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A New Paradigm for Water Management

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Abstract - In the future society will face daunting challenges to meet global water needs and sustain the environment, and to achieve this goal, a new paradigm is needed for the institutional and technical aspects of water management. The paper defines water management, states what the new paradigm should include, describes its component parts, discusses effectiveness measures, and describes case studies with wide-ranging management variables such as mix of players, geographic focus, purpose of water actions, leadership, financial responsibility, and nature of interdependencies. The cases show that in the United States issues of governance and control loom large in water management, and how the nation handles them speaks loudly about the health of democracy and citizen participation. These observations are transferable to other countries, depending on their political and cultural situations. Solving problems of coordination is an important feature of the new paradigm, and attitudes, learning, and investment are important in achieving this goal. More study is needed to determine how to implement the new paradigm, but society needs it to solve the problems of sustainable development.

1 - INTRODUCTION

Life is certain to be interesting in the 21st Century, and society will certainly face daunting challenges to meet global water needs and sustain the environment (World Bank, 1993). Achieving these goals is critical to reaching the ethic of sustainable development and improving society in every country.

Although technical advances such as aquifer storage and recharge, desalting, and water reuse will be required, the main challenges will be institutional—to establish correct policies, viable political institutions, workable financing arrangements, self-governing and self-supporting local systems, and a variety of other institutional arrangements (Frederiksen, 1992, Viessman, 1985, Grigg, 1996).

Anyone who studies water soon becomes fascinated with the many complexities and conflicts that surround these institutional issues, and you can find in the history of water management examples of old concepts or paradigms for them. Now, new paradigms are needed, and that is the topic of this paper. This new paradigm must be comprehensive and contain a number of elements because water management involves issues ranging all the way from technical practices to cultural approaches for dealing with sensitive decisions.

My goals in this paper are to define water management, state what a new paradigm should include, describe its component parts, and discuss how we can know if it is effective. Finally, I will give examples of how the paradigm can be applied.

2 – EVOLUTION OF PARAGIGMS FOR WATER MANAGEMENT

Alternative paradigms and definitions for water management have evolved over about the last 100 years. The pattern of their development varies in different countries, but general trends are discernible.

In the United States, there was little water development until after the Civil War, when, beginning about 1870, water development in the West began, mainly with irrigation projects. The nation also started to realize how important water is for industrial and urban development, and city waterworks and stream water wheels were constructed. In the 20th Century, water development started to take off. From 1900 to World War II, a number of reservoir projects were completed, both public and private. After World War II, construction of reservoirs continued until the pace slowed with the current regulatory era. You might say that 1900 to 1970 was the development era and 1970 to the present has been the regulatory era.

In the development era, the term “water resources management” mostly referred to facility development to meet limited-purpose economic goals such as hydropower and/or irrigation. Many Bureau of Reclamation and Corps of Engineer projects were built in this era.

As the nation developed, it became clear that water decisions involve many industries, geographical areas, and public interest viewpoints, and the possibilities of multiple purpose development became apparent, but coordination was mainly present in agency programs to build water projects.

The Depression, and its emphasis on public works to prime the economic pumps, gave increased attention to water development, and the National Industrial Recovery Act of 1933 called for a “comprehensive” program of public works to consider the full spectrum of water resources uses, which included, according to Holmes (1972): control, utilization and purification of waters, prevention of soil and coastal erosion, development of water power, transmission of electric energy, river and harbor improvements, flood control...” Some of the pork barrel image of water projects was set in these days.

After World War II, a Senate Select Committee on Water Resources was appointed. This led to the Water Resources Planning Act, first passed in 1962, which served to institutionalize the term “comprehensive planning.”

The period 1965-1980 was an active one in water resources planning. However, in this period shortcomings of the New Deal concepts of activist government involvement in water resources were brought to light. By 1981 the concepts of the Water Resources Planning Act were pretty much dead.

Today, the climate for the planning and decision process is more challenging than ever. Recent emphasis has been on tax cutting, regulatory reform, privatization, and other non-governmental initiatives. Rather than following a rationalized “comprehensive planning process,” proposals must pass a series of feasibility hurdles including technical, financial, legal, environmental, political, and judicial review. Environmental interest groups use national legislation and the courts to pursue their goals, states sometimes provide forums for coordination, national and state legislation set policy for decision-making, and interstate issues often involve complex negotiations. New emphasis on fish and wildlife and on species protection continues to render coordination more difficult. The process is worked out in the messy arena of participatory democracy, and no single person or agency has complete control of it, even for a single problem or issue.

Thus, in the United States, we passed from a development era to a regulatory era which features more public participation. It is much more difficult and time-consuming to implement water projects under this paradigm than before, but water decisions are more democratic.

In other countries, you see evolutionary patterns that depend on the political and economic situations in those countries, but in general, free countries are pursuing more democratic and balanced approaches than in the development era.

3 - ALTERNATIVE TERMS FOR PARADIGM

As we have moved toward a more democratic, balanced approach, a number of terms have come into use. Mostly, these terms attempt to capture the same elements of the water management paradigm, with some nuances.

“Water resources management” as a term has been in use for a long time and generally refers to the recognized discipline that water engineers and managers utilize. “Comprehensive water management” was coined to refer to an approach where everything is included. “Integrated water management” as a term is meant to capture the concept that concepts are linked and that interdependence is recognized (Mitchell, 1990). Kirpich (1993) introduced the term “holistic water management” to feature interagency coordination, top-down and bottom-up coordination, and linkage between water and agricultural policy.

From the energy field, we have the term “integrated resource planning” which has evolved to also serve the water utility industry. It does not appear to be comprehensive enough to solve broad water resource problems but the American Water Works Association (1994) offers it as a way “to mix demand-side and supply-side resources to provide long-term reliable service to utility customers at the lowest reasonable costs.”

AWWA itself sees the paradigm of "Total Water Management" as more responsive to these broad problems. I will explain this term later.

4 - DEFINITIONS

As many terms are in use, we must define our own to coordinate our discussion of a paradigm for water management. I will offer three levels of definitions:

For the first term, "water resources management," I have found that writers try to pack many concepts into it to make up a complex and cumbersome definition, thus I have tried to formulate a simple one: "Water resources management is the application of structural and nonstructural measures to control natural and man-made water resources systems for beneficial human and environmental purposes" (Grigg, 1996).

Nowadays, the term "integrated water resources management" has gained in popularity, and I define it as "a framework for planning, organizing and controlling water systems to balance all relevant views and goals of stakeholders" (Grigg, 1998).

The American Water Works Association (1996) has considered the need for a term to describe the complexities of water management and developed "Total Water Management." This term is rather comprehensive, and will be used later in the paper to outline elements of a water management paradigm. AWWA defines it this way: "Total Water Management is the exercise of stewardship of water resources for the greatest good of society and the environment. A basic principle of Total Water Management is that the supply is renewable, but limited, and should be managed on a sustainable use basis. Taking into consideration local and regional variations, Total Water Management:

Encourages planning and management on a natural water systems basis through a dynamic process that adapts to changing conditions;

Balances competing uses of water through efficient allocation that addresses social values, cost effectiveness, and environmental benefits and costs;

Requires the participation of all units of government and stakeholders in decision-making through a process of coordination and conflict resolution;

Promotes water conservation, reuse, source protection, and supply development to enhance water quality and quantity; and

Fosters public health, safety, and community good will."

These three definitions cover a wide spectrum, but do not, of course, exhaust the possibilities.

5 – ELEMENTS OF A WATER MANAGEMENT PARADIGM

These definitions reveal the elements or attributes of a management paradigm, and since the definition of Total Water Management is most comprehensive, it has been used as a starting point to identify elements for a suggested paradigm as shown on Table 1:

ELEMENT	OLD PRACTICE	NEW PRACTICE
Governance/ control		
▪ Authority	Command and Control, little regulation or participation	Distributed authority, coordinated approach, more regulation, more stakeholder involvement
▪ Regulatory structure	Weak regulations	Stronger regulations
▪ Central-ization	Centralized	Decentralized
▪ Process	Simpler, more authoritarian decision-making	Searching for new processes for coordination and conflict resolution

▪ Ownership	Mostly public ownership	More flexible approach, more privatization
Coordination		
▪ Geographic	Little basin or areawide coordination	Watershed and area-wide approaches
▪ Competing uses	Priority uses such as irrigation dominated	More complete consideration of competing uses, including environmental
▪ Purposes	Fewer purposes	More purposes
▪ Values	Focus on economic goals	Balances values with appropriate consideration of social and environmental values to go along with economic and political
▪ Stakeholders	Less involvement of units of government and stakeholders	Consideration of views of wide range of stakeholders
▪ Disciplines	Engineering dominance	Multi-disciplinary
Technical		
▪ Hydrologic	Focus on yield of hydraulic structures and systems	Focus on natural systems and sustainability
▪ Administrative	Simpler command-and-control administrative systems with less regulation and participation	Dynamic process adapting to changing conditions
▪ Legal	Water law focused on allocation with less emphasis on environmental issues	Extensive bodies of statutory, administrative, and case law
▪ Engineer-ing	Focus on structural solutions	Consideration of wider ranges of options to include non-structural and management strategies as well as structures
▪ Planning and assess-ment	Focused on economic issues	Extensive use of sophisticated planning tools to identify and assess alternatives throughout the planning and decision cycles
▪ Economic	Traditional benefit-cost analysis	Identifies full range of economic water needs and economic tools for use as incentives
▪ Ecological	Not very evident in water management	Identifies and considers full range of ecological water needs
Information Technology	Centralized control of limited information	Distributed control of much information on real-time basis
Financial		
▪ Fairness and equity	Not very sensitive to social issues	Considers social aspects of financial resources to provide appropriate solutions
▪ Feasibility	Less stress on ability-to-pay	Advances affordable options
▪ Subsidies	More subsidies	More market-based
Education and Ethics		
▪ Continued improve-ment	Not evident in old paradigms	enhances water quality and quantity
▪ Steward-ship	Weakly valued	Added emphasis on stewardship of water resources
▪ Sustain-ability	Not in old paradigms directly	managed on sustainable use basi
▪ Contribu-tions to society	Less emphasis on contributions to society	fosters public health, safety, and community good will
▪ Capacity-building	Little attention to capacity-building	More attention to capacity-building

Table 1. Elements of a Water Management Paradigm

Table 1 includes a few elements not found in the definition of TWM because the definition does not include issues relating to finance, assessment, law, and other tools and means. As you can see from the table, there are many alternative elements to the paradigm. For purposes of the discussion, I would like to focus on the following elements.

Governance and control. How water management decisions are made and water systems controlled reveals a great deal about the stages and health of democracy. It is much simpler to take the "water czar" approach, but a number of spectacular failures show the merits of a more participatory, decentralized approach. Also, more market-based approaches offer advantages. These things being said, we still have much to learn about how to effectively implement a decentralized, participatory, public-private approach to water management.

Coordination. If there is a single great challenge to water managers, it is how to coordinate effectively. As Table 1 shows, there are at least six facets of coordination: geography, water uses, purposes, values, stakeholders, and disciplines. Today, there is much more emphasis on balancing through coordination, and this is the reason for the statement in the TWM definition: "requires the participation of all units of government and stakeholders in decision-making through a process of coordination and conflict resolution." This decision-making must consider all of the facets of coordination in order to arrive at the best solution, and the decision-making thus integrates all of the considerations.

Technical features. In past years, water management was mostly an engineering and hydrology enterprise. Today, many more disciplines are involved. As Table 1 shows, these will include in addition, administrative managers, lawyers, planners, economists, and ecologists, to name just a few. The technical features of the paradigm is the place where different disciplines can make their separate inputs prior to the integration process which occurs in decision-making.

Information technology. As we all recognize, information technology has come a long way as a management tool. What we must also realize is that information technology changes society, just as society adapts IT to its own uses. In the field of water management, this means that there is much more potential for data sharing, for use of GIS, and for implementation of other information technologies that can change the way we work together.

Financing. In earlier times, the financial capacity of local government was much more limited, and water financing was largely done centrally. This is no longer the case, and in the United States for example, financial responsibility and government power are being devolved to state and local governments. So, the financial tool in water management has more possibilities than in the past.

Education - ethics. With the move toward democratization and local control of water, there is a concomitant need to educate citizens about the complexity of water issues. You can see this trend at work with the vast increase in locally-based programs for water management, such as our own "Children's Water Festival" which takes place at many locations in Colorado.

6 – EFFECTIVENESS TESTS

How do we know that these elements of a water management paradigm will make long-lasting improvements? If you examine the trends in the elements discussed in the previous section, you see that they require more local control and responsibility, more knowledge, more participation, more capacity on the part of all stakeholders, more use of information technology and financial tools, and more stress on education and imparting correct values to the water management enterprise. These are all positive trends which have been proved to contribute to a more positive society. Thus, by inculcating them into the water management paradigm, we would seem to create a more effective approach.

But are they doable? Or, are they visionary concepts that will not work? This may be the more important test, and I would say that the jury is out on this question, along with many other questions about trends in politics and society.

I think the bottom line about the effectiveness question is that more study is needed about the management paradigm to determine how much each attribute contributes to it. This was the subject of Adams (1998) recent Ph.D. dissertation, for example, and clearly, many questions still remain to be answered. Now, to examine how the elements are working out, I would like to discuss a few brief United States case studies that illustrate aspects of the paradigm.

7 - CASES

The cases are summarized in Table 2. As you consider them, please understand that they only examine the tip of the iceberg, because water management holds so many complexities that need to be studied. The case in Table 2 are arrayed according to my judgment of level of complexity (Grigg, 1998).

ISSUE	SCOPE	MAIN PLAYERS	ISSUES	LEAD ROLE	FUNDING
Ideal Water-shed	Water-shed Scale	Local water and power utilities, federal agencies, irrigators, recreation agencies	To coordinate reservoir releases, new facility development, and water management to minimize costs, conflict, and regulatory friction in a watershed.	Watershed council	Shared funds
Jam-aica Bay	Estuary in New York Metro Area	City, federal agencies, local interests in New York	To develop comprehensive water quality plan for 25 square miles of water, wetlands, and lowlands within New York City, to link six environmental and urban objectives	City of New York	Fed-eral and city govts
Vir-ginia Beach Water Supply	City and region near Virginia Beach	Va. Beach, two state governments, water utilities in region, federal agencies, federal court	To provide water supply for large, growing city, to resolve interbasin, interstate water transfer issue with many players and issues	City of Virginia Beach	City and rate-payers
Two Forks	Denver Metro Region	Denver Water Dept, local water utilities, federal agencies, Governor, environmentalist s	To provide water storage for metro region in face of environmental protests, to organize coordinated regional project, deal with disputes over impact and need for water supply in western context	Denver Water Depart-ment	Local water utilities
Albe-marle-Pamli-co Sound	Large estuary in coastal area of North Carolina, largely rural	Regional cities, county governments, industries, two state governments, federal agencies	To resolve serious estuary water quality and fish problems, to achieve agreement among states, local governments and industries about policies	NC State govern-ment	Federal and state govts
Platte River	Platte River in Nebr aska	Local irrigation and power districts, FERC, state governments, environmentalist s	To relicense hydropower projects and resolve disputes over endangered species, to coordinate studies, negotiations, court actions and a recovery plan	Coalition led by Federal agency	Federal state govts, districts
Cali-fornia Bay-Delta	Large scale Bay-Delta Region in Cali-	Federal, state, local agencies, water users, environment-alists	To balance urban, agricultural, environmental water uses, and water quality for 19 million Californians, to	CALFED	Federal state agencies

	fornia.		achieve best mix of policies, understand complex system		

Table 2. Case studies to Illustrate Aspects of Water Management Paradigm

Idealized watershed. Consider an idealized watershed with multiple players and goals of water management. Such a watershed was imagined nearly fifty years ago by the President's Water Resources Policy Commission (1950), and included as the frontispiece of their final report. Today, there is much interest in managing water according to a watershed basis, of course. The main issue is to organize the players to achieve coordination in building, operating, and paying for water facilities. In this idealized situation, a central body would collect funds to coordinate tasks; stakeholders would cooperate to solve shared problems and make decisions on reservoir releases; new facilities or changes in water use would reflect balance in all views; and regulatory authorities would coordinate health, environment, reliability, and cost of service without heavy-handed "command-and-control" approaches. Information technologies would provide shared information for management. Such an idealized case would reflect most elements of a new paradigm.

Jamaica Bay. Jamaica Bay requires a management plan for 25 square miles of water, wetlands, and lowlands within New York City (Wagner, 1995). The coordination framework was the Jamaica Bay plan which linked six environmental and urban objectives and while the work was under the control of a single entity, the City of New York, the participants considered the work "integrated." Extensive public involvement was utilized and the team believes that the approach offers potential savings of 50% of a $2 billion plan. Leadership was by the city, apparently using extensive stakeholder involvement.

Virginia Beach Water Supply. The City of Virginia Beach grew rapidly after World War II, and by 1983 had developed a plan for a 60 million gallon per day interbasin diversion for water supply from Lake Gaston in the Roanoke River Basin. Virginia Beach needed the cooperation of North Carolina and a number of federal agencies to gain permission for the pipeline. The two states had a bi-state committee to discuss water issues, and progress was apparent, but politics interfered, and North Carolina announced opposition to the project. This led to a long conflict which lasted for about 20 years (Walker and Bridgemen, 1985). This is an example of what can go wrong in water management today. Virginia Beach had to undertake the project in a hostile environment, fighting rather than cooperating with stakeholders. Lack of the integrated approach was costly.

Two Forks. In the Two Forks example, the Denver Water Department, joined by suburban water agencies, initiated planning for a joint water supply project (Adams, 1998; Grigg, 1996). Initial integration was attempted through negotiation, a Governor's water roundtable, and personal political work. The joint project seemed a triumph for regional cooperation and negotiation, but in 1992 environmentalists, who had participated in the planning process, convinced EPA to veto it. This threw the planning process into turmoil in spite of an environmental study that cost over $40 million. Two Forks had some leadership for integrated water management, but the process failed. Ultimately, ratepayers picked up the bill for the expensive planning process.

Albemarle-Pamlico Sounds. Albemarle and Pamlico Sounds, located in northeast North Carolina, have serious environmental and water quality problems requiring regulatory actions (Grigg, 1996). I was involved with others in 1979 on a plan to reduce pollutant loads, but a stumbling block was lack of agreement among the states, local governments and industries about the solutions needed. More recently, the region has been studied via the Albemarle-Pamlico Estuarine Study (1988), and environmental conflicts continue. Leadership is by state authorities. However, there is no mechanism for sustained attention to the integrated set of issues, other than the regulatory process. Unfortunately, players enter and leave this process without preserving much long term institutional memory. Payment has been via federal and state environmental program funds and federal estuarine study funds.

Platte River. The Platte River Basin example involves a long term effort to relicense hydropower under authority of the Federal Energy Regulatory Commission (FERC). Endangered species issues have resulted in studies, negotiations, court actions and a recovery plan. In 1994 and 1995 a federal-state negotiating group worked to seek joint plans and actions, and in 1997, a three-state accord was signed by Colorado, Nebraska, and Wyoming (DeSena, 1997). In this case, integrated management required federal intervention to coordinate negotiations, and the Secretary of Interior also signed the agreement. Paying for the cooperative agreement will involve $2.5 million in

federal funds and $1.8 million in state funds over the next three years. Of course, whether this agreement will work is still unknown.

California's Bay-Delta. California's "Bay-Delta" illustrates a very complex regional water management scenario, all in one state. According to Brickson and Sudman (1990), the issues are: balancing urban, agricultural, and environmental water uses; water quality and salinity standards; water for striped bass and salmon; water quality for 19 million Californians; flood protection and levees; and managing harmful flows such as from pumping actions." There are many issues, and a special coordinating mechanism, CALFED, has been formed. CALFED is "the joint state-federal planning organization created in June 1994 to provide more coordinated action in the Bay-Delta" (McClurg, 1996). CALFED is taking leadership in integrated water management. It is being paid for by federal and state agencies. However, "... it is not in either the state or federal budgets as a separate agency and does not have a definite source of revenue (McClurg, 1996b).

8 - CONCLUSIONS

The cases presented variables with wide ranges, such as mix of players, geographic focus, purpose of water actions, leadership, financial responsibility, and nature of interdependencies.

For example, Bay-Delta is a large-scale region, in a single state, with many interdependent water issues. Without the federal and state agency forum to resolve interdependent issues, it is hard to see how progress could be made outside of the dispute resolution process. This is a good example of the distributed authority attribute of the new paradigm.

Two Forks was a regional water supply effort that failed in spite of integration efforts that included a governor's roundtable and an EIS. Environmental goals conflicted with growth pressures, and Colorado water law, based on the appropriation doctrine, requires court action over water rights to resolve many interdependent issues. Perhaps this case shows the many aspects of the process required in a new paradigm, and how values can be balanced ultimately, albeit with great expense to ratepayers and taxpayers.

The Platte River example involved interstate as well as intrastate issues. Producing an agreement among the states was difficult and involved a three year negotiation process. The jury is out on whether it will work. The case illustrates geographic coordination, stakeholders, balancing, and distributed authority.

Albemarle-Pamlico and Virginia Beach are linked issues, and represent another large scale region with integration occurring through the regulatory and dispute resolution processes and with education of citizens who ultimately need to implement many best management practices.

Jamaica Bay involved a single metro region and seems to be a simpler, but apparently successful case. Control was within the realm of one main entity, the City of New York, and they had federal incentives and support for environmental investments. The case illustrates decentralization and involvement of stakeholders.

The idealized watershed case was much simpler than any of the real world examples, but it illustrated many of the elements of the new paradigm.

The cases showed that in the United States issues of governance and control loom large in water management, and how the nation handles them speaks loudly about the health of democracy and citizen participation. The "water czar" approach appears dead in the country, but at the price of a lot of friction and inefficiency in decision-making. The new paradigm provides abundant opportunities to solve the problems of coordination, and the cases illustrate that to coordinate properly requires the right attitude, learning, and considerable additional investment. Not only do a number of disciplines participate in the new paradigm, engineering does not dominate any longer. In fact, no discipline dominates; water management is a shared task.

The cases did not illustrate the power of information technology in shaping water management of the future, but behind the scenes, many models, data bases, and GIS systems are being used and they will surely affect the players. Similarly, little detail was given about the use of financial tools in water management, but water industry leaders speak a lot about the importance of finance. This also applies to education for citizen involvement in water issues—much is occurring, but the brief cases did not delve into it very much.

So, is the water management paradigm doable? More study is clearly needed, but it seems inevitable that if society is to be able to solve the problems of sustainable development, this paradigm offers a tool to help by improve how water is managed amidst the complexities and conflicts of today's world.

9 - **REFERENCES**

Adams, Alison, Analysis of Regional Water Conflicts: The Case Study Approach. PhD Dissertation, Colorado State University, Fort Collins, CO. Spring, 1998.

Albemarle-Pamlico Estuarine Study, 1988. Albemarle-Pamlico Advocate, Vol 1, No 1, Washington, N.C., July.

American Water Works Association, 1994. Integrated Resource Planning: A Balanced Approach to Water Resource Decision Making, Denver.

American Water Works Association Research Foundation, Minutes of Seattle Workshop on Total Water Management, Denver, Colorado, August, 1996.

Brickson, Betty and Ruth Schmidt Sudman, 1990. A Briefing on California Water Issues, Western Water, September/October.

DeSena, Mary, 1997. Governors Sign Three-State Platte River Agreement, US Water News, 14(8)1:1.

Frederiksen, Harald D., 1992. Water Resources Institutions: Some Principles and Practices, World Bank Technical Paper No. 191, Washington.

Grigg, Neil S., Water Resources Management: Principles, Regulations, and Cases, McGraw-Hill, New York, 1996.

Grigg, Neil S., Integrated Water Management: Who Should Lead? Who Should Pay? Journal of the American Water Resources Association, Submitted for Publication, 1998.

Holmes, Beatrice Hort, A History of Federal Water Resources Programs, 1800-1960, US Department of Agriculture, Economic Research Service, Washington DC, June 1972.

Kirpich, Phillip Z., 1993. Holistic Approach to Irrigation Management in Developing Countries, Journal of Irrigation and Drainage, ASCE, 119(2).

McClurg, Sue, Delta Developments, Western Water, January/February 1996, Water Education Foundation, Sacramento.

McClurg, Sue, 1996b. Building a Delta Consensus, Western Water, September/October, Water Education Foundation, Sacramento.

Mitchell, Bruce ed., Integrated Water Management: International Experiences and Perspectives, Belhaven Press, London, 1990, p. xiii.

President's Water Resources Policy Commission, 1950. A Water Policy for the American People, Washington.

Viessman, Jr. Warren and Claire Welty, Water Management: Technology and Institutions, Harper & Row Publishers, Inc., New York, New York, 1985.

Wagner, Edward O., 1995. Integrated Water Resources Planning Approaches the 21st Century, presented at the 22nd Annual Conference of the Water Resources Planning and Management Division, American Society of Civil Engineers, Cambridge MA, May 8.

Walker, William R. and Phyllis Bridgemen, 1985. Anatomy of a Water Problem: Virginia Beach's Experience Suggests Time for a Change, Virginia Water Resources Center, Special Report No. 18, Virginia Polytechnic Institute and State University, Blacksburg, Va., August.

World Bank, 1993. Water Resources Management: A World Bank Policy Paper, Washington.