Developing and implementing a TWM strategy-approaches and examples
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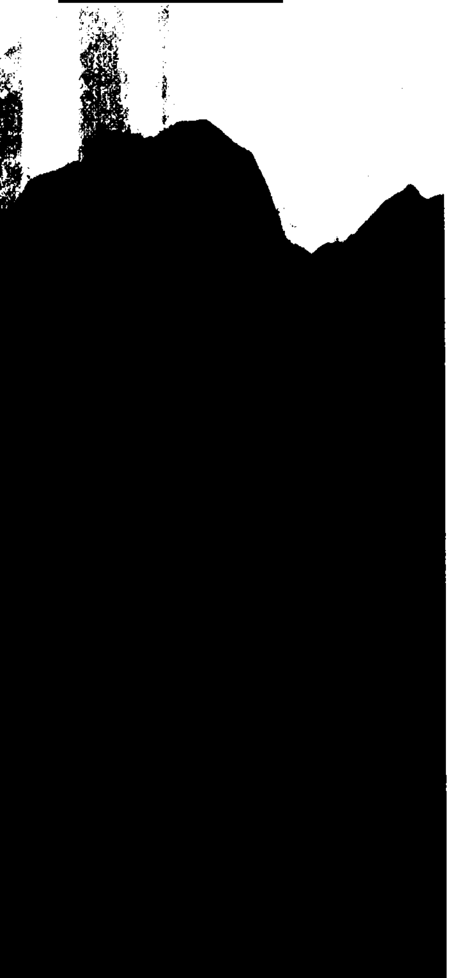
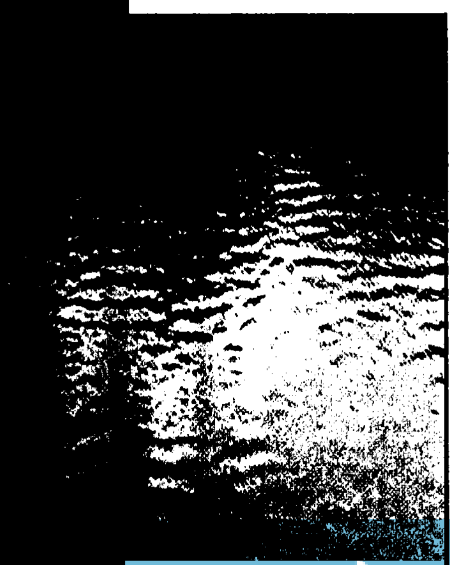


BY AVINASH S. PATWARDHAN, DOUGLAS BAUGHMAN, ADITYA TYAGI, AND JARED THORPE

Developing and implementing a TWM strategy—approaches and examples

TOTAL WATER MANAGEMENT OFFERS THE STEWARDS OF THE WORLD'S WATER RESOURCES A WAY TO BALANCE AND MEET MULTIPLE NEEDS.

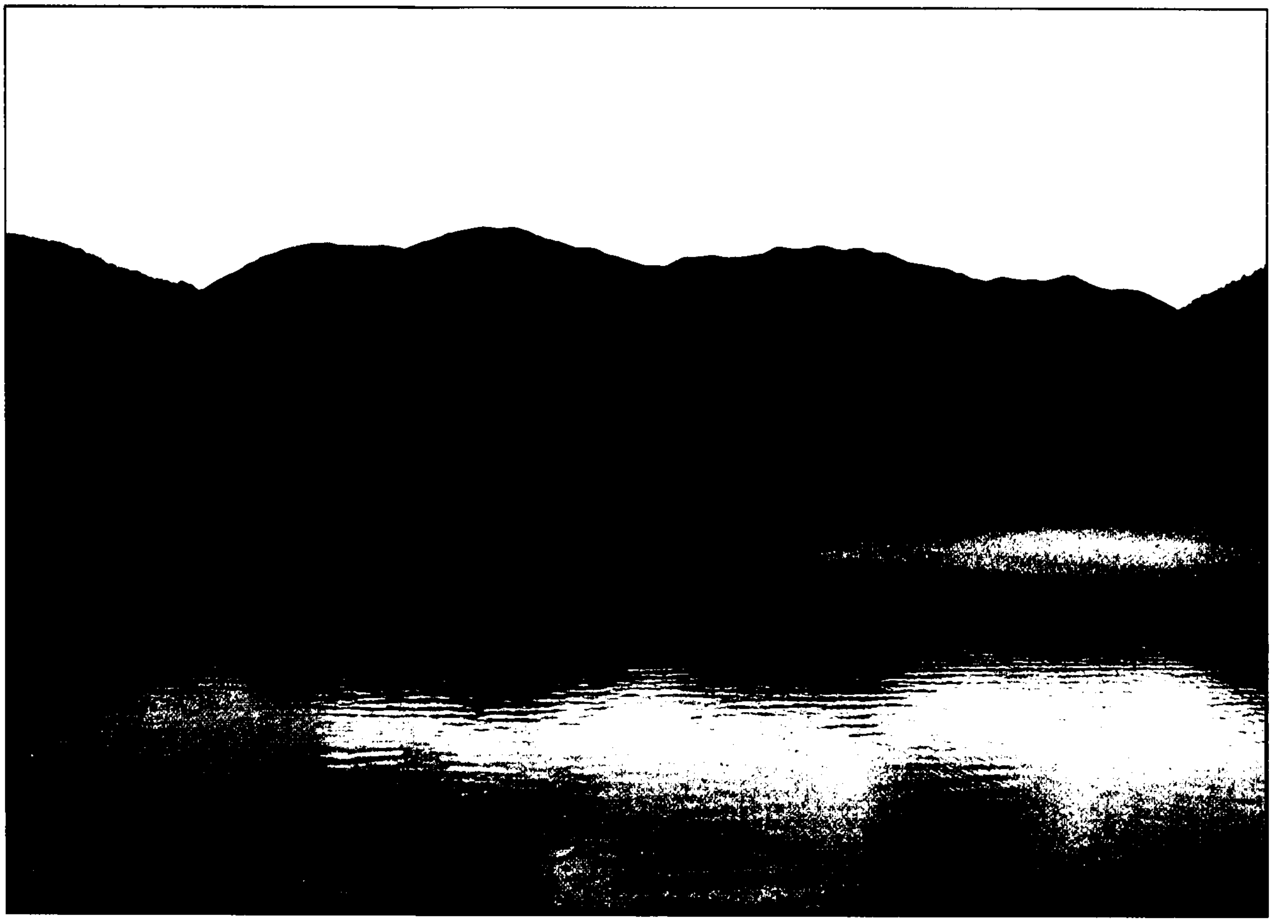


Water is an essential element of sustainable development and also poses its own development challenges. How countries overcome these challenges and meet the water needs of people, industries, and ecosystems depends on their situations and development priorities. To optimize the contribution of water to sustainable development water managers must consider the numerous and complex links among activities that influence—and are influenced by—water development and management. In addition, they need to create strategies to encourage more efficient use of water as a limited resource. To address these issues, more water managers are moving toward integrated water resource management approaches such as total water management (TWM). This article highlights TWM principles and precepts as used in two venues: the Tianjin Economic Development Area in China and the Metropolitan North Georgia Water Planning District in Atlanta.

COMPLEXITY OF WATER MANAGEMENT REQUIRES TWM

As communities expand, managing water resources becomes increasingly complex. Growing demands for water supplies intensify the need for new sources, conservation, and reuse. At the same time, from a watershed perspective, environmental needs are often considered to compete for water resources. Predicted climate change will only create further complications.

The interrelationships among the elements of the terrestrial water cycle and the complexity of water management—including source, supply, demands, treatment, and reuse—create significant challenges for water managers, who already must meet increasing demands while containing or



Total water management, which takes into account economic, environmental, and social considerations, can minimize detrimental effects resulting from utility operations such as withdrawals from surface sources such as lakes and rivers.

reducing system capital and operating costs. Decision-making priorities often focus on critical issues at specific points in the water management cycle, such as changing reservoir operations to provide flows for environmental purposes, adjusting the flow management regimen at a treatment facility, or dealing with the effects of discharging treated effluent for downstream users. However, management decisions based on only a single point or component in the water management cycle can have unexpected consequences elsewhere.

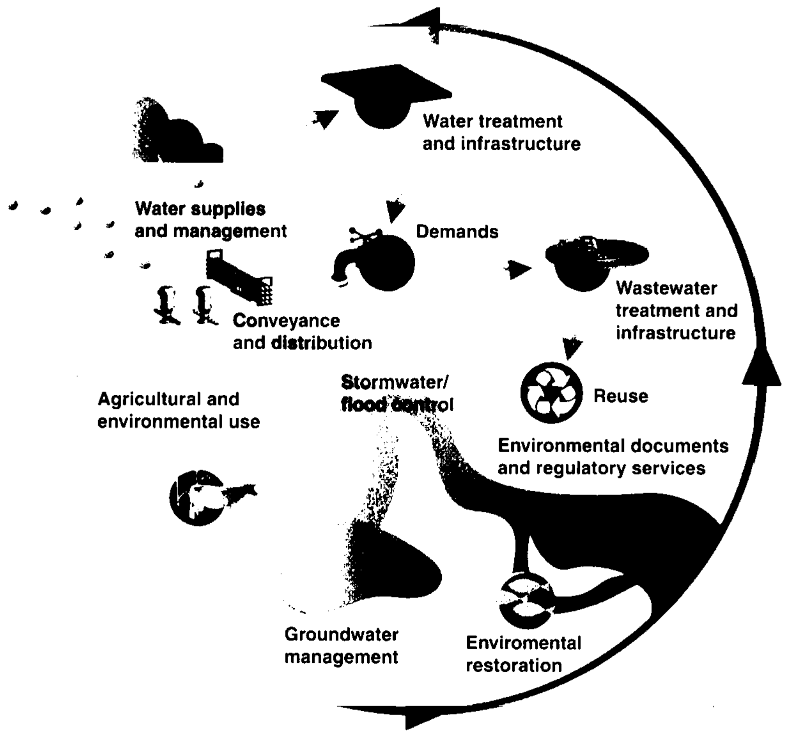
A TWM perspective is essential to ensuring that the entire system is managed as a whole, thereby providing for a long-term, sustainable water supply. TWM takes into account the triple bottom line—economic, social, and environmental considerations—and approaches sustainability from the bottom up rather than top down, creating stakeholder involvement, which in turn bolsters acceptance of water management decisions.

Water managers must weigh numerous factors. Meeting water resource and environmental needs for the future presents challenges and opportunities. Wise use of water resources is essential for environmental stewardship and economic prosperity. The factors that today's water managers must consider include

- ensuring water supplies that are sustainable and of appropriate quality;
- developing collaborative relationships with stakeholders (including local governments, state and federal agencies, and local citizen groups) for efficient use, protection, and restoration of natural resources;
- safeguarding the security and health of communities;
- fostering public involvement and support in developing politically, technically, and financially acceptable solutions; and
- identifying and mitigating hazards, both those caused by natural and human actions.

The TWM method integrates management of the terrestrial portion of the hydrologic cycle (which excludes atmospheric processes), land use practices, and related resources to attain equitable economic and social solutions while promoting ecosystem sustainability. TWM applies knowledge from various disciplines, as well as insights from diverse stakeholders, to devise and implement optimal, efficient, equitable, and sustainable solutions. Essentially, TWM is a problem-solving approach to

FIGURE 1 Total water management—a holistic approach



address key water resource challenges in ways that are economically efficient, socially equitable, and environmentally sustainable. Figure 1 shows the holistic concept that is the essence of TWM.

Seven principles lay the foundation for TWM planning. The TWM planning process is guided by these basic principles:

- Consider all water sources (including wastewater, seawater, and stormwater) in water resources planning, and base management on the terrestrial hydrologic cycle.
- Account for sustainability and equity in water resources.
- Account for all the end users of water within the planning area.
- Account for water quantity and quality for all components of the ecosystem.
- Give stakeholders a voice in water planning and management (i.e., bottom-up approach).
- Make TWM decisions at the local and river basin levels in line with (or at least not in conflict with) the achievement of broader regional and national objectives.
- Develop TWM strategies that are integrated into broader social, economic, and environmental goals.

As water quantity and quality have declined in populated areas of the world, more and more local and regional governments have taken a broader look at water resource management. Although the driver for TWM typically is water supply, in some cases the potential constraints on wastewater treatment and discharge associated with existing water quality problems—such as total maximum daily loads (TMDLs)—have required water managers to address stormwater more proactively. Application of TWM can range from simply considering more efficient capture and treatment of stormwater for water supply to fully integrated plans for water supply, wastewater treatment, and stormwater management. Development of a fully integrated TWM plan requires a flexible yet defined process to ensure that the recommendations are sustainable, meet local and regional goals, and are acceptable to local stakeholders.

In addition, as this process is expanded to a wider and wider group of stakeholders, the two primary barriers to sustainability—political boundaries and political will—begin to be addressed. The inclusion of a broad range of participants can assist decision-makers in maintaining the course of action that has reached consensus among the stakeholders, i.e., sustaining political will. A more diverse group can also cross political boundaries and assist in reducing this barrier as well.

TWM PLAN ENCOMPASSES SIX ELEMENTS

Element 1: Define goals, objectives, and alternatives. Effective, implementable policy can result from rigorous definition of goals and questions, appropriate analysis, application of critical thinking skills, and adoption of an integrated approach to water management that considers water supply, wastewater, and stormwater management as a single system. The process should include a comprehensive and rigorous identification of all options to meet the defined service levels, including options based on nonasset solutions. Goal development should be an iterative process that balances service needs with infrastructure, operations and maintenance (O&M), financial, and environmental options. Nonasset solutions, full life-cycle costs, risk, and maximization of existing infrastructure capability should be considered before a decision is made to construct new assets or replace existing ones. Such a decision can be accomplished through a series of interactive workshops with key staff from the utility or agency that is responsible for the project. Evaluation criteria for project success are developed at the same time and subsequently used to evaluate an alternative's ability to meet a stated objective.

Element 2: Perform data collection and analysis. The foundation of any study is the type and quality of information used as the basis for decisions. Thorough, complete, and accurate technical data affect every task, including development of problem-definition statements, alternatives analysis, and conclusions. To ensure the relevance of the data used, participants need to consider whether data are necessary and sufficient to guide decision processes. Executed appropriately, data collection includes those data that are essential to guide clearly defined decisions to achieve goals (and are sufficient to do so). Appropriate data collection does not include extraneous data, i.e., information not directly relevant to decision processes. Inclusion of what often are referred to as "nice to have" data can cloud decision-making.

Because the ability to easily manipulate the information gathered is just as important as the quality of information, data management should be an integral part of any project. The objective of data management is to collect all pertinent existing data for the system and make these data available for subsequent tasks. In order for available data to be used efficiently, a framework to store, retrieve, and analyze the data must be in place. Data collected and generated during the various project tasks can be most effectively managed using a geographic information system that allows efficient data analysis.

Element 3: Evaluate and select alternatives. Complex decision-making situations with numerous important variables or in which the costs or consequences of failing to select the best alternative are high call for a more refined prioritization process. In this high-end process designed to bolster decision support, weights for decision criteria and point assignments are used to score the candidate options that are more refined and specifically defined. These scores can then be applied to create cost–benefit comparisons and other outputs that can in turn be used to aid alternatives evaluation and phasing of selected projects into an implementation plan. Alternative selection and development involves four steps: (1) identifying alternatives, (2) screening and ranking alternatives, (3) analyzing costs versus benefits, and (4) prioritizing solutions.

Before water management solutions are developed, any applicable structural and management alternatives must be identified for consideration. Information obtained from the environmental impact assessment (EIA), social impact assessment (SIA), and stakeholder communications efforts should be used to assess the most significant problem areas to be considered for corrective actions. The evaluation criteria should focus on economic, environmental, and social effects to identify alternatives that have the best chance of implementation. Consideration of these major factors provides a systematic and sound basis for decision-making. Figure 2 summarizes the various criteria that influence decision-making and alternatives selection.

Element 4: Develop or select models to perform TWM analysis. Because data and information regarding the watershed are often limited, various tools (such as computer models) are used to analyze current conditions and evaluate alternatives to meet future water resource management

Wise use of water resources is essential for environmental stewardship and economic prosperity.

FIGURE 2 Typical evaluation criteria

Environmental impacts
- Soil erosion, geology
- Disruption to wetlands and/or floodplains
- Forest impacts
- Air and water quality

Social impacts
- Changes in developmental patterns
- Resettlement consequence for people

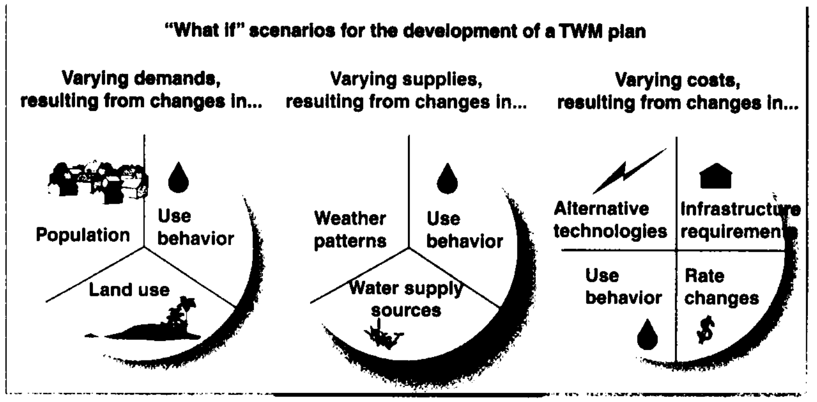
Operability, reliability, flexibility
- Performance record
- Ease of operation and maintenance
- Expansion capability

Energy, human, and natural resouce demands
- Energy consumption
- Manpower requirements
- Land area requirements

Construction concerns
- Conflicts with existing utilities
- Easements required
- Depth of excavation and groundwater
- Traffic effects

Decision-making and alternatives selection should be based on a set of criteria established with stakeholder input.

FIGURE 3 "What if" scenarios provided and evaluated by the modeling and simulation program



TWM—total water management

needs. This evaluation is an iterative process to ensure that the most suitable combination of measures is identified. To achieve this, potential water sources from within and outside the project catchment are typically quantified, and alternatives to protect water quantity and water quality are then developed. The first and perhaps most important step in any modeling development task is to clearly define modeling objectives and outcomes. This aids in selecting the appropriate model or, in some cases, determining that no model is needed because the solution is obvious (e.g., the only source of water available is from a neighboring lake or reservoir that has excess capacity and can provide the water).

A modeling and simulation program[1] is available that provides a platform for evaluating and recommending best alternatives in successfully developing a TWM plan. Advanced optimization algorithms in the model identify the best resource management strategies on a watershed-wide basis. Water managers can use the model to analyze various "what if" scenarios, as shown in Figure 3.

Element 5: Conduct impact assessment and solicit stakeholder participation. Impact assessment is the holistic application of a project's EIAs and SIAs to ensure that TWM plans are both environmentally responsible and address potential socioeconomic issues such as job displacement. This process provides the policy formulators and decision-makers with an integrated understanding of the environmental and social implications of the TWM plan. Impact assessment should include an initial assessment phase, baseline review, formulation of evaluation criteria, identification of key environmental issues, and formulation of the planning scenarios in the overall TWM plan.

For example, the EIA provides an environmental perspective and could examine various project alternatives including alternative wastewater treatment technologies, such as constructed wetlands; alternative sites for project facilities, alternative uses of treated effluent, including reuse; and estimated environmental improvements and negative effects of each alternative. Examples of social attributes that should be used to assess each of the problem areas include the effect on the local community, including demographic changes; effect on economic status; human health effects; effect on traffic patterns; and resettlement and rehabilitation issues.

Stakeholder involvement is essential to the successful implementation of a TWM project and should be used throughout its development. Buy-in by key stakeholders will help secure acceptance of solutions for complex water supply problems and the distribution of cost responsibili-

The interrelationships among the elements of the terrestrial water cycle and the complexity of water management—including source, supply, demands, treatment, and reuse—create significant challenges for water managers already tasked to meet increasing demands while containing or reducing system capital and operating costs.

ties to implement these solutions. The decision process—developed and coordinated with stakeholders, utilities, and other agencies—should ensure alignment of water supply plans with policy goals, rank strategies on the basis of specific performance measures, account for inherent uncertainties and effectively manage risks, and provide a readily audited, defensible documentation of decision-making.

Effective stakeholder programs incorporate options for both education about the water resource issues and involvement in the entire decision-making process. Various tools can be used to solicit participation and disseminate information among stakeholders:

- Organize stakeholder focus groups and workshops to assist in determining criteria, selecting alternatives, and making decisions.
- Disseminate information to stakeholders through such means as bill stuffers, fact sheets, websites, media advertisements, newsletters, displays, and kiosks.
- Solicit information and feedback from stakeholders through phone surveys, media advertisements, web-based comment forms, mail, one-on-one interviews, speakers' bureaus, or stakeholder committees.

Element 6: Develop implementation plan, monitor results, and establish institutional framework. A well-written implementation plan describes how the managers and other parties will work together to complete the proposed activities and meet the goals and objectives of the TWM plan. Items to be addressed in the plan may include policies, guidelines, and action steps on how the TWM plan will be completed; a schedule outlining the completion date, end results, resources needed, and contact person or agency; short-term, visible activities that create public awareness and interest; and management practices that have been evaluated for effectiveness, cost, maintenance, useful life, adverse effects, and public acceptability. Defining indicators of success or progress, establishing benchmarks, and setting up mechanisms to ensure ongoing monitoring and evaluation are all key activities in any successful TWM plan to move toward integrated problem-solving. Monitoring and evaluation activities have three main objectives: (1) to keep the implementation process on track, (2) to measure both short- and long-term effects, and (3) to evaluate effects to determine whether actions are indeed contributing to the larger development goals.

Funding of major items (capital and O&M) and institutional funding are important elements of the implementation plan (Figure 4). These efforts often involve long-range plans and require careful consideration to ensure that key items identified are not unfunded or underfunded.

TIANJIN CASE STUDY ILLUSTRATES SUCCESSFUL TWM

China has many development zones attracting investment for industrial and high-technology projects. One of Asia's most successful development zones is the Tianjin Economic Development Area (TEDA) in Tianjin, China. Founded in 1984, TEDA is located at the center of the Bohai economic ring situated along the coast of the Bohai Sea, east and south of downtown Tianjin (Figure 5). The project vision is for TEDA to become (1) a landmark modern port and metropolis, (2) a processing and manufacturing center in north China, and (3) a base for manufacturing high-tech products and commercializing high-tech research findings.

Concurrent with development of its capital improvement program (CIP), TEDA sought to develop a comprehensive, broad-based water supply plan that reflected expecta-

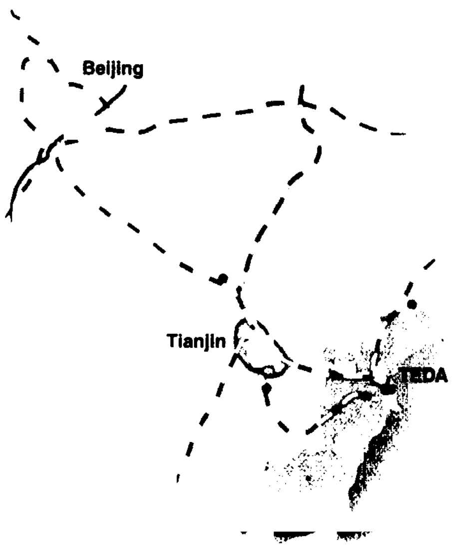
> Management decisions based on only a single point or component in the water management cycle can have unexpected consequences elsewhere in the cycle.

FIGURE 4 Implementation plan includes financing of integrated initiatives

Major funding (capital and O&M)	Institutional funding
Need for water resource development and infrastructure: • Pipelines • Storage system • Irrigation • Water treatment plants	Examples include: • Policy work • Law making or regulation development • Institutional and governance reforms • Development of management instruments • Capacity-building

O&M—operations and maintenance

FIGURE 5 Capital improvement program planning area for Tianjin, China



TEDA—Tianjin Economic Development Area

tions for future demand as a result of economic and population growth and competing needs for water sources while considering both conveyance and treatment costs of water supplies. The project team used the software model described previously to help choose the most cost-effective alternative for the CIP (CH2M HILL, 2005).

The model was applied to develop the most cost-effective CIP based on the shuffled frog-leaping algorithm, an advanced optimization procedure. This tool facilitated the development of a plan that satisfied both TEDA's potable and nonpotable future water demands. The optimization process considered the constraints of raw water availability from various sources, the timing of infrastructure development, and capital and O&M costs for both treatment and water conveyance in order to arrive at a cost-effective and implementable solution.

Model identifies optimal CIP plan. The computer model used in this project has been formulated so that simulations can be performed with and without optimization. Those who do not want to use the optimization must specify their own CIP planning scenarios. The model runs the plans, and the user can select the best CIP alternative. Those who want to use the optimization algorithm only have to provide user-defined CIP alternatives and criteria to initialize the model. The model then improves consecutive CIPs and terminates when the best solution is found.

Figure 6 shows a screen shot of the model's results for optimal water supply options for TEDA. Tables indicate both the timing and magnitude of additional water treatment facilities required and the amount of surplus water treatment capacity. The model consistently maintained surplus treatment capacity (i.e., never running out of treated water while expansions were being implemented) while identifying the most cost-effective combination of facilities.

Figure 7 plots cost versus a number of solutions. This figure shows how optimization helps find the most economical solution for a given system. In TEDA's case, the savings were more than 40% compared with the original plan. It is clear from this plot that a significant amount of money can be saved by using the optimization techniques when developing CIP plans for a given region or city.

CIP recommendations summarized. The CIP was developed by evaluating and analyzing future growth within the industrial park and then providing a cost-effective solution that identified the sources of water supply that should be developed to meet TEDA's emerging needs. The water demand projections made by the Tianjin Urban Planning Institute were 275 Lpcd for residential domestic water

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use, 20,000 m^3/d per km^2 for industrial water use, 10,000 m^3/d per km^2 for large public facilities water use, and 15% of total demand for unforecast water use.

By 2020, the total water demand in the Tianjin area will reach 750,000 m^3/d. Model results indicated that stormwater and wastewater reuse, combined with groundwater development, would provide significant cost savings while meeting TEDA's future needs. For the chemical and ocean industrial zones, as well as the residential areas, recommendations included increasing the ratio of reuse water and promoting water reuse in regions that are short of water resources.

Conclusions for case study 1. Successful CIP development should evaluate all water sources available to meet current and future demands. Sustainable and cost-effective solutions can be developed only by considering and developing solutions using the TWM concept of a systemwide solution. On the basis of current knowledge of water supply sources in the Tianjin area, optimization analysis recommended that the groundwater source should be used and dedicated to the potable water distribution system. This process provides a more suitable supply at lower cost and with better protection of public health. The remaining water demand should be supplied by use of the Luan River and/or the South-to-North Aqueduct to the extent possible. Regardless of which water source is selected and used, plans should be made to use treated effluent from the wastewater treatment facilities to the maximum extent possible, given that nonpotable water makes up almost 80% of total water demand in the area.

Data collected and generated during the various project tasks can be most effectively managed using a geographic information system that allows efficient data analysis.

TWM HELPS GEORGIA ACHIEVE WATER RESOURCE GOALS

To address the pressing need for comprehensive water resources management in the 16-county area of metropolitan north Georgia, the state legislature in 2001 established the Metropolitan North Georgia Water Planning District headquartered in Atlanta. The district is a planning entity dedicated to developing comprehensive regional and watershed-specific plans to be implemented by the local governments in the district. It includes 16 counties within the boundaries of 5 major river basins: Chattahoochee, Coosa, Flint, Ocmulgee, and Oconee (Figure 8). The legislation creating the district mandated the preparation of four plans to address (1) short-term wastewater capacity, (2) districtwide watershed management, (3) long-term wastewater management, and (4) water supply and water conservation management.

The integration of all three elements—water supply, wastewater, and stormwater management—provides consistency in how the district manages its interlinked water resources. By adopting an integrated approach to planning, the district is looking comprehensively at water supply and water conservation, wastewater and stormwater

FIGURE 6 Screen shot from modeling program showing both timing and magnitude of additional water treatment facilities required

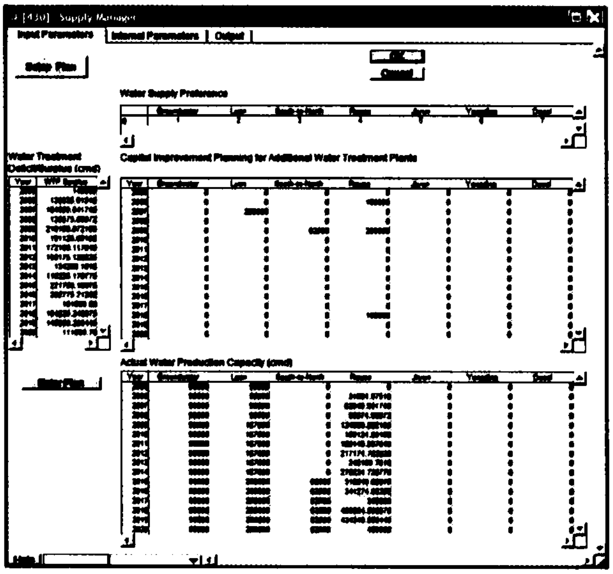
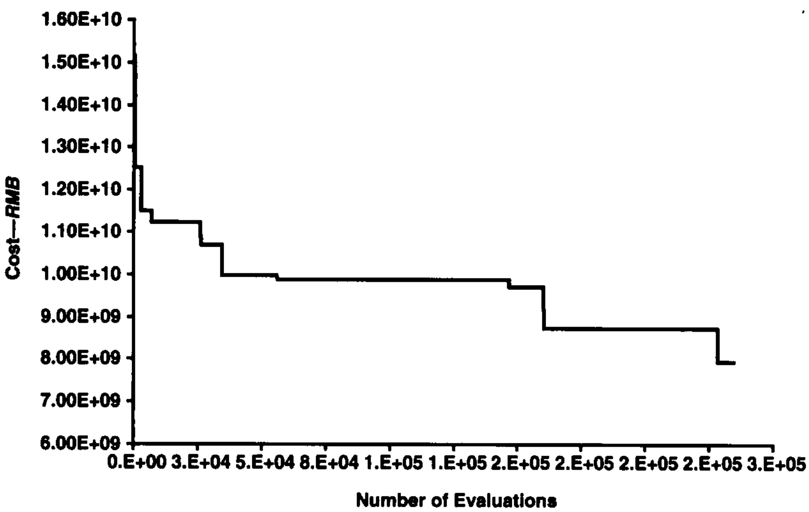


FIGURE 7 Optimal solution for the most cost-effective CIP for TEDA



CIP—capital improvement program, RMB—renminbi (Chinese currency), TEDA—Tianjin Economic Development Area

Total water management offers water planners and providers an approach to optimally manage the terrestrial water cycle and in so doing, develop equitable water management solutions.

management, and watershed protection. This integrated approach allows jurisdictions to consider all requirements related to water resources management in a holistic way, helping to avoid duplication of effort and improve the effectiveness of the recommended management measures.

Public involvement played a key role in the water management planning process and included participation by a technical coordinating committee and basin advisory councils. The law establishing the district defined the public involvement process and the configuration of the two stakeholder groups. More than 120 people were included in the six basin advisory councils, and more than 60 meetings were held during the planning process to obtain stakeholder feedback. Feedback from this diverse and extensive stakeholder group was used directly in development of the three water resource management plans and led to the successful approval of the recommendations by the district governing board.

Watershed management planning was a structured process. One of the main goals of the districtwide watershed management plan (WMP) was to develop a comprehensive and integrated 30-year regional plan to help the 16-county region meet water quality standards and remove streams from the 303(d) list, i.e., the list of impaired waters that the Clean Water Act requires all states to submit for US Environmental Protection Agency (USEPA) approval every two years (CWA, 2002). Other objectives included supporting TMDL implementation, providing water supply protection, addressing stormwater-related hydrologic changes and reducing downstream flooding, improving aquatic habitat and biotic integrity, and helping local governments meet the requirements for municipal separate storm sewer system permitting (Baughman et al, 2005; 2003).

The planning process used in developing the WMP was largely dictated by the legislation that established the district and called for development of integrated long-term management plans for watershed, water supply, and wastewater management. The planning process was closely coordinated among the consultant teams preparing the three long-term plans. The overall framework for watershed management is shown in Figure 9. WMP development involved seven key steps that highlight interaction with the water supply and wastewater plans:

Development of policy goals. Goals for watershed management

Stakeholder involvement is essential to the successful implementation of a total water management project and should be used throughout its development.

were developed in coordination with the wastewater and water supply management teams to ensure consistency among water resource planning efforts.

Characterization of existing conditions. Available data and studies were used to evaluate the district's existing water quality conditions and define the key issues to address in the districtwide WMP.

Development of a water quality model. To estimate existing and future sources and loads of pollution, a districtwide water quality model was developed using the BASINS (Better Assessment Science Integrating Point and Nonpoint Sources) analysis system available through USEPA (2006).

Evaluation of best management practices, source water protection, and TMDL implementation strategies. Potential best management practices were evaluated for inclusion in the WMP. Source water protection and TMDL strategies were also evaluated to select the most effective strategies for the district's meeting watershed management needs.

Development and evaluation of watershed management alternatives. Results of the best management practice, TMDL, and source water protection evaluations were used to prepare recommended watershed management measures for inclusion in the districtwide WMP.

Preparation of the recommended WMP and implementation plan. Feedback on the draft management alternatives was used in the preparation of the preliminary recommended districtwide WMP and implementation steps.

Adoption of final WMP. The previous planning steps culminated in the districtwide WMP. The recommendations were evaluated against

FIGURE 8 Major river basins in the Metropolitan North Georgia Water Planning District

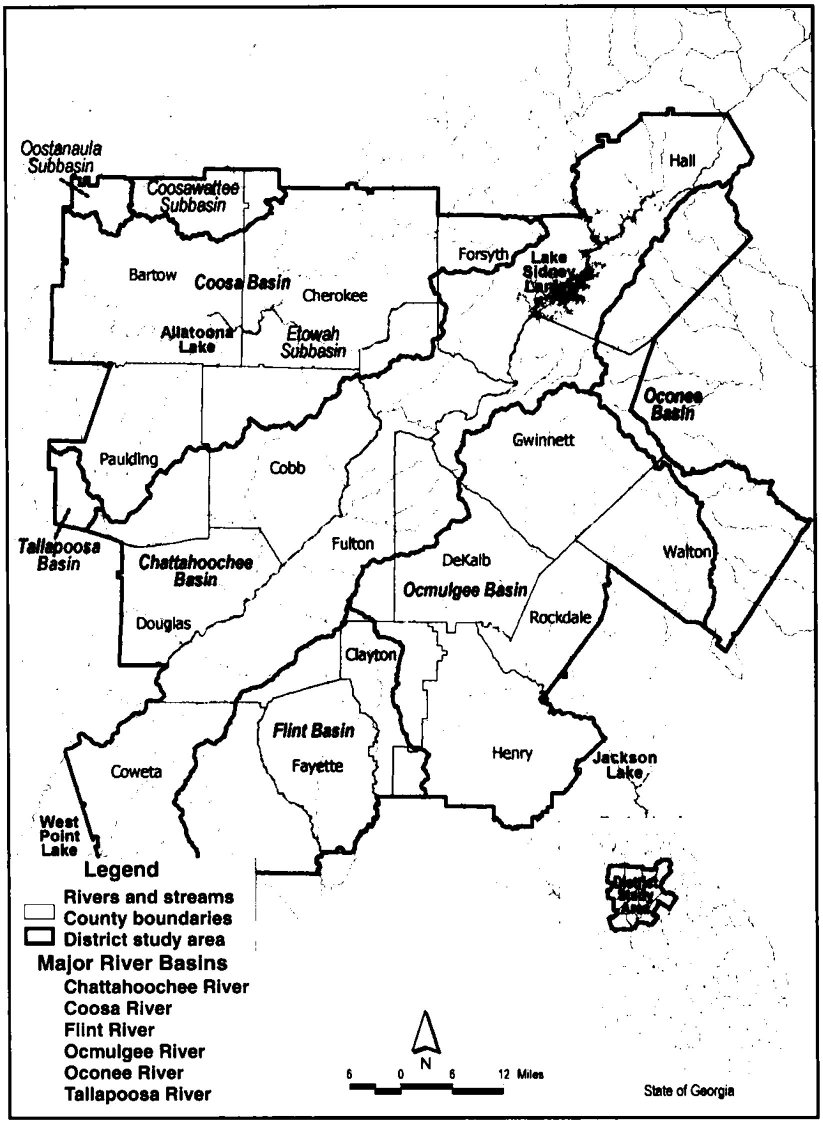
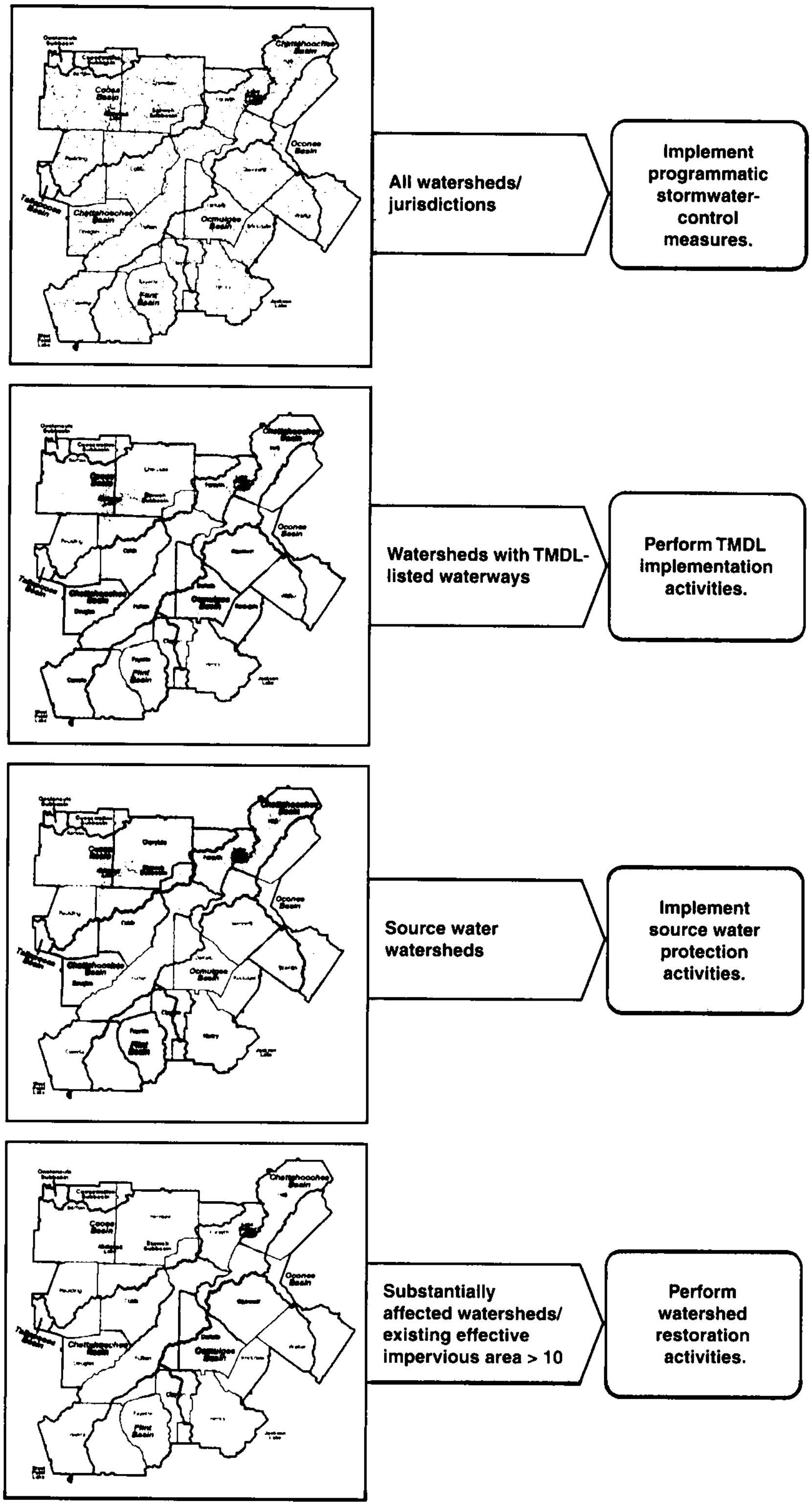


FIGURE 9 Watershed management framework



TMDL—total maximum daily load

the district policy goals and the Georgia Environmental Protection Division's planning standards to ensure that the final districtwide WMP met the goals for regional watershed management. After extensive public review, the draft WMP was revised, and a final WMP was adopted by the district board in September 2003.

Stormwater/watershed management recommendations summarized. The districtwide WMP addressed multiple objectives and regulatory requirements and offered recommendations for a number of watershed management strategies (CH2M HILL, 2003):

• Programmatic watershed management strategies include comprehensive watershed protection and stormwater management program activities carried out primarily at the local level.

• TMDL strategies specified management actions to address TMDL-listed waterways.

• Source water protection strategies were created to protect water supply watersheds.

• Watershed improvement strategies established a process for addressing substantially affected watersheds through the development of a watershed improvement plan specifying necessary restorations and retrofits.

• Land use strategies offered land use and zoning approaches for local governments to use in meeting watershed management and protection goals.

• Basin-specific strategies addressed specific management issues for each major river basin in the district.

• Model stormwater management ordinances were developed to complement the WMP and foster consistency as local governments implemented stormwater management.

Water supply recommendations summarized. The water supply and conservation management plan documented that the region's water demand is projected to double to approximately 1,200 mgd by 2030. To meet these needs, the plan recommended a combination of strategies and an emphasis on additional water conservation measures. Water supply needs will continue to be met by two major US Army Corps of Engineers reservoirs (Lake Lanier and Lake Allatoona) and several smaller community reservoirs. A regional approach to sharing water resources across the district was recommended to provide flexibility in meeting water supply needs in all five major river basins.

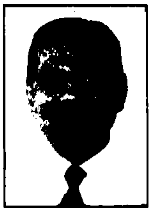
Wastewater recommendations summarized. The regional wastewater management plan was developed in close linkage with the water supply plan, with reuse of highly treated wastewater as a key component of the water supply plan. The district's wastewater treatment capacity needs are projected to reach 345 mgd by 2030. Key elements of the wastewater plan included consolidation of many existing wastewater treatment facilities, higher treatment standards and application of technologies to protect water quality, more intensive management of septic systems, and improved maintenance of sewer collection systems.

Conclusions for case study 2. Creation of the Metropolitan North Georgia Water Planning District provided an opportunity to develop integrated water resource plans using the concept of TWM in a rapidly urbanizing area. At a minimum, this legislatively mandated regional planning process gave local governments and the Georgia Environmental Protection Division a rationale for coordinating water supply, wastewater, and watershed management issues. Developing the WMP in parallel with the water supply and wastewater plans allowed local governments to better understand the connections between water resources and the need for a more comprehensive approach to regional planning.

SUMMARY

TWM offers water planners and providers an approach to optimally manage the terrestrial water cycle and, in so doing, to develop equitable water management solutions. An iterative process that focuses on developing strategies to address multiple watershed issues, TWM is flexible and can be used to create comprehensive solutions that protect valuable water resources and meet an array of beneficial uses and demands.

ABOUT THE AUTHORS



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FOOTNOTES

[1]VOYAGE™ modeling and simulation program (US Patent 7,103,479), CH2M HILL, Englewood, Colo.

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52 Aquatic ecosystem protection and drinking water utilities

Sandra L. Postel

Aquatic ecosystems provide irreplaceable benefits, including water supplies, food for people and wildlife, water purification and filtration of pollutants, flood and drought mitigation, even recreational opportunities. As the economic and ecologic services provided by aquatic ecosystems gain more recognition and the deleterious effects of mismanaging water resources become more apparent, the global water community is taking steps toward ecologically sustainable water management.

Because their operations have significant and far-reaching consequences for aquatic ecosystems, drinking water providers can play a major role in safeguarding the health of these systems. Strategies to protect aquatic ecosystems include reducing water demand through conservation, managing water within the bounds of an ecological flow prescription, planning for ecosystem allocation during drought, and protecting source watersheds. With urban populations growing and water demands on the rise, utilities must act now to ensure that the benefits provided by healthy aquatic ecosystems are available to future generations.—MPM

64 Developing and implementing a TWM strategy—approaches and examples

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Managing water resources has become increasingly complex, requiring water managers to balance the needs of people, industries, and ecosystems while ensuring the sustainability of finite supplies. At the local level, the integration of water supply, wastewater, and stormwater management is becoming more and more important to utilities. Total water management (TWM) offers water providers a holistic approach that depends on stakeholder participation and input to develop equitable and optimal water management solutions.

With water supplies for municipal and industrial uses increasingly stressed in terms of both availability and quality, it is clear that more proactive and comprehensive water resource management is necessary to ensure continued viable water supply sources. Using TWM and some of the more innovative approaches for optimizing water supplies can help ensure long-term water availability while providing significant cost-savings. Furthermore, by implementing TWM strategies, utilities are more likely to meet complex regulatory requirements.—MPM