greatest development potential. The end result has often been that PDR programs which are budget constrained may result in scattered patterns of protected parcels.

Transfer of development rights (TDR) programs are a response to PDR cost control and land preservation pattern problems. The preservation pattern problem is addressed by initially designating whole blocks of land as off limits to certain development. To compensate landowners in these "preservation areas" for lost

development rights they are assigned a certain number of transferable development "credits." Then a development area deemed capable of sustaining higher levels of development is designated. Landowners in the designated development areas are required to buy development credits from the preservation area, and in return are allowed to develop properties at densities exceeding the limits set by current zoning restrictions. The market price of development credits times the number of credits held by each landowner determines the level of compensation. Unlike a PDR program, the buyer of development rights (credits) is not a public agency. Instead payment for the development credits is secured through the market created for these for these development credits. Thus when specifying a growth area TDR administrators must ensure that adequate demand will exist for development credits. Also, program administrators must ensure each landowner in the preservation area is issued an acceptable number of development credits. Finally, program administrators need to overcome transactions costs inhibiting free negotiations such as assuring the legal legitimacy of development credits or facilitating buyers' and sellers' mutual identification and subsequent negotiations through a central TDR bank.

The TDR concept is used in many habitat conservation plans under the Endangered Species Act. Also, a TDR program has been in place for many years to protect the New Jersey Pinelands. The Hackensack Meadowlands SAMP has a TDR provision. An obvious benefit of the TDR approach is that the preservation area is secured in advance and the costs of a TDR rest on developers rather than the taxpayers. However, landowners in the preservation area bear a significant financial risk in agreeing to restrictions on their land in return for development credits to be sold in a market with uncertain demand. Thus, TDR programs need to provide for administrative intervention in the market to sustain a value for development credits, often as a buyer of last resort. Without some such assurance there will be landowner reluctance to accept a TDR system as the means for securing compensation for restrictions on development potential.

Implications for Watershed-based Wetlands Planning

Watershed planning for wetlands can be a complex and time consuming process, especially when the resulting product is parcel level categorization. The costs for technical studies can be substantial. The time to reach agreement on a plan with categorization appears substantial. And, the plan implementation often requires a mechanism to compensate landowners who lose the value of development rights through wetland categorization. However, there are significant barriers to a successful implementation of either a PDR or TDR compensation system. In fact, the three cases where parcel level categorization was attempted remain some distance from full implementation, despite the time and effort invested to date. Also, even if these efforts are finally successful, the costs are so significant that they are unlikely to be implemented widely across the country.

Meanwhile, the Dade County and DuPage County categorization guidelines have been issued, have not been challenged, and are being used. To be sure, as individual permits are reviewed and decisions made on those permits, environmental interests or landowners may protest the application of the guidelines to the particular case. However, the plans have succeeded in identifying wetland areas, in reaching a consensus on a decision criteria, and in developing a reproducible review and analysis process for each permit. As a result, the watershed plans have moved the regulatory program forward to protect the

watershed, secure landowner agreement, and reduce decision making costs. It appears that the most practical goal for watershed-based wetlands planning may be to establish categorization rules rather than parcel categorization to provide consistency for permit review.

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Economic Benefits of Urban Runoff Controls

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Overview

People have a strong emotional attachment to water, arising from its aesthetic qualities tranquility, coolness, and beauty. As a result, most waterbodies within developments can be used as marketing tools to set the tone for entire projects (Tourbier and Westmacott, 1992). A 1991 American Housing Survey conducted by the Department of Housing and Urban Development and the Department of Commerce also concurs that "when all else is equal, the price of a home located within 300 feet from a body of water increases by up to 27.8 percent" (NAHB, 1993).

Although there are a limited number of natural waterfront sites, many opportunities exist to create waterfront property. Homes and businesses can be sited along hydroelectric or water supply impoundments or near the banks of artificial lakes created for wildlife, recreational, or aesthetic reasons. A practice becoming more prevalent is to site developments around man-made ponds, lakes, or wetlands created to control flooding and reduce the impacts of urban runoff on neighboring natural streams, lakes, or coastal areas. When designed and sited correctly, artificial lakes or wetlands can help developers reduce negative environmental impacts caused by the development process and increase the value of the property.

Most local governments require some form of urban runoff management for new development. This

report describes certain urban runoff management controls that can be incorporated into a development in away that provides aesthetic and economic benefits. Table 1 summarizes examples of real estate premiums charged for property fronting these controls. For existing runoff controls that are unsafe or unsightly, corrective renovations are described.

Table 1.

Examples of real estate premiums charged for property fronting urban runoff controls.

Location	Base Costs of Lots/Homes	Estimated Water Premium
Chancery on the Lake, Alexandria, Virginia	Condominium $129,000 - $139,000	Up to $7,500
Centrex Homes at Barkley Fairfax Virginia	Home with lot: $330,000 - $368,000	Up to $10,000
Townhomes at Lake Barton Burke, Virginia	Townhome with lot: $130,000 - $160,000	Up to $10,000
Lake of the Woods Orange County Virginia	Varies	Up to $49,000
Dodson Homes, Layton Faquier County, Virginia	Home with lot: $289,000 - $305,000	Up to $10,000
Ashburn Village Loudon County, Virginia	Varies	$7,500 - $10,000
Weston Development Broward County, Florida	Home with lot: $110,000 - $1,000,000	$6,000 - $60,000 depending on lake size, location and the percent of lake front property in the neighborhood
Silver Lakes Development, Broward County, Florida	Varies	$200 - $400 per linear foot of waterfront, depending on lake size and view
Highland Parks, Hybernia, Illinois	Waterfront lot: $299,900 - $374,900	$30,000 - $37,500
Waterside Aprtments, Reston, Virginia	Apartment Rental	Up to $10/month
Village Lake Apartments, Waldorf, Maryland	Apartment Rental	$5 - $10/month depending on apartment floor plan

Lake Arbors Towers, Mitchellville, Maryland	Apartment Rental	$10/month
Marymount at Laurel Lakes Apartments Laurel Lakes, Maryland	Apartment Rental	$10/month
Lynne Lake Arms, St. Petersburg, Florida	Apartment rental: $336 - $566/month	$5 - $35/month depending on lake size
Sale Lake, Boulder, Colorado	Waterfront lot: $134,000	Up to $35,000
The Landing, Wichita, Kansas	Waterfront lot: $35,000 - $40,000	Up to $20,000
Fairfax County, Virginia	Commercial Office Space Rental	Up to $1/square foot
Laurel Lakes Executive Park, Laurel, Maryland	Commercial Office Space Rental	$1 - $1.50/square foot

Impacts and Controls

Urbanization leads to an increase in the amount of pollutants in an area. Sediment from construction sites can end up in streams and rivers, choking plant and animal life. Oil and gas from vehicles can leak onto roads and parking lots. Fertilizers and pesticides can wash off lawns (USGS, 1995). Pet waste can enter storm drains. Household chemicals, such as paints and cleaning products, can leak if not stored or disposed of properly. All of these pollutants can wash away when it rains and end up in streams, rivers, lakes, estuaries, or ground water.

Development also leads to loss of pervious areas (porous surfaces) that allow rainwater to soak into the ground and replenish ground water. This can increase the amount and velocity of rainwater flowing to streams and rivers. This increased speed and volume of water can have many impacts, including eroded stream banks, increased turbidity and pollution, increased stream water temperature, and increased water flow. All of these can have an adverse effect on the fish and other organisms living in the stream and the receiving waters.

"Best management practices," or BMPs, are designed to help reduce the amount of pollution in urban runoff. There are two general types of BMPs: structural and nonstructural. Structural controls involve building a "facility" for controlling urban runoff. This report discusses two types of structural controls that have been documented as providing economic benefits: urban runoff ponds and constructed wetlands. Nonstructural BMPs do not require construction of a facility, for example, buffers along stream banks to minimize the amount of impervious area.

Ponds and Wetlands for Urban Runoff Control

Many urban BMPs add value to adjacent property. This report focuses on two types of BMPs that are often used: urban runoff "wet ponds" and constructed wetlands.

Wet Ponds. Wet ponds are runoff holding facilities that have water in them all the time. Storm flows are held in the pond temporarily and then released to maintain healthy downstream habitats. Sediment and other pollutants settle out of the water and are not discharged to receiving waters. Wet ponds are usually vegetated, and the plants' roots hold sediment and use the nutrients that are often contained in urban runoff. They can usually be used for large drainage areas. Developers can design the wet ponds to look like natural lakes and enhance the value of surrounding property.

Constructed Wetlands. Because wetlands are heavily vegetated, they serve as a natural filter for urban runoff. They also help to slow the flow of water to the receiving waters and replenish ground water. When properly designed, constructed wetlands have many advantages as an urban BMP, including reliable pollutant removal, longevity, adaptability to many development sites, ability to be combined with other BMPs, and excellent wildlife habitat potential (MWCOG, 1992).

Making Urban Runoff Management Work for You

The impacts of urban runoff management controls on property values are site-specific (CDM, 1982). Controls can affect property values in one of three ways: increase the value, decrease the value, or have no impact.

Factors That Lead to Increases in Property Value

Urban runoff systems with standing water often appear to be natural systems. A clean lake or pond offers benefits to developers by creating an ideal setting for model units and for the sales office. If located close to the entrance and visible from the road, it will have considerable curb appeal and can repay installation costs through faster sales, in addition to raising the value of adjacent lots (Tourbier and Westmacott, 1992).

Many ponds planned for urban runoff control are also designed to provide recreational facilities. They are often surrounded by walking trails and picnic areas complete with gazebos and outdoor grills. The ponds also can be used by nonmotorized boats like canoes. This natural setting creates a home for a variety of birds and animals that homeowners find appealing. Fountains, often included in plans, also add to the aesthetic qualities of the pond.

Effective landscaping can do much to improve urban runoff systems. Banks of urban runoff storage areas and drainage ditches should be graded smoothly into adjacent areas where feasible. Steep slopes should be protected against erosion by stabilization techniques, such as gabions, rip-rap, or other practices that

detract as little as possible from the natural setting. Planting and preservation of trees, shrubs, and other vegetation should also be a part of the improvement plan (Poertner, 1974).

Sediment accumulation and waterlogging of otherwise usable land areas can be avoided by the use of proper design, construction, and operation techniques. Ponds used for urban runoff control can be spared from excessive sediment accumulation by the use of forebays for silt collection. The amount of silt transported can be reduced by directing runoff through vegetated areas or specially designed runoff filters. Waterlogging of land surrounding urban runoff storage areas can be minimized by sloping the ground toward storage areas, eliminating water pockets, and minimizing the frequency and duration of ponding on areas otherwise suitable for multipurpose use (Poertner, 1974).

Factors That Lead to Decreases in Property Value

Residential lots located near an urban runoff pond are often a concern to home buyers with young children. Parents fear their children will be attracted by the water or wildlife and drown. Incidents of drowning in urban runoff management areas have occurred in residential as well as commercial areas. Children who fall through frozen ponds or fall into the water without knowing how to swim are usually the victims. Adults have also drowned in detention ponds (Woellert, 1993).

One solution is to construct a fence surrounding the pond to deter entry and reduce accident potential. Chain-link fencing is often used. Rusting, poorly maintained chain-link fencing reduces any aesthetic qualities of the area, but fencing that has a black or green protective coating is more attractive and can improve the appearance of the runoff control. Prince William County, Virginia, has a fencing ordinance for constructed ponds aimed at preventing entry of children under 4 years of age (Guzman, 1995; MWCOG, 1983). A "protective device" of the developer's choice must be placed around ponds near residential areas with over 2 feet of standing water or more than 2 hours of drainage time. The protective device may be fencing or plantings of bushes and trees; in some cases, flat slopes or shallow beaches extending at least 20 feet from the perimeter of the pond are acceptable. These flat slopes or beaches provide protection for children who could roll down steep slopes directly into the pond. Using flat slopes reduces the amount of land available for development, however, and is the least used option. Fencing is the most inexpensive solution and is used frequently. It has been reported to be an "attractive nuisance," however, because some older children feel challenged to climb fences and enter restricted areas (MWCOG, 1983).

Poorly maintained wet ponds or constructed wetlands are often unsightly due to excessive algal growth or garbage build-up. Wet ponds and constructed wetlands can also become mosquito breeding grounds. Mosquito problems usually can be reduced or eliminated by designing the wet pond so that all portions of the basin are connected to open water to allow natural predators to control the mosquito larvae (Tourbier and Westmacott, 1992). Generally mosquitoes are not a problem in the presence of a good biological community. Organic controls such as mosquito-eating fish or insecticidal bacteria like Bacillus thuringiensis israelensis (Bti), however, are also options where mosquitoes need to be controlled.

Conclusion

Environmental benefits are not the only valid reason for encouraging developers to incorporate urban runoff controls into new residential and commercial developments. Increased property values can result from aesthetically landscaped controls. Both homeowners and developers have realized benefits from beautification of areas adjacent to waterways and detention ponds. Residents find the beauty and tranquility of water, as well as fish, birds, and other wildlife, highly desirable. Commercial property owners, too, can benefit when their property is adjacent to an aesthetically designed urban runoff control. They can realize lower vacancies, lower tenant turnover, and high rental prices. Real estate professionals agree that the more amenities a property has, the faster it will sell or rent. Of course, wet ponds and constructed wetlands require periodic maintenance in order to preserve their value. Moreover, for runoff controls to be successful, they must have the support of people in the community as well as developers (Adams et al., 1984). Then, everyone can benefit.

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Community-Based Stream Restoration Using State and Local Youth Corps

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Folks frequently mention youth corps as a great way to accomplish stream and waterway restoration projects. But what exactly is a youth corps? What are some of the ways they can help with local projects? What are the benefits of working with youth corps? And how does one find a nearby corps? This paper answers these questions and thus helps establish some context for understanding the growing community-based restoration movement.

Youth corps are organizations-sometimes community-based non-profits, sometimes arms of state or municipal agencies-that marshal the energy and idealism of the young to carry out a wide range of community service projects. Corps typically organize young people into crews, with each crew working under the supervision of a trained adult leader. Corpsmembers, as the participants are known, receive payment or stipends approximating minimum wage for their full-time work with the corps. Corps also provide basic education, life skills classes, and job preparation services for their corpsmembers, many of whom are educationally or economically disadvantaged.

A commitment to community service sets corps apart from many other job training programs. Each crew undertakes, and completes to specifications, highly visible, achievable, and measurable projects such as streambank stabilization, tree planting, mapping, and community outreach and environmental education. Corps are flexible and can work with a range of project sponsors to help fill a need. Corps actually prefer projects that require sweat, muscle, and teamwork, which corpsmembers can supply in ample quantities.

State and local corps have grown and thrived over the past 20 years because they offer great community benefits-in fact, a four-fold return on investment. Corpsmembers gain valuable work skills, and use those skills for the benefit of themselves, their families, and their communities (some of them may even

become professional restorationists!) Corps provide temporary employment, and participants and staff spend their wages in local stores and businesses. Corps accomplish and leave behind tangible, visible work projects that often improve recreational facilities and the environment simultaneously. And finally, corps focus on improving basic skills through work-based learning, so that corpsmembers will have the reading, writing and critical thinking abilities that employers demand.

The National Association of Service and Conservation Corps (NASCC) serves as an advocate, source of professional development, and central reference point for corps. NASCC is a membership organization supported by dues, foundation grants, and cooperative agreements with government. In 1994, NASCC sponsored an urban stream restoration training session to help the corps community begin to learn and practice key stream restoration concepts and techniques. The training brought representatives of 25 corps from 18 states to Minnesota for four days of lecture and field work on the banks of Minnehaha Creek. Already participants in the session have trained numerous fellow corps staff and corpsmembers, and have secured local stream restoration projects on the strength of their newly-gained knowledge. One associate corps director who attended the training reported that when she began looking around her state for restoration experts with whom she could launch projects, she found that she was the expert.

The training session also helped jump-start stream restoration projects at four pilot sites-Newark, New Jersey; Oakland, California; Atlanta, Georgia; and Tacoma, Washington-underwritten with funding from the Corporation for National Service and EPA and supported by community-based organizations. At these four pilot sites and elsewhere, hand in hand with local stream restoration groups, youth corps crews are building crib walls, maintaining newly planted streambanks, and conducting outreach to those in the streams' neighborhood. The success of these project has inspired NASCC to launch the Youth Corps Community Environmental Initiative, through which NASCC will provide additional training and support to corps interested in doing restoration projects, and will conduct outreach efforts to federal, state, and local agencies that can sponsor restoration.

So-take a log-choked stream, one that nearby hikers can hear better than they can see. Add spice in the form of eroding banks that are free of vegetation. Mix in native plants. Separate out non-native elements and crumbling concrete. Thicken trail foundations with local materials. Sprinkle with a healthy dose of volunteer labor provided by youth conservation corps, community groups, and Scout troops. Leaven with watershed protection funds. Allow to rise for at least one growing season. Observe the return of local people, plants, and animals. Voila! You have just restored an urban stream.

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Promoting Awareness of the Urban Connections to Watersheds in Cleveland

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The Cleveland: Heal the Waters Project has two components: research on the poison runoff problem and outreach and education on water quality issues. Our research focused on poison runoff loadings estimates, based on an analysis of the landscape patterns of Cuyahoga County. The results of this study are given later in this report.

Through our outreach activities, we found that the people of the diverse communities of Greater Cleveland care deeply about the problems caused by poison runoff and the land use patterns that lead to it.

Clevelanders Care About the Health of Local Watersheds

In 1992 and 1993, the staff of the Cleveland: Heal the Waters Project traveled around Greater Cleveland, met and talked with a wide variety of community leaders, and learned about how water pollution, and especially poison runoff, are everyday headaches for Clevelanders. Throughout 1994, we continued to exchange ideas with local watershed activists and officials about stormwater issues both local and national. We learned that the people of Greater Cleveland, rich and poor, black and white, care deeply about the quality of the waters from which they drink, fish, and draw spiritual sustenance. It became clear that Cuyahoga County's ecologic and socioeconomic problems are linked--degraded streams and rivers and decaying neighborhoods are linked to the process of suburban flight and abandonment of urban infrastructure.

Likewise, it became equally clear that the solutions to these problems must be linked. Shrinking public

budgets and the urgent need for jobs in disadvantaged communities mean that watershed restoration must not take place in isolation, but must instead be part of a larger community process of economic restoration.

In October of 1992, the Cleveland: Heal the Waters Project held a two-day workshop in downtown Cleveland to examine poison runoff problems and solutions. Water quality activists; college and high school students; government officials; and private consultants participated in the workshop and exchanged views about sewer overflows; suburban sprawl; poison runoff pollution loadings; and watershed restoration strategies.

Project staff ranged far and wide in the Greater Cleveland area in the search for clues to watershed problems and solutions. In May 1993, the Minority Environmental Association (MEA) organized a half-day workshop on urban stream restoration techniques and strategies, held at Cleveland State University. In June 1993, Diane Cameron, from the Natural Resources Defense Council, and geographer Dr. Thomas L. Millette surveyed Mill Creek, one example of a watershed in desperate need of restoration. We toured the Mill Creek watershed from headwaters to mouth, observing the blighted Creek's asphalt miles, twin blue lakes, and waste dumps. Conversations and travels with Garfield Heights Councilman Henry Warren and ecologist David Beach revealed various pollution threats to Mill Creek: numerous landfills; combined sewer overflows; and oil spills. With former East Cleveland Councilwoman Willie Bloodworth, we interviewed anglers fishing along Cleveland's 55th Street pier. In August 1993, MEA organized a "Picnic at the Fall," a forum for community leaders to discuss combined sewer overflow (CSO) issues at the site of the Mill Creek waterfall and combined sewer outfall. Throughout the project, MEA visited diverse citizen and government groups throughout the region.

The findings of this report reflect what we have learned about water quality and poison runoff problems from Clevelanders through these activities, and through resources like the lower Cuyahoga River Remedial Action Plan, Stage One Report (RAP Stage I Report). These problems did not spring up overnight, but are the result of centuries of unchecked, unplanned urbanization, that have added to the stormwater and sewage burden of the city's water quality infrastructure. In the first half of this report, we will examine five aspects of the poison runoff problem in Greater Cleveland: (1) the impact of poison runoff problems on the people of Greater Cleveland; (2) the magnitude of poison runoff pollution in Cuyahoga County; (3) the local land use patterns that are the root cause of the massive quantities of poison runoff in the region; (4) sources of chemical pollutants in poison runoff, and (5) a brief description of the County's sewer systems that carry the runoff to local waters and sewage plants.

Water Pollution and Poison Runoff Harm the People of Greater Cleveland in Diverse Ways

Clevelanders have to contend with numerous poison runoff problems. Some of these problems are simply annoyances, some ruin or degrade weekend outings, and some threaten financial and physical health. Fetid, foul sewer overflows flood the basements and streets of East Cleveland and other communities. Lawns begin to wash away as heavy rains gushing off of constriction sites and shopping mall parking

lots course through backyard streams, cutting into the streambanks, and lowering the resale value of private homes. A picnic near the bank of Mill Creek, or a walk along Euclid Beach, if attempted after a rainstorm, can be ruined by the stench of combined sewer overflows.

Fish can be caught off of the 55th Street Pier, but, depending on the type, might be ridden with sores, or laden with toxic chemicals, generated at least in part by poison runoff flows into the Cuyahoga River and Lake Erie. Urban and suburban land uses, as well as streets and highways and construction sites, are named as "major sources" in the RAP Stage I Report of the following harmful pollutants: pathogens, chlorides, oil and grease, sediment, and heavy metals. Urban runoff sources are also listed in the RAP Stage I Report as "intermediate" sources of pesticides, toxic organics, and the "nutrients" phosphorus and nitrogen.

The poison runoff problems encountered in Greater Cleveland can be divided into seven major categories, which we call "The Seven Deadly Sins of Stormwater."

Poison Runoff in Greater Cleveland: The Seven Deadly Sins

The lower Cuyahoga River RAP Stage I Report is an excellent source of information on the impacts of urban runoff on the people and ecosystems of Greater Cleveland. Below, we have relied heavily (but not exclusively) on the RAP Stage I Report for our list of the major water quality and property damages for which poison runoff is a prime (if not the only) culprit. Left unabated, poison runoff:

- Silts in the navigation channel of the lower Cuyahoga River, with contaminated sediments that must be dredged and disposed in expensive, specialized landfills because they are laden with heavy metals and other toxics, including arsenic, cadmium, chromium, copper, iron, lead, zinc, cyanide, and oil and grease. Urban poison runoff from Greater Cleveland is a major source of many of these heavy metals, and oil and grease.
- Contaminates game fish; harms all fish populations in the lower Cuyahoga. Due to PCB contamination, a health advisory from the Ohio Department of Health warns Lake Erie anglers not to eat channel catfish, lake trout, and large carp, more than six times a year, and to limit gamefish meals (e.g., white perch, white bass) to 12 meals a year. Poison runoff from various urban and industrial sites is one of several suspected sources of the PCBs and pesticides.
- The abundance and diversity of the fish populations in the lower Cuyahoga River ranges from "poor" to "very poor." Urban runoff is a major source of many of the heavy metals and toxic organics that are partly to blame, along with habitat loss, for the degraded fish populations.
- Fouls Cleveland's recreational waters. Just as fishing activities are harmed by poison runoff, other kinds of waterborne recreation in Greater Cleveland are thwarted by foul runoff-related pollution. Canoeing, wading, and swimming in local waters are not advised after "wet weather." According to the RAP Stage I Report summary, "For up to 3 days after a storm, bacteria levels in the entire length of the river below the Ohio Edison Dam are likely to exceed criteria established for safe water contact. The lower Cuyahoga is not the only local water fouled by fecal pollution-for several days after a storm, bacteria levels in nearshore bathing areas are likely to violate health

criteria. The bacteria sources include urban and suburban runoff, CSOs, and sanitary sewer overflows.

- Pollutes Lake Erie. Lake Erie is Cleveland's drinking water source. Although Cleveland has high-quality drinking water, stormwater pollution is an ongoing source of pollutants which must be reduced to ensure that the city maintains its excellent drinking water quality over the long term. Also, Lake Erie's "nearshore area" immediately adjacent to Cleveland is probably eutrophic, suffering from too much organic and nutrient pollution; some of this pollution comes from urban runoff from lawns and city streets.
- Reduces and destroys aquatic bug populations, major food sources for fish. All along the lower Cuyahoga, from the Ohio Edison Dam to the mouth, macroinvertebrates (aquatic bugs) are reduced in places. Although there was been an overall increase in aquatic bug populations from 1984 to 1988, the population rating remained only in the "fair" range. Decreased populations of macroinvertebrates are blamed on metals, nutrients, sediment, and destruction of habitat. Urban runoff and urbanization are major sources of all of these pollutants and damages.
- Obliterates small streams, springs, and wetlands during development. Small streams, springs, and wetlands are usually the first casualties of urban and suburban development, and of the uncontrolled stormflows that result from unmitigated paved and built-up areas. Other related habitat losses include: heated discharges from paved areas; clearing trees and shrubs from river banks and shorelines; river dredging; concretization; and rip-rapping. The RAP Stage I Report, focusing on these latter impacts, concluded that "The quality of fish habitat has been reduced throughout the Area of Concern [the Lower Cuyahoga and nearshore areas] while being virtually eliminated in the navigation channel.
- Damages homes and businesses. Urban runoff and runoff-related CSOs have been known to flood basements and streets in Greater Cleveland, and to threaten suburban residents with flooding and backyard erosion.

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Using Volunteer Water Quality Data in Assessing Human Health of El Paso/Juarez Valley Colonia Residents

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

History of the Rio Bravo River Watchers & Colonia Health Assessment Project

In 1988, concerned citizens from the region of the Rio Grande/Rio Bravo (RG/RB) contacted the River Watch Network (RWN) for assistance in establishing a river monitoring program to determine contamination levels. They were particularly interested in potential adverse health consequences due to river contamination. In early 1992, RWN had obtained seed monies from the Pew Charitable Trusts to begin a monitoring and protection program in El Paso/Juarez. RWN staff assisted volunteers in developing a study design, identifying appropriate sampling sites, and establishing a local advisory board. With the assistance of the Texas Natural Resource Conservation Commission (TNRCC) Texas Watch program, approximately thirty interested volunteers were trained to conduct basic water quality testing in the field. RWN trained volunteers in conducting fecal coliform analyses in the laboratory.

Eventually, the volunteers organized into a binational nonprofit called the Rio Bravo River Watchers (RBRWs). RBRWs monitor twice monthly at fourteen sites across forty-two river miles. RBBWs now are able to train new volunteers; they conduct quarterly volunteer training workshops. RBRWs seek to answer two questions from their river monitoring. First, does the RG/RB meet Texas and Mexico's standards for dissolved oxygen, pH, conductivity, temperature, and fecal coliforms? Second, what is the human health risk associated with river water contact? The presence of fecal coliform bacteria in the water indicates sewage or manure contamination that can introduce bacterial, viral, and parasitic disease causing agents. Other potential contaminants in the river and its sediments that may contribute to adverse health consequences include: heavy metals, semi-volatile organics, and volatile organics. These compounds may be associated with neurologic disturbances, skin irritations, blood disorders, birth defects, cancers, and immune system disorders.

Sampling began during the fall of 1994. The results of one year of monitoring are presented below. These data are being used to assess RG/RB floodplains colonia residents exposure to river contamination and their health risks. Colonias are unregulated settlements without access to potable water and sewage treatment facilities. A cohort1 of colonia residents have been interviewed on three occasions over the past year to determine if they interact with the river, by fishing or swimming in the river, or using it as a drinking water source. They also provided information as to their disease experiences and visits to health care providers. Using basic statistics and a multiple logistic regression model, the health risks associated with river water contact, while controlling for confounding exposures2, are assessed.

Results of RBRW Monitoring Activities

Volunteers from the RBRWs monitor dissolved oxygen, conductivity, pH, water and air temperature, on a twice monthly basis. They monitor for fecal coliforms in the laboratory on a monthly basis. However, due to inconsistencies in the volunteer labor force, some data are missing for a few sites during some months. Twice annually volunteers gather river and sediment samples at three sites. The Citizens Environmental Laboratory (CEL) located in Cambridge analyzes these samples for metals, semi-volatile and volatile organics.

Two of the fourteen sites are of particular interest for the purposes of assessing colonia resident exposure to contaminants: (1) Zaragosa International Bridge, on the Southeast outskirts of the City of El Paso; and, (2) Riverside Canal, also Southeast of the City of El Paso. These two sites are immediately upstream of the colonias of Campestre and San Elizario on the U.S. side of the border, and El Sauzal, Loma Blanca, and San Isidro on the Mexican side. Information presented in the graphs below include data from these two sites. For comparison purposes, we include data from an upstream site located on the Northwest outskirts of El Paso/Ciudad Juarez.

Results from these sites, particularly fecal coliform bacteria results, provide information about contaminant exposure among colonia residents who swim near these sites. Also, many residents of the U.S. colonias use water, for bathing and washing, from shallow wells (10-25' deep) located in RG/RB floodplains. These wells may be contaminated with river water, water draining into the river, and fecal

matter from nearby leaky, uncertified, septic systems. To determine the impact on well water, a few volunteers from the RBRWs sampled and analyzed colonia well water twice annually. These results are also used in assessing colonia residents' health risks.

RBRW river monitoring results are presented below in the following graphs. We do not include pH results as volunteers found all sites at all times to be within the 6.5-9.0 range considered preferable for indigenous species of RG/RB aquatic animals. This indicator is measured in the field using a color comparator pH kit and procedures recommended by Texas Watch. From 1994-95 across the fourteen sites, the minimum pH found was 7.25 and the maximum 8.7.

We also do not include river conductivity results or estimates of total dissolved solids, as these also were consistently below the standards. The Texas Water Quality Standard above the international dam, located where the New Mexico, Texas, and Mexico borders converge, is not to exceed an annual average of 1800 mg/l.3 Texas Watch protocols. In this region, the inorganic substances likely to affect TDS include sodium, chloride, sulfates, nitrates, and phosphates.

Dissolved oxygen (DO) is measured from samples collected in the field using Texas Watch protocols. The samples are fixed in the field using reagents to stabilize the oxygen content and color the sample.3 The Texas Water Quality Standard for the El Paso/Ciudad Juarez region of the RG/RB is a minimum of 5.0 mg/l.4 DO is generally considered an indicator of aquatic ecosystem health. As can be determined from viewing Graph 1, DO was above the minimum at the upstream site, Vinton, during every month monitored by the volunteers, ranging from 6.0 to 9.0. DO was below the minimum considered acceptable at the downstream site, Riverside, nearest the colonias. DO was below the standard during the months of October through December of 1994 and April, May and December of 1995.

Fecal coliform bacteria are a group of bacteria commonly found in human and animal feces. These bacteria indicate the possible presence of disease-causing bacteria, viruses, and parasites that are harbored in feces. Hence, the presence of fecal coliforms suggest that human contact with the river may cause adverse health consequences. RBRWs collect river samples in pre-sterilized plastic bags at each site. Samples are cooled and transported within two hours to the RBRW laboratory. Samples are analyzed using a RWN adaption of Standard Method 9222D.5 Each sample is filtered, placed on a nutrient broth in petri dishes and incubated. Resulting colonies are counted and reported as "colonies per 100 mL". Results are not composited over a 30 day period and reported as a geometric mean, rather individual results are reported.

Based on Texas Water Quality Standards, the criteria for fecal coliform above the international dam is a geometric mean, computed over 30 days, of 200 colony forming units per 100mL. No more than 10% of individual samples should exceed 400. Below the dam, the criterion is a geometric mean of 2000 colonies per 100mL. According to the "Clean Rivers Program Data Analysis Task Force," no sample should exceed 4000 colonies per 100mL below the dam.6 The portion of the RG/RB below the International Dam and above the Riverside Dam is the only stretch of river where the standard is not based on contact recreation and hence is less health protective. In truth, that stretch of river is used for

recreational purposes by EL Paso and Juarez Valley residents, particularly colonia residents.

The results presented in Graph 2 are individual results, and each standard is indicated. These results demonstrate that the upstream Vinton site may not be in compliance with the standard, either geometric or individual, during the months of September, October, December, and July. The Zaragosa and Riverside sites sre in compliance with the less health protective standard of 4000 colonies per 100mL. However, if a more conservative standard were applied, the Riverside and Zaragosa sites would frequently exceed them.

The CEL detected arsenic, iron, and manganese in floodplains wells. In river sediments, high levels of aluminum, chromium, iron, manganese, and zinc were detected. However, few volatile and semi-volatile organic compounds were detected. Sodium chloride, nitrates, and sulfates were detected in river water samples.

To determine the illness experiences of colonia residents, over 400 residents were interviewed during the winter of 1994, and re-interviewed during the summer and winter of 1995. The survey instruments and questions used were developed using epidemiologic7 methods. Respondents reported recent symptoms of gastro-intestinal, respiratory and dermal illnesses. They also reported recent visits to a health care provider. Respondents were asked questions designed to determine socio-economic status, smoking status, occupation, food and water storage and handling practices, water source, and interaction with the river.

The results of the epidemiologic survey in the colonias, incorporated into the RWN human health assessment, indicate that 15% of residents fish, and 9% swim, in the river. This information provides evidence that residents do come into contact with the river below the international dam. Hence, the rationale for the less health protective fecal coliform standard below the international dam is unclear. Preliminary results also provide evidence that with increasing reports of exposure to river and contaminated well water, residents report increasing amounts of gastrointestinal and skin illnesses.

Conclusion

Once the analysis of the volunteer data is complete, RWN and RBRWs intend to submit this information to enforcement authorities such as the TNRCC, the International Boundary and Water Commission, the Texas Attorney General's Office, and the City-County Health Authorities. Jointly, RWN and RBRWs will recommend a more proactive effort towards protecting the RG/RB and its human inhabitants.

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Urban River Restoration: How One Group Does It

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Friends of the Chicago River

Where urban rivers are concerned "restoration" can be broadly defined. While a return to some form of ecological health is highly desired1, successful restoration of an urban river is not limited to a return to ecological integrity. "Restoration" in an urban setting is inevitably linked to a range of goals_safety, recreation, flood and waste water storage and conveyance, as well as economic development. Indeed, improving an urban river in terms of any of these goals can be a step stone to achieving ecological goals.

Friends of the Chicago River has been "restoring" the Chicago River for 17 years. The Friends' restoration work may be viewed as both a series of projects_on the ground, published, or enacted into law_or as a series of processes_the processes being as important to restoration as the projects themselves. "How One Urban River Group Does It," specifically how Friends of the Chicago River does it can be understood by looking at the last 17 years of the Friends' work.

Since its formation in 1979, the Friends have used various types of activity: awareness and vision building, advocacy, constituency development, and inclusive planning and project implementation. All of these types of activities have gone on simultaneously to some degree. Nonetheless, Friends' history shows that during certain periods, some types of activities have been more prominent than others. The key to the success of these activities, however, has been dependent on three key factors: leadership, institutional development, and a focus on opportunity. Though activities and projects have varied over time, they have always been driven in part by circumstances, trends, and opportunity. Perhaps the most significant circumstantial change is the improvement of water quality which seems to have driven renewed interest in the river.

The Early Years_Awareness and Institution Building

The early work of the Friends is most characterized by awareness raising_establishing vision, reversing negative impressions, creating understanding of the River's potential, and programs to foster bonds between people and the River. In fact, Friends of the Chicago River was formed when in 1979 Chicago Magazine published its cover story article entitled "Our Friendless River." This article pointed to the need for care of the River and the potential that the River offers. It even suggested that a "friends" group be formed. Indeed, people began calling the author, and Friends of the Chicago River was formed.

One of the Friends' first initiatives was "Chicago River Day" (1980), actually a weekend-long event. It included an informational festival at a downtown plaza near the River, with walking and canoe trips. In addition, the Friends held its first river clean up in the heart of downtown Chicago in 1980. While the cleanup did have ecological benefits of trash removal, what was more significant was the creation of awareness. The downtown was the most well known and visible part of the River, and how it was treated was deemed key to public and agency perceptions of the river and its value. As a result, many of the Friends efforts have focused on the downtown. The cleanup ultimately did achieve its goals-_regular cleanups downtown after 1981 became virtually unnecessary as local businesses and agencies now maintain this River reach.

Other initiatives during the first years included, for example, "river adventures"_teams of people going to different parts of the river to get to know it and bring information back to the others. This was an information gathering exercise, but was also intended to be a bonding experience. These excursions evolved into "design charettes." At these charettes, maps of the river were spread out on the floor for people to draw in their visions and ideas. Ideas for river trails, public boat access, and greenery were all included. These charettes were designed to maximize a sense of community between the various participants_architects, planners, city officials and citizens. David Jones, one of the organizers, notes that, "we consciously made it difficult to tell the city planners from the neighborhood people." Out of these charettes, ideas were generated. The notion of public access and a Chicago River Trail emerged and became accepted as a worthwhile goal.

"Institutional development" was a key ingredient in the generation of real river improvements. As early as 1972 there had been efforts made to revive the River, though these were sporadic. Without a committed and organized constituency, it seemed little would happen for the River. In 1980 and 1981, start up grants were made for the Friends to hire their first staff person, and a local non-profit, the Open Lands Project, gave the group an office and other support.

Friends of the Chicago River had a big fight on its hands right off the bat. When a proposal for a heliport along a central part of the River downtown was put forth, visions of a publicly accessible and green river corridor were threatened. Friends strongly opposed the proposal. The heliport issue became an organizing focus for the organization. At one meeting, a public official pulled one of the Friends early members aside and urged the group to get organized. Friends began to build its constituency. At a local boat show and other events, people were asked to join the Friends. Approximately 2400 people signed up (at no charge).

Victory against the heliport ultimately hinged on environmental and safety regulations. However, other significant benefits were the growth of an active river constituency, citizen and civic leadership, and a proof of the need for both statutory protection of the river and a vision that would guide river edge land use.

While the heliport battle was going on, Friends began a series of meetings to secure the passage of a river protection ordinance. Numerous meetings were held, and a local business association became a partner in the effort. While their interests were primarily business related, they provided feedback necessary for the development of an ordinance. The ordinance was passed in 1983.

The Mid 80's_Planning and Design

In the mid 1980's, the seeds of vision that were sown began to sprout. The River was increasingly more accepted as an asset and two community-based planning initiatives were undertaken. Friends played the role of a facilitator as well as project coordinator. During this period Friends engaged many partners in the creation of two significant documents. The first, the North Branch Riverwalk Concept Plan (1988) was a guiding document for three miles of the river. It envisioned a continuous trail, parks, and wetlands. The second was the award winning Chicago River Urban Design Guidelines (Downtown Section). This document establishes a set of guidelines for river edge property owners to follow when their properties are redeveloped. These guidelines, are not predominantly ecological in nature or intent. They are more oriented to the creation of a downtown tourism destination. They do, however, address stormwater runoff, preservation of natural river banks, and use of native trees for landscaping. In addition, by making the river accessible and attractive, they contribute to "psychological restoration." Re-establishing the River as a key feature of the landscape, and a living thing that all Chicagoans use and depend upon, is considered by the Friends to be a vital part of restoration. Moreover, support for this form of revitalization of the River has helped the Friends to cultivate a broad base of support from the business community.

Both the North Branch Riverwalk Concept Plan and the Urban Design Guidelines were developed using meeting facilitation skills, design sessions, and other group planning techniques. They both, however, hinged on the drive of local constituencies. In the case of the North Branch Plan, two local citizens groups, the North River Commission and the Albany Park Planning Committee pushed for the development of this plan. Volunteers from the neighborhood played lead roles. According to an early board member, the work of the Friends' staff to oversee these projects and find solutions to obstacles was vital.

Moreover, portion of the River that became the focus of the North Branch Concept Plan seemed like a part of the river where a victory could be accomplished. There was leadership and interest. In addition, river conditions seemed to indicate that significant improvements were possible. It was a point of opportunity.

The downtown was also a point of opportunity, largely due to the real estate boom of the mid 1980's. The

economics of waterfront real estate development for tax revenue, real estate values and tourism spurred both local agency and business interest. As if overnight, the river seemed to become the focal point of at least half dozen major development proposals. Economic trends and the converging interests of the business community, city government and citizens made the development of downtown development guidelines possible. There was strong support from City leadership. While the City of Chicago secured funding to hire consultants to develop these guidelines, ultimately they were authored by a Friends of the Chicago River volunteer Ed Zotti.

To write the guidelines the Friends developed what it called the Policy and Design Committee. This committee consisted of representatives from numerous government agencies, planners, designers, environmentalists, citizens, and private developers. (These people were "experts" and helped to build credibility.) The committee also reviewed every development proposal for the river edge. Because of the converging interests of all these parties, they were disposed to come together. Friends began to identify itself as a "facilitator of progress."

Today, the Urban Design Guidelines continue to improve the river corridor downtown. Every new river edge development downtown is subject to review under the Guidelines. The "gateway" park, envisioned in the North Branch Riverwalk Concept Plan in the mid 80's, is now nearing completion. It will feature native vegetation along the river edge as well as trails and interpretive signage. Recently, Friends and its many partner organizations were able to implement another feature of the plan, a wetlands reconstruction at Gompers Park.

During this Planning and Design phase the Friends also enhanced its awareness raising and volunteer programs. Walking trail maps were developed and "docents," volunteer tour leaders began to lead regular river walks. Friends held cruises to promote the River in collaboration with the Mayors office. The Friends had cemented its role as a part of the local civic landscape.

As the real estate boom settled down, new issues rose to the fore. In the late 1980's, after significant flooding on the river's North Branch, and amid massive urban sprawl in the river's upper watershed, the Friends began to work on new issues and opportunities.

Current Trends_On-Site Projects and Citizen Involvement

In the early 1990's planners and river advocates from the upper watershed contacted the Friends with concerns about flooding and stormwater management. In response, Friends held two events entitled "Voices from the Stream." At these events (1991 and 1992), more than 100 people representing developers, municipalities, conservationists, and local citizens were given an opportunity to speak for a few minutes on the river topic of their choice. The spirit of collaboration generated by the "Voices" forums inspired funding for a Chicago River based demonstration project. This project received the support of the National Park Service Rivers and Trails Conservation Assistance program and Congress, and was meant to establish the Chicago River as a model for interagency collaboration on urban waterway improvement. Since that time, the U.S. Fish and Wildlife Service, the U.S. Forest Service,

Army Corps of Engineers, and National Park Service have been collaborating on this effort.

Initially, this project was meant to create a resource assessment and develop a master plan and action items for the entire watershed. However, the project was redirected. It would be too difficult to develop a vision and plan of action for the entire 156-mile river's watershed. Moreover, unlike downtown, the opportunities for many stretches of this were less clear and potentially divisive. Finally, there had been plans made earlier and citizens and agencies wanted to instead to focus on projects. This focus on projects emerged from the recognition that a window of opportunity existed, and that during this window we needed to show on the ground results. Therefore, the project was refocused. The research studies would be completed, and there would be an effort to implement specific projects.

On-site projects are at the heart of the current phase of the Friends' restoration work. Friends has taken on a role as a project coordinator and facilitator. Rather than develop plans, the focus is on the ground results. This shift to projects was also bolstered by growing awareness that citizens can undertake waterway restoration projects.2

There are, however, potentially thousands of bank stabilization projects, stormwater retrofit, and access points that can be created on our river. How then, does a group decide what projects to undertake? Faced with this dilemma, FOCR has developed an operating philosophy_"Go for the Light." What this means is, river improvements will most likely be successful where there is interest, desire, feasibility, and leadership, particularly from citizens.

The types of processes that Friends has used during this current period include communication building sessions_River Forums (similar to the earlier "Voices" conferences). In addition, Friends convened interested and concerned parties to establish criteria for collaborative projects. Then, these groups selected two projects to focus upon. Friends and its partner the National Park Service worked to ensure that citizens were included in this process.

As a result, two on-site restoration projects are being implemented and more are on the way. These include a 25-acre wetlands restoration along the river and a 2-acre wetlands reconstruction. (The wetlands was included in the North Branch Riverwalk Concept Plan in 1988.) All of these projects are being completed with multi-agency participation and citizen and youth corps labor.

Friends continues to respond to opportunity. For example, when approached by community residents about a bank restoration/public access/beautification project, Friends helped to raise funds, bring in agency support, provide technical and volunteer labor, participate in education projects, and publicize the project. This project, conducted in conjunction with the Waters Elementary School, happened because of the local leaders and because of the flexibility and assistance of government representatives. It happened because in these leaders Friends saw the opportunity to help get a project done.

Friends continues to build awareness and to develop itself as an institution. The Friends walking tours continue and have been supplemented by a schedule of extremely popular canoe trips. Our "Halloween

Boat Float," a cruise which shows people the offbeat parts of the river they would normally not see, has been a sell-out for three years and has helped to expand membership. The Policy and Planning Committee still reviews river edge developments. The Friends volunteer programs have been expanded to include more activities that engage people in hands on river improvement, such as river bank work days and water quality monitoring. Vision exercises_such as design charettes and corridor planning efforts_have been less a focus of activity than they have been in the past. As circumstances change along the River, however, it may once again be time for some of the tools and strategies used earlier.

Conclusion

River restoration in an urban setting means defining restoration broadly. The alliances and credibility built by working on non-ecologically driven priorities may bring resources and develop institutional capacity needed to undertake more ecologically oriented projects. Moreover, the tools needed to undertake and effect urban river restoration are varied, and may be more or less useful depending on the larger cultural, economic, and policy considerations of the time. The tools used, the projects undertaken, and their level of success must in part be influenced by the unique opportunities of the moment and the presence of strong leadership and vision. Nurturing collaboration based on citizen involvement and interagency collaboration is vital.2

The Coalition to Restore Urban Waters (CRUW) was formed in 1992. This Coalition helped the Friend of the Chicago River to recognize that as a small non-profit we could play a creating

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A Ground-water Lens Based Strategy For Water Quality Protection on Cape Cod

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Cape Cod has traditionally enjoyed high quality water resources that support a wealth of economic and recreational opportunities for the fifteen coastal communities. The conflicts between preserving water quality and land use activities from a growing year round population are becoming more complex and difficult to solve as the intensity of land use increases. This is demonstrated by the fact that the Cape has doubled its population in the past twenty years, while the percentage of supply wells experiencing some degradation to its water quality has increased nearly 40% percent in the past decade. Land suitable for future water supply development has shrunk to less than 6% of the peninsula.

The aquifer located on Cape Cod, Massachusetts, is composed of six hydrogeologically separate ground-water lenses (Figure 1). The largest two lenses, known as the Sagamore and Monomoy lenses serve as the sole source of water to eleven of the fifteen Cape Cod communities. Besides providing excellent quality water for public and private wells, the lenses also feed the many lakes, ponds, and marine embayments that are an extremely important resource to Cape Cod. These two lenses were the focus of detailed ground-water protection projects aimed at developing a comprehensive picture of potential land use threats to ground-water quality and emphasizing the need for a regional approach to protect resources that are not defined by political boundaries but by ground-water flow within the lens itself. This paper describes techniques that are intended to provide resource based information in a graphical format to

motivate regional ground-water protection efforts.

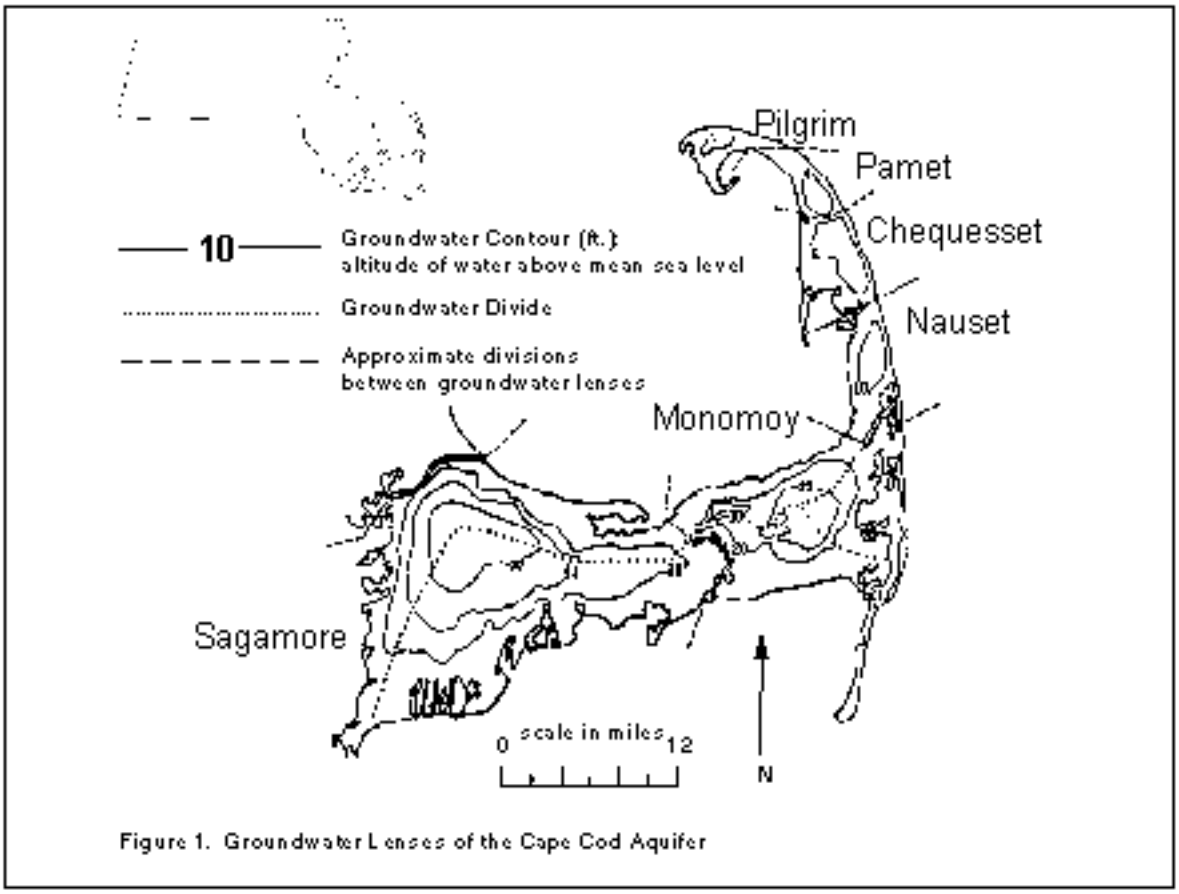

Figure 1. Ground water lenses of the Cape Cod aquifer.

Ground-water Lenses as Watershed Equivalents for Management

The six ground-water lenses on Cape Cod Massachusetts can be envisioned as mounds of ground-water bordered by salt water at the edge, bedrock on the bottom, and separated from each other by tidal rivers that stretch across the Cape peninsula. The soils on Cape Cod are predominantly sandy, which contribute to the rapid percolation of precipitation, the only source of fresh water to the ground-water lens. The combination of rapid percolation and generally shallow depths to ground water make the peninsula vulnerable to contamination. These conditions also limit the process of overland flow. This means that the use of watersheds defined by topography cannot be used to define water resource recharge areas. Instead all recharge areas must be defined by ground-water flow paths within each of the ground-water lenses.

Because it is not possible for ground water to move from one lens to another, the lenses, and not town boundaries, are the key management units for ground-water protection. Within each lens, recharge areas to public water supplies, lakes, ponds and coastal embayments represent the equivalent of subwatershed units, with the added distinction that they often overlap each other. These defined resources formed the

basis for land use analysis and regulatory strategies in the Sagamore and Monomoy lens projects (Belfit et al., 1993, 1995).

Land Use Analysis

A detailed parcel based land use coverage was developed using the Cape Cod Commission Geographic Information System (GIS). The parcel by parcel coverage links information from tax assessors records such as specific land use, acreage, zoning, and owner, to each geographically defined land parcel. Water resource area delineation overlays were added to the land use coverage enabling a wide variety of land use analyses to be performed for each recharge area including land use mapping, nitrogen loading analysis, and private supply well screening.

Land use maps were created for each town showing the relation of land use to water resources areas. Potential land use risks such as underground storage tanks, landfills, and sewage treatment plants were added to the maps in addition to the land use information. A regional map was compiled that dramatically demonstrated the interconnectedness of the water resources with respect to town boundaries and major potential conflicts with existing land uses such as industrial or commercial property and landfills. The maps also provided a visual assessment of remaining developable lands. Separate land use statistics provided a comparative assessment to visual development patterns.

Land use information was used to prepare estimates of nitrogen loading for selected wellhead protection areas based on a cumulative mass-balance method (Eichner et al., 1992). Accounting for the total acreage of lawns and paved surfaces, residential occupancy and commercial water use provided a conservative estimate of the nitrogen contributing to water supplies from fertilizer, wastewater, roads, and precipitation as nitrate-nitrogen. Dilution to the nitrogen mass is provided by the amount of recharge available to the particular wellhead recharge area. The total nitrogen load, divided by the available recharge results in a conservative estimate of nitrogen concentrations that may be expected in the public water supply well. By making some assumptions on future growth potential, nitrogen loading can be projected into the future to see if zoning is adequately protective. Due to the large amount of time needed to determine commercial water use and verify all the figures used in the nitrogen loading calculations only a limited number of wellhead protection areas were completed in each of the lenses (Belfit et al., 1993, Belfit and McCaffery, 1995). Methods of shortcutting the technique by using assumptions were compared. The advantage of a parcel by parcel nitrogen loading analysis is that it allows an ongoing estimate of water quality impacts as new development occurs or buildout patterns are altered. The use of generalized assumptions precludes the more refined approach.

The GIS land use analysis was also used to locate private wells. A screening method was developed by overlying water distribution lines with the land use maps. A 250-foot buffer from the distribution lines, which represented the maximum feasible distance that a water supply would be connected to a main, was created. Developed lots that fell outside the buffer area were assumed to be served by private wells. This method was tested in one town that had excellent records on private well locations, and predicted 73% of the recorded wells. Wells that were not accounted for by the screening method were either irrigation

wells, or lots with available town water that decided not to connect. The method was used throughout the lens to create town by town lists of potential private wells.

Mechanisms for Regional Regulatory Consistency

In 1990, the Cape Cod Commission (the Commission) was established as a land use regulatory agency, in part due to the concerns of Cape Codders that water quality was being jeopardized by the rapid growth of this coastal community. While many of the towns have enacted wellhead protection strategies in the form of zoning overlay districts or board of health regulations, there is a lack of consistency from town to town and many resources such as marine embayments are not adequately protected. Through the creation of a Regional Policy Plan, the Commission enacted regulatory controls to include all water resources including lakes and ponds, coastal embayments, and private and future water supplies (Cape Cod Commission, 1991).

A local ground-water protection matrix was developed for each of the lenses. The matrix helped the towns to see inconsistencies between towns and also compared each town's activities to Massachusetts' wellhead protection regulations and regional performance standards of the Cape Cod Commission. The matrix encouraged the towns to be creative in protecting the entire resource regardless of political boundaries. Through the use of the matrix, recommendations for intermunicipal goals to improve water quality protection were created.

Regional strategies above and beyond town regulations are available to Cape towns through the Cape Cod Commission Act and other legislative procedures. The Regional Policy Plan (RPP) itself is a powerful regulatory document intended to guide future development on Cape Cod and assist in review of developments of regional impact (DRIs). DRIs are classified by regional impact thresholds and are generally large scale projects. The water resources section of the RPP recognizes the limited carrying capacity of water resource recharge areas and uses a resource classification system (Figure 2) to address non-point source performance standards. The use of this classification system achieves a certain level of regional consistency. For example in wellhead protection areas, drinking water nitrogen limits are reached when housing density is greater than one house per acre. A marine embayment may reach its capacity with a density as low as one house per three acres. The system also recognizes impaired water quality areas such as commercial or densely developed areas, and imposes less stringent performance standards on these areas. The Commission review procedure is especially useful in that it looks at problems that extend beyond town boundaries and allows off-site mitigation, which towns are unable to do themselves.

Under the Cape Cod Commission Act, towns are required to adopt Local Comprehensive Plans (LCPs) which are essentially small scale versions of the RPP, implemented on the local level. Development of the plans requires that the towns do a buildout analysis that is compared with resource limitations. This process may result in rezoning or other protective measures that direct growth away from pristine areas. By understanding the resource limitations of surrounding communities intermunicipal goals may be incorporated into the plans. Intermunicipal wellhead protection agreements, zoning bylaws, and board of

health regulations are all possible enforcement mechanisms.

The LCP has the most potential to ensure regional consistency. By its nature, DRI review cannot address the cumulative impacts of small projects. LCPs have the most well defined planning process, requirements for intermunicipal coordination and most important of all, require a time-table for implementation of the recommended actions of each LCP to assure resources will be protected.

Education and Outreach

Several techniques were used in both of the Sagamore and Monomoy Lens projects to educate citizens about regional water quality issues. The Monomoy project involved the use of a 15-member task force to help facilitate town communications, host workshops, and review written material. Over 80 volunteers also participated in the project and provided valuable assistance with the creation of the GIS land use inventory and nitrogen loading assessments. Coordination of the task force and volunteers was a time intensive effort, but one that greatly paid off in the long run. A vast amount of work was accomplished with very little capital cost through the joint contributions of the project participants. Dialogs at both task force meetings and workshops encouraged citizens to get involved with local decision making, and certainly illuminated concerns with neighboring towns.

Educational workshops were incorporated into the Monomoy Lens project including a wide variety of topics on resource assessment and protection. The workshop series was popular with individuals who already had a strong interest in water resource protection. Noting that the same individuals were attending the workshops, it was concluded that the format was not the most suitable for reaching new audiences and a different media that would reach individuals learning about ground-water protection issues for the first time was needed.

To educate a broader population, a regional ground-water protection poster was developed for each of the lenses. The poster included general hydrologic information, resource based protection strategies, water quality information, and a regional land use map as a centerpiece, which defined the resource areas and noted major contaminant plumes. It was widely distributed to municipal agencies, schools, libraries, and a variety of environmental organizations. The format of the poster is colorful and easy to understand, making it a valuable education tool for both youths and adults.

Project Accomplishments

After many years of planning efforts, bylaw enactment, and education, it seemed as though attention to ground-water protection issues was taking a back seat to other planning concerns such as economic development and traffic planning. The success of both the Sagamore and Monomoy projects can be measured in part by the increase in water resource protection activities among the Cape towns. These ground-water protection projects served as an important reminder that there were many new residents of Cape Cod who were not aware of the sensitive nature or limited carrying capacity of its water resources. Educating these individuals was critical to continuing resource protection efforts.

Using land use analysis techniques, graphical media, and workshop presentations, the outstanding water resource protection issues were clearly defined. Throughout the project establishing goals for regional consistency was stressed as an important outcome. Many zoning changes to protect neighboring water resources were made as the result of the project and suggestions for continuing intermunicipal coordination were incorporated into the LCPs of most communities.

Using some of the material generated from these two projects, the Cape Cod Commission spearheaded the nomination of Barnstable County as a Ground-water Guardian Community. The designation was awarded to Cape Cod in November of 1995 by the Groundwater Foundation, Lincoln Nebraska. This program is very helpful in continuing to keep awareness of ground-water protection issues at the forefront of the media, even without a catastrophic event such as a hazardous material contamination spill. The designation also helps keep the various groups involved in ground-water protection activities communicating by forming a ground-water guardian team. The Barnstable County Ground-water Guardian Team has representatives from county government, water suppliers, agriculture and environmental activists and educators. As a team the group plans on organizing several events in the coming year to draw attention to their water resource protection efforts.

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Acronyms

DRI Development of Regional Impact

GIS Geographic Information System

LCP Local Comprehensive Plan

RPP Regional Policy Plan

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Searching for Common Goals; Protecting Potable Water Supply Watersheds

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United Water New Jersey (the Company) is implementing a strategic water quality protection plan for the Company's Hackensack River watershed. Components of the plan include public education, partnering with other stakeholders in the watershed, a strategic plan document, a program to evaluate additional buffer land acquisition, and individual management plans for select golf courses in the watershed. The Company faces the challenge of protecting water quality in spite of very limited authority within the watershed.

The Company is one of the largest investor-owned water utilities in the United States, currently serving approximately 750,000 people in the New York metropolitan area. Its major source of supply is surface water derived from three reservoirs; Lake Tappan, Woodcliff Lake, and Oradell. The three reservoirs are located within the Hackensack River watershed and have a combined watershed area of 86 square miles, excluding Lake DeForest and its watershed in Rockland County New York. Additional water is diverted to the Hackensack River watershed from other sources including the Saddle River. The watersheds of the three reservoirs and the Saddle River diversion encompass all or parts of 30 municipalities in Bergen County New Jersey, and six municipalities in Rockland County New York. Approximately 85 percent of the Hackensack River watershed is already developed. This development is primarily residential. There is some commercial and industrial development.

Company land ownership in the watershed amounts to 3.1 square miles or 3.6 percent of the total

watershed area, which is typical of water utilities nationwide. In addition to multiple political jurisdictions and limited land ownership, the absence of a holistic regulatory framework for watershed protection in New Jersey hinders water quality protection. New York's public health statutes have provisions for utility specific watershed protection regulations similar to those promulgated recently by New York City. However, to date the Company has not pursued regulations for its watershed in Rockland County. Furthermore as an investor-owned utility the Company lacks the powers and rights of government such as eminent domain that some water utilities use to acquire land for water quality protection.

In the past Company actions have produced a range of reactions from other stakeholders. A plan over a decade ago to develop land holdings no longer considered necessary for water quality protection provoked virulent opposition from environmental groups and municipalities which culminated in litigation. Since then the Company has attempted to work more proactively with other stakeholders.

The Company's watershed management objective is to control specific pollutants in a program designed to:

- Avoid the need for changes in treatment.
- Share equitably in the costs and benefits of watershed protection.
- Minimize risks from hazardous chemicals.
- Preserve aesthetic qualities to assure customer acceptance.

Achieving this objective requires overcoming obstacles posed by the Company's limited land ownership within the watershed, the fragmented political composition of the watershed, and the often contradictory objectives of the other stakeholders in the watershed.

Stakeholders

As in most watersheds, high quality water is only one of the products that the watershed is expected to produce. Other demands on the watershed include recreational use, residential, commercial and industrial building, farming, and open space. As Robbins et al. (1991) states "Almost without exception it is these secondary land uses that constitute a threat to water quality. Watershed management is usually, therefore, a process of balance and compromise among competing and often conflicting demands for various products or uses. Because of this competing and conflicting relationship between the need for high quality water and the need for other watershed products, the extent to which sources or potential sources of contamination are to be controlled can and must be determined only in conjunction with planning for these other uses."

Stakeholders in the Company's watershed include the Company, local governments, and environmental

preservation advocates as noted in the introduction. Other stakeholders include fisherman, bird-watchers and golfers who utilize Company lands, developers, state and federal regulators, and the Company's rate payers. The Company has to acknowledge the goals of all of these stakeholders as it implements its water quality protection plan. The strategy is to share goals and resources to accomplish as much as possible.

Company Actions

The Company has established a water quality protection program including

- Ownership of buffer lands.
- Water quality monitoring.
- Watershed surveillance.
- Review of proposed construction activities in the watershed.

Company owned watershed land is located along the banks of its three reservoirs and tributaries to those reservoirs. The Company monitors water quality at approximately 30 locations throughout the watershed at a frequency of 12 times per year. In addition, raw water samples are taken at the Haworth Water Treatment Plant. Proposed construction activities are reviewed when the Company receives public notice as a nearby property owner (generally within 200 feet of the proposed project) or as a concerned party. About 60 development projects are reviewed annually. Company employees from Engineering, Environmental Resources, Patrol Force, Real Estate, and System Operations and Regulatory Compliance monitor and inspect activities and projects in the watershed. The Company does not have any formal authority to require reviews or impose reviews beyond those contained in statutes. Other Company actions related to water quality protection are limited public access to Company owned lands, participation in emergency response programs, participation in stormwater management, and aspects of the Company's public education and outreach program. Company actions that best exemplify sharing of goals and resources include access to Company lands, emergency response, and the public education and outreach program.

Access to Company Lands

Company land surrounding the reservoirs is fenced to prevent access. Consistent with industry practices, the Company allows certain activities on its property such as fishing and bird watching. The Company also leases land to three golf courses. It recently completed best management practice plans for these three courses. The plans are intended to minimize the risks to water quality posed by the intensive fertilization and pest control practices normally used on golf courses.

Public access to Company land shares a most valuable resource, the land which both protects the water

supply and provide opportunities for recreation. Likewise the Company encourages and received water quality benefits from land owned by others being used for recreation.

The Company's relationship with operators of golf courses on its leased land is more complex. Both stakeholders want to see that the courses are profitable and well run. However implementing the best management practice plans for the courses has required delicate negotiations because the plans challenge traditional golf course management practices and create more work for the course superintendents and their staffs. The Company is making a considerable effort to persuade the superintendents that integrated pest management and other techniques are good for the environment and their employees and may even reduce operating costs without threatening any characteristics of the courses valuable to golfers.

Emergency Response

The Company's emergency response plan is consistent with industry practices pertaining to dumping or spills in the watershed. Primary responsibility for immediate response to spills and other incidents threatening water quality rests with local government including counties; sewer authorities; and municipal police, fire, and other public agencies. Notification is made to the Company depending on the responding agency's assessment of the dangers posed by the incident. One initiative in the Company's water quality protection plan is to educate emergency responders from other entities regarding the types of incidents and locations of greatest concern to the Company.

Emergency response best characterizes a shared goal among stakeholders; minimizing environmental damage from dumping or spills. It also illustrates how resources can be shared. There exists tremendous potential for duplication of equipment and training among the many entities sharing the responsibility for emergency response. Duplication of equipment and training is avoided by cooperation among the responders. This benefits all the stakeholders and frees resources to address other needs. Cooperation is fostered through a network of informal communications among stakeholders who know one another and share common concerns. The Company maintains a list of emergency responders in each of the governments in the watershed and its own response team. Ordinarily a member of the Company's Patrol Force or one of its Special Sanitary Inspectors responds to an incident. The company's representative establishes whether further Company involvement is needed to protect water quality and contacts the appropriate staff. The Company's emergency response team is oriented towards preventing spills from reaching watercourses. The team also acts as the primary responder to incidents occurring on Company properties.

Public Education and Outreach

Some of the initiatives taken by the Company in terms of outreach and education within the watershed are as follows:

- Membership on the Rockland County Water Quality Committee. This committee has made presentations to municipal planning boards throughout Rockland County concerning nonpoint

source pollution and soil and sediment erosion control practices. The goals of the committee are: to have a County or municipal ordinances governing stormwater management and soil erosion and sediment control and to educate municipal and county officials, builders and developers, and the citizens of Rockland County as to how to protect water resources from nonpoint source pollution.

- Offering assistance to a municipality in developing the section on watershed protection in its master plan. Areas which are addressed are soil erosion, especially important due to the steep slopes throughout the town; groundwater recharge and base streamflow; stream corridor protection; and stormwater management as it relates to both quantity and quality.

- Membership on the Bergen County Watershed Management Coordinating Committee. The goal of this committee is to establish a cooperative effort among private citizens, business and government to identify, assess, and address water quality problems; and to coordinate and implement an education program that informs the public of the impacts of nonpoint source pollution on the waters of Bergen County.

- Participation in regional meetings of environmental commissions when the subject is watershed protection. Offering information to the commissions such as the golf course best management plans to serve as models for other courses throughout the watershed.

- The Company has written letters of support for municipalities applying for New Jersey Green Acres funding. Green Acres is a state program that provides aid to local governments to acquire open space and park lands. If granted, the funds will be used to acquire land along streams which are tributary to or diverted to a water supply reservoir. The purchasing of land within the watershed by municipalities is consistent with the belief that all the stakeholders in the watershed need to take an active role in protecting water resources. An interesting and revealing reaction was expressed when the Company offered a letter of support for one Green Acres funding request by a municipality. The application was brought to the attention of the Company through its membership in the Bergen County Watershed Management Coordinating Committee. The Company contacted the municipality's consultant on the project and offered a letter of support. The consultant though it would be very helpful and stated that the applicant had considered asking the Company for support, but had decided that they would not receive cooperation from the Company. Clearly we have more work to do explaining our objectives.

The Company's corporate communications group has no dedicated program relating to water quality protection. However, the communications group organizes several activities that increase awareness of the Company's facilities and lands. These activities include tours of the Haworth Water Treatment Plant for visitors and school children, fishing and bird-watching, and beginning in 1995, nature trails. A publication called "Community Currents" is sent three times per year to elected officials, public works officials, public safety officials, and libraries in communities in Bergen and Hudson Counties. The publication provides updates on the Company's activities and programs, and is a potential vehicle to educate the public on watershed issues. The Company publishes a quarterly customer bill insert which

often emphasizes watershed protection. The Company also runs a spring advertisement campaign which features an advertisement focused on proper disposal of household hazardous waste as one way to protect the watershed.

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Ground Water, Source Water Protection and the Watershed Approach

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

Competing demands for water have reached critical levels in watersheds nationwide. Multipurpose management for activities such as: ground water quality and quantity, drinking water supplies, stream baseflow, resident and anadromous fish habitat, transportation, hydropower, industrial interests, and irrigation water have required a need for an improved understanding of the multiple aspects of resource management. Management strategies and management tools must be developed from an integrated, system-based perspective that considers all pertinent uses of the resource and all activities impacting or potentially impacting both water quality and quantity (surface and ground water). Ground water has been recognized as an integral component of watershed management for many years (Goodman and Jehn, 1993). Yet many watershed management activities still do not incorporate ground water protection. Indeed some activities are still using surface water BMPs that transfer the pollutant to ground water and subsequently to drinking water and surface water. For example, disposing of stormwater runoff into shallow drain wells, a practice gaining favor in many areas of the country, is not the answer. This is merely pollution trading.

In another example of pollution trading the EPA, as directed by the Clean Water Act, is imposing more

stringent water quality requirements through regulation of toxics and bioconcentratable pollutants in addition to traditionally regulated pollutants. Point source dischargers are receiving increased pressure to install expensive conventional tertiary treatment to address these requirements. Many NPDES dischargers use holding lagoons and settling basins before discharging the wastestream to surface waters. Many of these holding lagoons are merely percolation ponds that transfer the pollutants to ground water.

A further deficiency is that ground water is virtually neglected under the Clean Water Act and is only tangentially addressed under the Safe Drinking Water Act. Ground water comprises more than 97% of available fresh water supplies and on the average supplies approximately 40% of the stream flow in this country (U.S. EPA 1990). In some parts of the country and during certain seasons of the year, ground water can account for 90-100% of streamflow. Ground water and surface water are integral components to the hydrologic cycle, yet these resources are often managed by different programs in federal, state and local agencies where protection of one resource may have been achieved at the expense of the other. Sometimes while the quality of surface water has been improving over the past 20 years the quality of ground water has been declining (Jehn, 1995). Degraded ground water has also been shown to be a major source of nutrients to surface water and is locally causing the eutrophication of ecosystems (e.g., Goodman and Jehn 1993, Ward 1993, Andres 1992; Mason et. al. 1990; Valiela and Costa 1988, Boynton et. al., 1982). Because of the slow contaminant transport rates observed in many ground water systems, contaminant loads from upgradient ground water may not impact surface water for years or decades.

The fundamental elements for comprehensive watershed management planning are known. However, traditional geochemical and biochemical models for determining "total maximum daily load" (TMDLs) do not factor in the ground water contribution to the watershed. Consequently, disproportionate emphasis may be placed on surface water sources of contaminants. In addition, water quality managers have historically assumed that phosphorous is the only limiting factor in the eutrophication in many fresh water systems. This in spite of the fact that the system may be receiving tons of nitrates per day from ground water sources that are not being accounted for in the assessment of eutrophication potential or actual cases of eutrophication (Halberg, 1993).

Source Water Protection and the Watershed Approach

There are broad based economic implications of drinking water contamination (surface and ground water sources) to companies, counties, and municipalities. These potential problems could be eliminated or alleviated in the future if more preventive, proactive management strategies are developed and carried out. Source water protection allows a community to focus its management efforts, avoid excessive management and regulations in areas that do not contribute ground water or surface water to public water supplies and avoid spending time and funds on protecting non-critical areas where source water contamination is low. Just as watershed protection is a method of prioritizing activities within a state or region, source water protection is a method of prioritizing activities in a given watershed.

Source water (drinking water) protection is a primary beneficial use that must be protected in any

successful watershed management plan. Watersheds typically encompass a much larger area of land than actually drains to the drinking water supply. Within a watershed there may be different types of source water protection needed each with its own prioritization needs. In this paper we will examine the protection needs of three common types of source water supplies: drinking water received from aground water supply that is not dependent on streams or lakes for recharge but is recharged by precipitation infiltrating through the soil column. Drinking water received from a surface water supply influenced by ground water; and drinking water derived from ground water with surface water recharging the wellhead protection zone (figure 1).

Watershed protection requires an integrated and holistic approach to program management. Source water protection contains many of the same elements as watershed protection but focuses on a much smaller area or subwatersheds that contribute to drinking water supplies (figure 1). Successful source water protection requires the integration of traditional ground water and surface water protection efforts with programs like: emergency response; hazardous materials handling and storage; land use planning; and pollution prevention. Depending on the area, source water protection may involve wellhead protection, the protection of surface water reservoirs, or the protection of rivers and streams. In reality, most source water protection areas will be a combination of at least two of these protection activities. Successful source water protection programs can be viewed as a progression of five main steps: Delineation: Where is the drinking water for the community coming from? Contaminant Source Inventory: What activities in this identified recharge area has the potential to contaminant drinking water? Source Management: What programs are needed to manage the sources of contamination? Projected Future Activities: What are the projected future activities in the recharge area that have the potential to contaminate drinking water? Public Ownership: Create public ownership by involving all stakeholders in the process.

Successful programs must go beyond the traditional state and federal requirements and include special management practices specifically tailored for the identified recharge area. Often, comprehensive watershed and source water protection can be achieved by re-prioritizing existing programs. For example, RCRA, UST, and CERCLA activities should be prioritized in source water protection areas. In other cases it will require more emphasis on local program development. Both regulatory and voluntary programs can be effective at source water protection. Whatever the approach taken, successful programs involve all stakeholders (e.g., federal state, local governments, industry, and citizen interest groups) in the decision making process.

Drinking Water Derived from a Ground Water Source

This is perhaps the typical type of water supply when we think of wellhead protection. Research has shown that in many areas of the country some public and private ground water drinking water sources continue to degrade in quality (Jehn, 1995). This degradation is a result of accidental and intentional spills and dumping. Sometimes the incidental disposal of hazardous chemical is a result of lack of knowledge of the ground water contaminant potential. Some communities, (e.g., Dayton Ohio) are restricting the amounts of hazardous materials that can be stored within a wellhead protection area. Some of these same municipalities also post signs in wellhead protection zones and provide special training to

emergency responders for spill response. Zoning overlay districts are also being used to attract ground water "friendly" businesses to locate in wellhead protection zones.

Drinking Water Derived from Surface Water

This is perhaps the most dramatic example of ground water and surface water interaction. In many alluvial valleys and flood plains this is a constant interaction. States are in the process of developing criteria for the delineation of surface water source protection areas. These areas include the obvious areas upstream of the surface water intake and the not so obvious areas of ground water contribution to the system. Table 1 provides a summary of some of the criteria developed to date.

Table 1. Surface water delineation criteria for source water protection.

State	Zone A	Zone B	Zone C
Delaware, New Castle County	All land surfaces in the 100-year flood plain located upstream of a public water supply intake	erosion prone slopes (greater than 15 percent grade)	Areas that drain on the surface or underground to public water supply reservoirs
Massachusetts	200-400 feet from the stream bank	one-half mile from the stream bank	the remainder of the watershed
Utah	Minimum protection area defined as 300 feet on either side of drinking water source streams for a distance of 15 miles upstream of a public water supply intake.		
Connecticut	Land within 250 feet of a reservoir or public water supply diversion or land within 100 feet of a tributary stream.		

The Massachusetts DEP has developed criteria for the protection of surface water supplies. These criteria place restriction on land use activity within the drinking water subwatershed (figure 2). The intent is to prevent contamination from all type of surface activities that have the potential to contaminant either ground water or surface water. The proposed regulations would prohibit activities such at underground storage tanks and hazardous waste treatment storage and disposal in Zone A (200 - 400 feet from the upper boundary of the bank of a Class A surface water source). Zone B (one-half mile upgradient of Zone A) would prohibit activities such as landfills and hazardous waste treatment, storage and disposal facilities and Zone C (the remainder of the subwatershed) would prohibit the siting of radioactive waste disposal facilities.

Drinking Water Derived from Ground Water Being Recharged by Surface Water

Pekin, Illinois, determined that if one of the well recharge areas in their wellfield was contaminated it would result in a loss of 5 - 7 million gallons of production supply. It was also determined that the approximate costs for treating ground water would be $4,000,000. It would cost approximately $15,000,000 to build a surface water treatment plant. It was also concluded that contamination of this supply would be detrimental to further economic development. New businesses coming into the area will place an increased demand on the use of uncontaminated ground water.

The community water supply for Pekin Illinois provides approximately 4,200,000 gpd to 13,514 services. The drinking water wells draw from a homogeneous, unconfined sand and gravel aquifer recharged in part by Arlen Lake which is the 2 - 3 year time and travel of the wellfields (figure 3).

Land use activities in the source water protection area include residential, commercial, industrial and recreational. The primary industrial activities in the area are automotive repair shops. The recreation use is Arlen Lake. Nearby Lake Arlen provides recharge to the Pekin municipal wellfield. Endothall, an algicide used in surface water, has been detected in the Pekin municipal wells. Pekin Illinois has developed an ordinance to include surface water protection activities in the wellhead protection plan.

To implement a ground water protection program the team first organized a pollution prevention and shallow injection well (Class V) workshop for the businesses in Pekin. A second pollution prevention workshop was organized specifically to provide technical assistance to automotive repair shops that comprise the majority for the existing businesses located within the recharge areas of the Pekin community water supply wells. The team also developed an amendment to the existing ordinance that required certain best management practices for existing potential contaminant sources and created a new overlay zoning ordinance with special\conditional use permits in the commercial and industrial zoned parcels within the well recharge areas.

Conclusion

All three examples require activities that may be more stringent and focused than those required for the watershed approach. Ideally all water should be "swimmable, fishable, and drinkable." In reality, this is an unrealistic goal, particularly as a short term goal. Caution must be exercised to avoid pollution trading, which in the short term may benefit one resource at the expense of another but will eventually come back around in the hydrologic cycle.

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Progress in Addressing Coastal Nonpoint Source Pollution

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Since the passage of the Clean Water Act in 1972, significant improvements have been made in addressing point sources of pollution. However, despite this progress, a major portion of our Nation's waters remain threatened or impaired. More than fifty percent of these remaining water quality problems are attributed to nonpoint sources of pollution. In 1987, Section 319 of the Clean Water Act was established as the first national program to deal specifically with nonpoint sources of pollution. Section 319 required states to assess their waters and establish management programs to address polluted runoff. Section 6217 represents the most recent and comprehensive approach to the continuing efforts to address nonpoint sources of pollution impacting coastal water quality.

In response to water quality problems evidenced by beach closures, shellfish harvesting prohibitions and the loss of biological productivity, Congress determined that additional protection for coastal waters was necessary and enacted Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) (codified as 16 USC 1455b). Section 6217 applies to the 29 states and territories with coastal management programs approved by the National Oceanic and Atmospheric Administration (NOAA) under the Coastal Zone Management Act (CZMA) and requires the development of Coastal Nonpoint Pollution Control Programs (coastal nonpoint programs). State and territorial programs are reviewed and approved by the U.S. Environmental Protection Agency (EPA) and NOAA.

Section 6217 requires the implementation of management measures reflecting the best available,

economically achievable technology to reduce polluted runoff to coastal waters resulting from nonpoint sources. This technology-based approach is a departure from previous efforts to control nonpoint pollution in that it does not rely on a direct connection between sources of pollution and water quality impacts. Rather than focusing on the burdensome and costly process of proving cause and effect linkages, 6217 applies proven runoff controls to all nonpoint sources that impact coastal waters. This allows for more comprehensive, watershed-based nonpoint source control, resulting in more extensive implementation and water quality improvements in a more cost-effective manner.

Categories of nonpoint pollution addressed by the coastal nonpoint program include urban, agriculture, forestry, marinas and hydromodification. State programs must also address the protection of wetlands and riparian areas which can function to limit the impact of runoff from upland areas on coastal waters. Coastal nonpoint programs must include enforceable policies and mechanisms to insure implementation of the management measures. The goal of section 6217 is to restore and protect coastal waters by strengthening the links between state coastal management and nonpoint source pollution or water quality (Clean Water Act Section 319) programs.

CZARA provided states and territories with 30 months to complete program development and, to date, all 29 states and territories have submitted programs to NOAA and EPA for Federal review and approval. Although full implementation of coastal nonpoint programs is several years away, this paper will identify some of the early successes of this effort to develop coastal nonpoint programs.

Program Development/Threshold Review

EPA, in consultation with other Federal agencies, developed guidance specifying management measures that reflect the best available, economically achievable methods to control nonpoint pollution in coastal waters. The Guidance Specifying Management Measures for Sources of Nonpoint Pollution ((g) guidance, published January 1993) represents the only compendium of its kind on methods to reduce nonpoint source pollution. As part of the technical guidance development, EPA published an Economic Achievability Analysis which includes important information on the costs of implementing nonpoint source controls. Prior to this economic analysis, there were few documents available that compiled information on costs of nonpoint source controls. In an effort to further specify what state coastal nonpoint programs should look like, NOAA and EPA also published Program Development and Approval Guidance. These guidance documents and supporting analysis have proved to be extremely valuable, not only to states and territories developing programs, but also to other government agencies, consultants, and interested citizens.

States and territories were given the opportunity to get early feedback on their program development efforts through a process called "threshold review." Threshold reviews included development of program summary information by states, an analysis of program material by NOAA and EPA, and a face-to-face meeting in the state or territory. NOAA and EPA completed threshold reviews for most of the coastal states and territories subject to the requirements of section 6217.

A number of early successes were evident from the threshold review process. Drawing on a number of different agencies for information to produce a program document, coordination at the state and territorial improved and resulted in increased communication and cooperation between coastal zone and water quality agencies and other state agencies, such as Departments of Agriculture, Forestry and Transportation. These ongoing improvements have resulted in better sharing of information, enhanced interagency knowledge of activities and programs, and cooperative ventures to address coastal nonpoint pollution. Development of coastal nonpoint programs also improved public awareness of the impacts of polluted runoff and the need to more comprehensively address nonpoint sources. States conducted public meetings, developed newsletters, and made presentations to the public and affected interests. These efforts have led to a greater public awareness that daily activities within an entire watershed can affect the health of coastal waters.

New Flexibility for Coastal Nonpoint Programs

Based on the threshold reviews, NOAA and EPA learned that states faced a number of challenges in developing their coastal nonpoint programs, including economic, political and institutional barriers. The comprehensive nature of the program and potential costs of implementation have been and remain a significant obstacle to achieving success. The statute provided only 30 months for program development, which left a limited amount of time for pulling together necessary documentation, much less seeking new legislation or major program restructuring. As institutional change is often in conflict with human nature's reluctance to change, there have also been difficulties in getting both government agencies and private sector interests to adopt the approach of 6217. Recognizing the magnitude of these challenges, NOAA and EPA agreed that several significant changes needed to be made to provide additional time and flexibility to states and territories developing coastal nonpoint programs. These provisions included further flexibility by which states could receive conditional approval of programs, an extended time line for implementation, general deference to states on determination of geographic boundaries, allowance for phased implementation of management measures, and a broader definition of acceptable enforceable policies and mechanisms by which states could ensure implementation.

EPA and NOAA agreed to grant conditional approval of coastal nonpoint programs for up to five years in order to provide more time in cases where states have not fully developed management measures or where states proposed to demonstrate that voluntary approaches, backed by broad authorities such as water quality laws, could serve to ensure widespread implementation of management measures. During the conditional approval period, the penalty provisions of the statute do not apply. In addition, the time frame for implementing management measures for existing nonpoint sources was extended from three years to five years, giving states until 2004 to complete implementation of the basic (g) management measures and until 2009 to complete implementation of any additional management measures necessary to meet water quality standards.

NOAA and EPA agreed to generally defer to state proposals for the 6217 management area, unless NOAA and EPA determined that the proposed management area excludes either existing land or water uses that reasonably can be expected to have a significant impact on coastal waters of the state, or

reasonably foreseeable threats to coastal waters from nearby activities landward of the state's 6217 management area. NOAA and EPA reemphasized to states that they could exclude categories, subcategories, and individual nonpoint sources from their programs where those sources, either individually or cumulatively, did not have a significant impact on the coastal waters of the state. Further, states were given greater flexibility for phasing in necessary nonpoint source controls as a result of the extended time frames for program implementation.

Perhaps most importantly, NOAA and EPA expanded the range of acceptable back-up enforcement authorities. This expanded list of authorities could include, for example, "bad actor" laws, enforceable water quality standards, general environmental laws and prohibitions, and other existing authorities. This new flexibility provides states and territories with the opportunity to demonstrate that voluntary approaches, in combination with existing, general state authorities will be effective in achieving widespread implementation of the management measures. In these cases, EPA and NOAA will conditionally approve state programs for up to five years, including an evaluation of progress after three years. When states cannot achieve widespread implementation of the management measures through this voluntary-regulatory strategy, states will need to develop more specific authorities for implementation.

Program Submittal, Review and Approval

Section 6217 required that states and territories submit their coastal nonpoint programs by July 19, 1995. Since that time, NOAA and EPA have received program submittals from all of the 29 states and territories currently participating in the coastal zone management program. In light of the limited funds available to states and territories to develop programs, the fact that all of them managed to submit a program document is in itself a success story. While some program submittals were more complete than others, all of the coastal states showed a commitment to addressing the serious problem of nonpoint pollution in coastal waters.

NOAA and EPA are currently in the process of reviewing the state and territory coastal nonpoint program submittals. The Federal agencies are evaluating the extent to which state programs include management measures in conformity with the management measures specified in the (g) guidance published by EPA, as well as the extent to which states can demonstrate the ability to ensure widespread implementation. For this latter test, NOAA and EPA are considering the degree to which authorities specifically require management measures or whether states are proposing to use a combination of increased technical assistance, education or other incentives backed by a broader authority. NOAA and EPA are communicating the results of this analysis to states and territories in the form of a program findings document. For categories (e.g., agriculture), subcategories (e.g., urban runoff) or individual management measures, NOAA and EPA make a finding that the state or territory program either includes or does not include management measures in conformity with the (g) guidance and enforceable policies and mechanisms to ensure implementation. Where the finding indicates that either or both of these fundamental requirements have not been met, there will be a condition placed on that program element. These conditions vary in terms of the need to further develop management measures, such as the need to revise a BMP manual to conform with the (g) guidance, or to extend the applicability of existing

authorities to a wider range of activities.

Early results of the program review process are encouraging. As of this writing, NOAA and EPA have taken a preliminary look at most of the programs submitted to date. Our initial reactions are very positive. We are impressed by the effort taken by states to assess the current status of their programs and to make or propose significant improvements to those programs. The overall national trend clearly indicates significant progress by states in their efforts to protect their coastal waters from nonpoint pollution. In many cases, the coastal nonpoint program has served as a catalyst to further initiatives that were already planned or underway. In other cases, the coastal nonpoint program has established a programmatic context for an array of activities designed to advance nonpoint pollution control. By inventorying this variety of nonpoint source activities, states and territories are better able to coordinate multiple programs and more efficiently use limited resources.

Looking Back/Looking Ahead

The coordinated efforts of NOAA and EPA to develop the coastal nonpoint program at the Federal level have resulted a better program than could have been accomplished by either agency alone. The marriage of NOAA's coastal resource and land management expertise with the more technical water quality focus of EPA has expanded the Federal capacity to address the complex issue of managing nonpoint pollution. NOAA and EPA have also worked closely to provide both technical and programmatic guidance to states and territories for designing programs that will meet Federal requirements. As available financial resources are declining at the state and territorial level, "doing more with less" means that cooperation between coastal management and water quality agencies will be necessary in order to accomplish mutual program goals.

Implementing coastal nonpoint programs will demand even greater involvement by the public. The goal of restoring and protecting coastal waters can only be accomplished if there is support from all stakeholders in coastal watersheds. As we are all part of the problem, we must all work together to implement the solution. The challenge ahead will not only be educating the public and affected interests on the need for nonpoint source control, but ensuring that individual responsibility and action lead to real improvements in the coastal water quality. As businesses and industry have already recognized that environmental stewardship can improve the economic bottom line, so too may we, as a society, begin to realize that controlling polluted runoff can improve our quality of life.

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Integrating the Point Source Permitting Program into a Watershed Management Approach*

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Background

The direction of the National Pollutant Discharge Elimination System (NPDES) permits program is changing. Over 20 years ago, the NPDES program was created as one of the primary vehicles for achieving the goals and objectives of the Clean Water Act (CWA). Since 1972, the CWA and its amendments have significantly expanded the coverage and scope of the NPDES program. In its conception, the program focused on requiring national minimum levels of treatment for industrial and publicly owned treatment works (POTWs). The program then evolved to require more stringent controls necessary to achieve water quality standards, including chemical-specific water quality-based permit limits and whole effluent toxicity monitoring requirements and permit limits. The 1987 Water Quality Act greatly expanded the program scope by clarifying that storm water discharges through point sources required NPDES permits. Today, the baseline requirements plus the newer initiatives cover hundreds of thousands of point source dischargers.

The efforts of states and EPA in administering the NPDES permit program have resulted in significant environmental improvements. Not all aquatic environmental problems, however, have been corrected. The 1994 305(b) report shows that, for the waters monitored, over a third are not meeting their water quality standards. For rivers, 36% of the miles are impaired, and states attribute 12% of this impairment to urban wet weather runoff. Similarly, 37% of the lake acres are impaired, and 18% of the cause is urban runoff. Finally, 37% of estuary miles are impaired, with 46% attributed to urban wet weather runoff.

At the same time, the ability of EPA and states to issue NPDES permits on a five year cycle is being challenged by the increase in scope and complexity of all the NPDES programs. For example, in 1990, EPA regional offices were able to reissue all expired permits by the end of the fiscal year. By contrast, in 1995, these same offices were unable to issue 37% of the permits that expired. There are similar trends in several states that issue permits.

Table 1. Facilitites Covered by the NPDES Program

15,600	POTWs with individual permits
48,600	non-POTWs with individual permits
20,000	industrial non-storm water sources with general permits
140,000	industrial storm water sources with general permits
833	municipals with storm sewer systems
1,100	municipals with combined sewer systems

The combination of continuing environmental problems, information showing that urban runoff is now a large contributor to these problems, and a realization that current funding of the programs is insufficient to cover all requirements has led the national NPDES program office to reexamine its programs with the objective of making them more efficient and effective. For several years, EPA has been promoting a watershed-based approach to addressing these challenges facing water quality agencies. As part of its overall goal of promoting a watershed approach, EPA released the NPDES Watershed Strategy in March 1994. The purpose of the strategy is twofold: 1) to support development of statewide watershed management approaches, and 2) to integrate NPDES program functions into a watershed management framework.

Supporting Statewide Watershed Management Approaches

The NPDES Watershed Strategy represents a commitment by EPA to support statewide watershed management approaches. The Office of Water recognizes that the key to fully integrating the NPDES program and other programs into a watershed management approach is ensuring that all related water management activities are coordinated both spatially and temporally around watersheds. Under the watershed management approach, a state is divided into geographic management units drawn around river basins. Activities such as monitoring, planning, assessment, and implementation of management controls are conducted within each basin according to an established schedule.

While basin management units provide a geographic focus for water management, activities also must be coordinated over time to ensure integrated and consistent program implementation within the basin. A

statewide watershed management approach achieves this temporal focus through watershed management cycles. A management cycle has three features that create an orderly system for coordinating and regularly evaluating resource protection activities: 1) a specified time period for completing all elements of the management cycle; 2) a sequence for addressing basins to balance the workload from year to year; and 3) a schedule of management activities for each basin.

At least 18 states are now developing or implementing a framework to synchronize monitoring, assessment, NPDES permitting, and other activities within geographic management units. The scope, complexity, and maturity of these programs vary from state to state. EPA's Office of Water is working with EPA regional offices to find ways to support statewide watershed management in other states, including facilitation support to develop watershed frameworks, technical support for watershed projects, and training for state staff and management.

- Facilitation Support: In 1995 and 1996, EPA's Office of Water provided facilitation support for Alaska, Arizona, California, Florida, Georgia, Kentucky, Montana and Utah. Facilitation provides an expert in watershed protection to help participants learn how adoption of a watershed-based program may help them better organize and satisfy their multiple water quality management requirements and goals. These projects involve a wide variety of stakeholders and often include representatives from federal, state, local, and tribal agencies, and from industry and environmental groups.

- Water Quality Cooperative Agreements: Since fiscal year 1994, EPA's guidance for awarding cooperative agreements has emphasized training, demonstration, or experimental projects that would lead to the development or implementation of statewide watershed management approaches. The NPDES Watershed Strategy provides the framework for the project selection criteria.

- Training Support: In 1995, EPA began offering the Statewide Watershed Management two-day course. The course reviews the basics of designing and implementing a statewide watershed management framework and was offered in four cities across the country. This course provides the first component of a Watershed Academy curriculum, currently under development by the Office of Water. The curriculum will include basic training about watershed management in the context of decision-making at the local, state, regional, and federal levels as well as a series of more specialized courses on analytic and management tools for watershed management.

Integrating Program Functions

Integrating the NPDES program functions into a watershed management approach is critical to successfully managing the program within the context of limited resources and spatially varying environmental impacts and priorities. The Office of Water is now pursuing this objective through both the baseline NPDES program and current initiatives to address urban wet weather pollution sources such as stormwater and combined sewer overflows (CSOs).

Baseline NPDES Program

Traditionally, the NPDES program has addressed individual dischargers in isolation, usually in response to a permit application or required inspection. This method of operating makes it difficult to place individual discharger activities and impacts in a larger context and distinguish priorities for program resource allocations. As a result, most large point source dischargers receive the attention of permitting authorities (EPA and states) regardless of their environmental significance, while smaller, though not necessarily insignificant, point sources and many nonpoint sources receive little attention. In addition, addressing dischargers within a watershed at different times often results in inconsistent management decisions.

Understanding the relationship of point source discharges to other watershed characteristics offers opportunities for more efficient and environmentally focused program management. For example, a permitting authority can organize permit issuance so that all permits within a watershed expire and are reissued at roughly the same time, thus allowing for more consistent and equitable permit requirements among dischargers. Also, permit requirements can be developed in the context of basin plans that consider a range of management options to achieve water quality objectives. The permitting authority may then place increased emphasis and resources on discharges with the greatest environmental impact and decrease emphasis on those with low impact.

For example, by addressing all NPDES facilities within a basin at the same time, a permitting authority can decide to place more stringent controls on those discharges that have the greatest impact on surface waters. In addition, a state has the opportunity to consider other controls on nonpoint sources as a way to reduce the need for placing more stringent limits on NPDES facilities. Finally, this process allows states to combine the information collection aspects of permits with ambient monitoring, thus providing a more comprehensive picture of surface water quality.

The watershed approach to permitting also opens the door for effluent trading within the context of a total maximum daily load (TMDL) of a pollutant to a waterbody that will still maintain water quality standards. EPA issued a Trading Policy Statement in January 1996 which supports and promotes effluent trading within watersheds to achieve water quality objectives, including water quality standards, to the extent authorized by the Clean Water Act and implementing regulations. EPA is currently developing a framework for watershed-based effluent trading, as well as information exchange workshops, and limited technical assistance for trading projects in specific areas.

Integrating Urban Wet Weather Initiatives

Just as the baseline NPDES program at the federal and state levels has tended to address individual sources or types of sources in isolation, municipalities often address storm water management, the operation of sewage collection systems, and the operation of wastewater treatment plants separately, despite the common issues that may cut across these functions and the benefits that may be obtained by

addressing them all through an integrated approach. In recognition of the need for a comprehensive approach to urban wet weather discharges, EPA established in 1995 the Urban Wet Weather Flows Advisory Committee under the Federal Advisory Committee Act to develop recommendations to coordinate the implementation of urban, municipal wet weather water pollution control programs. EPA's Urban Wet Weather Flows Advisory Committee is developing recommendations on how to address the water quality impacts associated with urban wet weather discharges on a watershed basis.

Watershed stakeholders in urban areas face many challenges in addressing water pollution sources, particularly those sources which result from rainfall and snowmelt. In any given urban area wet weather sources may include municipal and industrial storm water discharges; sanitary sewer overflows (SSOs), which occur when the volume of flows in a separate municipal sanitary sewer exceeds its capacity due to, among other things, unintentional inflow and infiltration of storm water; and CSOs, which occur during wet weather events in some cities that have combined sanitary and storm sewers (these are known as combined sewer systems). Urban wet weather discharges, such as storm water, SSOs, and CSOs should be addressed in a coordinated and comprehensive fashion in order to reduce the threat to water quality, reduce pollution control costs, and provide state and local governments with greater flexibility to solve wet weather problems. Urban areas may also be impacted by other wet weather sources, such as agricultural runoff, and runoff from active, inactive or abandoned mines; hydro modification; and high flow conditions. Among the urban watershed-related issues that the Committee is considering are:

- Intra- and Intergovernmental Coordination: Since watersheds do not generally follow jurisdictional boundaries, a watershed approach both encourages and necessitates intergovernmental partnerships as well as partnerships among the various levels of government and other stakeholders. Effective federal, state, and local partnerships draw upon all relevant resources to facilitate negotiation among local stakeholders to evaluate and identify local priorities and the appropriate roles of all parties and to coordinate the funding, planning, and implementation activities necessary to control wet weather discharges. Partnerships are also necessary within urban areas, where wastewater treatment facilities, sewer collection systems, and storm water programs are often administered by different departments.

- Flexibility: Flexibility would include allowing a phased approach to implementation of wet weather discharge controls. For an urban watershed approach to be most effective, federal, state, and local stakeholders would work to reduce and eliminate the institutional and regulatory barriers to addressing wet weather discharges in a coordinated and comprehensive manner, including the identification of sensitive areas, monitoring, and watershed assessment. Additional flexibility can be achieved through the use of non-regulatory tools, including pollution prevention and incentive-based mechanisms, to address the impacts of wet weather flows.

- Performance and Accountability: The public and others should have the opportunity to understand the benefits for which they are paying. Ideally, urban watershed stakeholders work from a common information base to achieve their common objectives. Programmatic-based management which deals with individual discharges or specific categories of pollutant sources is not conducive to measuring performance in terms of improved water quality in a watershed in an expeditious

manner. Monitoring (accompanied by modeling in appropriate cases) is necessary to identify the hydraulic and pollutant characteristics of wet weather discharges; assess their impact on receiving waters; assess the effectiveness of existing controls; predict the effectiveness of additional control options; provide data to support the development of allowable pollutant loadings for the receiving water; and measure compliance with permit conditions. Opportunities exist to coordinate monitoring guidance and program requirements to ensure that monitoring addresses impacts on a watershed basis and in the most cost-effective way, as well as to establish a clear set of monitoring priorities for all wet weather source categories.

Summary

The NPDES program, rather than focusing only on additional or more stringent controls, is moving toward integrating the program within watersheds to better target controls of those sources causing water quality impairment. EPA will continue to integrate NPDES programs into the watershed protection approach by supporting development of statewide watershed protection frameworks in partnership with states and tribes, by allowing resources dedicated to developing permits to vary depending on environmental impacts of each source, and by addressing urban

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Stakeholder Issues for the Watershed Science Institute of the Natural Resources Conservation Service

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Introduction

The Natural Resources Conservation Service or NRCS, formerly known as the Soil Conservation Service, is the federal agency in the U.S. Department of Agriculture (USDA) that works hand-in-hand with the American people to conserve natural resources on private lands. During 1995 and 1996, the agency was reinvented under the provisions of the USDA Reorganization Act of 1994 and the requirements of the Government Performance and Regulations Act.

NRCS's initiatives are designed to assure the free flow of information and expertise to ranchers, farmers and others who work the 70 percent of American land in private hands. The agency hopes to build more flexibility and practicality into its traditional voluntary efforts. As NRCS assists landowners in developing conservation plans for their property, the entire operating unit is considered including cropland, pasture land and forest land as well as related resources such as water and wildlife. The agency is also increasing its emphasis on ecosystem and watershed resource management and assistance (Johnson, 1996).

In 1995, the NRCS created the Watershed Science Institute (WSI) to accelerate the development of "ecosystem-based assistance" technology at the watershed level and to assist with incorporating ecological principles into the agency planning process for farms and ranches. The institute is charged with the goal of working with partners to expedite the identification, development and transfer of such

technologies for use in the watershed and farm-level conservation programs within the NRCS.

To accomplish these objectives, the Institute was faced with identifying and defining the technologies of ecosystem-based assistance at the watershed level, implementing recommended processes to integrate ecological principles and concerns at the field level, and developing mechanisms to transfer technologies to appropriate offices in a relevant fasion and in context with agency protocol. Although these tasks appear to be straight-forward, the actual prescription for producing and transferring relevant and in-context technology "products" proved to be a challenging assignment.

This paper describes the institute's early and close collaboration with stakeholders and customers to:

- determine topics of importance,
- identify major activities and functional areas,
- identify relevant technical products and services,
- listen to opinions on how to conduct business and fine-tune activities, and
- insure a high level of ownership of products.

Pre-Workshop Questionnaire Regarding the Watershed Science Institute

In August 1995, a questionnaire regarding the Watershed Science Institute's roles and responsibilities was distributed within the NRCS to eighteen State Conservationists, two Regional Conservationists and National Headquarters (NHQ) Division Directors. Each individual who received the questionnaire was asked to distribute it to five more people including field staff. One hundred and two responses were received and a summary produced (Table 1). The questionnaire was considered a preliminary investigation to help in preparing for a later strategic planning workshop.

Table 1. Questionnaire Summary.

Question:	Number of items and ranking categories:	Top 4 items based on the average of rankings:

1. Which of the following *topics* do you think would be important for attendees to address at a strategic planning workshop for the WSI?	*Items = 11 topics. Ranking Categories were Very Important, Important, Not too Important, and Unimportant.*	1. Technology Transfer. 2. Product relevancy at the Field Office Level. 3. Product relevancy at the State Office Level. 4. Product timeliness (Note: Field Office and State Office refer to administrative levels within the NRCS. A Field Office staff includes specialists who work directly with the landowners of one to several or counties other local subdivision.)
2. Which of the following *products* from the WSI would be important to you and the work you do?	*Items = 11 products. Ranking Categories were Very Important, Important, Not too Important, and Unimportant.*	1. Guidance on inventory methods and the use of satellite or photo imagery in assessing ecosystem health. 2. Guidance on sustainable agriculture management approaches. 3. Image processing and visualization tools to assist planning. 4. New conservation products.
3. Which of the following *services* from the WSI would be important to you and the work you do?	*Items = 11 services Ranking Categories were Very Important, Important, Not too Important, and Unimportant.*	1. Be effective in producing and delivering technology in a timely manner 2. Develop guidance documents and technology in a form that is usable to the field with little or no modification. 3. Develop materials and provide instructors to train regional technology teams and consortia in innovative technology. 4. Develop a unified process for NRCS watershed planning.

4. Given the name "watershed science," what should the Institute be doing?	*Items = 8 Criteria. Ranking Categories were Strongly Agree, Agree , Disagree, and Strongly Disagree.*	1. Produce technology that include humans as an integral part of ecosystems. 2. Promote technology that seeks to balance diverse objectives rather than a preference for the natural. 3. Produce technology for a wide range of spatial scales, including regions, watersheds, and ecoregions. 4. Address urban watershed or ecosystem issues.

The questionnaire was not a scientific-based survey. However, State and Regional Conservationists and NHQ Directors are prominent stakeholders vested in the successful functioning of the Watershed Science Institute. Their responses carry significant weight in formulating the Institute's work activities. The additional 70 or so responses from other questionnaire participants provided further insight from a group representing a cross-section of the agency. The aggregation of these responses gave an excellent (albeit general), preliminary determination of topics, products and services of importance and some definitive functional criteria.

Another value of the questionnaire was that over one hundred stakeholders and potential customers of the Institute were asked to personally participate in "start up" activities. The sense of ownership this fostered cannot be underestimated. Ownership necessarily begins at the personal level. It involves an alignment of values between the individual and the group(s) with which they become involved. The questionnaire was an offering that such an alignment was in the making.

Strategic Planning Workshop of Stakeholders, Customers and Institute Scientists

In November 1995, the Watershed Science Institute hosted a Strategic Planning Workshop of stakeholders, customers, institute scientists and "external" scientists from partner organizations. NRCS attendees included 25 participants from State Offices, 15 scientists from Institutes (7 from WSI), 10 participants from Field Offices (or offices beneath the State Office level), 9 participants from NHQ (including Technical Centers) , and 2 participants from Regional Offices. There were 3 scientists from partner groups.

The workshop consisted of a number of small-group breakout sessions. These sessions were task-oriented to produce a number of outcomes: (1) criteria for effective technology transfer, (2) identification of short and long-term products, (3) process for developing products, and (4) methods to increase efficiency of technology transfer and communication to field, state and regional offices.

Criteria for Effective Technology Transfer

Participants were divided according to regional representation and generated a list of 8 criteria: (1) applicable to the field, (2) timely, (3) high quality, (4) packaged for end-user, (5) deliverable, i.e., delivery of product is planned and coordinated beforehand, (6) designed with a feedback loop, (7) involves key partners, and (8) available in a wide variety of appropriate media.

Identification of Short and Long-term Products

Participants then developed ideas for needed products. Ideas were categorized into development cycles of short-term, i.e., 1-2 years, and long-term, i.e., 3-5 years:

Short-term

- Protocol for identifying problems at varying landscape scales.
- Protocol for assessing cumulative impacts of changing land use and on-going practices.
- Conservation practice guidelines.
- Ecosystem-based planning guidelines.
- Watershed evaluation techniques.
- Centralized data base models, procedures and techniques.
- Water quality and quantity problem and effects identification.
- Socially acceptable data gathering methods.
- Summarization and distribution of unique and current watershed products and processes.
- Models for dam overtopping and breach evaluations.
- Referral services.
- Maintain and enhance existing models related to watershed science.
- Guidance on inventory methods.

- Process for literature searches on Internet.

Long-term

- Procedures for watershed evaluation.
- Protocol for bringing local partners into the watershed evaluation process.
- Alternatives for nutrient management.
- Develop and release of new technology.
- User-friendly watershed-scale models.
- Coordinate federal agency planning processes.
- Evaluation of habitat diversity and placement in the landscape.
- Reinforce use of ecosystem-based assistance.
- Training for watershed planning.
- Technology transfer workshops.

Process for Developing Products

Workshop attendees felt strongly that the process for developing products must include a number of partners and customers. Each partner and customer group bring unique attributes and qualities necessary for the creation of meaningful products.

Academic and Governmental. These external partners can broaden the base for generating ideas, identifying processes, setting priorities and helping to transfer and market individual products.

Landowners. As a customer group, landowners bring "real conditions" to the planning table and help establish how products must be implemented at the grass-roots level.

State Office. This internal partner has a wealth of built-in procedures and priority-setting techniques to act as a clearing house for technology development ideas from the field. Such ideas can be handed off to the Institute with a higher degree of confidence that products which result will be relevant and meaningful to a greater number of field clients. State Offices, for some products, may be both a partner and a customer of the Institute.

Field Office. As the primary customer group, Field Offices need a more direct pathway to reach the Institute with their ideas. Granted such ideas for needed technology products and tools may be very local or unique, the Institute can aggregate inputs and determine commonality of needs, i.e., repeated demands for a particular product elevate the priority for start-up of that product. Additionally, using Field Office personnel to develop products brings a perspective that would otherwise be lacking.

Regional Office. Agency reinvention subdivided the nation into 6 administrative subdivisions each with a Regional Office. Each office is an internal partner responsible for developing regional and state strategic plans for allocating staff, resources and funds. Without close communication between Regional Offices and the Institute, product marketing and transfer can "disconnect" at a variety of junctures between the Institute, State Offices and Field Offices.

Methods to Increase Efficiency of Technology Transfer and Communication

Participants were divided according to stakeholder groups and assessed current and future needs for methods and equipment essential for increasing efficiency of networking and technology transfer. Groups included Field Offices, State Offices, Regional Offices and Sub-regional Technology Teams.

All groups had an in-common desire for up-to-date and modern communication techniques: E-mail, Internet access, teleconferencing, voice-messaging and the latest versions of computer hardware and software. The groups did not reach consensus on a standard or universal procedure for technology transfer or communication. Indeed, all groups expressed the importance of lateral and flexible communication among all levels of the organization.

Next Steps

By early and close collaboration with stakeholders and customers, the Watershed Science Institute was able to determine important and relevant topics, identify major activity and functional areas, identify relevant technical products and services, and integrate recommendations on how to conduct the business of technology development and transfer. Also, by implementing the questionnaire and the strategic planning workshop (which entailed numerous phone calls, preparation meetings, and voice messages), the Institute fostered a high degree of partner and customer ownership.

The next steps will involve bringing the "general" to the "specific" and distributing product starts to appropriate Institute staff members. The 7 scientists of the Institute staff will face the challenging tasks of continuing the collaboration process, maintaining stakeholder and customer ownership, reaching the greatest number of customers with relevant products, and sustaining a presence and identity in an agency with over 12,000 employees.

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Role of the U.S. Geological Survey in Water-Resource Planning in Kansas

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Abstract

As Kansas' water-resources planning agency, the Kansas Water Office coordinates the management, conservation, and development of the state's water resources through the Kansas Water Plan. Within the state, 12 major river basins have been established as geographic planning areas within which priority water-resources issues are identified and addressed. Through its Federal-State Cooperative Program, the U.S. Geological Survey provides information that not only assists state agencies in implementing the Kansas Water Plan but also guides subsequent policy development and management strategies by the state.

Introduction

Water supplies in Kansas consist of a complex, interrelated system of ground- and surface-water resources. In western Kansas, water demands are satisfied almost exclusively by ground water, whereas in eastern areas many demands are met through diversions from rivers and reservoirs. Water-resource planning is a challenging task given (1) the dynamic nature of water-resource quantity and quality as affected by various natural and anthropogenic factors, and (2) the multitude of environmental, political, economic, and social issues that must be considered in the attempt to achieve balanced approaches and actions. In Kansas, the major river basins provide the geographic framework within which the Kansas Water Office (KWO) develops and implements integrated water-resource plans.

Water-Resource Planning in Kansas

The Kansas Water Plan

The Kansas Water Plan is the comprehensive document used to establish state water policy on issues of management, quality, conservation, and development. Administered by KWO, the Plan serves as the framework for coordination of state programs in managing Kansas water resources. There are two components of the Kansas Water Plan-state Water Policy sections and Basin Plan sections. The Water Policy sections contain specific subsections that describe water issues, options for dealing with those issues, and policy recommendations from a statewide perspective. These subsections also outline the legislative, administrative and financial requirements, and timeframe needed for implementing the policies.

Basin Plan sections provide guidelines for directing state programs toward basin-specific issues. Basin Plans are in place for each of the 12 major river basins in the state (Figure 1). Each Basin Plan has subsections addressing water supply, water quality, flooding, fish and wildlife, recreation, and environmental protection. Typically, these guidelines and their implementation form the basis of agency budget requests each fiscal year. With the advent of the State Water Plan Fund, an annual $16 million fund of water user fees and fund transfers, the implementation of the priority basin guidelines carries significant weight within each of the water agencies. This implementation process can draw on state-federal partnerships to help carry out state programs.

Figure 1. The 12 major river basins in Kansas.

The Planning Process

The Kansas water-planning process has taken place annually during the last decade. The process is the critical means by which KWO coordinates proposed policy and programs among the three levels of government, interest groups, and the general public. The process attempts to develop final policies such that implementing agencies may consider those policies as they plan programs and draft budgets for the next fiscal year. KWO uses basin advisory committees to develop appropriate basin guidelines, establish

priority issues, and debate statewide policy. Input on policies and guidelines also is solicited from the public and interested parties.

The Kansas Water Authority approves all drafts of Water Policy and Basin Plan sections and authorizes their release for public meetings or hearings. The Authority also develops an annual implementation plan that moves beyond the guidance of the Kansas Water Plan and suggests to the state water agencies specific issues they need to direct their programs toward as well as the emphasis each program should take within the basins. Some of the more prominent issues in recent years have included river and reservoir management, flood management, contamination remediation, water conservation, wetland and riparian area protection, nonpoint-source pollution, water-use efficiency, ground-water declines, water supply and demand, water quality, and river recreation.

The State-Federal Partnership

State Perspective

In order to implement the current and guide the future development of the Kansas Water Plan, hydrologic data and investigations are needed to provide guidance toward effective water management. Through the Federal-State Cooperative Program (described below), KWO is able to satisfy many of its information and research needs through cooperative efforts with the U.S. Geological Survey (USGS). The information gained assists KWO in better understanding the hydrologic system being managed, provides long-term assessment of hydrologic-system response to administrative actions, and assists in targeting state resources to priority issues and areas. Practical benefits to KWO include resource sharing in terms of funding, expertise, field personnel, and equipment. Another advantage is that information provided by USGS is third party and objective.

Of particular importance is the information provided by the USGS automated streamflow-gaging station network. Streamflow data can be accessed and utilized in real-time decisions. In a state which manages water through the prior appropriation doctrine, such data are essential. Water-rights management, including management of instream flows, begins with an assessment of available flow in the river. Management of water releases from reservoirs to maintain adequate flows in the receiving river or to meet downstream demands also depends on real-time information.

Federal Perspective

As part of its mission, USGS provides hydrologic information needed by other agencies for the best use and management of the nation's water resources. To accomplish its mission, USGS collects several types of hydrologic data and conducts a variety of hydrologic investigations that address water-resource issues of national, regional, and(or) state importance. Types of hydrologic data collected include stream discharge, ground-water levels, and water quality. Examples of topics addressed in studies include water availability, water quality, water use, surface-water/ground-water interaction, aquifer properties, and

flooding. The cooperative relation that supports the gaging network is an excellent example of how diverse national and state interests may be satisfied by a common program.

USGS is responsive to KWO's needs while maintaining the perspective of what is important to the nation as a whole. The results of the cooperative efforts between KWO and USGS are useful beyond a specific water-resource issue.

The Federal-State Cooperative Program

Local, regional, state, and federal agencies often have common responsibilities in assessing water resources and in finding solutions to water-related problems. To provide an avenue for addressing such mutual interests, USGS established the Federal-State Cooperative Program in 1905. The primary objectives of the Cooperative Program are to: (1) systematically collect data needed for the ongoing determination and evaluation of the quantity, quality, and use of water resources in the United States, and (2) assess the availability and the physical, chemical, and biological characteristics of surface and ground water through analytical and interpretive investigations. Studies undertaken through the Cooperative Program are set up as joint-funding agreements (JFAs) between USGS and regional, state, and(or) local agencies. Under a JFA, most of the work is performed by USGS, with at least 50 percent of the funds provided by the cooperating agency. The Cooperative Program is used extensively to conduct studies important to the nation and the State of Kansas.

USGS Activities

Data Collection

In cooperation with KWO and several other agencies, USGS systematically collects data from a statewide network of 166 automated streamflow-gaging stations in Kansas (Figure 2). Real-time data are available from 152 of the stations via satellite, and 22 stations are accessible via telephone for immediate retrieval of current streamflow information. The KWO uses USGS streamflow data to address a variety of issues including: water-supply availability, water quality, water conservation, reservoir management, flood management, minimum desirable streamflows, and the protection of wetland and riparian areas.

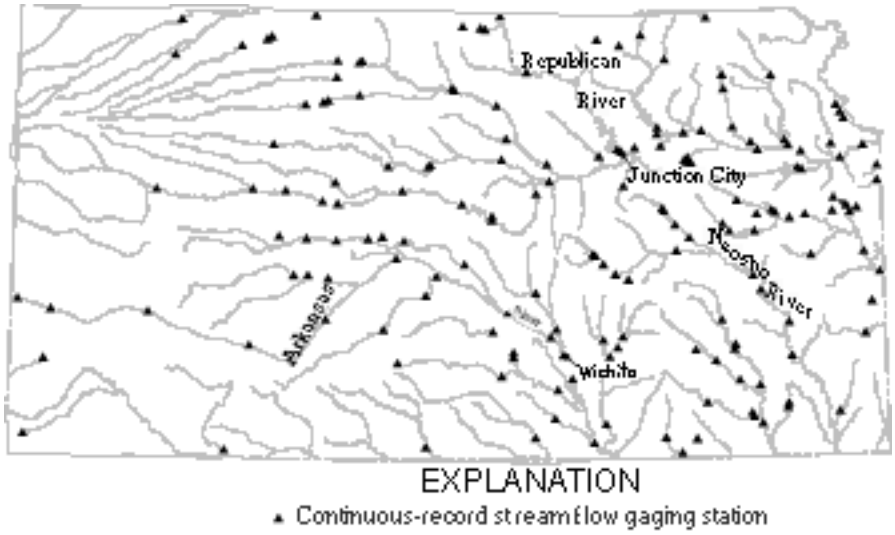

Figure 2. Network of automated U.S. Geological Survey stream flow-gaging stations in Kansas.

Another example of interagency cooperation is the evaluation of annual water-use data collected by the Kansas Department of Agriculture's Division of Water Resources. Through the Cooperative Program, USGS works with KWO to provide quality assurance of reported data for the two largest categories of water use in Kansas-irrigation and municipal. KWO uses the data to document annual water use, assess water-use efficiency, and target water conservation planning efforts for individual irrigators and municipalities.

Recent Cooperative Investigations With KWO

Water quality was the primary concern in a study to determine the effects of the Arkansas River on the adjacent Equus Beds aquifer, which is a major source of water for irrigation and municipal supplies in the Wichita area of south-central Kansas. Extensive use of the aquifer has decreased ground-water levels as much as 30 feet and caused increased recharge from the Arkansas River. Large chloride concentrations in the river have the potential to degrade water quality in the aquifer. USGS developed a ground-water flow model for use in understanding the flow system and the water-quality profile between the river and the aquifer. KWO will use the results of this study to develop and implement water management strategies to minimize undesirable effects of the river on the aquifer.

A study to evaluate the effect of pumping municipal wells on flow in the Republican River was conducted by USGS at Junction City in northeast Kansas. Quantification of the amount of river water infiltrating into the aquifer to satisfy well-field demand was needed by KWO to optimize release strategies for an upstream reservoir. A ground-water flow model was developed and used to simulate the effects of municipal pumping on flow in the river.

A series of digital maps of the major aquifers in Kansas is being developed by USGS and the Kansas Geological Survey through a cooperative agreement with KWO. The digital maps provide information on the geographic extent of each aquifer, altitude of the land surface, altitude of the top and bottom of each aquifer, and the potentiometric surface (i.e., altitude of the water table). Together, the digital maps will

provide readily accessible aquifer information that is directly applicable to water-resources management and research activities within the state.

Because Kansas water law requires that water obtained from reservoirs be purchased at the release point rather than the point of diversion, potential water purchasers need to know how much water will be lost during transit in the channel from the release point to the point of diversion. To address this issue, a study was conducted to determine transit losses (or gains) and traveltimes for reservoir releases during drought conditions along the Neosho River in east-central Kansas. A streamflow-routing model was used to simulate transit losses (or gains) and travel times for selected reservoir-release volumes and durations. The information resulting from the simulations assisted KWO in determining the required amount of water released from a reservoir to satisfy the downstream demands.

The Neosho River is presently the focus of considerable activity. USGS is involved in concurrent investigations that are addressing the issues of flooding and channel stability. Progress to date includes completion of a study to characterize high flows and scour and deposition trends, and completion of a digital inventory of stream obstructions (e.g., levees, low-flow dams, elevated roadbeds). These results, along with future studies, will assist KWO in developing and implementing a long-term management plan for the Neosho River Basin.

Summary

Cooperative efforts between state agencies and USGS have made a substantial contribution to water-resource planning in Kansas. Through hydrologic data collection and studies, USGS has provided information that assists state agencies in better understanding the hydrologic system being managed and in targeting state resources on priority issues and areas. KWO relies on USGS to provide real-time data on hydrologic conditions that are essential for a variety of activities including water-rights and reservoir management, and flood monitoring. The assessment of water-use patterns assists KWO in water conservation planning. Furthermore, USGS studies of such topics as stream-aquifer interaction, channel stability, and flow conveyance provide information that allows the state to adjust existing policies and programs to most effectively manage and use the state's water resources. The partnership has benefited the state and the nation in several ways, including resource sharing, knowledge gained, and improved intergovernmental agency relations.

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Procedures for Indexing Monthly NPS Pollution Loads from Agricultural and Urban Fringe Watersheds

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

Nonpoint source (NPS) pollution is the leading cause of surface water degradation in the United States, affecting over two-thirds of the nation's river basins. NPS pollution from agricultural activities contributed to the impairment of 72% of the impaired stream miles reported by the 48 states reporting sources in EPA's 1992 Report to Congress (EPA,1994). While NPS assessment and management programs now complement point source management programs in all U.S. states and territories, effective and standardized procedures for assessment are still in the development stage. Program managers, however, are held accountable for assessing the current degree of pollution, and for progress being made in its reduction. Assessment is complicated by the very nature of NPS pollution, which is not definable by a single parameter. One means of assessing an entity subject to measurement with of a variety of parameters is with an index. Water quality agencies began using indexes starting around 1965 to rate the quality of water in streams for a variety of chemical, physical, biological and visual parameters. In the

United States, most states use some type of water quality index to assess trophic status, a measure of pollutant input to lakes, as a basis for grant selection under the Clean Lakes Program (EPA, 1994). An index is a unitless number which ascribes various qualities to an aggregate set of measured parameters. Water quality indexes generally consist of sub-index scores assigned to each parameter by comparing its measurement with a parameter-specific rating curve, optionally weighted, and combined into the final index. NPS pollutant indexes are relatively new in comparison with water quality indexes, and are distinctly different from them in several ways. First, NPS parameters are measured in terms of pollutant loading rather than in terms of concentrations. Second, the procedures used to arrive at a final NPS index are not generally based on rating curves and are more concerned with rank order than with comparison to quantitative criteria. The procedures presented in this paper are proposed as a means to create a NPS pollution index with a more quantitative basis than current ranking procedures.

Two basic changes are proposed as the basis for a newly formulated NPS pollution index: a change in the unit of measurement, and a change in the time period of assessment. NPS pollution is generally reported as annual loads in units of kg/ha or its equivalent, and NPS indexes are consistently based on these units. Although the annual kg/ha unit is useful in comparing effects of differing landuses, it does not lend itself for use in establishing a fixed-scale index, because it does not differentiate seasonal or annual variations in runoff, the primary factor behind NPS pollution. Furthermore, without standards or criteria as a basis for a quantitative relationship between index values and parameter loads, acceptability or meaning of index values is difficult to establish, except in a relative sense. A different unit of measure, kg/ha-mm, is proposed to overcome some of these obstacles. While not a new term, kg/ha-mm is less frequently used in assessing load and has not been used to-date in published NPS indexes. The kg/ha-mm unit has some attributes which make it desirable for use with an index. For one thing, it normalizes load with respect to watershed area and runoff depth, making it equivalent to long-term concentration in units of ppm. Although there are no established standards or criteria related to watershed loadings of nutrients and sediment, ground water and lake classification represent two related waterbody categories whose measurements more closely resemble long-term concentrations, and for which some standards and criteria are available. These can serve as an interim basis for the development of rating curves that relate sub-index values to individual NPS pollutant loads. The base time period chosen for this unit is the month in order to allow seasonal variation to manifest itself, and to be comparable with generally available monitored data.

Index Structure

Procedures for developing a NPS pollutant index based on the kg/ha-mm unit have been created, which incorporate monthly loads of four modeled NPS pollutant parameters: total nitrogen (N), total phosphorus (P), sediment, and chemical oxygen demand (COD). These parameters were chosen to represent the major expected NPS pollutants in agricultural and rural residential watersheds, and their form was chosen with the monthly basis in mind. The NPS indexing procedures follow the general form outlined previously for water quality indexes: rating curves based on criteria or standards to score individual pollutants, optional weighting of individual pollutants, and aggregation into a final index value. The criteria in Table 1 was chosen subjectively from various sources to illustrate possible values and sources for use in defining low (1), moderate (5), and high (9) sub-index values for each of the four chosen parameters. Other criteria,

with a long-term basis, can be substituted, if more applicable to a specific situation. Because of a lack of specific data on COD, BOD criteria were used along with the assumption of a decreasing COD:BOD ratio with increasing load.

An open-ended index scale has been chosen for each of the four parameters as a basis for individual parameter log-normal rating curves, as illustrated for total nitrogen in Figure 1. Rating curves are used to score each monthly pollutant parameter load and assign a sub-index (SI) value. The index (I) is then calculated as:

where w is an optional weighting factor. The developed procedures recognize the need for flexibility in configuring an indexing protocol, because of variable site conditions, variable program requirements, and local data availability. The user is provided the following options in configuring the NPS pollution index using these procedures (default values are shown in parentheses):

- choice of 3 sub-index scale values, to represent the majority of the scale range (1,5,9),
- choice of parameter values corresponding to the sub-index values for each parameter (see Table 1),
- choice of rating curve shape: linear, segmented linear, log-normal and segmented log-normal; (log-normal), and
- choice of relative weights (equal weighting).

Linear and log-normal curves are based only on the values provided corresponding to sub-index values 1 and 9, while both of the segmented curve shapes use all three values.

Table 1. Rating curve parameter and sub-index values.

	Source	**Value (mg/L)**	**Sub-Index Value**
Total Nitrogen			
Lake Tahoe Standard	Briggs and Ficke, 1977	0.24	1
Potomac Embayment POTW effluent monthly standard	VWCB, 1990	1	5
Severe eutrophication problem threshold	Mills et al., 1982	9.2	9
Total Phosphorus			
Proposed oligotrophic classification threshold	Reckhow, et al., 1980	0.01	1
Chickahominy watershed monthly standard	VWCB, 1990	0.1	5
Nutirent Enriched Waters monthly standard	DEQ, 1994	2.0	9

Sediment			
Beginning sedimentation problem threshold (SS)	Mills et al., 1982	10	1
Probable sedimentation problem threshold (SS)	Mills et al., 1982	100	9
COD (BOD*COD:BOD Ratio)			
Rappahannock River/Lake Tahoe standard: 1 mg/L * 6:1	VWCB, 1990	6	1
Chickahominy watershed standard: 6 mg/L * 5:1	VWCB, 1990	30	5
Minnesota state standard: 25mg/L * 4:1	Young et al., 1982	100	9

Modeling Monthly Loads

The indexing procedures were designed to utilize model output from a cell-based water quality model and to interface with a raster-based geographic information system (GIS), in order to evaluate monthly loads at all points within a watershed, as well as at the outlet.

AGNPS Model

The Agricultural Nonpoint Source (AGNPS) model was developed at USDA-ARS (Young et al., 1987) as a single-event watershed model for evaluation of alternative agricultural management scenarios. AGNPS is a grid-based model, whose spatial variability is a function of cell size. AGNPS simulates loads of total and soluble N and P, soluble COD, erosion, sediment, and runoff. The latest AGNPS model, version 5.00, was used to model NPS pollutant loads, which are aggregated for monthly load estimates. The model is designed for watersheds where overland flow dominates, since channel processes are not considered, except for decay of soluble pollutants during transport in stream channels. AGNPS 5.00 has many enhancements over previous versions, such as improved sediment detachment and transport, variable flow rates throughout a storm through the use of a triangular hydrograph, and its use of extended memory compilers to eliminate the previous 1900 cell limit. Additionally, many soil nutrient parameters which were treated as black-box constants in the 3.65 version, are now made accessible for user modification.

GIS Interface

GIS are tools to collect, store, manage and display spatially varying data. GIS are useful in reducing manual data input requirements when linked with distributed parameter models. Use of GIS data further simplifies debugging of model input files, interpretation of output files, and creation of alternative scenarios. AGNPS 5.00 File Builder is a GIS utility for creating input files to the AGNPS model, versions 4.03 and 5.00 (Yagow and Shanholtz, 1995). File Builder was developed as a component within the existing PC-VirGIS geographic information system (Shanholtz, 1995), with support from the Virginia

Division of Soil and Water Conservation. File Builder facilitates user input of required data through a menu and prompt-driven interface. While AGNPS comes with a user-friendly spreadsheet editor interface to facilitate user input, a minimum of 22 parameters must be specified for each cell, a daunting and time-consuming task for large watersheds. By accessing GIS data layers and relational attribute tables, repetitive user input is minimized, while spatial variability is enhanced and consistently characterized, making it feasible to parameterize watersheds in the range of 10,000 to 30,000 cells.

Uncertainty Analysis

A further procedure, based on the observations of Haan and Schulze (1987), was used to estimate the uncertainty associated with index values classified as having average antecedent moisture conditions (AMC II) on a study watershed. The 6,500 ha (14,621 cells) Bull Run Watershed in northern Virginia is being modeled to test model response using the expanded capabilities of AGNPS 5.00, and to illustrate the indexing and uncertainty procedures. Four monthly segments from a 15-year monitored period of record were identified where 6 consecutive storms met AMC II conditions in each segment. Loads are being modeled for all storms and aggregated by monthly segment, for each of the three moisture conditions. The loads at AMC I and III can then be used to approximate the 80% confidence level of the loads generated under AMC II conditions.

Summary

A rationale and procedures have been developed for creating a NPS pollutant index from four pollutants using the monthly kg/ha-mm unit. Flexibility is provided within the procedures for setting the index scale range, for defining points to use within the rating curve for each pollutant, for defining the rating curve shape, and for assigning relative weights to each pollutant. The index can be used together with a statistical procedure to approximate the uncertainty of aggregate loading from consecutive AMC II storms.

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Abbreviations Used

AGNPS Agricultural NonPoint Source pollution model.

AMC antecedent moisture condition:

I=dry, II=average, and III=wet.

BOD biological oxygen demand.

GIS geographic information system.

NPS nonpoint source.

PC-VirGIS the personal computer-based Virginia Geographic Information System.

SS suspended sediment.

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A Dynamic Programming Approach to Storm Water Management Systems Design

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Conventionally, most storm water detention ponds are designed individually without considering the integrated flow and pollutant load effects of all the ponds within the watershed. Such design approach is haphazard at best. Thus, it is possible that a system of ponds designed individually may actually exacerbate potential flood hazards while not meeting the predefined water quality goal. To understand the combined effect of a system of detention ponds on the watershed in terms of water quality and flood hazards control, a holistic design algorithm using techniques in operations research is usually needed. These design algorithms are usually so complex that they are best implemented by computer programs. Only a computer-based numerical model can handle the enormous amount of computations necessary to select the best system of ponds from tens of thousands of competing systems. Furthermore, a computer-driven design heuristic based on operations research methodology has the unique advantage of allowing water resources planners to rapidly come up with many optimal design alternatives based on different combinations of design variables and cost factors. These computer based algorithms are usually flexible enough to handle a great variety of watershed characteristics, meteorological conditions, land use patterns, and detention basin designs.

In the design algorithm, two major inputs are hydrographs and pollutographs of the subwatersheds, which are generated by the P8 Urban Catchment Model. P8 consists primarily of algorithms derived from other tested urban hydrologic models like SWMM, HSPF, and TR-20. The model simulates a number of best management practices (BMPs), and simulations are driven by continuous hourly rainfall time series.

Two variables are needed for input to P8. The first is percent imperviousness, and the second, runoff curve number (RCN). To calculate the percent imperviousness of a subcatchment, all the subcatchments of a watershed are first delineated, and then superimposed on a land use map of the watershed. The percentage of each type of land use within each subcatchment is then estimated from the map. Each percentage of land use is then multiplied by a fraction of imperviousness associated with the corresponding land use, and the products totaled to equal the average imperviousness of a subcatchment. This process is repeated for each subcatchment.

To calculate the runoff curve number, SCS soil survey maps can be used to estimate the percentage of each soil type in a subcatchment. Each soil type has a corresponding hydrologic soil group (HSG): A, B, C, or D. For each land use at each hydrologic condition, there are four HSGs associated with it, and for each HSG there is a corresponding runoff curve number. A weighted-average runoff curve number is then computed for each subcatchment. The device name, curve number, and percent imperviousness are then input into the P8 model to find the hydrograph and pollutograph of a subcatchment.

The system constraints are allowable peak flow, minimum pollutant removal rate, and minimum pond volumes. If peak flow rates exceed the maximum allowable rate, channel erosions may occur. Minimum pollutant removal rate is imposed at each pond location to ensure that only those pond sizes that meet the minimum pollutant removal requirement will be considered in the dynamic programming selection process. The last system constraint simply states that no retrofit will result in a pond being smaller than its original, pre-retrofit size.

The Muskingum river routing method, a hydrologic technique founded upon the equation of continuity, is used throughout the program to route flood hydrographs from ponds to ponds. In applying the Muskingum routing method, a value of 0.5 is assigned to "k", the storage time constant for a river reach. The weighting factor "x" is assigned a value of 0.25, while the routing time interval delta t is assigned a value of 0.34.

Hydrographs are routed through each detention pond using the storage indication method, which is a hydrologic reservoir routing technique. The pond routing subroutine follows the following procedure when implementing the storage indication method of reservoir routing:

1. Open the inflow hydrograph file for the corresponding detention basin location.

2. Develop an elevation-storage curve and an elevation-discharge curve for the structure.

3. Select a routing interval, prepare the working curve, and do the routing using the curve.

Pollutant removal rate of each detention pond is computed by reference to a curve found in Controlling Urban Runoff, A Practical Manual for Planning and Designing Urban BMPs published by the Department of Environmental Programs, Metropolitan Washington Council of Governments. This curve shows the relationship between VB/VR and sediment removal percentage, where VB is volume of basin and VR is volume of runoff from mean storm. The mean storm is defined as one having a duration of six hours and an intensity of 0.07 inches per hour.

The physical arrangement of a system of detention basins in a watershed can be represented schematically by the so-called iso-drainage lines (IDLs). IDLs are drawn starting at the most downstream pond location and proceeding upstream stage by stage. They are numbered starting from the most upstream location and proceeding stage by stage to the most downstream. The number of IDLs is the same as the number of stages, and is denoted by the letter i. The pond within an IDL is denoted by the letter j. Thus the subscript "ij" identifies the coordinate of a candidate pond within a system of detention basins.

Dynamic programming (DP) is an extremely versatile and powerful optimizing technique. Problems amenable to DP solutions are those divisible into spatial or temporal stages. Associated with each stage and location (in space or time) is a finite number of discrete state variables which describe the state of the system. Each state variable is divisible into discreet values, and each combination of these discreet values is a state vector which defines the state of the system. A set of all possible state vectors represents a state space. Associated with each state vector is a cost or benefit (depending on the problem formulation) referred to as the return cost or return benefit of the system.

Central to DP is a partial objective function (POF) which is solved recursively starting at the most upstream IDL, and then proceeding downstream, stage by stage and pond by pond, until the last pond at the last stage is evaluated. The partial objective function for a serial system of detention basin is expressed as

$$F_{ij}(S_{ijk}) = \mathrm{Min}\left[R_{ij}(S_{ijk}, D_{ijk}) + F_{i-1,j}(S_{i-1,j}) \right] \qquad (1)$$

where i is the stage number, j the basin number, and k the state vector. $F_{ij}(S_{ijk})$ is the partial objective function, which is the minimum cost of the partial system comprising of the current basin and all basins from previous stages which are connected to it. $R_{ij}(S_{ijk}, D_{ijk})$ is the return cost, which is the cost of the current basin at a state denoted by state vector k. $F_{i-1,j}(S_{i-1,j})$ represents the optimal subpolicy cost, which is the minimum cost of the upstream system of basins which is connected to the current pond. The sum of the return cost and optimal subpolicy cost is evaluated for each state vector k and the lowest cost option becomes the optimal subpolicy cost of the current basin, and this cost will be used in the next-stage recursive solution of the partial objective function.

For a nonserial system of interconnecting detention basins, the partial objective function is written as

$$F_{ij}(S_{ijk}) = \mathrm{Min}\left[R_{ij}(S_{ijk}, D_{ijk}) + \sum_{1}^{b} F_{i-1,j}(S_{i-1,j}) \right] \tag{2}$$

where b is the number of upstream basins immediately connected to the current basin. In essence, for each state vector of the current basin, the optimal subpolicy costs of all upstream basins which are immediately connected to the current basin is summed and the total added to the return cost of the current basin to form the current basin's subpolicy cost. This set of subpolicy costs is then evaluated to find the minimum subpolicy cost, which becomes the optimal subpolicy cost of the current pond.

When applying the design algorithm to the Marley Creek watershed, the maximum basin width is used as a state variable. This variable and other input parameters are used to derive the elevation-discharge and elevation-storage relationships, and a working curve is derived based on these two curves. A subcatchment's inflow hydrograph is then combined with the upstream inflow hydrograph (which has been routed through the connecting open channel) and together they are routed through the detention pond using the working curve. The resulting outflow hydrograph is then evaluated to see if the peak flow exceeds the stipulated constraint. Only those candidate basins whose resulting outflow hydrographs meet the peak flow requirement and other constraints will be admitted to the next-stage DP selection process.

The cost associated with a particular state vector can be determined from the pond volume associated with that vector, using a set of linear regression cost functions. Each state vector which yields a routed outflow hydrograph that violates the system constraints will be eliminated from the state space for a given pond location. The cost associated with a feasible state vector is then added to the optimal subpolicy cost to form the subpolicy cost of the current pond. When all vectors within the state space has been evaluated, the lowest-cost option becomes the optimal subpolicy cost of the current pond. This DP algorithm is repeated stage by stage and pond by pond until the last pond is evaluated. A trace back is then performed to identify the optimal pond type for each pond location and the associated cost.

Once the trace back is completed, the pollutant removal efficiency of each detention basin in the optimal system is evaluated, after which the inflow pollutographs are "routed" through the system. The program will then compare the total pollutant load at the watershed outlet with the predefined pollutant cap to see if the watershed's water quality goal is met.

To examine its overall characteristics and potential, the design algorithm is applied to the Marley Creek urban watershed in Anne Arundel County, Maryland. The watershed lies within the Atlantic Coastal Plain, and comprises 8784 acres of mostly medium-density residential areas. Because most of the watershed were developed before the adoption of storm water management regulations, many developed areas in the watershed have no storm water BMPs. Consequently, uncontrolled runoffs have led to increased level of nonpoint source pollution.

The Marley Creek watershed can be divided into twelve subwatersheds. However, for the purpose of this study, only subwatersheds 1 and 2 were used in the dynamic programming design. These two subwatersheds were further delineated into 22 subcatchments using technical reports prepared by Greenhorne and O'Mara, maps of Anne Arundel County, and topographic maps of the Marley Creek watershed. Using the P8 Urban Catchment Model, a hydrograph and pollutograph were generated for each subcatchment. Only one pollutant was considered for this study_total suspended solids.

The design objective was to find the lowest-cost system of detention ponds that would meet the stipulated water quality and peak flow conditions. A peak flow constraint of 20 cfs was imposed for each candidate detention pond. Additionally, a 40% pollutant reduction constraint was imposed at the watershed outlet. This was achieved by imposing a minimum pollutant removal rate of 43% at each detention pond site. In practice, the minimum removal rate can only be determined by trial and error. It is obtained when the predefined water quality goal at the watershed outlet is just achieved.

For this study, the state variable used in the DP design algorithm was maximum basin width. This variable was discretized into nine different values (50, 60, 70, 80, 90, 100, 110, 120, 190). The total number of possible designs (state vectors) for each pond location is therefore nine. The results of the DP design is shown in Table 1 below.

Table 1. Dynamic programming results

Stage	Pond	Best Pond Type	Optimal System Cost
1	1	5	123,843
2	1	6	255,381
2	2	2	105,618
2	3	1	101,163
2	4	5	123,843
3	1	0	255,381
3	2	9	237,243
3	3	0	0
3	4	2	312,399
3	5	0	123,843
4	1	0	492,624
4	2	0	436,242
4	3	9	237,243
4	4	3	110,883
5	1	7	140,043

5	2	0	928,866
5	3	9	585,369
6	1	0	1,068,909
6	2	9	822,612
7	1	0	0
7	2	0	1,068,909
7	3	0	822,612
8	1	0	1,891,521 (Total system cost)

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Modeling Nutrients From The Minnesota River Watershed

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

The Minnesota River (Figure 1), which originates at the Minnesota-South Dakota border, flows 533 km through some of the richest agricultural land in Minnesota, to the confluence of the Mississippi River in the Minneapolis/St. Paul area. The watershed includes all, or part, of 37 counties in Minnesota, and about 92% of the land use is dedicated to agriculture production activities. Nonpoint pollution entering the river contributes to water quality degradation and violations of standards through out the entire basin and especially in the lower reaches. The parameters most often violated in the lower reaches are dissolved oxygen, unionized ammonia, fecal coliform bacteria, and turbidity. The Minnesota River Basin is composed of approximately twelve major tributaries. These tributaries each drain on the average about 3,584 square km.

A Waste Load Allocation study for the Lower Minnesota River determined that a 40% reduction in organic BOD in the Minnesota River at Shakopee is necessary to meet water quality limits in the lower Minnesota during critical conditions. To determine the feasibility of reaching the 40% reduction in organic BOD a detailed modeling analysis was necessary. The objectives of the modeling study for the Minnesota River consist of (1) quantifying atmospheric, point, and nonpoint source contributions (by land use category); and (2) quantifying pollutant contributions by tributary subwatershed for targeting priority areas for clean-up and remediation. Complete details of the Minnesota River Assessment Project can be obtained from MPCA (1994).

This paper describes the application of U.S. EPA Hydrological Simulation Program-FORTRAN (HSPF) (Bicknell et al., 1993) to the LeSueur River watershed located in the southeast portion of the Minnesota River basin. The paper also discusses: (1) the procedure used in discretizing the watershed; (2) presents a brief overview of the LeSueur calibration results; (3) presents the effect of selected best management practices for reducing nutrient loads; and (4) briefly narrates how the modeling approach will be used in quantifying nutrient loads in the remaining subwatersheds within the Minnesota River basin.

The HSPF model was selected for use in this study because it is unique in its capabilities of linking detailed simulation of soil processes, runoff contributions from surface and subsurface components, and complete in-stream water quality modeling to allow comprehensive watershed scale modeling and assessment. The watershed processes simulated consisted of sediment erosion, soil temperatures, and nitrogen and phosphorus runoff. The in-stream module receives loadings from the watershed and then simulates complete water quality conditions in the stream channel, including water temperature, sediment transport, dissolved oxygen (DO), biological oxygen demand (BOD), nitrogen and phosphorus species, and selected algal species. Complete details on HSPF can be found in the Release No. 10 HSPF User Manual (Bicknell et al., 1993).

Basin Segmentation

The availability of meteorologic data is critical to models, such as HSPF, that use continuous time series to drive the simulation of hydrologic responses in watersheds. Normal annual precipitation totals exhibit a strong gradient across Minnesota, increasing from the northwest to the southeast. Average temperatures do not significantly vary over the basin. To account for the observed spatial variability in meteorologic conditions in the model, the basin was divided into 38 meteorologic zones, each representing a Thiessen polygon constructed around a network of long-term weather reporting stations. The area represented by each weather station averaged 993 sq km.

Land segmentation goals for the model are to depict the watersheds in such a way that the hydrologic integrity is maintained and the spatial variability in the basin characteristics is captured. Each distinct land segment in the model is assumed to produce a more-or-less homogeneous hydrologic and water quality response to a given set of meteorologic conditions. Such watershed segmentation requires spatial analyses of basin characteristics affecting runoff. An essential tool for this process is a geographical information system (GIS) to provide a means to visualize and to statistically analyze large amounts of

geographically referenced data. For this project, we used a GIS program called EPPL7, which was developed by the Minnesota Land Management Information Center (LMIC, 1992). EPPL7 was used to analyze Minnesota environmental and natural resources data coverage's compiled by LMIC. These 100 meter, raster based data coverage's employ a 40 acre parcel as the basic data collection and interpretation unit. Some of the more useful data coverages included: land use/land cover, soil landscape units, slope, major/minor watershed boundaries, county boundaries, and soil atlas interpretations (e.g. drainage class, hydrologic group, erodibility constant).

The Minnesota River basin is segmented into 12 areas representing the major tributary watersheds. Hydrologic integrity of existing drainage divides was maintained to facilitate flow routing and computation of pollutant loads at watershed outlets. Using spatial analyzes of the LMIC data coverages, the individual tributary watersheds were further sub-segmented to represent their unique hydrologic characteristics.

HSPF Model Application to the LeSueur River Watershed

The LeSueur River watershed area is approximately 285,518 ha, two tributaries namely the Maple and Cobb river drain into the LeSueur River. For modeling purpose the watershed was segmented into ten smaller subwatersheds. Within each subwatershed tributary area the land area is further divided into six PERLNDs (Pervious Land Segments) and one IMPLND (Impervious Land Segments) categories. The simulated PERLND categories consisted of Forest, Conventional Till Cropland, Conservation (Low) Till (30% residue cover) Cropland, Pasture, Urban, Marsh/Wetland, and Manure Application Area. The IMPLND land use consists of the impervious portion of the Urban/Residential area.

In order to evaluate the impacts of proposed best management practices, base conditions were established in terms of current practices using a representative long term meteorological record for simulation and comparison. Base conditions were defined in terms of 1986-1992 land use, cropping, tillage, manure/fertilizer application, and management practices so that changes to these characteristics could be identified and their impacts evaluated. Under the base condition only 3% of the cropland in the LeSueur Basin was under conservation tillage (minimum 30% residue cover maintained on the field). For the Manure Application area it was assumed that only 25% of recommended application area actually received manure application. The alternatives analyzed consist of (1) increasing conservation tillage acres to 27% (transect survey acreage's), 50%, 100% of the row crop area; (2) application of the animal manure to 95% of the recommended area; and (3) a 66% reduction of Phosphorus load from point sources.

LeSueur River stream channels and its tributaries are the major pathways by which pollutants are transported from the watershed. Characterization of the channel system was based on measured channel cross section data, changes in channel geometry, and bankfull flow travel times. Accurate characterization is needed to provide a sound basis for routing streamflow, sediment, and water quality constituents through the channel system in order to reproduce field data and measurements. Comparison of the simulated routed streamflow results with measured streamflow data, as part of the calibration

process, allows us to evaluate the adequacy of the representation of the channel system by HSPF. A total of 10 channel reaches are used to represent the movement of runoff and associated constituents through the main stream channel and its tributaries. The stream reaches range in length from 10 to 102 km, with an average length of 52 km and average drainage area of 282 square km.

Simulation Results

The HSPF model was calibrated for the base conditions for hydrology, sediment, and water quality parameters. Details on the HSPF model application along with the calibration results can be obtained from Patwardhan et al., 1996. The following conclusions were drawn from the initial calibration results obtained under the baseline conditions:

1. The hydrology calibration resulted in well simulated flow volumes, the daily flow timeseries generally showed good agreement, and the flow frequency curves match well.

2. In-stream sediment concentrations showed fair agreement with the limited observed data.

3. Water temperature and dissolved oxygen simulations were quite good, and tracked the limited observed data well.

4. The BOD simulations were reasonable as the peaks were in the general range of observed data, and appeared to be associated with runoff events.

5. Both the NO3 and Organic N simulations were very good, and the NH3 simulations fair. The loadings for these constituents were in the expected range.

6. The Organic P is reasonably simulated, and PO4 concentrations are in the proper range for the period of August 89 to March 1990, further work for the other periods.

7. The benthic algae simulation look reasonable, and is consistent with previous simulations, but there is little or no data for confirmation.

8. The Total Organic Carbon simulations look good and consistent with the data.

Further work to improve the calibration is continuing as we gain additional experience with simulations in the other subwatersheds of the Minnesota River watershed.

Simulation of Alternative Scenarios

The objective of this portion is to demonstrate how the HSPF model could be used to evaluate the impacts of best management practices (BMPs) on water quality. After calibrating the model for the

baseline conditions, we analyzed best management practices to reduce nutrient loads to the LeSueur River. Figure 2 depicts the total phosphorus loads obtained from the analyses of various BMPs. The loads shown in the figure are for baseline conditions (3% low till), transect survey (27% low till), 50% low till, 100% low till, and for complete adoption which refers to 100% low till practices in the watershed along with application of animal manure to 95% of the recommended area and reducing the point source phosphorus concentrations from 3 mg/l to 1 mg/l.

Residue management scenarios on 27%, 50%, 100% of the row crop acreage's, and complete adoption scenario resulted in a four percent, fourteen percent, twenty percent, and fifty five percent reduction is phosphorus load to the LeSueur River respectively as compared to the baseline loads. An increase in conservation acres to 27% resulted in a seven percent decrease in sediment load, while adoption rates of 50% and 100% resulted in 24 percent and 50% reduction respectively. The above scenarios were developed to demonstrate how a model of the LeSueur River watershed can be used to evaluate best management practices for reducing nutrient loads to receiving waters.

Future Directions

The HSPF model is currently being applied for estimating nutrient loads from the remaining eleven subwatersheds within the Minnesota River watershed. After the loads from all the subwatersheds are estimated we will prioritize watersheds for the implementation of best management practices. The best management practices will be recommended for the subwatersheds which deliver the largest nutrient load to the Minnesota. Future plans are to continue the development of the Minnesota River watershed model, including parameter sensitivity analysis and verification of current model parameters with an independent period of observed data. Current recommendations and planned improvements in the modeling activity for the next several years consist of modeling surface and sub-surface drain tiles, modeling the wetlands with the newly implemented HSPF wetland module, and a detailed application of HSPF-AGCHEM module to simulate the mass balance, fate, and transport of nutrients through the watershed.

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Managing Watershed Data with the USEPA Reach File

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

Introduction

A key component of watershed assessment is the effective organization and management of watershed information. The US Environmental Protection Agency's (USEPA) Reach Files are tools expressly designed to provide a consistent national framework for managing watershed data. The Reach Files are a set of hydrographic databases of the surface waters of the United States. The files consists of a collection of surface water features (e.g. streams, lakes, reservoirs, and estuaries) each of which is described both by a set of attributes and a spatial representation. Two essential characteristics of the Reach File are Reach Codes and navigation attributes. The Files also contain names for major rivers and many other

streams and lakes.

The Reach Code is the unique identifier which is assigned to each surface water feature in the Reach File. Using the Reach Code, all types of attributes may be associated with specific locations on features. The Reach Code can provide the common link for water quality related data from diverse sources.

The Reach Files' navigation attributes define the connected stream network. These attributes provide connectivity regardless of the presence or absence of topologic continuity of the network's spatial representation. An additional benefit is the flow direction inherent in the navigation attributes. These attributes enable the Reach Files to provide hydrologic ordering (the upstream or downstream sequence of events or conditions encountered in the stream network) as well as network navigation proceeding either upstream or downstream. Traversal around and through open waters (e.g. wide rivers, lakes, and reservoirs) is also supported.

Background

The first Reach File was conceived in the 1970s with a proof-of-concept file, known as Reach File Version 1.0A or RF1A, completed in 1975. The first full implementation, referred to as RF1, was completed in 1982. RF1 was created from scanned 1:500,000 scale National Oceanic and Atmospheric Administration (NOAA) maps and consisted of approximately 68,000 features comprising 650,000 miles of stream. RF1 still supports broad-based national applications. During 1987/88, the Feature File of the US Geological Survey's (USGS) Geographic Names Information System (GNIS) was used to add one new level of streams to RF1. The resulting file, known as RF2, contained 170,000 features. Development of the latest Reach File, RF3, began in 1989 and has produced, to date, a preliminary version known as RF3-Alpha. The RF3 production process involves the overlay of the RF2 file, the GNIS II Feature File, and the USGS 1988 1:100,000-scale Digital Line Graph Version 3 (DLG3) hydrography. RF3-Alpha contains nearly 3,300,000 individual hydrographic features and over 93,000,000 coordinate points.

The Reach Files reside on the USEPA's IBM mainframe computer located in Research Triangle Park, North Carolina. Standard procedures have been developed to extract all or parts of the Reach Files for use on personal computers (PCs) and UNIX workstations with a variety of custom and commercial software including Geographic Information Systems (GIS). The remainder of this paper describes a selection of Reach File applications highlighting various ways the files have been used to facilitate the management and analysis of water quality information on a watershed basis.

Reach File Application Highlights

One of the primary objectives for developing the Reach File was to provide a common framework for interrelating data contained in the many USEPA environmental databases. By linking data using Reach Codes and other data provided by the Reach Files, it is possible to co-analyze data occurring in many files, and to enrich that analysis by associating information from upstream and downstream. For example, pollutant discharges, described in the USEPA's Permit Compliance System, may be related to

downstream domestic water supply intakes, stored in the USEPA's drinking water system, and these data may be related to upstream and downstream water quality monitoring data, from the USEPA's STORET water quality system. Prior to the existence of the Reach Files, it was impossible to co-analyze these and other data because they were collected by separate organizations without a common integrating framework.

The Reach Code is the unique surface water feature identifier that provides the common nomenclature for integrating water quality data. Any database that links its attributes to Reach Codes can be combined with any other database containing Reach Codes, thus establishing the upstream and downstream relationships of these data to one another. Collections of water quality information related to monitoring, drinking water supplies, permitted dischargers, and dams have been indexed to RF1 and RF3-Alpha. In addition, flow estimates, e.g., 7-day 10-year low flow, for the reaches defined within RF1 have been computed to facilitate pollutant modeling.

Spatial analysis and display applications have been developed to retrieve data from these mainframe databases during upstream and downstream navigation of the Reach Files. For example, during the mid-1980s, the RF1 was the basis for a national water quality modeling effort. Using RF1 navigation attributes, pollutants were routed down every stream in RF1 and an estimate for in-stream water quality was computed for every feature. This application developed relative water quality impact rankings for municipal treatment facilities throughout the United States. Another example of a mainframe-based Reach File application is the Environmental Data Display Manager (EDDM) which resides on and is accessible to users of the USEPA mainframe (Samuels et al 1991). EDDM provides easy access to several of the USEPA databases mentioned above, as well as automated analyses and reports including data, graphics, images, and text in formats that can be used by numerous output devices, software packages, and other computer platforms.

In addition, numerous USEPA programs and offices have found the Reach Files useful for simply cataloging and categorizing the water resources within the nation and at the state level. The USEPA's Environmental Monitoring and Assessment Program (EMAP) used RF3-Alpha to define a monitoring framework for lakes throughout the US and the Office of Water currently uses RF3-Alpha to estimate the Total Waters for each state.

Reach Codes can be combined into expressions that define watersheds or surface water study areas. Reach expressions are a shorthand means of identifying subsets of the Reach Files ranging from part of a single reach to all of the hydrologically-connected reaches comprising a large watershed. All of the reaches upstream or downstream from a single location, with or without tributary reaches, can be described within a reach expression. A reach expression may also consist of a polygon which defines the features of interest to be those within the polygon boundaries. Since RF3-Alpha contains the historical origin of each feature, filtering can be applied to reach expressions to include or exclude those features identified within RF1, RF2 or RF3. Combining reach expressions with other Reach File attributes, in this manner, provides a powerful meta-language for defining nearly any combination of features. Reach expressions have been put to use in the identification of state priority waterbodies for the Waterbody System, in compliance with section 305(b) of the Clean Water Act. Both RF2 and RF3-Alpha have been

used successfully to describe the 305(b) waterbodies using reach expressions. The Reach File indexing software, known as PCRF3, provides a convenient and easy-to-use method for building reach expressions in a PC-based graphical environment. These capabilities have also been implemented using GIS technology via route systems and dynamic segmentation.

The Reach Files were designed and created prior to the relatively recent growth in GIS technologies. However, the Reach Files, particularly RF3-Alpha, have proven to be very useful in the GIS environment. Much of the Reach Files' value can be attributed to several unique characteristics of the data:

- Since Reach File hydrologic connectivity is carried in it's attributes, it maintains connectivity where topologic discontinuity exists in the original data sources.
- Reach File coordinates have been consistently ordered from downstream to upstream.
- The Reach File contains names for major rivers and many other streams and lakes.

To support access to RF3-Alpha data for use within GIS applications, procedures exist on the USEPA IBM mainframe to produce several export formats that can be imported into various PC and UNIX-based GIS environments.

Several demonstrations of the usability of the Reach File and its navigation attributes have been developed in a GIS. A spill contingency application developed by the USEPA laboratory located in Las Vegas, Nevada demonstrated hydrologic routing upstream and downstream, locating and highlighting water intakes and discharge points that could be potentially impacted by a toxic spill.

Since 1988 individual States have been using a PC-based database program supported by the USEPA Office of Water, called the Waterbody System (WBS), to enter and manage assessment information related to their State's waters. The WBS provides States with a mechanism for maintaining consistent water quality assessment information and reporting that information as required under section 305(b) of the Clean Water Act. Over the last two years waterbodies defined by States have been geo-referenced to RF3-Alpha in a GIS environment (Clifford, et al., 1994). The result of this process is the ability to display, query, map and analyze water quality assessment information from WBS. It also provides USEPA with a mechanism for aggregating and managing states' data in a consistent nationwide database of water quality assessments. Figure 1 illustrates the link between WBS assessment data and geo-referenced waterbodies tied to RF3-Alpha.

For the State of North Carolina, a demonstration project illustrating the usefulness of RF3-Alpha's network routing structure was completed in 1995. The goal of the project was to code all non-classified stream reaches with the use classification of the closest downstream segment. Using RF3-Alpha's network connectivity, a simple program was written to route upstream through the network. As each reach was traversed, the program checked to determine whether or not it already had a use classification.

If the reach did not have a use classification, it was given the same use classification as the closest downstream reach in the network.

Another interesting GIS application employing RF3-Alpha was the Rouge River National Wet Weather Demonstration Program (Westman et al 1994). The RF3-Alpha data was combined with a dynamic segmentation data model to create a spatial data structure to better manage the Rouge River watershed. The data structure is designed to allow for the integration of a broad spectrum of information pertaining to watershed water quality. It supports both hydraulic and hydrologic network analyses and provides a spatial indexing system for the many different types of data collected by the project. The Rouge River Project data model operates in both the desktop (PC) and workstation (UNIX) environments.

What's Next?

USGS and USEPA are teaming to complete RF3 during 1996 (EPA 1994). This collaborative effort to embed the RF3 network and associated attributes within the next release of the USGS's DLG product, known as DLG-F, positions the agencies for shared maintenance including the incorporation of higher resolution hydrography from state and local sources.

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Stream Water-Quality Data from Selected U.S. Geological Survey National Monitoring Networks on CD-ROM

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Introduction

Stream water-quality data from two U.S. Geological Survey (USGS) national monitoring networks, the Hydrologic Benchmark network and the National Stream Quality Accounting network (NASQAN), are now available on CD-ROM. These networks provide some of the best available data for quantifying changes in the water quality of major U.S. streams during the past 20 to 30 years, estimating the rates of chemical flux from major continental watersheds of the United States, and investigating relations between water quality and streamflow as well as relations of water quality to watershed characteristics and pollution sources. Examples of these applications of national network data include Smith et al. (1987), Lettenmaier et al. (1991), Smith et al. (1993), and Alexander et al. (in press). During the period

of operation, the networks have included a total of 673 monitoring stations in watersheds representing a wide range of climatic and land cover characteristics. A maximum of about 85 physical, chemical, and biological properties have been analyzed during more than 60,000 site visits using relatively consistent sampling and analytical methods. The water-quality data reflect sampling over a wide range of streamflow conditions. USGS quality-assurance (QA) information on network operations, method changes, known and suspected data-quality problems, and laboratory measurement error complements the network environmental data. This QA information assists in the proper use of the environmental data, and has been used to systematically assess the accuracy of the environmental measurements (see for example, Alexander et al., 1993). In the following sections, we describe the characteristics of the national networks, the quality-assurance information associated with the network data, and the contents and organization of the data presented on CD-ROM.

National Stream Water-Quality Network Characteristics

The selected data published on CD-ROM for the two USGS national stream water-quality networks span the time period from the beginning of network sampling through early 1994. NASQAN began operation in 1973 in response to federal and state needs for more systematically-collected information on the quality of the nation's rivers. Data collection occurred during a period when significant environmental legislation was being implemented, most notably the Clean Water Act of 1972 and its subsequent amendments. The primary objectives of the NASQAN program were (1) to measure the quantity and quality of stream water exiting major watersheds of the United States, (2) to describe spatial variability in stream water quality, and (3) to detect long-term changes in stream water quality (Ficke and Hawkinson, 1975). Using the Water Resources Council (WRC) hierarchial classification of hydrologic drainage basins of the United States (Seaber et al., 1987), NASQAN stations were located at the outlets of most of the WRC's 352 accounting units. This provided equitable geographic coverage of major U.S. rivers, and, in particular, addressed the goal of accounting for a sizeable fraction of the chemical mass and water transported from the continent and its major interior watersheds. The watersheds range in area from less than 100 square miles to tens of thousands of square miles with a median drainage area of about 5,000 square miles.

NASQAN began operation in January, 1973 with 51 stations. An additional 50 stations were added in 1974, with significant expansion occurring in 1975 as the network grew to 345 stations. A total of 612 stations have been monitored since the creation of the network with the largest number of stations in operation in any single year being 513 stations in 1980. The number of sites was relatively constant at about 500 from 1980 to 1985. In 1986, a major review of NASQAN led to the elimination of 90 stations that were either located downstream of major reservoirs, located in close proximity to other stations on the mainstem of large rivers, or experiencing sampling problems. Thirty-one sites were also added to the network in 1986 to give a total of about 408 sites. After 1986, budgetary constraints led to steady declines in the number of sites to about 280 in 1994. The number of stations was sharply reduced in 1995 to 142. In 1996, the network was reduced to 31 stations in the Mississippi, Columbia, Colorado, and Rio Grande River Basins and seven stations in major coastal drainages of the United States to accomodate more intensive sampling at each site.

The Hydrologic Benchmark network began operation in the early 1960s, and has included stations in 64 relatively undisturbed watersheds in 37 states. In any given year, the network has typically consisted of 50 to 57 stations. The watersheds range in area from two to 4,000 square miles with a median drainage area of 57 square miles. The network's purpose is to provide a standard base of hydrologic data from minimally disturbed watersheds that could be used to accurately investigate naturally-induced changes in streamflow and water quality (Cobb and Biesecker, 1971). Many of the monitoring stations were located in national parks, wilderness areas, State parks, national forests, and specially-protected areas set aside for scientific investigations. A few stations were located in moderately disturbed watersheds (e.g., agriculture, logging) in cases where land use was not expected to change radically. The network has provided excellent opportunities to investigate the effects of atmospherically-derived pollutants on stream water quality (especially sulfate and nitrogen) independent of the effects of culturally-derived land disturbances common to most watersheds (e.g., Smith and Alexander, 1986). A survey of the network was conducted in the early 1990s to evaluate the integrity of each watershed with respect to the original network objectives. This included assessments of the effects of geologically- and atmospherically-derived substances such as sulfur on stream chemistry as well as inventories of land use practices in the watersheds. The survey led to the elimination of six stations and the addition of two sites in 1993 and 1994 as described in documents included on the CD-ROM.

Water-quality measurements from the two networks have included a comprehensive set of approximately 85 physical, chemical, and biological properties. Sixty-two water properties are included in the published data on CD-ROM (see Table 1). Instantaneous measurements of streamflow coincident with the time of water-quality sampling are routinely available. In addition, values of daily mean streamflow are available for most network stations, and can be used to calculate chemical loads. Radiochemical measurements have been sampled since the mid 1970s at a subnetwork of about 50 NASQAN stations and at all Benchmark stations. Most of the biological constituents were monitored prior to 1982, although fecal bacteria have been monitored in both networks throughout their period of operation. Total recoverable analyses of trace metals on whole water samples were discontinued in 1982 due to budget reductions. Selected dissolved trace metals including arsenic, beryllium, cadmium, chromium, copper, lead, mercury, and zinc were discontinued in 1992 because of concerns about sample contamination (Windom et al., 1991). USGS investigations of trace metal contamination of samples led to the implementation of a new sample collection and processing protocol for low-level inorganic analyses in 1994 (Horowitz et al., 1994). The results of these investigations and related documents are provided on the CD-ROM to assist in the proper use of trace metal data collected prior to 1992. Organic pesticides were measured at about 160 NASQAN stations from 1975 to 1982. These data are not included on the CD-ROM, but have been previously summarized by the USGS (Gilliom et al., 1985).

Laboratory analyses of water properties have typically been made on dissolved (0.45 micron filtration) and whole water (total, unfiltered) samples for national network stations (Ficke and Hawkinson, 1975). All network samples were collected from the water column using depth- and width-integrated techniques (Edwards and Glysson, 1988) with the exception of pesticide monitoring which also included sampling and analysis of bed sediment.

Water-quality samples have been collected from the two networks according to fixed time intervals ranging from monthly to yearly, depending on the constitutent and year (see Table 1). Prior to 1983, monthly samples were collected at nearly all NASQAN stations and at 34 of the approximately 50 Benchmark stations. In response to budgetary constraints, reductions occurred in sampling frequency at virtually all stations after 1982. From 1983 to 1994, slightly more NASQAN stations were sampled bimonthly than quarterly, whereas most Benchmark stations (about 80 percent) were sampled quarterly with the remaining sites sampled on a bimonthly basis. Beginning in 1996, all Benchmark stations are scheduled to be sampled only twice a year.

Table 1.

Water Properties and approximate sampling frequencies for U.S. Geological Survey national water-quality network data on CD-ROM.

Water Properties	**Frequencies* (samples/year)**
Physical Measurements	
• Temperature, specific conductance (field and lab), dissolved oxygen, pH (field and lab), suspended sediment, turbidity, instantaneous streamflow	2 - 12
• Streamflow, daily mean	365
Major Dissolved Substances	
• Calcium, chloride, magnesium, potassium, silica, sodium, sulfat e , fluoride, dissolved solids, hardness, alkalinity, bicarbonate, and carbonate	2 - 12
Nutrients and Carbon (dissolved, total)	
• Ammonia, nitrite, nitrate+nitrite, ammonia+organic nitrogen, and phosphorus	4 to 12
• Organic Carbon (includes suspended also)	4 to 8
Radiochemicals	
• Gross alpha and beta, radium-226, tritium, uranium	1 or 2

Biological Measurements	
• Fecal coliform and streptococci	4 to 12
• Periphyton (chlorophyll A and B), periphyton biomass	4
• Phytoplankton (chlorophyll A and B), phytoplankton (total)	7 to 12
Inorganic Trace Elements (Dissolved, total)	
• Aluminum, arsenic, barium, beryllium, boron, cadmium, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, vanadium, and zinc	4
*The range of sample frequencies for any contituent group reflect differences in frequency among the two networks, changes in frequency with time, and differences among stations within a single network. See the text for a discussion of temporal changes in sampling frequency.	

Quality-Assurance of National Water-Quality Network Data

The national network programs have benefited from the use of a variety of USGS quality-assurance practices for ensuring the accuracy of water-quality measurements. These practices have included the use of standard methods of sample collection, processing, and analysis, independent evaluations of USGS laboratory methods using standard reference water samples, and regular training and evaluation of personnel (Friedman, 1993). A bibliography with references to USGS documentation of standard field and laboratory methods is provided on the CD-ROM. In addition, a collection of the most relevant internal USGS memoranda describing network operations, changes in methods, and quality-assurance problems related to field and laboratory methods are included on the CD-ROM to assist in the proper use and interpretation of network monitoring data. Summaries of these memoranda and the most significant method changes and data-quality concerns are also included to assist data users.

National network samples have been routinely analyzed in one or more USGS operated laboratories. In addition to internal USGS laboratory quality-assurance evaluations, the USGS has operated since 1981 an independent, external program of laboratory quality assurance called the Blind Sample Program (BSP; see for example, Maloney et al., 1994). In this program, USGS laboratories process and analyze regularly submitted standard reference water samples (i.e., spiked, natural filtered surface waters) having "known" chemical concentrations determined as the statistical median of analyses from as many as 150 laboratories (Schroder et al., 1980). Laboratory measurements of reference samples for a wide range of chemical concentrations are used to estimate the measurement error (i.e., bias and precision) associated with laboratory analyses of environmental samples. The CD-ROM includes selected BSP data on

measurement bias and precision for the period 1986 to 1994 for nutrients, major dissolved ions, and inorganic trace elements. Additional details of the BSP data appear in a report included on the CD-ROM. This report also discusses the various ways of using BSP data to assess the accuracy of the national network environmental data.

CD-ROM Contents and Organization

The CD-ROM presents all water-quality and ancillary data in an ASCII format. The water-quality and streamflow ASCII files are organized by the 21 major hydrologic regions (Seaber et al., 1987). Within each region, as many as 11 data files are available for each network station. These files include a daily streamflow file and as many as 10 separate water-quality files arranged by constituent classes (e.g., nutrients, major dissolved ions). An ASCII file of station attributes includes station number, station name, watershed name, latitude, longitude, hydrologic unit code (HUC), state, county, and the population and land cover characteristics for the hydrologic unit containing the station. The BSP data on measurement bias and precision are presented in two separate ASCII data files. Quality-assurance information on network operations, significant method changes, and data-quality concerns is provided in chronologically- and constituent-ordered ASCII files.

DOS-PC search and retrieval software supports logical data queries of station-attribute, water-quality, and BSP data. The software accesses national data files containing the data for all stations. Water-quality data may be queried by station, date, station attributes, and water-quality constituent and its value. BSP data may be queried by date, constituent type, and constituent values of bias and precision. The software allows user-selected variables and data records to be output in a variety of formats for subsequent use in other software packages including statistical analysis and geographic information systems.

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The National Water Information System-A Tool for Managing Hydrologic Data

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The U.S. Geological Survey (USGS) is in the final phases of the development of a new hydrologic database system called the National Water Information System-II (NWIS-II). NWIS-II is a distributed, UNIX1-based, Ingres relational data base that will manage the hydrologic data collected by USGS offices, located in the 50 states and Puerto Rico, as well as data collected at major program offices in Regional centers. The system will be installed on up to 70 sites.

NWIS-II integrates two types of hydrologic data, discrete and time-series, into a single data base. Discrete data are those collected periodically, such as water-quality analyses, field measurements of ground-water levels and surface-water flows, information about data collection sites, and well information. Time-series data are collected and recorded by instruments either on a continuous basis or an event-driven basis, such as hourly stage or water-level measurements, water-quality monitor records, and rainfall records. These data are then processed to provide results such as stream discharge calculated from the stage data.

The NWIS-II system provides major improvements over existing systems including:

- All hydrologic data integrated into one data base.
- Capability of storing additional types of metadata, information about a measurement or analysis.

- Use of a graphical user interface with extensive on-line reference lists.
- Integration of a geographical information system with the data base.
- Separation of applications for analyzing data from the data base system.

Replacement of Existing Systems

NWIS-II will replace two aging hydrologic data systems. NWIS-I is a minicomputer-based system distributed in 40 locations and provides local data processing capability to the USGS District Offices. Once the data are processed locally, they are uploaded to the Water Data Storage and Retrieval System (WATSTORE), a mainframe-based system maintained in Reston, Virginia. WATSTORE was designed in the late 1960s to provide data processing for District offices as well as a National data base. It has had only minor software upgrades and limited increases in the types of data that may be stored within the system. NWIS-I provided local data processing capability but processed and stored the same limited types of data as WATSTORE.

Both WATSTORE and NWIS-I store time-series and discrete data in separate data files only loosely integrated through yet another data file containing site information. Users wanting to retrieve and work simultaneously with data from the various data files were frustrated by the complexity required to bring the data together.

Storage of Metadata

NWIS-II marks a major improvement in the amount and quality of information about a measurement or an analysis that can be stored. Commonly called metadata, this information includes the who, what, why, when, and how of data collection and analyses. Metadata increases the value of data for reuse. The original collectors of data selected techniques that met the needs of their intended use of the data. In some cases, subsequent users of that data are unable to determine what methods were used to collect or analyze the data and what accuracy was associated with the data. These factors can determine whether use of the data would be appropriate for a new study. By storing the metadata with the actual data results, future users of the data can make more accurate assessments of its appropriateness to their needs.

As an example of this increased ability to store metadata, consider a typical visit to a site on a river to collect water-quality samples. At the site, samples are routinely collected at two locations, 100 yards downstream from the gaging station at a site suitable for sampling by wading at low flow and 2000 yards upstream at a bridge for sampling at higher flow. Table 1 shows some examples of the additional data and metadata that may be stored in NWIS-II.

Table 1. Examples of metadata storage capability in WATSTORE/NWIS-I and NWIS-II.

Data type	WATSTORE / NWIS-I	NWIS-II
Sample location	Gage house location only.	Description of location where samples were collected.
Sample method	Occasionally stored as a fixed value code.	Procedure identified along with specific time, persons sampling, and comments to describe any deviations from standard procedures.
Sample preparation	No information stored.	Complete information including how composited, split, filtered, treated , and shipped. Individual samples can be traced back to sample method and location.
Measurement or analysis	Result value with a method code specific to each laboratory.	Result value, procedure used to make measurement or analysis, rerun values if any, date and time of the measurement or analysis. Each result can be traced back to an individual sample. Each procedure can be tracked to a bibliographic citation

Graphical User Interface

NWIS-II provides a graphical-user interface under the X Window System for data entry and retrieval and includes extensive reference lists. Users of the system specified that the system should be easy to use and intuitive for the user. Accessing the reference lists from the graphical-user interface should simplify or eliminate the need for users to memorize codes and instead allow them to pick from lists of easily understood information. The NWIS-II system uses 266 reference tables, 18 of which will be maintained locally; the remainder will be maintained nationally.

In processing time-series data, the graphical-user interface leads the user through the steps required to convert stream stages to the additional products of streamflow information. The system keeps track of the steps the user has taken in the process and leads the user to the appropriate next step.

One major advantage of using the graphical-user interface rather than a character-based interface is that time-series data are easily viewed and edited graphically on the screen. For example, periods of missing

streamflow or water-level records can be estimated by superimposing the hydrograph from another site and tracing the portion that must be estimated. Hydra, as this portion of NWIS-II is called, gives the user the ability to quickly view and, if necessary, edit data on screen.

Geographic Information System

A geographic information system (GIS) is an integral part of the NWIS-II system. GIS can be used to establish or verify the location information of a data site. On the basis of available data coverages, information such as county, hydrologic unit, river reach, geologic unit, land use, and congressional district can be automatically entered into the data base. Well data from different sources often will have slightly different location information. The GIS system notifies users if there is an existing site close to one being established. This allows the user to determine if the data are for two separate sites or are actually from the same site.

GIS has increased the flexibility of selecting sites for retrieval of data. Without GIS, users are limited to spatial searches tied to political units stored in the data base, such as counties or within polygons or circles. GIS allows the user to specify far more complex retrieval specifications based on the spatial data layers available. For example, with GIS it is possible to select data for wells located within 1500 meters of a stream reach or data for surface-water sites located in forested areas.

Using GIS to display sites with data meeting specified criteria gives the hydrologist an additional interpretive tool or a quality-assurance tool. For example, in a given aquifer, wells that exceed user-supplied criteria could show a pattern of contamination from a point source.

Interpretive Applications Separated from Data Processing

Applications for interpretation of data are limited within the NWIS-II system. Applications focus on data entry and verification, processing time-series data such as converting continuous stage data to daily maximum, minimum, and mean discharge values, and output of data into reports or machine-readable format. This change from the older NWIS-I and WATSTORE systems reflects the growth of readily available commercial software, including spreadsheets and statistical packages. NWIS-II produces output easily imported into these applications.

Other specialized hydrologic application programs that can be used to analyze, review, display, or synthesize data (as in a model) are external to the NWIS-II system. A separate group within the USGS, the Hydrologic Analysis Support Section (HASS), writes, maintains, enhances, and distributes USGS-developed models and application programs. NWIS-II will produce output that can be easily imported into the HASS programs.

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Watershed Boundaries and Digital Elevation Model of Oklahoma Derived from 1:100,000-Scale Digital Topographic Maps

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Introduction

Good quality digital drainage-basin, or hydrologic-unit maps are needed to support many water-resource related activities, such as watershed-based planning for Oklahoma. Automated tools to support delineation of a drainage basin above any point also are needed for activities such as processing surface-water withdrawal permits and engineering designs of bridges, culverts, and other structures. Standardized hydrologic-unit maps and digital topographic data sets have been developed to meet these needs.

Prior to the development of data sets described in this report, the most detailed digital basin maps available on a statewide basis were the nationally-standardized cataloging units that are designated with 8-digit hydrologic-unit codes derived from 1:250,000-scale maps (Steeves and Nebert, 1994) . The cataloging units were developed as part of a nationally uniform hierarchical system organized by the U.S. Water Resources Council in the mid-1970's. The system divides the country into regions, subregions, accounting units, and cataloging units. A hierarchical code consisting of two digits for each level is used to identify units. Eight-digit cataloging units average 450,000 acres in size (Seaber et al., 1987). The U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS), formerly known as the Soil Conservation Service (SCS), further divided cataloging units into subunits with 11-digit hydrologic-unit codes in Oklahoma. Unlike the hydrologic units of higher levels, many of the NRCS subunits were delineated along project or administrative boundaries rather than hydrologic divides.

The availability of Geographic Information Systems (GIS) and digital data sets made it possible to automate the watershed-delineation process using Digital Elevation Models (DEM's). However, many of the existing DEM's were derived from old, inaccurate topographic data using outdated techniques of data conversion. Many DEM's were created using older methods that introduced systematic errors into the DEM's. Additionally, 1:100,000-scale hypsography (land-surface point elevation and contours) and hydrography data in Digital Line Graph (DLG) format became available for the entire state in early 1995. New GIS algorithms were available, allowing the use of the DLG data to produce a statewide DEM and watershed map of better quality than previously available.

Approach

The ANUDEM1 software package, version 4.4, developed by Michael Hutchinson at Australian National University was used to make a statewide DEM with a horizontal grid-cell resolution of 60 meters. Four types of input data were used for the production of the DEM: both contour-line and point hypsography, hydrography, and depressions extracted from the hypsography data. After processing with ANUDEM, further processing was done to remove all depressions except a few large depressions. Watershed outlet points were selected and watersheds were delineated using an automated process, followed by interactive editing of the watershed boundaries.

The U.S. Geological Survey (USGS) 1:100,000-scale Digital Line Graph (DLG) files were used for input hypsography data. The DLG files were converted into ARC/INFO coverage format and elevations were associated with the contours and points.

ANUDEM retains depressions specified by the user. ANUDEM requires that a depression be represented by a point within the depression. Small depressions_those less than 3 cells wide at the widest_are likely to be smoothed over by the gridding algorithm, so only depressions larger than this were specified for retention. The elevations associated with these points were set to the elevation of the surrounding depression contours minus half of the contour interval.

The 1:100,000-scale hydrography data were acquired in the form of ARC/INFO data sets. When acquired, these data had been separated into hydrologic cataloging units but were later appended into one data set. These data were an early release of the River-Reach File (RF-3) distributed by the U.S. Environmental Protection Agency (EPA). Cataloging units that included any part of Oklahoma were processed.

Four significant problems in the RF-3 were corrected before use in ANUDEM. 1. Many small waterbodies and streams that were not connected to the main stream network were eliminated. 2. Centerlines were generated for all large lakes, wide streams, and other waterbodies. The polygons forming the waterbodies were removed. 3. ANUDEM requires that all hydrographic lines point downstream, so all lines pointing upstream were flipped. 4. The RF-3 data were incorrect in several places. Large parts of several rivers and lakes were missing and two streams were incorrectly connected at their headwaters. Also, the stream segments in an area covering one 7.5-minute quadrangle were shifted approximately one kilometer to the west. Corrections were made using data extracted from the USGS

1:100,000-scale hydrography DLG's.

The ANUDEM software is based on an algorithm that produces a hydrologically-conditioned DEM by interpolating elevations using hypsography and hydrography data. It uses a method of drainage enforcement to remove erroneous depressions from the DEM. The drainage enforcement algorithm "significantly increase[s] the accuracy, especially in terms of their drainage properties, of digital elevation models" (Hutchinson, 1989). This algorithm removes depressions only when drainage conditions contradict input elevation data by less than a user-specified tolerance. The interpolation method is implemented by fitting a thin-plate spline to the data, conditioned by a surface-specific roughness penalty (Hutchinson, 1989). Four user-specified tolerances are used to control how the data are interpolated. The tolerances were set as suggested in the software documentation, based on the contour interval of the USGS quadrangle maps being processed.

The state could not be processed at one time because of computer storage limitations and contour interval differences. When available, data from quadrangles adjacent to the state boundary were used. Different tolerances were used for each processing block according to the contour interval. The processing blocks overlapped, in most cases, by 12 kilometers on each side. All input hypsography and hydrography data were appended and trimmed to cover the areas for each processing block. After ANUDEM processing, 6 kilometers were trimmed from the overlapping edges of each processing block, to avoid problems introduced by interpolations near the edges of the input data sets. The elevations in the remaining overlapping areas were averaged together using a distance-weighted method. Using the ARC/INFO GRID function MOSAIC (ESRI, 1994), the processing blocks were combined to create two DEMs: one for the Oklahoma panhandle and the other for the rest of the state.

The combined DEM's resulting from ANUDEM processing contained numerous depressions that had not been removed by the drainage-enforcement algorithm using the specified tolerances. Because the presence of many small depressions would complicate the process of watershed delineation and because most depressions in DEM's are errors resulting from the representation of the surface in raster form (Jenson and Domingue, 1988 and Hutchinson, 1989), the DEM's were processed using the ARC/INFO command FILL in the GRID module, an implementation of the approach outlined by Jenson and Domingue (1988). The FILL command fills depressions to their pour points that are the minimum elevations along the drainage basin boundaries of the depressions. The identification and removal of depressions is an iterative process. Filling a depression may create new depressions along its boundaries that will be filled in the next iteration (ESRI, 1994). In order to retain large depressions such as playa lakes, cells with values of nodata were entered at the centers of depressions larger than 3 cells wide shown by depression contours on the 1:100,000-scale USGS topographic quadrangles. Areas draining into cells with a value of nodata were not filled by this procedure. After the FILL procedure, the original elevations were replaced into the cells that had been set to nodata.

The two filled DEM's were trimmed to have a 12-kilometer overlap. They were combined using the MOSAIC function to create a seamless statewide DEM with floating-point elevations in meters. The direction of steepest descent for each cell (flow direction) was computed from the statewide floating-point DEM. To save disk space, the DEM elevations were rounded to the nearest meter after calculation of flow

directions.

A statewide grid of accumulated flow was generated from the flow-direction grid. Accumulated flow is the number of cells flowing into each cell in the output grid. Cells with high accumulated flow values may be used to identify stream channels. Cells with accumulated flow values of zero are local topographic highs and can be used to identify ridges and drainage basin boundaries. To save disk space, the accumulated flow data were reclassified to five categories.

Watershed boundaries were derived from the flow-direction data set using automated procedures (Jenson and Domingue, 1988). The flow-accumulation data set was used in the selection of watershed pour points or outlets. Outlets were selected at stream confluences in cells with high accumulated flow. Some errors were observed when the boundaries derived from the DEM were compared with the 1:100,000-scale contours and streams. The boundaries were revised so that the watershed boundaries would be consistent with the contours and streams from 1:100,000-scale quadrangle maps. Errors were corrected interactively using the ARCEDIT module of ARC/INFO. Watershed delineation was done using the two separately filled DEM's, one for the panhandle, the other for the rest of the state. The two data sets of watershed boundaries were combined after the necessary revisions were made, then hydrologic-unit codes were added. Eleven-digit watershed codes were assigned following guidelines established in USDA National Instruction 170-304 (USDA, 1995). The first 8 digits of the 11-digit codes match the nationally-standardized system of hydrologic cataloging units. The last three digits generally begin at 010 and increase by ten for each watershed downstream within a cataloging unit. The watershed boundaries were trimmed to the state boundary and inserted into 1:250,000-scale 8-digit cataloging-unit boundaries for the rest of the Arkansas, Red, and White River basins.

Several closed basins not draining into the main stream network resulted from the retention of large depressions. Boundaries of these closed basins, known as noncontributing drainage areas, are provided as a separate data set.

Results

The project described in this report resulted in the production of a seamless hydrologically-conditioned statewide DEM of Oklahoma with a horizontal grid-cell resolution of 60 meters. The DEM is well suited for automated watershed delineation. Because the centerlined stream network was used in the creation of the DEM rather than water-body polygons, the DEM is not flat in the areas covered by water. In some cases, contours of the land surface before construction of reservoirs were included in the DLGs and were used with ANUDEM. Because these input data were used, DEM elevations in areas covered by water are not reliable. Four grid data sets and three vector data sets resulted from this project. The four grid data sets prepared are the hydrologically conditioned DEM of Oklahoma, the flow-direction data set, the reclassified flow-accumulation data set, and the shaded-relief data set derived from the statewide DEM. The three vector data sets prepared are the watershed boundaries for Oklahoma with hydrologic cataloging units outside Oklahoma, noncontributing drainage areas, and the downstream-directed stream centerline network used in the generation of the DEM. The statewide data set of watershed boundaries consists of 11-digit subdivisions of the nationally-standardized 8-digit cataloging units. The watershed

map has been edited to be consistent with the contours and streams shown on USGS 1:100,000-scale quadrangle maps. A shaded-relief data set was created by using the HILLSHADE function of the GRID module of ARC/INFO Version 7.0.2 (ESRI, 1994) on the statewide floating-point DEM.

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Best Management Practices: Cost-Effective Solutions to Protect Maine's Water Quality

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Nonpoint source pollution is a major contributor to water quality degradation in the lakes, rivers, streams, and coastal waters of Maine. Concerns about the impacts of storm water runoff from urban, suburban, agricultural, and timber harvesting areas have prompted several Maine regulatory agencies to develop manuals describing best management practices (BMPs) and to require their use on construction activities licensed by the Maine Department of Environmental Protection.

While some development projects require state permits, the majority require only municipal review and permitting under locally-adopted land use ordinances. Most ordinances do not have specific performance standards for erosion control or storm water quality management and do not require the use of BMPs.

In 1990, Casco Bay, an estuary located in the most populous southern region of Maine, was designated as an estuary of national significance and included in the National Estuary Program. Impacts from the increased volume of polluted storm water runoff caused by the rapid pace of suburban development in the watershed are a priority concern for the future health of Casco Bay. Increasing the use of BMPs in all land use activities has been identified as an effective tool for reducing these impacts while accommodating future growth.

Interviews with local elected officials and the volunteer planning boards which are responsible for reviewing and approving local land use permits revealed a limited understanding of BMPs. In addition, both groups expressed concerns about the additional costs that may be imposed on developers and residents if these techniques were required for local development.

The Casco Bay Estuary Project (CBEP) determined that information about the use of BMPs in a range of Maine development projects and evidence that these practices could be cost effective for both municipalities and property owners would be useful in promoting a wider acceptance of BMPs by municipal officials.

The CBEP selected Dufresne-Henry, Inc. (consulting engineers), Timson & Peters, Inc. (environmental services), and Walnut Hill Graphics (graphics design and layout) to develop a product which would:

- Educate municipal officials and the public about BMPs and the range of techniques available; and

- Demonstrate that BMPs are cost-effective.

The project team which included the CBEP identified three tasks to meet the project objectives:

- Research existing studies that document the cost effectiveness of BMPs.
- Research and document case studies, preferably in Maine, that highlight the cost-effective use of BMPs in various types of land use activities.
- Develop a booklet documenting the case studies in an attractive format suitable for public distribution.

Research of Existing Studies

Research for existing studies that document the comparison of BMP installation costs to the costs incurred to maintain or repair a site where no BMPs were used was unsuccessful. The majority of studies reviewed provided the following types of information:

- An estimate of the pollutant removal efficiency associated with various BMPs.
- A conceptual discussion of comparative costs associated with various BMPs that achieve similar water quality protection.

A bibliography with annotations of the relevant sources is included as an appendix to the project's final report which is available from the authors of this paper.

Case Study Selection

Municipal, regional, and state agencies were consulted in developing a comprehensive list of potential projects to be reviewed for successfully implemented BMPs and analyzed for the cost-effectivness of the BMPs.

The sites selected reflect the range of land-use categories found throughout the Casco Bay watershed including:

- Residential
- Commercial
- Timber harvesting
- Roadways
- Agricultural

In documenting the nine case study sites, it became apparent to the project team that in most cases, a direct cost/benefit ratio was not obtainable. Therefore, the test for cost effectiveness was one of the following:

- The BMP cost was low compared to the costs of conventional construction practices.
- The BMP cost was small when compared to the overall project cost.
- The BMP provided additional aesthetic benefits that cannot be easily assigned a dollar value.

Following is a profile of one project from each land-use category.

Residential

During the past twenty years, Maine has experienced significant growth in the number of single-family, year-round homes around many lakes. Residents around China Lake have witnessed regular algal blooms as a result of phosphorus loading from residential and agricultural activities in the watershed. One concerned couple incorporated two BMPs into the design for an addition to their lakeside home to reduce the impact of stormwater runoff from the additional impervious surface:

- Infiltration trenches with filter fabric and crushed stone were placed along the drip line of the house instead of the traditional gutters and downspouts.
- A vegetative buffer of shrubs and wildflowers was planted along the top of the shoreline bank.

The traditional approach of gutters and downspouts was estimated to cost $800, slightly more than the infiltration trenches and vegetative buffer which cost approximately $750. The owners were pleased that the infiltration trenches and buffer allow the subsurface soils and vegetation to absorb the phosphorus.

Commercial

L.L. Bean, Inc. of Freeport, Maine recently completed construction of a major expansion which included a 7.5 acre building and 6.0 acres of paved roadways and parking lots. The company's consulting engineers designed stormwater management systems to regulate storm water runoff in each of the two primary watersheds draining the site. Each system included:

- A water quality pond to treat the "first flush."
- A detention pond to regulate the discharge rate to the receiving stream.

The approximate cost for grading, stabilization, vegetation, and piping associated with both 23,000 cubic feet water quality ponds was $20,000. The site work cost for the entire site including earthwork, erosion control, structural fill, detention ponds, paving, curbing, landscaping, and lighting was $2,000,000, while the total project cost, including building construction, was $11,000,000. The $20,000 cost of the water quality ponds represented less than 0.2 percent of the total project cost, $11,000,000.

Timber Harvesting

A Soil and Water Conservation District maintains approximately 126 acres in southern Maine to demonstrate proper forestry management. The heavy machinery traffic typically associated with silvicultural practices causes erosion by disturbing low-lying, vegetative cover. Because most erosion problems result from the road systems built into the forest to collect the product, the District included BMPs designed to minimize soil loss from truck traffic over unpaved roads. The BMPs include:

- A gate to prevent unauthorized traffic.
- A landing, or central staging area for the storage and transport of timber.
- Stone fords and fabric crossings that provide strength for truck crossings, allow water drainage, and trap sediment.
- Water bars and broad-based drainage dips that provide frequent points from which water can drain.

- Vegetative ground cover to stabilize the soils.

The total cost to install the BMPs along the 1,700 linear feet of roadway was $2,815. The cost effectiveness was determined by comparing the cost of the BMP installation to the annual road maintenance costs of $3,000 for a similarly sized roadway with no BMPs in another town.

Agricultural

The University of Suthern Maine operates a working beef cattle farm in Freeport. Dedicated to research and education on agriculture and proper resource management, the facility is supported by its retail beef sales. The property abuts Casco Bay and has highly erosive soils that are easily washed into the Bay if not managed with proper conservation practices.

The facility adopted rotational grazing and an in-paddock livestock watering system to minimize the potential for erosion. Rotational grazing divides a large parcel into smaller paddocks which are grazed one at a time, for a sufficient duration to harvest the existing forage while not allowing consumption of new growth. Water is provided to each paddock helping to prevent erosion by reducing vegetation loss as animals travel to watering locations. It also prevents manure from being concentrated in one central location allowing it to be more easily absorbed into the paddock areas.

The benefits of rotational grazing are documented in a study from another local farm. These include:

- Increased value of the pasture in the number of animal days it supports.
- Savings in feed supplements and labor costs to provide feed.
- Improved quantity and quality of milk production.

That study documented $3.70 in benefits for every $1.00 invested in the BMPs.

Roadways

A steep, gravel road along Thompson Lake in Poland, Maine serves both seasonal and year-round residences. Each spring, the town's road crew had to repair storm water damage to the road by replacing lost gravel and regrading the surface. Local residents claim that the erosion was contributing to siltation and sandbars in the Lake forcing a local boat launch to be closed.

The town worked with the local Soil and Water Conservation District to incorporate several BMPs:

- Ditch stabilization to prevent erosion by protecting exposed soils with vegetation or stone.
- Intermediate ditch turnouts and culverts to divert runoff to avoid overloading ditches.
- Level-lip spreaders to disperse concentrated storm water flow across wide, vegetated areas.

A ten-year payback period was estimated in comparing the $20,000 capital BMP cost to the $2,000 annual maintenance costs. Avoided "costs" include the continued deterioration of recreational uses and the possibility of lowered property values.

Case Study Booklet

The third project task was the creation of an attractive, nontechnical case study booklet which would appeal to municipal officials and the general public. The booklet, BMPs: Cost-Effective Solutions to Protect Maine's Water Quality, is a marketing tool for BMPs. For each of the nine case study sites, it offers a brief problem description, a simple explanation of the BMP

solution, a cost-effectiveness analysis, and a testimonial from the property owner. The graphic layout is informal, easy to read, and avoids technical jargon wherever possible. A sample graphic from the booklet is included as Figure 1.

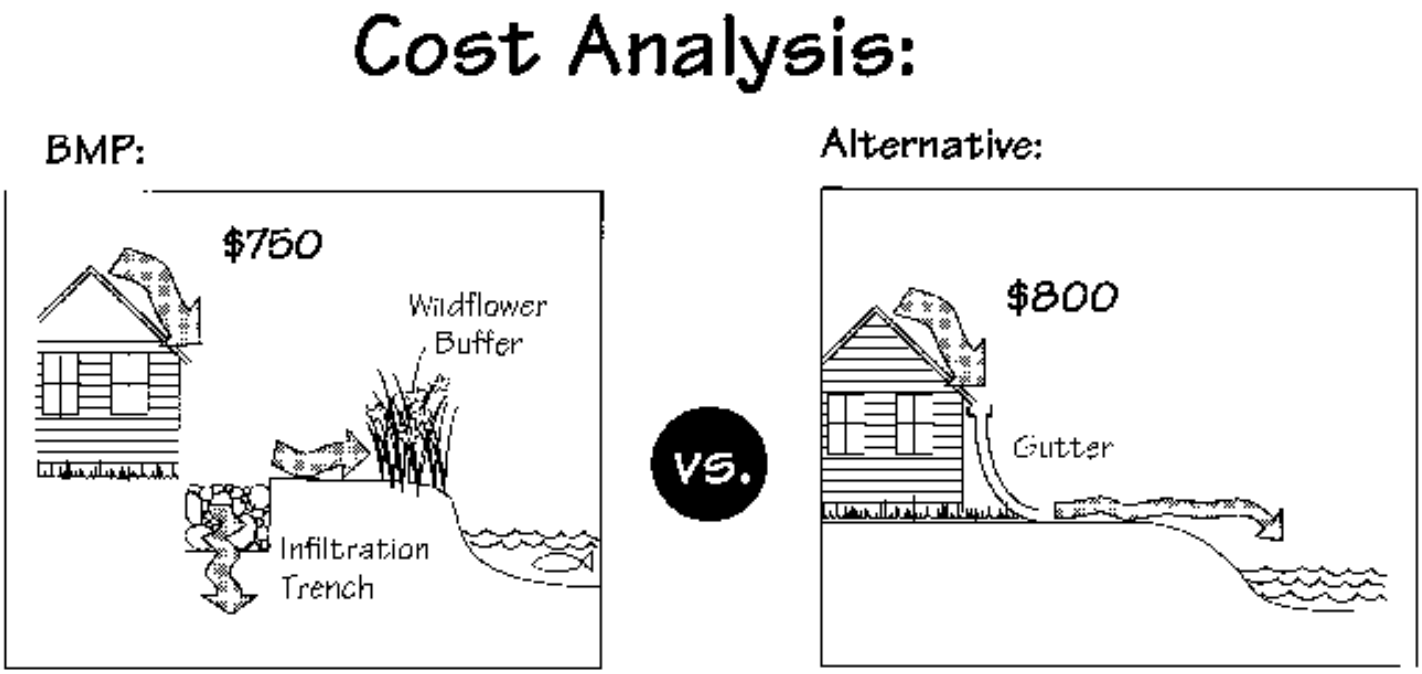

Figure 1. Sample cost analysis graphic.

The booklet has been well received by municipal boards and will be used more extensively in several municipal technical assistance programs scheduled for winter/spring 1996.

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The StormTreat System Used as a Storm Water Best Management Practice

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Web Note: *Plesae note that images for this session of the Watershed 96 Proceedings are not available at this time, but will be available soon.*

The STORMTREATTM System (STS), developed in 1994, is a storm water treatment technology consisting of a series of sedimentation chambers and constructed wetlands which are contained within a modular, 2.9-meter diameter recycled-polyethylene tank, as shown in Figure 1. Influent is piped into the sedimentation chambers where pollutant removal processes such as sedimentation and filtration occur. Storm water is conveyed from the sedimentation chambers to a fringing constructed wetland where it is retained for five to ten days prior to discharge. Unlike most constructed wetlands for storm water treatment, the storm water is conveyed into the subsurface of the wetland and through the root zone. It is within the root zone that greater pollutant attenuation occurs through processes such as filtration, adsorption, and biochemical reactions.

Current Status

The first STS was installed in Kingston, Massachusetts (MA) and has been operational since November 1994. The need for a storm water treatment system in this area became evident as increased bacteria levels caused the closing of shellfish beds in the Jones River. Additional systems were installed in 1995 in the City of Gloucester, MA, the Town of Harwich, MA, and the Town of Waltham, MA. Two systems were installed in November 1995 in Gloucester to help mitigate impacts to the downstream shellfish beds which had been identified as having high counts of fecal coliform bacteria. The system installed in Harwich in November 1995 treats polluted runoff from the town landing prior to discharge to Wychmere Harbor, a scenic boating harbor on Cape Cod. A system was also installed at GTE in Waltham in October 1995. The industrial complex is located in a sensitive watershed. The system collects rooftop runoff and runoff from a parking lot. If these installed systems prove to be cost effective, there are additional needs in Massachusetts where 40 percent of the shellfish beds have been closed due to high levels of metals and bacteria.

Applications

The STS has applications in wide range of settings. The system's size and modular configuration make it adaptable to a wide range of site constraints and watershed sizes. Designers of the system indicate that the system can be used to treat runoff from highways, parking lots, airports, marinas, and commercial, industrial, and residential areas. The STS is an appropriate storm water treatment technology for both coastal and inland areas. The manufacturers of the system indicate that the STS could be used throughout the US, with only minor modifications to the system to make it effective in that geographical area.

Performance

Preliminary monitoring results from four sets of samples collected in November 1994, December 1994, and February 1995 indicate removal rates of 94 percent for total coliform bacteria, 83 percent for fecal coliform bacteria, 95 percent for total suspended solids, and 90 percent for total petroleum hydrocarbons, as shown in Table 1. Preliminary nutrient removal rates have been determined to be 44 percent for total dissolved nitrogen, 89 percent for total phosphorus (TP), and 32 percent for orthophosphorus. Total nitrogen (TN) performance data are not available at this time; however, the manufacturer of the system indicates that they should be high based on the results of other wetland systems where particulates, and therefore TN, are

Table 1. STORMTREAT(TM) Monitoring Results.

Pollutant	Percentage Removed
Total Coliform Bacteria	94
Fecal Coliform Bacteria	83
Total Suspended Solids	95
Chemical Oxygen Demand	75
Total Dissolved Nitrogen	44
Total Phosphorus	89
Orthophophorus	32

removed. Removal rates are anticipated to increase as the wetland vegetation becomes more established and during warmer months. The pollutant removal rates achieved by the system for other pollutants are as follows: 65 percent for lead, 98 percent for chromium, and 90 percent for zinc.

Total Petroleum Hydrocarbons	90
Lead	65
Chromium	98
Zinc	90

Design Criteria

The STS is a modular, 2.9-meter diameter recycled-polyethylene tank containing a series of sedimentation chambers and constructed wetlands. The sedimentation chambers are in the inner ring of the tank, which has a diameter of nearly 1.7 meters. The 2.9 meter diameter outer ring, which surrounds the sedimentation chambers, contains the wetland. The tank walls and bulkheads, which separate the sedimentation chambers, have a height of 1.2 meters.

Flow enters the STS unit by connecting to existing catch basins with PVC piping. Influent is conveyed through the PVC piping to the first of six internal sedimentation chambers. The 10.2 cm diameter inlet pipe is covered with a burlap sack that traps larger particles and debris. Synthetic screens and woven geotextiles placed within the bulkheads filter the flow as it passes into the succeeding chamber. Flow is conveyed through larger mesh sizes in the first series of sedimentation chambers, followed by smaller mesh sizes in the remaining sedimentation chambers. In addition to the filter screens, skimmers have been installed in the tanks. Skimmers replace the previously used screens and combination of screens and skimmers. The screens and skimmers perform the same pollutant removal mechanism; however, the screens require more maintenance than the skimmers.

The skimmers float on the water surface within each chamber and have an opening 15.2 cm below the surface through which flow is conveyed to the following tank. The skimmers prevent sediment from being conveyed to the subsequent chamber. Sediments which collect in the bottom of the chamber remain in that chamber until the unit is maintained. The bulkhead separating the last two sedimentation chambers is fitted with an inverted elbow which traps oil and grease within the fifth chamber. The elbow is located approximately 25.4 cm from the chamber bottom.

Flow is conveyed from the last sedimentation chamber through four, 10.2 cm diameter, PVC, slotted outlet pipes into the wetland portion of the STS. Storm water flows subsurface through the length of the wetland, which has a length of 7 meters, width of 0.7 meters, and contains 0.9 meters of gravel and sand. The types of gravel used at the Kingston facility are rice stone (0.6 cm) and bluestone (1 cm). The weight of the gravel provides the force that counteracts the buoyancy forces that would be present at a high water table site. The wetland has approximate storage capacity of 2,880 liters. The entire system has a capacity of 5,260 liters.

Vegetation within the wetland will vary depending on the local, naturally occurring wetland vegetation and the maximum expected root depth of the plant. Bulrush and burreeds have been used in

Massachusetts and have maximum root depths of 0.8 and 0.6 meters, respectively (EPA, 1993). Mature vegetation should have roots that extend into the permanent 15.2 cm of water in the bottom of the tank. Insufficient root depth may result in a lack of water supply to the plants during the periods between storm events.

Effluent from the wetland is discharged through a 5.1 cm diameter pipe that is controlled by a valve. Flow rates and holding times can be varied by manipulating the outlet control valve. At the Kingston facility, the control valve is adjusted to provide for a recommended discharge rate of 0.8 l/min. and a 5-day holding time in the wetland. The valve has an added benefit that in the event of an upstream toxic spill the valve can be closed and the pollutants will be trapped in the STS.

Tanks are available in one size but multiple tanks can be installed at a site to capture the volume of runoff from the site. The size of the tank was selected so that the prefabricated tanks could be transported without requiring conformance to oversized load regulations. The determination of the number of tanks needed for a site is based on three factors:

- Area of impervious drainage surfaces.
- Design storm to be treated.
- Detention storage prior to the STS tanks.

To capture and treat the first 0.6 cm of runoff from 0.4 hectares of a completely impervious drainage area, the designers of the system estimate that two tanks would be required when preliminary detention is provided and five tanks when it is not. For a design storm of 1.3 cm, four tanks are required with preliminary detention and ten tanks without preliminary detention. Preliminary detention may be provided in the drainage pipes and catch basins which convey flow to the STS. In some instances, settling tanks may be located upstream that detain the runoff. A typical site would require 9.3 m3 per tank, which includes sufficient space for the tank and access to the tank for maintenance.

Maintenance

Anticipated maintenance of the STS is minimal. The system should be observed at least once a year to be sure that it is operating effectively. At that time the burlap sack that covers the influent line should be removed and replaced. If the system installed uses filters, these should be removed, cleaned, and reinstalled. Sediment should be removed from the system once every 2 to 3 years, unless the system has higher than normal sediment loads. After six months of operation the unit installed in Kingston, MA was found to have 5.1 cm of accumulated sediment. The sediment can be pumped from the tank by septic haulers or by maintenance personnel responsible for sediment removal from catchbasins. It is not anticipated that the sediment will be toxic and may be safely landfilled. However, sediment toxicity will depend on the activities in the contributing drainage area and testing of the sediment may be required to determine if it should be considered hazardous.

Costs

The STS is a prefabricated unit that is easily installed in most locations. Installation time for a normal site (i.e., bedrock not encountered) is approximately four man-days. This time includes both site preparation and installation. The estimated cost for one installed tank is $3,600 to $4,000, which includes the site work, tank, skimmers, gravel, wetland plants, external PVC piping, and installation by the manufacturer. Costs of systems that have been installed or are planned for installation have been lower that the estimated costs due to the municipalities providing the site preparation at no charge. The higher end of the cost range may be encountered if complications with site preparation occur. Capital and installation costs decrease as the number of units on a site increases. The cost for an installed system consisting of four tanks is approximately $15,000. The four tank system would effectively treat a 0.4 hectares, completely impervious drainage area with preliminary detention designed to capture the first 1.3 cm of runoff.

The estimated maintenance cost for removal of sediment from one tank ranges from $100 to $150. This cost is incurred every two to three years when sediment removal is necessary. Costs have not been determined for an annual site inspection and removing any debris and leaves from the wetland area. However, these costs should be minimal (i.e., one day of labor for one person).

Environmental Impacts

Systems have been installed in Massachusetts due to the increased bacteria levels resulting in the closing of shellfish beds. Regulators and environmental groups in Massachusetts are concerned over the closing of 40 percent of the shellfish beds in the state and are utilizing storm water management practices, including the STS, to improve the water quality in the downstream beds. The STS also protects the groundwater by removing pollutants prior to infiltration. The STS has shown high TPH, TP, metals, and suspended solids removal rates, which improves water quality. An additional benefit of the STS is the system's spill containment feature which results in capture of a release, and therefore, lessens the impact from the spill on the environment.

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Watershed Source Identification and Control for Heavy Metals

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This paper describes work performed to identify significant pollution sources and potential controls in the urbanized watershed of the Santa Clara Valley, a 360 square mile area that contains approximately 1.4 million people. The work was conducted by the Santa Clara Valley Nonpoint Source Pollution Control Program, a consortium of 15 municipal agencies in the Santa Clara Valley, in response to NPDES storm water and total maximum daily load (TMDL) regulatory requirements.

The paper describes the process by which water quality monitoring, modeling results, and ecological data were evaluated to prioritize metals of concern discharged from the watershed into South San Francisco Bay, a water quality limited water body. The metals of concern were the 304(l) listed metals which consisted of cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc.

Sources of metals were organized into five source classes: atmospheric emissions, automotive, industrial, residential, and water supply. Within each of these classes, source activities were identified. For each source activity, a "pathway diagram" was developed which described how pollutants could enter the storm drain system. Local and national data were then analyzed to estimate the percentage of the mean annual nonpoint source load to south San Francisco Bay associated with each source. A prioritization of sources for each metal was then conducted based on the relative contribution of each source. A major source of copper was identified as brake pad wear, and a subsequent study was conducted to evaluate the

amount of copper contained in various types of brake pads.

Based on the prioritization of sources, a control program was developed that consisted of 26 specific control measures. One of the more striking results of the source identification is that most of the major sources are regulated under other environmental regulations (e.g., the Clean Air Act) or other local jurisdictions and regulatory agencies. Successful implementation of controls therefore requires active coordination with other jurisdictions and regulatory agencies.

Prior Work Relevant To Source Identification

The Santa Clara Valley Nonpoint Source Pollution Control Program has been conducting monitoring and modeling studies for several years which in part have been directed at identifying sources of nonpoint source pollution. In general, these studies were designed to identify fairly broad classes of sources (i.e., as associated with different land-use types) rather than specific individual sources within a given land-use area.

Since 1987, wet- and dry-weather runoff sampling and flow measurements have been conducted as part of a comprehensive monitoring program at various stations throughout the Santa Clara Valley. Water samples have been analyzed for a broad range of water quality parameters and toxicity. Sediment samples have also been analyzed. The resulting data have been reported in a series of documents provided to the San Francisco Bay Regional Water Quality Control Board as part of the permit application and subsequent annual. The purpose of these studies included problem identification, development of control measures, compliance evaluation, and broad scale source identification.

Approach for Identification of Sources

A step-by-step approach was used for identifying important sources, identifying controls, and developing a strategy for targeting controls for specific sources and specific pollutants. The specific steps taken were:

- Select Target Metals
- Select Source Classes (including conducting a literature review, identifing representative source classes, selecting categories, and selecting sources and pathways)
- Prioritize Sources
- Develop Source Control Measures

Selection Of Target Metals

To select which metals are possibly causing adverse impacts in streams serving as tributaries to the Lower South San Francisco Bay, monitoring data and toxicity identification evaluation (TIE) were reviewed for evidence of metal toxicity. Based on this review, copper and mercury were selected as first-

tier priority metals, with nickel, lead, and zinc selected as second-tier metals for implementation of control strategies. The remaining 304(l)-listed metals (cadmium, chromium, silver) were identified as third-tier implementation metals based on lack of water quality exceedances or low concentrations in storm water as compared to other sources.

Selection Of Source Classes

Pollutant sources have been organized into five classes of sources. Individual sources have been grouped into land-use classes or area-wide source classes. The term land-use sources refers to activities that are principally associated with a specific land use (e.g., illegal dumping/disposal of household products is a residential source). The term area-wide sources refers to activities that tend to cut across geographic lines or are associated with mobile sources (e.g., automotive emissions). The source classes chosen are as follows.

Source Class A: Atmospheric Emissions
These are emissions from stationary point sources (e.g., industrial and commercial) and mobile sources (e.g., tail-pipe emissions from cars and trucks) that indirectly contribute to runoff pollution by affecting the quality of rainfall and dryfall.

Source Class B: Automotive
These are sources associated with the maintenance and operation of automobiles and trucks, exclusive of their respective tail-pipe emissions (which are covered in the Source Class A category). This class specifically addresses wear and tear (e.g., brake pads and tires) and spills and leaks of automotive fluids (e.g., motor oil).

Source Class C: Industrial
These are sources associated with runoff from industrial facilities which expose chemicals to rainfall through such activities as processing, materials handling and storage, and maintenance. Class C sources do not include the area-wide sources (e.g., industrial or mobile emissions) which are covered in Source Class A or the automotive/trucking sources which are covered in Source Class B. These sources will not be discussed in this paper.

Source Class D: Residential
These are sources associated with residential activities or construction products used in home building. Class D sources do not include area-wide sources associated with atmospheric emissions and automotive. Examples of the sources considered in this source class include: household products, wood preservatives, pesticides, algicides, fertilizers, paints, erosion, and corrosion of downspouts and gutters.

Source Class E: Water Supply
These are sources associated with that portion of the potable water supply which ultimately enters the South San Francisco Bay through the storm drain system. Sources of pollutants are associated with chemical additives (e.g. corrosion inhibitors and algae suppression inhibitors) and corrosion products.

Screening And Prioritization Of Metal Sources

Annual metal loads contributing to urban runoff were estimated for the following classifications of sources: atmospheric emissions, automotive, residential, and water supply.

First, the percentage of the total mean annual load of each metal contributed by a specific source (aggregated across the Santa Clara Valley) was estimated. Next, a priority was assigned to that source for that metal based on the percentage of the total mean annual load of that metal contributed by the source. Ranges for each priority are shown below:

Priority Definition

1. The source is believed to contribute more than 10 percent of the total mean annual load for the metal under consideration.

2. The source is believed to contribute from 1 to 10 percent of the total mean annual load for the metal under consideration.

3. The source is believed to contribute less than 1 percent of the total mean annual load for the metal under consideration.

NE Not evaluated (due to insufficient data or because the source is not known to contribute the given metal to storm water).

For example, tail-pipe emissions of mercury from diesel-fueled vehicles would be assigned a priority of 1 (i.e., the highest) because these emissions are believed to contribute more than 10 percent of the total mean annual load. These estimates of annual load are order-of-magnitude estimates and, as such, priorities based on these estimates are subject to some uncertainty. However, this method is systematic and produces reproducible results.

Finally, an overall priority was assigned to each source. The process of assigning the overall priority weighted critical metals (mercury and copper) more heavily than the other metals of concern, as shown below:

Overall Priority Definition

1. First priority, at least one critical metal assigned a priority of 1.

2. Second priority, at least one metal of concern assigned a priority of 1 or one critical metal assigned a priority of 2.

3. Third priority, no critical metal assigned a priority of 1 or 2 and no metal of concern assigned a priority of 1.

For example, tail-pipe emissions would be assigned an overall priority of 1, because at least one critical metal (e.g.., mercury) was assigned a priority of 1.

Metal Sources Matrix

The results of the prioritization are shown in Table 1. Priority group 1 sources include tail-pipe emissions from diesel-fueled and unleaded-fueled vehicles, wet and dry deposition and brake pad wear. Using the information from this study, as summarized in Table 1, a list of Source Control Measure that would focus on priority sources was developed. Priority group 1 sources were a primary focus of the Source Control Measures. An additional study on brake pad contributions was also performed to help better understand this source.

Table 1. Metal Sources - Assigned Priority

Priority for Specific Metals (B)									
Identified Sources	**Cu**	**Hg**	**Cd**	**Ni**	**Ag**	**Zn**	**Pb**	**Cr**	**Overall Priority (A)**
AIR POLLUTION									
Stationary	3	3	3	3	NE	3	3	3	3
Diesel-fueled vehicle exhaust	1	1	3	3	1	2	1	2	1
Unleaded-fueled vehicle exhaust	3	1	NE	2	3	2	2	3	1
Wet deposition & dry deposition	1	1*	1	2	NE	1	1	1	1
AUTOMOTIVE									
Coolant-leaks	3	NE	NE	3	NE	3	3	NE	3
Coolant-dumping	3	NE	NE	3	NE	3	3	NE	3
Oil-leaks	3	NE	NE	3	NE	3	3	NE	3
Oil-dumping	3	NE	NE	3	NE	2	3	NE	3
Tirewear	NE	NE	1	NE	NE	1	NE	NE	2
Brake-pad wear	1	NE	NE	NE	NE	NE	NE	NE	1
RESIDENTIAL									
Paints	3	2	3	NE	NE	3	NE	3	2
WATER SUPPLY									

Source Water	2	NE	1	2	NE	3	3	2	2
Corrosion inhibitors	3	3	3	3	3	3	2	3	3
Corrosion of plumbing	2	3	3	3	3	3	3	3	2
Copper sulfate algicide	3	3	3	3	3	3	3	3	3

Legend for assignment of Overall Priority (A)

- 1- First-priority source, at least one critical metal (Hg or Cu) assigned a priority of 1
- 2- Second-priority source, at least one non-critical metal assigned a priority of 1 or critical metal assigned a priority of 2
- 3- Third priority source
- NE- Not Evaluated

Legend for Priority Assigned to Specific Metals (B)

- 1- Greater than 10% of the total load
- 2- 1 - 10% of the total load
- 3- Less than 1% of the total load
- NE- Not Evaluated

*Based on limited data from Knoxville, TN

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