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THE REGIONALIZATION OF WATER UTILITIES: PERSPECTIVES, LITERATURE REVIEW, AND ANNOTATED BIBLIOGRAPHY

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July 1996

This report was prepared by The National Regulatory Research Institute (NRRI) with funding provided by participating member commissions of the National Association of Regulatory Utility Commissioners (NARUC). The views and opinions of the authors do not necessarily state or reflect the views, opinions, or policies of the NRRI, the NARUC, or NARUC member commissions.

EXECUTIVE SUMMARY

Regionalization constitutes fundamental structural and institutional change in the way water and wastewater utility services are provided. Regionalization reflects structural change in terms of consolidating water utility ownership, operations, or management within a politically geographic or hydrogeologic area. Regionalization reflects institutional change in terms of establishing public policy and resource planning frameworks that encompass regional considerations. This bibliography provides a contemporary, broad-based, and multidisciplinary collection of works on regionalization in the water sector. Those contemplating regionalization for the first time may be impressed by the extent to which others have contemplated this issue as well.

This report provides a brief literature review and a lengthy annotated bibliography on the subject of regionalization in the water and wastewater utility industries. A comprehensive and iterative approach was taken in developing the literature database, which consists of books, reports, articles, and conference papers. Many important contributions to the literature are highlighted in the bibliography, which is organized into seven general areas:

1. Economic Analysis
2. Utility Operations
3. Natural Resources
4. Implementation
5. Policies and Institutions
6. Case Studies in Regionalization
7. General Planning and Administration

The water literature, defined here broadly, clearly speaks to the issue of regionalization in important ways. Emerging paradigms, especially watershed management, directly reflect regional perspectives. The literature is very *multi*disciplinary and gradually becoming *inter*disciplinary, as well as very international in character. The blending of scientific and institutional considerations in water

resource planning and management appears to be one of the more noteworthy trends. Taken as a whole, the studies in the literature find much agreement over the technical and economic benefits of regionalization, but frustration with the institutional context of implementation. As new approaches to regionalization are explored, the literature will grow.

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FOREWORD

Regionalization is a timely topic in water resources planning and management. Public utility regulators may find occasion to consider the implications of regionalization in the context of developing economic regulatory policies for the regulated water sector. This bibliography provides a comprehensive overview of the regionalization perspectives.

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THE REGIONALIZATION OF WATER UTILITIES: PERSPECTIVES, LITERATURE REVIEW, AND ANNOTATED BIBLIOGRAPHY

Introduction

Regionalization constitutes fundamental structural and institutional change in the way water and wastewater utility services are provided. Regionalization reflects structural change in terms of consolidating water utility ownership, operations, or management within a politically geographic or hydrogeologic area. Regionalization reflects institutional change in terms of establishing public policy and resource planning frameworks that encompass regional considerations. This bibliography provides a contemporary, broad-based, and multidisciplinary collection of works on regionalization in the water sector. Those contemplating regionalization for the first time may be impressed by the extent to which others have contemplated this issue as well.

Many of the authors represented in the bibliography offer definitions of regionalization:

> Regionalization refers to large, physically united systems or the coordinated management of two or more independent systems (American Water Works Association, 1979).

> Regionalization is the administrative or physical combination of two or more community water systems for improved planning, operation, and/or management. Regionalization should be viewed in the context of a range of possible approaches, from the actual physical interconnection of systems to an administrative and management arrangement to provide common technical, operational, or financial services for two or more systems (SMC Martin, Inc., 1983: III-1).

> Regionalization is the integration or coordination of the physical, economic, social, information, or personnel structure of water resource projects to better [address] national, regional, and local societal objectives and constraints (Whitlatch and ReVelle, 1990: 70).

> Regionalization is the consolidation of two or more water systems for the purpose of increased viability (Pennsylvania Public Utility Commission, 1995, as reported in Holland, 1995).

Emerging evidence, reflected in the case study literature, suggests a possible trend toward regionalization in the water industry, both domestically and abroad. Systematic and conclusive evidence of a trend toward regionalization is not readily available. A trend that is easier to document, however, is the growing literature on regionalization. Although not a new concept, regionalization seems to be getting increasing attention. Rapidly rising water costs have brought water system economies (or diseconomies) into focus. The interest in regional solutions also can be linked to the growing interest in closely related subjects, such as watershed management, integrated resource planning, and privatization.

Regionalization has been studied from theoretical, empirical, practical, and ideological viewpoints. Some studies of regionalization are highly scientific; others are more subjective. The literature leans heavily in favor of regionalization as the preferred approach to water industry organization. As a generalization, regionalization is believed to offer substantial economies of scale and scope, yielding efficiency benefits as well as ecological benefits through improved resource management. Support for regionalization comes from many corners. The literature provides not only very specific rationales for regionalization, but also specific strategies for implementation.

Two important caveats accompany this observation. First, from a technical standpoint, analyses found in the literature recognize limits to economies of scale. Bigger is not always better because economies in certain utility operations (such as source development and treatment) are offset by diseconomies in other operations (such as transmission and distribution). Second, from an institutional standpoint, studies in the literature also recognize the institutional tradeoffs involved in establishing regional water utility operations. Water utility operations historically have been very local, if not parochial, in character. Yet in many respects, existing institutions do not

adequately address the legitimate needs of communities to participate in water resource decisionmaking. The strong desire to maintain local control, therefore, remains a significant barrier to regionalization.

The purpose of this bibliography is not to fully explore or analyze these and other salient dimensions of the literature. Specific methodologies or findings are not evaluated or critiqued. Rather, the purpose of the bibliography is to expose readers to the larger context of regionalization and the full range of issues addressed in the literature, while highlighting some key findings of interest. The numerous contributions to this area, and the many vantage points represented, can help inform and guide decisionmakers as they consider the implications of structural and institutional change in the water sector. While no one publication has all of the answers, much can be gleaned from the collective works.

Approach

This report provides a brief literature review and a lengthy annotated bibliography on the subject of regionalization in the water and wastewater utility industries. A comprehensive and iterative approach was taken in developing the literature database, which consists of books, reports, articles, and conference papers. Scholarly and applied research, as well as select commentaries and popular pieces, are included. A conceptual typology was used to classify the multiple disciplinary and practical approaches to the subject. Extensive electronic searches of various library collections, using various keywords and keyword combinations (such as "watersheds" and "water and regional") were used to identify contributions from the many fields represented. The typology was revised in the course of the investigation as some topics merged and others emerged.

The bibliography errs on the side of inclusion rather than exclusion. One consequence is a certain amount of redundancy, although each publication contributes to the literature in unique ways. Some entries in the bibliography deal directly with the

issue of regionalization; others are included because they seemed to address a related concern or represent a relevant perspective. Only studies dealing strictly with technical issues (such as measuring regional rainfall or flooding) were excluded from consideration. Although the database surely is not complete in an absolute sense, especially since the literature on regionalization seems to grow with every journal's publication cycle, the works included are broadly representative of the several key perspectives. The summary discussions and annotations provide breadth of coverage, but not necessarily depth of understanding. Though not a fair substitute for the actual works, the report should provide readers with a thorough introduction to the literature and a resource guide for pursuing items of particular interest. Not every citation in the bibliography is annotated in detail. Brief abstracts or citations alone are provided for some works.

The categorization of individual works required a considerable degree of judgment (and a certain degree of frustration). Many contributions to the literature contribute substantially in more than one respect. One article, for example, may offer important technical evidence but equally important institutional insights. Another might present a theoretical argument while also providing a comprehensive case study. Some topical areas defined in the typology, such as watershed management, are distinctively multidisciplinary. As the analysis of regionalization becomes truly *inter*disciplinary (not just multidisciplinary), this trend will continue. Categorizing some works (such as those in the cost modeling and system modeling areas) was highly subjective. The choice of where to list a citation was based on the predominant theme of the work; a secondary criterion was the author's principal academic or practical vantage point. The result is a reasonable but imperfect grouping of complementary analyses. Readers interested in a particular topic are encouraged to scan the other topics as well for works that may be relevant to particular interests.

Organization

The literature review follows the organization of the bibliography. Seven general topical areas, and several specific areas within these broad categories, are used to organize the various bibliographic citations. The general categories in the typology are:

1. Economic Analysis
2. Utility Operations
3. Natural Resources
4. Implementation
5. Policies and Institutions
6. Case Studies in Regionalization
7. General Planning and Administration

As noted above, these categories are not mutually exclusive. Nevertheless, they provide a heuristic device for organizing and presenting the literature on regionalization. A brief introduction to each of the categories follows.

1. Economic Analyses. Economic analyses of regionalization focus on the potential efficiency advantages of regionalization. Many of these studies explore the hypothesis that water and wastewater services display one of the chief characteristics of monopolies, that is, decreasing unit costs of production with increasing output. Many important contributions to the literature, characterized as cost modeling, develop specific tools for evaluating water production economies. An area of emerging importance concerns markets and market value, both of which affect and are affected by regionalization.

2. Utility Operations. This second category builds substantially on the first, while expanding somewhat to include a general operational or systems engineering or systems perspective. Issues related to regional water or wastewater utility operations are considered. System modeling, which sometimes includes economic and engineering variables, is included here. Finally, the fairly well-defined literature on

small water utilities is placed under this category because of the special concerns associated with small system operations.

3. Natural Resources. A natural resource perspective views water and water-sector utilities in a larger and long-term ecological or ecosystem context. Water quality and quantity issues, and their interrelationships, are paramount. Regionalization is viewed primarily as a potential tool for more effective water resource planning and management. The natural resource literature also offers a variety of modeling techniques for use in regionalization applications. Watershed management, perhaps the fastest growing segment of the literature, is placed here.

4. Implementation. Regionalization would be "all theory and no practice" without attention to implementation, or the means by which consolidation actually occurs. With time, more attention to implementation probably will be needed. Process guidance can be found in some of the contributions to the literature. Some analyses address specific restructuring strategies, (such as mandatory takeovers) and incentives (such as an acquisitions adjustment to a utility's rate base). Another new area in the literature concerns the potential use of information systems, particularly geographic information systems, in water resource planning and management.

5. Policies and Institutions. Closely related to the implementation literature is the literature on policies and institutions. One way or another, regionalization usually raises issues of governmental jurisdiction and authority. Regionalization can redefine existing governmental roles and require new forms of intergovernmental coordination. New policies, institutions, authorities, and legal frameworks may be needed for effective regionalization. Economic regulation is a specific policy area in which regionalization, and regulatory incentives for regionalization have been considered. An emerging planning device that also addresses institutional and policy concerns is integrated resource planning.

6. Case Studies in Regionalization. The findings of case studies, although not usually generalizable, can be very useful to researchers and policymakers. Case studies run throughout many contributions to the regionalization literature. This category is reserved for publications that primarily are case studies, including U.S. experiences, as well as international and transboundary experiences. The latter studies recognize both the global nature of the regionalization issues and the need for intergovernmental coordination at the international level.

7. General Planning and Public Administration. The last category of literature encompasses general planning and public administration. Water and wastewater utility services often are at the heart of urban and regional planning. Utility infrastructures are regarded as central to urban and regional economic development, although empirical evidence in this area is mixed. The last subcategory, regionalization in other sectors, borrows substantially from analyses of regionalization in the area of solid waste management.

Literature Review

The following literature review provides some highlights from the annotated bibliography in each of the specific categories in the typology. The bibliography can be consulted for more citations or additional details on particular citations.

1. Economic Analyses

1.1 Scale and Scope Economies. Water and wastewater utilities are considered utility monopolies because of perceived economies of scale and scope in their operations. Economic efficiency, and the lack of economies of scale at the local level, have long been a concern (Clemens, 1959). Not all analysts have agreed, however, that efficiency should be the sole criterion for evaluating water resource

options. Development, preservation, and the well-being of the people also are worthy evaluation criteria (Castle and Youmans, 1970).

The analysis of potential efficiency gains through regionalization received much attention following the passage of the 1974 amendments to the Safe Drinking Water Act (SDWA). In fact, the act expressly encouraged regionalization (Clark, 1979). The 1974 SDWA placed many small systems under the jurisdiction of the U.S. Environmental Protection Agency (EPA) for the first time. A series of government-sponsored research reports considered whether regionalization would be beneficial in achieving both economies of scale and regulatory compliance (see Sauerlender, et al., 1974). One EPA-sponsored report focused on regionalization in the electricity industry and transferability to water utilities, although the differences between the industries and their functions may not have been fully appreciated. (Hooks 1980). An observation made in this and other analyses is that regionalization has been justified in part on the basis of improved efficiency in *regulation* (because regulators would have fewer systems to regulate), not just improved efficiency in the water industry: "The potential advantages of large regional systems appear to result from economies of scale and size that can partially offset rising consumer costs with the declining unit costs that occur as system size increases. . . . Another benefit of consolidation would be to regulatory agencies, who would have fewer systems to monitor. . . (Hooks, 1980: 2).

Not every study supports the idea that economies of scale in water supply are sufficient to justify regionalization. (Offsetting economies are discussed the next section on cost modeling). One study even concluded that "water utilities have no perceptible tendency to behave as a natural monopoly" (Kim and Clark, 1988). Though this particular observation is not well supported throughout the literature, the underlying point that diseconomies and tradeoffs must be recognized in designing regional strategies is well taken. Economies of scale in water supply operations are limited (bigger is not always better). A key tradeoff required by regionalization is the sacrifice of local political control (Clark, 1979).

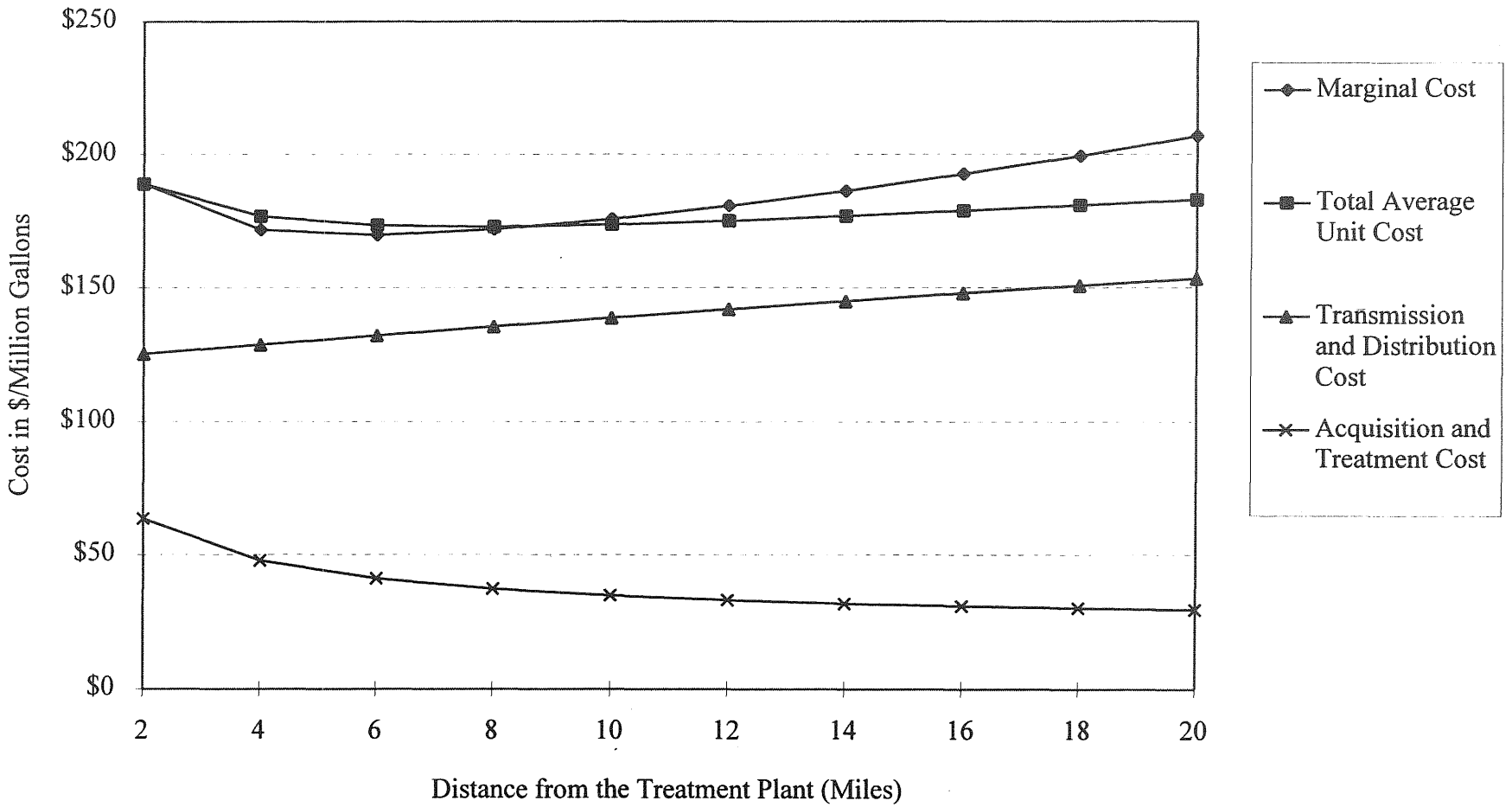
1.2 Cost Modeling. The cost modeling literature responds directly to the challenge of quantifying the benefits and costs of regionalization. Given the assertion that regionalization will lower costs through economies of scale, but knowing that these economies may be limited, cost modeling becomes an essential evaluation tool for regionalization. Examples of various programming, modeling, and simulation approaches can be found in the literature. Many similar or related analyses also can be found in the system modeling area (discussed later).

Several critically important studies have looked at regionalization in terms of the tradeoffs between economies of scale associated with source development and water treatment (or wastewater treatment) and diseconomies associated with transportation and distribution (or collection) systems. In other words, savings from centralized support or treatment are offset by other costs, mainly infrastructure and pumping costs. Thus, for engineering-economists, regionalization is defined as an optimization problem (for example, meeting standards at a minimum cost).

In a path breaking series of articles, Clark and Stevie (*WRPM,* 1981) demonstrated how *increasing the distance* from a water treatment plant lowers the supply (water "acquisition") and treatment costs but increases transportation costs: "By developing a deterministic relationship between total cost and the cost of acquisition-treatment and transmission-distribution in terms of water produced and transport distance, it is possible to find a point at which system economies of scale are lost" (Clark and Stevie, *WRPM,* 1981).

In the illustrations provided, the researchers found that the minimum cost point ranged from 8.3 to 8.5 miles from the treatment plant (depending on per capita water consumption). At longer distances, regionalization introduces inefficiency in the total water system (as measured by upward sloping average and marginal cost curves). These relationships are illustrated in figure 1.

FIGURE 1
ECONOMIES AND DISECONOMIES OF REGIONALIZATION:
SAMPLE UNIT COSTS FOR WATER UTILITIES BY DISTANCE FROM THE TREATMENT PLANT
(1981)



Source: Clark and Stevie (1981).

Similarly, Whitlatch and ReVelle (1990) stressed that increasing the *number of wastewater treatment plants* lowers transportation costs but increases wastewater treatment costs. The authors encourage a long-term point of view when evaluating the potential effects of regionalization. Based on their assessment, various *degrees* of regionalization can be identified and summarized:

Over-	Excess capacity, bureaucratic inefficiency, and externalities
Complete	Comprehensive and multipurpose-oriented
High	Highly coordinated and multipurpose-oriented
Intermediate	Closely integrated and special purpose-oriented
Low	Loosely integrated and special purpose-oriented
Zero	No integration or coordination
Under-	Uncaptured scale economies, short-term orientation, and externalities

In a similar study (Voutchkov and Boulos, 1993), the authors developed a heuristic screening method, with limited data requirements, for evaluating the cost-effectiveness of regionalizing wastewater treatment. Nonoptimal sites can be eliminated from further consideration with the use of a "critical distance" measurement. Design flows and elevation also are considered. In the example provided, the critical distance ranged from 5,673 to 8,039 meters (about 3.5 to 5 miles). For sites at further distances, transportation diseconomies undermine the value of regionalization. For sites that qualify, further analysis can be conducted. These analyses recognize that economies of scale that can be achieved through regionalization in the water sector are not unbounded. Physical interconnection of systems can go beyond achievable economies, leading to inefficiency and higher costs. Logically, when diminishing returns to physical interconnection are reached, nonstructural options for regionalization should be explored if the benefits of those options outweigh the costs.

As the cost profile of the water industry changes, replicating and expanding on these studies will be important. For example, if the cost of source development and treatment rises at a faster pace than the cost of transmission and distribution, the

distance at which minimum cost can be achieved may become longer (or the optimum number of centralized treatment plants may decline), because economies will outweigh diseconomies by a greater factor.

1.3 Markets and Market Value. The subset of literature on the role of markets in the water sector presents a contemporary perspective of how water is valued. Water resource planning has begun to take into account consumer preferences for alternative water uses. In one study, contingent valuation was used to estimate the value consumers place on reliability (Howe and Smith, 1994). Analysts have struggled with how to assign different values to different water uses (Saarinen and Lynne, 1993; New approaches to valuation in the water sector include hedonic pricing models (Bhattacharyya, Harris, and Raffiee, 1995; Crouter, 1987) and travel-cost models (Ward, 1989).

Market-based approaches are being selectively explored on a regional basis, both for water allocation or "takings" (Horbulyk, 1993) and for pollution control (Hall and Howett, 1994). Some economists have advocated the development of regional "spot markets" for water (Zarnikau, 1994). The issue of water transfers obviously lends itself to economic evaluation. In one study, Lund and Israel suggested that a successful market depends on cooperation among urban, agricultural, and "environmental" water users. Water transfers can be used for alternative purposes: to meet demand, to improve system reliability, to improve source water quality, and to satisfy environmental constraints. In this analysis, linear programming is used to generate least-cost water supply alternatives including both conservation and transfers. The least-cost mix depends on cost and reliability conditions; typically, a wide range of options qualify as near-optimal solutions.

As preferences for using markets and incentives to promote better utility performance, this area of the literature will surely grow. Some models and applications found in other sectors, such as tradeable emission permits for achieving air quality standards, are not perfectly transferable to water because of technical, environmental,

and public health considerations. Nonetheless, water resource boundaries (or watersheds) also can be used to define marketplace boundaries for certain activities.

2. Utility Operations

2.1 Trends and Perspectives. Several studies look at the apparent trend toward regionalization from a general operational or systems engineering standpoint. Provisions in the 1974 Safe Drinking Water Act (SDWA) promoted regionalization as a solution to water supply problems and led to a flurry of analysis and debate. Passage of the 1986 SDWA amendments led to further consideration of regionalization options. In the 1970s, as noted above, regionalization appeared to promise much needed economies of scale in water treatment (assuming that various forms of resistance could be overcome). Drawing in part on Great Britain's experience, Okun (1976) advocated regionalization for drinking water supply as a means of addressing many issues, including regulatory compliance.

Regionalization has triggered much discussion within the water supply industry and, perhaps, a healthy skepticism. Industry representatives and professional associations have contemplated the implications of a consolidation trend (Hill, 1985), as well as the potential advantages and disadvantages of regionalization (Brewer, 1979; Manwaring , 1979; Rice, 1979). According to an American Water Works Association (AWWA) member survey in the late 1970s, communities are motivated to consider regionalization because of supply needs, but that local attitudes can hinder implementation (AWWA Regionalization Committee, 1979). The utilities surveyed expressed a preference for minimally intrusive solutions at the lowest possible level of government (AWWA Regionalization Committee, 1979).

The AWWA Management Division (1979) issued a policy analysis of regionalization reflecting some of the industry's concerns. The Association recommended that water resource management, water pollution control management, and public water supply system management be integrated only after each of these

processes has been considered individually. The association encouraged the identification of each community's long-term water resource needs and opposed mandating regionalization because of the unique needs of different communities. The association also asserted that each water system should be able to meet all water supply needs within its service area. Finally, when regionalization is implemented, all affected utilities should participate and future service areas for adjacent utilities should be delineated.

For the most part, regionalization finds a great deal of favor throughout the literature. A few authors, however, have raised important "downsides" of regionalization. Rice (1979) notes that objections to regionalization might include: an increase in litigation as existing contractual relationships are altered, the lack of local control over water supplies, the inequity inherent in allowing those who did not plan adequately to gain from the foresight of others, and the financial implications of transferring ownership to a regional organization. The author concludes that a national regionalization program is impractical and that state and local governments should be allowed to assess their unique needs, resources and circumstances. These issues are addressed further in the section 5.0 of the bibliography.

2.2 System Modeling. A number of studies of regionalization can be classified as system modeling studies because they consist of statistical assessment of regionalization options. Many of these studies consider regional operations within an existing water or wastewater utility. System modeling obviously has very close linkages to the cost modeling studies already reviewed; both are concerned with efficiency issues. Many of the studies represented in the bibliography could be classified in either group. System modeling, however, often deals with specific system design and operational choices as well. Operations modelers understand water systems as complex networks, which can allow for rather complex modeling (Darabos and Gocze, 1991; Goulter, 1992; Jarrige, Harding, and Knight, 1991; Sun, et al., 1995). A regional network could include, for example, multiple reservoirs (Karamouz, Houck, and Delleur,

1992; Vreke, 1994; Wurbs, 1993). More recent studies include conservation among the available resource management options.

System models provide optimization solutions to problems defined in multiobjective terms. According to de Melo and Camara (1994: 1):

> The planning of regional wastewater treatment systems is a classic optimization problem, which may be generally formulated as follows: to define the characteristics of the treatment and transport system, in a region or water basin, which assure compliance with given pollution control criteria, with minimum economic cost.
>
> In addition, one may try to satisfy other goals, which render the problem multiobjective:
>
> - To minimize the environmental impact;
> - To maximize system reliability;
> - To maximize system flexibility under certain conditions;
> - To assure equity among users of the system;
> - To maximize benefits from reuse of treated effluent
> (de Melo and Camara, 1994: 1).

"Optimization" models have been used to identify potential solutions to a variety of complex regional utility operations problems (Gengdong and Haitao, 1989). One study, for example, considered the optimal number, location, and level of treatment for regional wastewater treatment plants along an estuary or river (Whitlatch and ReVelle, 1976: 590). A model was formulated to minimize treatment and transport costs while achieving a water quality improvement target for dissolved oxygen. The authors found that regionalization of wastewater treatment can offer a cost effective solution for regional water quality management. Authors de Melo and Camara (1994) prepared a valuable summary review of key optimization models used in analyzing regional wastewater treatment systems, as presented in table 1. The models vary by optimization criteria, solution technique, and other objectives. Many rather complex

TABLE 1
MODELS FOR OPTIMIZING
REGIONAL WASTEWATER TREATMENT SYSTEMS

Author	Year	Criteria	Solution Technique	Other Objective
Deininger	1965	Distribution	Linear programming	(na)
Liebman and Lynn	1966	Distribution	Dynamic programming	(na)
Loucks, et al.	1967	Distribution	Linear programming	(na)
Shih	1970	Distribution	Dynamic programming	(na)
Converse	1972	Emissions	Dynamic programming	(na)
Graves, et al.	1972	Water quality	Nonlinear programming	(na)
Wanielista and Bauer	1972	Emissions	Mixed integer programming	(na)
Deininger and Su	1973	Emissions	Convex programming	(na)
Hahn, et al.	1973	Emissions	Integer programming; branch & bound	(na)
McConagha and Converse	1973	Emissions	Heuristics	(na)
Whitlatch	1973	Emissions	Heuristics	(na)
Joeres, et al.	1974	Emissions	Mixed integer programming	(na)
Rossman and Liebman	1974	Water quality	Dynamic programming	(na)
Ecker	1975	Distribution	Geometric programming	(na)
Klemetson	1975	Emissions	Dynamic programming	(na)
Lauria	1975	Emissions	Mixed integer programming	(na)
McNamara	1976	Emissions	Geometric programming	(na)
Weeter and Belardi	1976	Emissions	Heuristics	Cost uncertainty
Whitlatch and ReVelle	1976	Emissions	Dynamic programming; linear programming; heuristics	Water quality
Bayer	1977	Emissions	Nonlinear programming	(na)
Chiang and Lauria	1977	Emissions	Heuristics	Phasing
Lashkari, et al.	1977	Emissions	Generalized gradient reduction	(na)
Brill and Nakamura	1978	Emissions	Integer programming; branch & bound	(na)
Jarvis, et al.	1978	Emissions	Network algorithm; integer programming	(na)
Lohani and Thanh	1978	Distribution	Linear programming with stochastic constraints	(na)

TABLE 1 (continued)

Rossman	1978	Emissions	Heuristics; dynamic programming	Phasing
Gugenheim	1978	Emissions	Linear programming (adapted simplex)	(na)
Pingry and Shaftel	1979	Water quality	Heuristics; gradient reduction	(na)
Nakamura, et al.	1981	Emissions	(na)	(na)
Leighton	1982	Emissions	Mixed integer programming	Groundwater recharge
Phillips, et al.	1982	Emissions	Mixed integer programming	(na)
Smeers and Tyteca	1982	Water quality	Shortest path; nonlinear programming	(na)
Kansakar and Polprasert	1983	Water quality	Linear programming; objective programming	Land-use impact
Kitabatake and Miyzaki	1983	Water quality	(na)	(na)
Leighton and Shoemaker	1984	Emissions	Mixed integer programming	Groundwater recharge
Camara	1985	Emissions	Heuristics; shortest path	Multiple solutions
Klemetson and Grenney	1985	Emissions	heuristics and shortest path	Multiple solutions
Ong and Adams	1987	Water quality	Poliedron random search	(na)
Zhu and ReVelle	1988	Emissions	Linear programming	(na)
Joshi and Modak	1989	Distribution	Heuristics	(na)
Melo	1992	Emissions	Cluster analysis heuristics	Multiple solutions

Source: Joao Joanaz de Melo and Antonio S. Camara. "Models for the Optimization of Regional Wastewater Treatment Systems," *European Journal of Operational Research* 73, no. 1 (February 24, 1994): 3.

(na) = not applicable

models were advanced during the period following enactment of the 1972 Clean Water Act.

Mathematical approaches to optimization ultimately must be combined with human decisionmaking to solve water management problems (Uber, Brill, and Pfeffer, 1992). Complex, spatially scattered, multipurpose water systems, according to one modeler, are needed to meet the demands of all types of human activity; for the developing world, these activities include industrial development and urbanization (Miloradov, 1992). A multiphased optimization approach is recommended for simplifying modeling without sacrificing essential analytical dimensions.

Many systems analyses rely on the development of specialized programs or software (Camara, Viegas, and Amaro, 1986; Sun, et al., 1995). In one case, a computerized hydraulic data management program was considered a potential catalyst for regionalization (Miller and Hamilton, 1988). Staff at two rural water districts were trained in using the model to evaluate the benefits of mergers or coordination; based on the analysis, a strategy of coordination was selected. A merger, according to the study, might become more attractive if funding becomes a problem for the individual systems.

2.3 Small Systems. An important, albeit "small" part of the operations literature concerns the operations of small water systems. The water supply industry in the United States is highly fragmented: more than 50,000 community water systems and nearly 200,000 noncommunity water systems are in operation.[1] Many of these systems are small in size and suboptimal in performance (including regulatory compliance). The technical, financial, and managerial viability issues associated with small water systems have been well documented. (See the section 5.2 of the bibliography). If smaller water systems were *viable,* even if they were *suboptimal,* the interest in regionalization might not be as extensive as it appears to be; inefficiency is more tolerable when it is relatively inexpensive. The combination of nonviability, lacking

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[1] U.S. Environmental Protection Agency, *Federal Reporting Data Service,* 1995.

efficiency, and regulatory compliance problems is far less tolerable. For many small water systems, the least-cost solution to these issues may be a form of regionalization.

Nonviability on the part of small water systems is manifested perhaps most visibly in the area of compliance with federal and state drinking water standards. As the standards have been strengthened, compliance issues have mounted. Many analyses of the 1974 and 1986 amendments to the Safe Drinking Water Act focused on noncompliance and potential solutions. More often than not, "restructuring" has been recommended to small communities. A 1982 review by the General Accounting Office, for example, suggested that long-term compliance could be improved through physical interconnection or the formation of regional networks for sharing technical and managerial expertise (GAO, 1982).

In the past few years, small systems have been "at a crossroads" in terms of facing an uncertain future and difficult choices (Cromwell, et al., 1992). Some studies have emphasized the need to asses the root causes of small system viability. Screening and diagnostic tools have been developed for this purpose (Dreese and Beecher, 1994; U.S. EPA, 1996). These tools make use of financial and operational performance benchmarks to identify troubled systems, as well as identify potential remedies. Various authors have suggested various solutions to the small systems issue: technology (Clark, 1980; Deb and Richards, 1982); training (Burke, 1982); and planning (Cromwell, 1994). Strategic approaches to regionalization, such as acquisitions and takeovers, are addressed in section 4.2 of the bibliography.

The states have regulatory primacy with regard to many aspects of water utility operations. The role of the states in addressing small-system viability has received considerable attention (Association of State Drinking Water Administrators, 1995; Ford, 1982; Levin, 1981; Miller, Cromwell, and Marrocco, 1988; Wade Miller Associates, Inc., 1991). The role of state public utility commissions in regulating and restructuring small water systems is addressed in section 5.2 of the bibliography.

3. Natural Resources

3.1 Planning and Management. The natural resource literature can be characterized by a few key generalizations. Resource planners tend to take a long term view and place a high priority on issues of water quality and quantity, as well as threats to water quality and quantity (Kneese and Brown, 1981). Increasingly, the interaction among quality and quantity variables is recognized. Water quantity depletions, for example, can result in water quality degradation. Similarly, degradation (namely, point and nonpoint sources of pollution) can lessen available quantities. Resource planners today emphasize planning for areas defined by ecological systems. For water resources, as discussed below, watersheds can be used to delineate the scope of a planning and management area. Resource planners also consider the multiple and sometimes conflicting uses of water (for example, domestic, agricultural, and industrial uses). One recurring point is that while drinking and sanitation are the priority uses of water, they are not the only uses.

Resource planners have worried about the fragmented nature of municipal water supply and advanced the interest in regionalization (Holtz and Sebastian, 1978). According to Hall (1978), the advantages of the regional resource management approach are that it maintains authority at the appropriate level, promotes cost-effective quantity and quality management, and enhances achievement and maintenance of water quality standards. Regionalization in water management involves: identifying the region, developing a rationale for the agreement, drafting a charter document, and using moral suasion to overcome mutual distrust and suspicion among parties. Strong local leadership can help transform fragmented loyalties into a common regional loyalty under which local conflicts are subordinated to common needs in resource management.

In many respects, a new paradigm for water resource planning and management has emerged (although it echoes earlier approaches). The contemporary literature emphasizes the challenges, opportunities, directions, and improvements that coincide

with a paradigm shift. The paradigm urges an even more comprehensive view of water resources--spatially, temporally, and ecologically. As noted in one journal discussion, water management would benefit from a more "holistic" approach that recognizes the importance of sustainability and the environment itself as a "water user" (Grigg, Kirpich, and Viessman, 1992). In the new water management paradigm, better *coordination* may be as important as better *planning.* Although seemingly subtle, this fundamental shift in thinking will affect how water resource professionals are educated and trained. A barrier to implementation, however, is that policy continues to deal with *regional* issues on a *local* basis.

Many a natural resource scholar has acknowledged, if not bemoaned, the fact that political and hydrologic boundaries seldom coincide. Thus, planning usually is considered within its institutional context (Dworsky, Allee, and North, 1991). Comprehensive planning, according to most of the authors in this area, is needed to meet multiobjective goals and avoid "policy gridlock" (Heany, 1993). Planning may have taken a back seat to regulatory policy in the 1980s. The perceived shortcomings of the regulatory approach have rekindled interest in water resource planning, although funding has been inadequate. A new theme in watershed planning is the importance of seeking "continuous improvement." A variety of more or less complex evaluation, analysis, and decision support tools (such as modeling and geographic information systems) have emerged in the planning and management field.

3.2 Natural Resource Modeling. Natural resource modelers also seek optimal solutions for problems defined in mathematical terms. However, the optimum often (but certainly not always) will be defined in noneconomic terms. For example, the optimum may be the management strategy causing the least pollution or depletion of a water source in a river basin or region. Many of the works in this area emphasize methods for use by decisionmakers in screening alternatives making better resource management decisions (Bryce and Cottcher, 1993; Loucks, 1992; Orlob, 1992). For regional water

resource planning, modelers have recognized how spatial and temporal factors affect results (Kirshen, 1980).

Specific modeling methods vary, including regression, optimization, game theoretic, simulation, and scenario techniques. Specific applications also vary (Rossman and Liebman, 1974; Davis, 1981; Vreke; 1990). In one simulation study of water balances for groundwater aquifers, results were believed to be superior to those obtained using conventional field techniques because the effects of climatic conditions and stress factors could be introduced (Maimone, 1991). Scenarios have been used to evaluate the adequacy of surface water supplies (Singh, Broeren, and Durgunoglu, 1992) or groundwater supplies (Peralta, Cantiller, and Terry, 1995) in meeting future demand, based on a combination of hydrogeologic and demographic conditions.

Although models have a variety of uses, and their use is expanding, models also have limitations. Data availability and accuracy can present serious limitations (Lystrom, et al., 1978). According to a discussion of the role of systems models in planning, modeling can help planners understand the consequences of their actions or the choice to not take action (Loucks, 1992). Modelers and managers must continually communicate with each other and weave their respective expertise into the entire planning process. Modeling is considered by many to be one part of a process that also includes stakeholder and public participation as well (Maimone, 1991).

As information management systems and computer software programs continue to improve, assuming that adequate input data are available, modeling will play an increasingly important role in natural resource planning and management. The variables and decision criteria embedded in these models also will reflect a broader range of concerns.

3.3 Watershed Management. The collection of works listed under the term watershed management appears to be the fastest growing literature related (very directly) to regionalization. Watersheds, by definition, are regional areas defined by hydrologic boundaries. Watershed boundaries rarely, if ever, match the manmade,

geopolitical boundaries of cities, townships, counties, or states. Ideally, water quantity and water quality within the watershed can be managed and sustained to serve the needs of all species who live there (including, but not limited to, the human variety). Some analysts emphasize that smaller watersheds are "nested" within larger, encompassing water basins (Wayland, 1993). A highly integrated approach to watershed planning views the entire ecosystem within the watershed, as well as related socioeconomic systems, as a complex whole (Ballweber, 1995; Margerum, 1995).

Watershed management is a well-established concept, at least in principle (Farrow and Bower, 1993). In a very recent report, watershed management is described as a continuous cycle with several essential elements: strategic monitoring, basin assessment, prioritization and targeting, developing management strategies, management plan and documentation, implementation, and back to strategic monitoring (Clements, et al., 1995). Watershed management tools identified in the report include: environmental indicators and data integration methods, quantitative risk assessment, water-use attainability analysis, procedures of setting site-specific water quality standards, ecological restoration information, pollution trading guidance, monitoring consortiums, information management and analysis, administrative structures to implement watershed approaches, and watershed zoning.

The intellectual roots of watershed management appear to be in the natural resource disciplines, but most of the writings in this field take on a distinctively institutional character. In fact, many of the prominent contributions in this area are very normative or prescriptive in representing the view that watersheds *should be* the basic unit of water resource planning and management. The watershed perspective has advanced as an essential paradigm for water resource planning and management, combining both scientific and practical considerations.

Watershed management is a very "elastic" concept because implementation occurs on a relatively *ad hoc* basis (Ballweber, 1995). Implementing a watershed approach seems to be more difficult from an institutional perspective than from a

scientific one. Scientific agreement about watersheds as an appropriate unit for analysis, planning, and management is not matched by local political support. Even national policy traditionally has emphasized the need to manage water resources at the lowest possible level of government (Bulkley, 1995).

A watershed perspective is not mandated, but it is making its way into the federal policy framework. According to the U.S. EPA, watershed management consists of: (1) recognizing the interconnectedness of ecosystem resources, (2) identifying priorities and tailoring solutions, (3) building partnerships, (4) integrating programs, and (5) securing local commitment to implementation (Wayland, 1995). Guidance in designing and implementing watershed-based programs is provided (Apogee Research, 1991). Watershed management involves governments at every level, but new umbrella institutions (such as interstate regional agreements) may be needed (Wayland, 1995). For example, watershed teams can be used for developing a vision, building understanding, and facilitating implementation. In a more formal conception, an effective watershed institution, among other things, will have adequate resources, authority, and accountability to carry out its responsibilities (Bulkley, 1995).

Protecting drinking water supplies through watershed management has gradually become a higher priority for water utilities, regulators, and consumers (Burby, et al., 1983; Mahon and Dieffenthaller, 1994). New "partnerships" are being formed to accomplish this purpose. For some water and wastewater utilities, watershed protection programs may be their first introduction to a more regional perspective.

4. Implementation

4.1 Process Guidance. For water providers interested in implementing a regional strategy, some general process guidance is available. These articles, manuals, and reports are premised on the idea that regionalization can offer some communities advantages over independent operations. Specific ideas are provided for

evaluating regionalization options, overcoming opposition, and implementing the preferred course.

The U.S. EPA, concerned primarily with the capacity of small water systems to comply with drinking water regulations, has promulgated a number of important works in this area. As noted in the introduction, a 1983 study defined regionalization as:

> [T]he administrative or physical combination of two or more community water systems for improved planning, operation, and/or management. Regionalization should be viewed in the context of a range of possible approaches, from the actual physical interconnection of systems to an administrative and management arrangement to provide common technical, operational, or financial services for two or more systems" (SMC Martin, Inc., 1983: III-1).

Nonstructural options include informal agreements, basic service contracts, joint service contracts, and the formation of a regional council of local officials. Structural options include annexation as well we the formation of water-supply associations, corporations, special districts, and areawide authorities. Each option has advantages and disadvantages. Evaluation criteria for use in regionalization assessment include: economic efficiency, fiscal equity, political accountability, administrative effectiveness, legal authority, costs, and policy/political constraints.

More recent guidance manuals emphasize the importance of both evaluating options and "selling" the idea of regionalization. In another EPA report, five "how-to" steps for restructuring are identified: (1) define the problem, (2) conduct a feasibility study, (3) find a "champion," (4) choose a restructuring option, and (5) develop a plan to sell the concept (U.S. EPA, 1991). In another study, restructuring is presented on a continuum of five categories, from making internal changes, to establishing informal cooperation among systems, to forging contractual arrangements between systems, to establishing agencies with joint powers, and finally, to transferring ownership (U.S. EPA, 1995). The first category preserves the greatest degree of local control, while the

last involves transferring responsibility through an acquisition by a larger entity (which may be existing or new, as well as public or private). Thirty case studies are presented, in hopes that they will "inspire" other small systems to consider the benefits of restructuring.

One area where additional guidance is emerging concerns how to involve citizens in water resource planning and restructuring (Gillies, 1989; Syme, Mapherson, and Seligman, 1991; Syme and Nancarrow, 1992). Regionalization options, as already noted, cause communities to surrender a degree of local control. Citizen-stakeholders may perceive regionalization as a form of disenfranchisement or loss of a meaningful voice in how local water resources are managed. Privatization options, in particular, may add to the sense that citizens cannot call on "City Hall" to hear their concerns. Citizen advisory groups can play an important role in implementing regionalization. One study concluded that satisfaction with water quality planning can be improved if participants are better educated about the requirements of the process, their particular roles, the positions of other participants, and the problems that might be encountered (Plumlee, Starling, and Kramer, 1985).

Given the disjointed nature of political and planning boundaries, and the prevailing skepticism about regionalization at the local level, guidance in this area will continue to be a pressing need. Political barriers to regionalization are as real and important as technical or economic barriers, if not more so. A regionalization without adequate understanding and political support, will be highly vulnerable to criticism and may not achieve desired benefits.

4.2 Strategies and Incentives. In addition to general guidance, the literature also provides examples of specific restructuring or regionalization strategies. These strategies include specific actions on the part of larger utilities in forming regional water supply systems (including but not limited to physical interconnections). A related issue is the presence or lack of incentives for strategic restructuring.

As a structural solution, mergers and acquisitions play a fundamental role in regionalization to achieve economies of scale, as well as economics of scope. Regardless of the ownership of the acquiring or the acquired utility, certain implementation issues arise. According to one study, acquiring a water system requires a number of considerations: (1) system income and expenses, (2) level of contributions in aid of construction, (3) rate base, (4) condition of facilities, (5) reasonableness of price and terms, (6) impact on customers, (7) required additional investments, (8) alternatives to sale and impacts of no sale, (9) ability to operate facilities, and (10) public interest assessment (Cloud, 1994). Other authors have explored in depth such issues as compensation for contributed property (Kucera, 1994).

When investor-owned utilities pursue expansion, regionalization becomes inevitably linked to the issue of *privatization.* Historically, high rates and poor service associated with private ownership, the infeasibility of serving remote areas, municipal law, and nationalization movements have promoted government ownership of water and wastewater utilities (Kucera, 1995). Many of the forces underlying the interest in privatization, such as concerns about economic efficiency and long-term viability, also underlie the interest in consolidation or regionalization.

When investor-owned utilities pursue expansion, regionalization also becomes inevitably linked to the issue of *regulation*. State regulatory commissions have a long-standing interest in the viability (or nonviability) of small systems because many regulated systems are very small in size. Many state regulatory bodies have encouraged larger, viable utility systems to take over the operations of smaller, nonviable utility systems; some states have enacted legislation authorizing the use of mandatory "takeovers." Experience with takeovers has been documented (Cawley, 1984; Holmes, 1984; Limbach, 1984; Miceli, 1986). Many water utilities would prefer positive incentives to mandated takeovers. Regulators can provide investor-owned systems with various financial and ratemaking incentives to stimulate regionalization activity. Some of these incentives are addressed in section 5.2 of the bibliography.

4.3 Information Systems. An exciting recent development in and of itself is the introduction of new information technologies to the water resource planning and management processes. Managing large amounts of new and complex information presents a challenge to analysts, but it is a necessary endeavor. Advances in computers and software have expanded the range and accessibility of information management devices. Better information serves better decisionmaking, particularly in terms of modeling applications. Many of the utility systems and natural resource models mentioned earlier make use of these tools.

New data technologies are assisting water utilities and resource analysts in general planning but also in specific management areas, including drought management (Baum, 1994), demand forecasting (Dean, et al., 1994), system operations (Drake, 1994; Preswitt, 1994; Jacobs, Goulter, and Davidson, 1993; Schillgalies and Kreiling, 1995), water quality monitoring (Hren, Childress, and Michael, 1990; Norris, 1992), and water rights negotiations (Reitsma, et al., 1996).

Perhaps most exciting and relevant for the issue of regionalization is the accelerated use of geographic information systems (GIS). The numerous articles in the recent literature are uniformly positive about the benefits of using GIS. In keeping with the adage that "a picture's worth a thousand words," GIS applications allow analysts to see spatial data spatially (that is, on a map). Mapping and expert systems can be used to generate alternatives for regional water management (McKinney, Maidment, and Tanriverdi, 1993). GIS and decision support systems (DSS) are being linked, providing a new class of systems called spatial decision support systems (SDSS) (Walsh, 1993).

GIS applications also will make their way into regionalization policymaking. A timely and important research project sponsored by the American Water Works Research Foundation tested the hypothesis that many smaller water systems in the United States can be physically interconnected with larger or medium-sized systems or managed on a satellite basis (Castillo, Keefe, and Raucher, 1996). Screening criteria were developed to evaluate the cost effectiveness of these restructuring alternatives.

A geographic information system was used to screen for physical barriers (such as bodies of water and elevation changes) that would impede interconnection. Driving distance was used to screen for satellite management potential. A series of computer-generated maps illustrate restructuring opportunities within each state. The researchers found that on a national scale the potential for cost-effective restructuring was tremendous, with variations in opportunities from state to state.

Technological advances in information management may prove to be another catalyst for regionalization if these tools can be used either to demonstrate the potential benefits of regional approaches or to monitor regional operations for assuring sound performance. No database, simulation, or map can substitute for policy deliberations but these tools should enhance the deliberative process. In some instances, valid and well-presented information could help overcome institutional resistance to change. However, making information technologies and analytical results accessible to all potential beneficiaries is a continuing concern. Larger institutions and governmental authorities may need to take the lead in developing information resources that address the needs of smaller communities or water systems.

5. Policies and Institutions

5.1 Government Roles and Coordination. Of the water resources literature relevant to regionalization, a prolific portion is devoted to policies and institutions and especially to government roles and coordination. Fragmentation, pluralism, and lacking coordination in water resource and regulation are frequently mentioned as the key barriers to effective water resource management (Gellis, 1985; Grigg and Vlachos, 1993). Modern water resource management, according to one scholar, raises fundamental issues of federalism and the respective roles of the federal, state, and local governments (Blomquist, 1991).

Concerns about the capacity of existing institutions to provide an adequate framework for regionalization run throughout all of the perspectives represented in the

bibliography. According to Okun (1978: 72): "In the U.S., the adoption of many proposals for planning and management is severely constrained by archaic institutional arrangements for managing municipal water supply." As an example, the federal Water Pollution Control Act of 1972 contains language that implies independent planning for water supply and water quality, even though the two issues are inseparable (Milliman, 1978). Many scholars believe existing institutions must be reformed or new institutions must be formed to enhance regional solutions.

As mentioned earlier, water resources rarely match jurisdictional boundaries (even groundwater and surface watersheds do not match) and the need for coordination among institutions is as great as the need for planning by institutions. Watersheds cross nations, states, counties, and cities. Grigg (1993) recommends a "new paradigm for coordination in the water industry." Coordination is needed to increase efficiency, reduce conflict, and prevent environmental damage in the U.S. water industry. New roles are suggested for players within existing institutions to facilitate coordination for several purposes: (1) to improve recognition of the integrated nature of the water industry, (2) to establish a national water-management reporting function, (3) to provide plans and arrangements for geographic coordination, (4) to carry out national water policy studies, (5) to coordinate water data and research, and (6) to provide education and training programs.

Mechanisms for coordination are needed at different levels of government. Global cooperation and conflict management is an emerging theme in resource management (Frey, 1993; Rotival, 1991). The United States and Canada, for example, coordinate efforts in managing Great Lakes waters (Allee, 1993; Francis, 1989). Diminishing water resources at the U.S.-Mexico border also raise issues of international law (Cornell, 1991). Guidance for multistate regionalism is available from intergovernmental organizations (Advisory Commission on Intergovernmental Relations, 1972, 1992). In some instances, interstate regionalism is accomplished more formally through interstate compacts and regulatory bodies, such as the Delaware

River Basin Commission and the Susquehanna River Basin Commission. The Delaware River Basin Commission is noted for its accomplishments in regional water resource management and regulation (Roberts, 1989). Interstate compacts are considered a potentially important vehicle for resolving interstate conflicts over water resources (Girardod, 1989; Lord and Kenney, 1993; Sherk, 1994).

Many of the emerging institutions for water management are at the substate level. In Florida, water management districts were formed to deal with the state's regional water resource issues (Hubbell, 1989). At a more localized level, regional institutions formed to address water supply issues include water supply districts and authorities (Blase, Gottman, and McNabb, 1972; Hesse, 1977; Smith, 1981), county-wide management systems (Maxwell and Wubbena, 1982), and metropolitan councils (Einsweiler, 1981). In some cases, regional agreements have been initiated to facilitate emergency management (Hooker, 1981). Experimentation with alternative institutional forms may be a necessary part of the regionalization process.

Identifying and defining appropriate institutional roles and responsibilities with respect to regionalization will likely continue to be a focus of attention. Some studies imply that a strong federal role is needed to provide a framework for coordinated water resources policy (Pinkham and Chapin, 1996). Others recommend the creation of strong regional entities with the capacity to develop forecasting and planning models that integrate demographic, economic, and water resource variables at the regional level (Milliman, 1978). Grigg (1989) finds that the states are the logical place for sustained attention to regionalization because federal intervention would be unpopular and local intervention is unlikely. As a generalization, regional institutions must be broad enough to effectively address watershed management issues while being local enough to be politically accountable. The effectiveness of regional water organizations at any level may depend on the political environment of the region, including political and public support (Ingram, 1973).

5.2 Economic Regulation. A subset of literature considers the structure of the water supply industry in the context of economic regulation. Although public ownership prevails in the water industry, public utility commission jurisdiction extends to a significant number of water utilities (Beecher and Dreese, 1994). Many of the smaller systems "targeted" for regionalization are privately-owned and commission-regulated. Also, many of the larger regulated water systems are actively involved in consolidation through acquisitions.

Regulatory research has focused extensively on small water systems (Davis, et al., 1984; Lawton and Davis, 1983). Commission options and policies on mergers and acquisitions have been documented (Mann, Dreese, and Tucker, 1986). Viability assessment methods and policies also have received considerable attention (Beecher and Dreese, 1994). From an institutional standpoint, coordination of economic regulatory policy and other state policies affecting the structure of the water industry is considered important.

Interstate regional cooperation also has been considered in the context of state economic regulation of public utilities, although less so for the water industry because of its relatively local character. According to a research report by Jones, et al. (1992), technological and organizational developments in the electricity and telecommunications sectors have heightened interest in regional economic regulation (that is, two or more state commissions acting jointly to carry out their regulatory responsibilities). Coordinated efforts in public utility regulation can be accomplished through a variety of methods, including the formation of regulatory "clubs" (based on club theory). The authors conclude that collaborative multistate regulatory action may be appropriate when one or more of the following applies: the threat of federal preemption, incongruent jurisdictional and utility operational boundaries, integrated planning concerns, inconsistent regulatory rules or practices, desire to improve governmental efficiency, and the need to match technical staff resources and political power with major regional utilities.

Recently, some of the larger investor-owned water utilities have taken a very active role in addressing regionalization. The Pennsylvania-American Water Company (1994), for example, strongly endorses, and has actively pursued, the strategy of regionalization to achieve economies of scale (including physical interconnection and the formation of satellite service areas having enough "critical mass" to be viable). Specific legislative and/or regulatory policy changes to promote regionalization include making market entry more difficult, changing state revolving loan funding standards, supporting the repeal of the tax on customer advances, strengthening state legislation on takeovers to include participation by municipal utilities (possibly extending commission jurisdiction to municipals), providing clearer incentives for acquisitions (including a forward-looking approach to acquisition and rate-base additions), providing tax relief for acquisitions of municipal systems, and providing advance ratemaking treatment of acquired property.

Public utility regulators have become actively engaged in the regionalization debate. In a recent collaborative process, regulators in New York formulated a strategic plan for regulatory reform of the water industry (New York Department of Health, 1994). Some authors have actively promoted structural reform of the water industry (including consolidation and privatization) to promote efficiency, financial viability, and compliance with standards (O'Connor and Patel, 1994). Regulatory agencies, at least in some jurisdictions, appear to be receptive to the consideration of incentives for acquisitions (Holland, 1995).

Many regulatory issues related to implementing regionalization (such as valuation, costing, and pricing) have not been fully resolved. Incentives for consolidation, particularly in the regulatory context, are not entirely clear or consistent. Adaptations to commission jurisdiction and authority may be needed to create an environment more conducive to cost-effective strategies, assuming that economic regulators find regionalization to be in the public interest. Regionalization will continue

to present regulators with numerous challenges, but also important opportunities to shape the future of the water supply industry in terms of ownership and operations.

5.3 Integrated Resource Planning. In the public utility literature, integrated resource planning emerged as a paradigm for energy utilities in the 1980s and for water utilities in the 1990s to promote resource conservation and efficiency (Beecher, Landers, and Mann, 1991; Beecher 1995). Integrated planning became a tool of economic regulation in the energy sector; in the water sector it is defined primarily as a planning tool.

Integrated planning subsumes the goals of least-cost planning, while also emphasizing the need to integrate the many institutions involved in water resource policy and planning and the many public policy issues they address. The least-cost planning literature emphasizes internal coordination of utility management functions (forecasting, financial analysis, engineering, supply management, demand management, and so on). At least as important is the integration of water utility planning externally, such as with other water resource planning processes conducted by state agencies and neighboring utilities in the region. The comprehensive approach and institutional emphasis of integrated planning relate naturally to the idea of regionalization. According to a regulatory staff member, comprehensive planning is the key to regionalization, as well as conservation, because of the need to overcome parochial thinking in both of these areas (Allen, 1992).

Some integrated planning concepts are reflected in emerging state policies. According to Ruzicka and Hartman (1996), integrated resources includes attention to conservation, involvement of multiple entities, and consideration of uncertainty. Connecticut adopted these principles in the state's Coordinated Water Supply Plan. Utilities are required to incorporate conservation plans as part of their supply plans. The planning process invites participation from various interests. Various planning horizons are used to deal with uncertainty and change. Planners believe that the process will help them address infrastructure needs, land-use conflicts, small system

viability, competition, and other issues. Benefits of planning so far include better defined service areas, identification of potential safe yield deficits, reduction in the number of small and nonviable water systems, development of multiple interconnections, and development of a statewide conservation program. Integrated planning also is linked to the promotion of a *regional ethic* for water supply.

Applications of integrated planning on a regional scale are emerging. For the Delaware River Basin Commission, demand management and conservation have become an integral part of the commission's comprehensive water resource management strategy for the multistate region (Featherstone, 1996). Integrated planning processes, using various methodologies, also have been implemented to address regional water supply needs in Nevada (Fiske and Dong, 1995) and Kansas (Warren, Blain, and Klein, 1995). Integrated resource planning, as implemented thus far, seems quite compatible with regionalization because it provides a forum for addressing regionally-defined environmental, economic, and political issues.

6. Case Studies in Regionalization

6. 1 United States. Case studies of regionalization are readily available for water and wastewater utility systems with various demographic, geographic, and ownership characteristics. While case studies cannot be used to make generalizations about regionalization, they provide insights about implementation approaches. Over time, some water utilities in the U.S. have adopted an expansion strategy resulting in regional utility operations (Bakken, 1981; Ritchlin, 1995).

A relatively early case study highlighted the opportunities and obstacles associated with regionalization (Hurd, 1979). The study described economic, legal, political, and social implications of regionalizing the water supply system in Northern New Castle County, Delaware. The project was expected to economically benefit the entire county. Obstacles to the regionalization included competition among the four existing water utilities, legal issues concerning water rights, the technical feasibility of

interconnecting the systems, the allocation of costs and how these would affect rate structures, and contracts concerning the minimum and maximum amounts of water to be supplied. The author concluded that public and political support is essential to successful implementation.

In a more recent study, the U.S. Army Corps of Engineers (1995) conducted a regionalization study for Lebanon County, Pennsylvania. The analysts examined a range of structural and nonstructural alternatives for meeting the present and future water needs of twenty-four water systems in the region. The purpose of the study was to assist systems in the region in evaluating and optimizing their operations and to promote the most efficient use of water resources. Data were compiled for the systems in the region from existing information sources and water quality issues played a prominent role in the analysis. The study was conducted in phases: (1) data collection and needs analysis, (2) compilation of alternatives with a view toward regionalization, and (3) economic analysis of the alternatives. Another study was proposed to address market feasibility and other economic aspects of regionalization.

6.2 International and Transboundary. One certain finding about the subject of regionalization is that it transcends international boundaries. Many important contributions to the literature on regionalization draw from the experiences of various corners of the world. Analysts have conducted numerous case studies of regionalization issues within nations and across international boundaries. Some studies compare the U.S. experience with that of others (Wagner, 1982). Other studies report the results of methods and models used in specific regionalization applications (Datta, 1995; Dingzhong, et al., 1992). Thus, the experiment with alternative institutional, economic, and engineering approaches to regionalization is a global experiment.

In the international arena, water and politics co-mingle regularly and intensely. Numerous studies of regional water politics focus on the Middle East (Abebe, 1995; Dinar, 1994; Kettani, 1977; Middle East Water Commission, 1995; Shady, Adam, and

Mohamed, 1994). Finding means of cooperation for developing, managing, and planning for water resources presents a continuing challenge to the larger peace process in the Middle East region.

In the developing world, in particular, considerable attention has been paid to the role of water resources in economic development (Ghosh, 1984; Yijian and Shen, 1990), particularly with respect to the combined needs of the developing world. One author notes that governments often provide water supply and sanitation to urban areas but not the same level of service to outlying regions (Muyibi, 1992). A sequential procedure is suggested by the author to encourage community involvement in the planning construction, and operation and maintenance processes, and promote equitable consideration of needs in rural and peri-urban areas. A case study of Sudan proposed management strategies for rural water development (Livingstone and McPherson, 1993). An empirical study in rural Indonesia found that some rural communities can be served by small-scale and sustainable technologies more cost effectively than through large-scale piped systems (Perkins, 1994). A case study of Mexico City highlights the role of conservation programs in serving the region's water needs (Singleton, 1995)..

The language of modern water issues seems to translate well across boundaries and paradigms seem more common than disparate. A case study of Austria describes integrated catchment (watershed) management as "the co-ordinated management of land and water resources within a region, with the objectives of controlling and/or conserving the water resource, ensuring biodiversity, minimizing land degradation, and achieving specified and agreed land and water management and social objectives" (Hooper, 1993). The author recommends that catchment management in Australia should be bioregional, integrated, systems-based, strategic, and stakeholder-driven with clearly identified roles and responsibilities. Best management practices require: correct scale, the best technical approach, congruence and accountability, a task

force/teamwork approach, and measurable indicators of ecosystem and socioeconomic success.

One of the most impressive case studies in the field was compiled by Okun (1977) in a book devoted entirely to Great Britain's regionalization of the nation's water supply systems. Among other insights, the author notes how watershed management was envisioned more than a century ago, as evidenced in a series of essays appearing in the *Journal of the Society of Arts* in 1879 on the subject of "suggestions for dividing and England and Wales into watershed districts." (Okun, 1977: 15) One of the prize-winning essays proposed the formation of twelve districts (not so different from the ones that eventually were delineated) with broad authority for water resource management.

Okun documents the various details of the regionalization process, culminating in the establishment of ten regional water authorities in 1974. Interestingly, at the time of Okun's analysis, the eventual *privatization* of the British water industry (only a decade later) was *not* anticipated. At the time of regionalization, the future of the existing private companies seemed to be in peril:

> The Labour Party had consistently maintained that retaining the privately-owned water companies (that serve 22 percent of the population) was wrong in principle and anomalous in practice. Accordingly, the government decided to integrate the companies into the [Water Authorities], with fair compensation (estimated at about 300 million pounds), as soon as practicable. Despite protestations of the companies that they are viable and efficient, they are not likely to long survive unless the money for their purchase does not become available (Okun, 1977: 335).

It might be easy to presume that regionalization was part of a calculated plan for the eventual privatization of the British water industry, but Okun's extensive historical documentation does not support this interpretation. Regionalization was a precursor to privatization, but not necessarily by grand design. Britain's current experience with privatization of water utilities on a regional scale also has been studied (Booker, 1994).

7. General Planning and Public Administration

7.1 Urban and Regional Planning. Planning for urban is guided by a general and multisector literature. This planning literature tends to recognize that many of the services delivered by and for communities, such as transportation and waste management, lend themselves to regional approaches. Examples of comprehensive plans for urban regions date to the early part of the century (Levy, 1991). Yet local communities continue to be very guarded about surrendering control to regional entities when it comes to fundamental economic development concerns.

Regionalism has been promoted by policy entrepreneurs at all levels. The secretary of the federal Department of Housing and Urban Development refers to regionalism as the "new geography of opportunity," and calls for communities to consider promoting both "things-regionalism" (referring to community services), as well as "people-regionalism" (referring to community spirit) (Cisneros, 1995). Some entrepreneurs have made a career of promoting regionalization (Mahtesian, 1995). Various models of regional governance can be found (Metropolitan Association of Greater Indianapolis Communities, 1995).

Water supply and wastewater treatment are at the heart of local and regional development concerns. These services have been used as tools of development, although not always effectively. Lack of local planning and zoning, coupled with other state and local policies, often is blamed for the numerous nonviable water systems in the United States. Today, the role of water planning and growth management in managing "urban sprawl" has become a priority (Nelson and Duncan, 1995). For example, doubling demand within a fixed service area places far less stress on infrastructure needs than doubling the service area itself. According to some planners, "'Containing urban sprawl' does not imply halting growth, but holding it inside compact increments, whose ultimate density is known in advance and will be reached quickly, saving utilities from the waste of under- or oversizing their lines in the face of uncertainty" (Mason Gaffney, 1964, as quoted in Nelson and Duncan, 1995: 6).

Some states are encouraging, if not mandating, local and regional growth management. States with comprehensive (that is, multifunctional) growth management legislation include California, Florida, Georgia, Hawaii, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont, and Washington (Nelson and Duncan, 1995: 21). These policies also may create a new environment for regional planning and regionalization. However, the absence of effective regional political institutions will continue to present an obstacle to regional solutions (Levy, 1991).

7.2 Infrastructure and Economic Development. Communities invest heavily in physical infrastructures, namely roads, schools, water supply, and wastewater treatment facilities. The water sector figures heavily in the nation's infrastructure needs (Wade Miller Associates, Inc., 1987). Public administration scholars have long pondered whether regional planning and management of infrastructure systems will yield cost savings and other benefits to communities. Cost savings through regionalization can be realized through economies of scale in production and maintenance. Other benefits include aesthetic and lifestyle improvements. A more controversial area of research concerns whether dollars invested in regional infrastructure will actually produce measurable economic development benefits. Scholars in this field ask whether a road improvement project, for example, will attract new business development in a region that will benefit all of the communities in the region. Measuring and allocating the benefits and costs of regional economic development is challenging and controversial, particularly because the political stakes can be high.

A statistical study of the effects of public investment found that the effectiveness of public capital varies with a region's level of development and the ratio of public to private capital (Moomaw, Mullen, and Williams, 1995). Aggregate public capital investment, highway investment, and water system investment contribute positively to a region's output. Investments in water and sewer systems *have a much larger effect* on

state output than investments in highways or other public capital stocks. Thus, water system investments can stimulate regional economic growth and enhance a region's competitive position in attracting economic activity. Substantial variations in the magnitude of output elasticities were found across the states, indicating that some regions experience an upper limit on the economic benefit that can be derived from investments in public infrastructure.

Robert Krol (1995) reviewed a series of studies that attempted to link public investments to local or regional economic development, as reported in table 2. Controlling for differences in state production characteristics (which many previous studies had failed to do), Krol found that only the investment in water and wastewater facilities was positively related to state economic activity. Accordingly:

> [I]nfrastructure investment in water and sewer systems makes a positive contribution to state economic development; the other components [of public investment] do not... Public capital can influence private capital in two different ways. It can increase the productivity of private capital and, as a result, increase private investment and the private capital stock. For example, a complementary relationship exists when a water and sewer system makes industrial investment more attractive (Krol, 1995: 334).

Infrastructure investments usually are analyzed through the cold facts and figures of impact studies, but exceptions can be found. In many ways, community services help define what communities are about. According to Keating (1994), public works form invisible networks that usually are taken for granted until they break down. Yet the role of these networks goes well beyond basic service delivery:

> In a very tangible way, public works are the sinews that make modern life possible: Without them, we are wilderness campers. We could not long survive in any but the smallest group without rudimentary public works. Disease, starvation, or other privations prevent humans from living together in communities without a water source, transportation for needed supplies, and a means of disposing of waste. Human beings have for millennia developed public works to allow themselves to congregate (Keating, 1994: 3).

TABLE 2
MODELS FOR THE EVALUATING THE BENEFITS OF PUBLIC INVESTMENT IN INFRASTRUCTURE

Author	Year	Sample	Model	Controlled for State Effects	Infrastructure Significant with Expected Sign
Ratner	1983	Aggregate 1949-1973	Cobb-Douglas	(na)	Yes
Eberts	1986	SMSA 1958-1981	Translog	No	Yes
Aschauer (1989)	1989	Aggregate 1949-1985	Cobb-Douglas	(na)	Yes
Munnell	1990a	Aggregate 1949-1987	Cobb-Douglas	(na)	Yes
Munnell	1990b	State 1970-1986	Cobb-Douglas translog	No	Yes
Hulten and Schwab	1991	Regional 1978-1986	Growth accounting	Yes	No
Evans and Karras	1994	State 1970-1986	Cobb-Douglas translog	Yes	No
Morrison and Schwartz	1992	Regional 1970-1987	Cost function	Yes	Yes
Garcia-Mila and McGuire	1992	State 1969-1983	Cobb-Douglas	No	Yes
Garcia-Mila, McGuire, and Porter	1993	State 1970-1983	Cobb-Douglas	Yes	No
Holtz-Eakin	1994	State 1969-1986	Cobb-Douglas	Yes	No

Source: Robert Krol, "Public Infrastructure and State Economic Development," *Economic Development Quarterly* 9, no. 4 (November 1995): 334..

(na) = not applicable

Whether the communitarian perspective on public utility infrastructure can be elevated to the regional level remains to be seen.

7.3 Regionalization in Other Sectors. Water and wastewater utility services, of course, are not the only services that can be provided on a regional basis. Other traditional utility service providers, namely energy and telecommunications utilities, are much more regional (as well as more private) in character.

One service area in which regionalization has received considerable is solid-waste management. As landfill space becomes scarce, many planners are encouraging communities to pool resources and implement solid waste management on a regional basis (Jadun, 1992; O'Neil). Benefits of integrated solid waste management include the ability to share implementation efforts, shorten project schedules, increase reliability, and promote self-sufficiency (Birnesser, Moore, and Kaye, 1993). As in the case of water supply and wastewater treatment, solid-waste management involves economies of scale in the "treatment" function, but diseconomies in transportation. Optimization models also are used in regional planning for solid-waste disposal (Salo and Saarikoski, 1982).

Successful regionalization in solid waste management is linked to statewide management strategies, strong county authority, tonnage capacity and tipping fees to ensure financial viability, and cooperation among participants through a governing council (Redd, 1993). Some states have provided a framework for regional solid-waste management. As one case study describes, Missouri enacted an integrated management strategy in 1990 that included the delineation of nineteen solid waste management districts with responsibilities for planning and implementing waste reduction, recycling, composting, public education and proper disposal. Although county participation is voluntary, most have chosen to participate in the districts (Berger and Hull, 1992). The implementation successes and generally positive views of regional solid-waste management programs seem to bode well for regionalization of water and wastewater systems.

Observations

The water literature, defined here very broadly, clearly speaks to the issue of regionalization in important ways. The literature is very *multi*disciplinary and gradually becoming *inter*disciplinary. In particular, the blending of scientific and institutional considerations in water resource planning and management appears to be one of the more noteworthy trends.

Paradigm shifts in the literature are indicated, and they appear to favor regional planning and management strategies to promote contemporary economic and environmental values. Watershed planning may emerge as the defining paradigm. Indeed, water resources also could be the trigger for regional governance on a broader basis. However, the enthusiasm for regionalization is tempered by the awareness and understanding of technical limitations, offsetting economies, institutional constraints, and political realities.

Despite the literature's several important contributions on the economics of regionalization, a comprehensive model of cost-effectiveness has not yet been offered. Analysts have studied the actual cost of line extensions, the total cost of capital improvements and operations, the unit cost of treatment and transportation, the cost implications of serving different customer classes, and the avoided cost associated with regionalization--but not the combined effects of these cost considerations. The existing models are worth revising to account for changes in the industry's cost profile. To judge the prudence of regionalization, a total cost model that also addressed fundamental uncertainties, externalities, and long-term effects is needed.

The literature also includes numerous important contributions from a public policy and institutional perspective, most of which reflect the view that regional issues call for regional solutions. Although regionalization often offers technical and economic advantages, communities also have legitimate concerns about surrendering control over water resource planning and management. To date, the institutional barriers to

regionalization are perhaps better understood than the means to overcome them. New institutions and mechanisms for coordination will be necessary for effective regionalization. The experiences of communities across the globe surely will continue to provide insights on these fundamental issues. In the process, the literature on regionalization surely will continue to grow.

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Urban and Regional Planning
0.12. Infrastructure and Economic Development
0.13. Regionalization in Other Sectors

1. ECONOMIC ANALYSIS

1.1 Scale and Scope Economies

Aron, Gert and Stephen P. Coelen. "Economic and Technical Considerations of Regional Water Supply," *NTIS Report* Ad-A045 105. Washington, DC: National Technical Information Service, 1977.

This reports examines prospects for regionalizing water systems in the U.S. and potential advantages, such as improved supply reliability. Barriers to regionalization include political and institutional constraints, as well as inability to resolve efficiency and equity issues. A statistical model for evaluating changes in land values brought about by regionalization is presented.

Braat, Leon C. and Wal F. J. van-Lierop, eds. *Economic-Ecological Modeling.* Studies in Regional Science and Urban Economics Series, No. 16. New York: North-Holland, 1987.

Boyd, K. A. and F. A. Bell, Jr. "A Rationale for the Regionalization of Public Water Systems," *Water Resources Bulletin* 9, no. 1 (1973).

Studies have shown that small water systems usually are less efficient than larger ones in providing adequate supplies of safe drinking water. Based on this assumption, this study used economic projections and population data to determine the financial feasibility of consolidating public water systems of a given size.

Cabezas, L. Moris and Ralph A. Wurbs. "Economic Evaluation of Urban Water Supply Systems," *Journal of Urban Planning and Development* 112 (December 1986): 46-59.

Campbell, Michael D. and Jay H. Lehr. "Engineering Economics of Rural Systems: A New U.S. Approach," *Journal American Water Works Association* 67 (May 1975).

Castle, Emery N. and Russell C. Youmans. "Economics in Regional Water Research and Policy," *American Journal of Agricultural Economics* 50, no. 4 (December 1968): 165-66.

Castle, Emery N. and Russell C. Youmans. "Economics in Regional Water Research and Policy: Reply," *American Journal of Agricultural Economics* 52, no. 1 (February 1970): 145-46.

This brief article responds to criticisms of an earlier article by the authors. The authors argue that in a highly developed economy, economic efficiency (as measured by increases in national income) is at a lower order of priority than other possible objectives. Based on prevailing public policy, these other objectives are national and regional economic development, preservation of the nation's natural bounty, and the overall well-being of the populace. This last criterion should be the overriding determinant when considering the best use of water and related land resources.

Clark, Robert M. "Minimizing Water Supply Costs: Regional and Management Options," *Proceedings of the American Water Works Association Seminar on Small Water Systems Problems,* June 7, 1991 (Denver, CO: American Water Works Association, June 1982).

Clark, Robert M. "Water Supply Regionalization: A Critical Evaluation," *Journal of Water Resources Planning and Management* (ASCE) 15, no. 2 (September 1979): 279-294.

The Safe Drinking Water Act of 1974 expressly encouraged water supply regionalization, which regulators have interpreted as a centralized system with a single large-scale treatment plant. Despite economic, environmental, and public health benefits, regionalization sacrifices a degree of local political economy. Research studies also indicate that economies of scale in water supply are limited.

Clemens, E. I. *Economics and Public Utilities.* New York: Appleton-Century-Crots, 1950.

This book includes very dated but interesting observations about the prevalence of local municipal control of water supply, relative to other public utilities: water operations are relatively simple and can be carried out on a small scale; over the years, few changes in treatment technology have occurred to make the process more costly or difficult; treated water can be supplied jointly with municipal fire protection service; treated water involves the public health, which is a governmental concern; significant scale economies are lacking at the local level; and the private sector has failed to enter the water supply market in many areas.

Heggen, Richard J. and Williamson, Kenneth J. *Economic and Energy Analyses of Regional Water Pollution Control.* Springfield, VA: Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, 1978.

Helms, Billy P. *Treated Water Demand and the Economics of Regionalization: The Residential Demand for Treated Water.* Cincinnati, OH: Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, 1980.

This report considers the effects of the Safe Drinking Water Act of 1974 on residential water demand and costs and describes a methodology for demand forecasting.

Hooks, Donald L. *Treated Water Demand and the Economics of Regionalization: The Electric Power Example.* Cincinnati, OH: Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, 1980.

This two-volume report addresses the issue of regionalization in the context of the 1974 Safe Drinking Water Act. The first volume considers the determinants of water demand (including price, income, and appliance ownership). A demand forecasting model is presented, along with a discussion of methods for adapting the approach for particular water utility needs. The second volume considers industry consolidation as a possible means of offsetting rising costs. Reasons for the prevalence of public ownership and the potential advantages of regionalization are provided. The structure of the electricity industry, the history and benefits of consolidation, and mechanisms for coordination, are discussed. The author asserts that electricity and water supply have much in common in terms of operations and costs. Regionalization in water supply requires further studies to evaluate potential economies of scale and determine optimal size in the context of alternative ownership forms and technologies.

Kim, H. Youn and Robert M. Clark. "Economies of Scale and Scope in Water Supply," *Regional Science and Urban Economics* 18, no. 4 (November 1, 1988): 479.

The methodologies of previous studies to estimate water utility cost functions are criticized as oversimplified. The water utility is described as concurrently producing two outputs, water used by residences and water used by businesses, for which demand and supply conditions substantially differ. The water supply industry's cost

function is modeled as a translog multiproduct joint cost function. Operating variables include service distance and capacity utilization rate. Other model inputs include labor, capital, and energy and their respective prices. The model was run using 1973 data for sixty United States water utilities. Distribution networks are shown to erode economies of scale achieved in water treatment, indicating that water utilities should be expanded only within certain limits. The ray average cost curves produced by the model reveal that costs increase as the proportion of residential water use increases. The M locus derived from the ray average cost curves indicate that water utilities experience economies of scope from joint production. However, economies of scale in serving nonresidential customers are offset by diseconomies of serving residential customers, because treatment economies are offset by distribution diseconomies. The authors further conclude that "water utilities have no perceptible tendency to behave as a natural monopoly." Tradeoffs must be recognized in designing regional strategies for water supply.

Maass, Arthur and David C. Major. "Economics in Regional Water Research and Policy: Comment," *American Journal of Agricultural Economics* 52, no. 1 (February 1970): 144-45.

Sauerlender, Owen H., Benjamin V. Dall, James G. Halteman, J. Dean Jansma, and Samuel M. Leadley. *Criteria for Regionalization of Water and Waste Management Systems.* NTIS Report Pb-239 168. Washington, DC: National Technical Information Service, 1974.

Against the backdrop of growing concerns about water quality and rising costs, this article evaluates the potential for achieving economies of scale through regionalization and considers the factors that might make communities receptive or resistant to the idea of regionalization.

Vaughn, Gerald F. "The Geography of Resource Economics," *Land Economics* 70, no. 4 (November 1994): 515.

1.2 Cost Modeling

Baker, Barrie M. and Amandio Pereira Baia. "Branch-and-Bound Algorithms for a Regional Water Authority Distribution Problem," *Journal of the Operational Research Society* 46, no. 6 (June 1995): 698-707.

A locational operations model is adapted for use by regional water authorities in managing distribution systems.

Belardi, James G. and Dennis W. Weeter. *A Rational Approach to Decision Making in the Regionalization of Wastewater Treatment Systems.* NTIS Report Pb-250 749. Washington, DC: National Technical Information Service, 1975.

This article focuses on wastewater treatment regionalization and includes a literature review, a model for cost estimation with case study applications, and a discussion of the implications for planning.

Clark, Robert M. "Cost Estimating for Water Supply: Research Needs," *AWWA Seminar Proceedings: Small Water System Solutions.* Denver, CO: American Water Works Association, 1982.

This brief article presents a list of recommendations for research in water supply cost estimation. Cost estimates are characterized on a continuum from order-of-magnitude estimates ("ballpark numbers") to detailed estimates. Research is needed in the areas of unit process costing, water delivery costs, and systems financing costs.

Clark, Robert M. and Richard M. Males. "Developing and Applying the Water Supply Simulation Model," *Journal American Water Works Association* 78, no. 8 (August 1986): 53-61.

The authors' Water Supply Simulation Model organizes water supply network data and can provide spatial cost, time of travel, and contaminant concentration data for a given water supply system. The model conceptualizes a water supply system as a network servicing spatially distributed demands. The model depicts the network as a series of links, representing pipes, and nodes representing places (such as houses, treatment plants, and storage tanks), where water leaves or enters the system. The model consists of a database, including the node and the link files, and

seven software modules. The model can be used to characterize other systems that are comprised of a service network with a spatial distribution of supply and demand. An application of the model to the water system in New Vienna, Ohio, is reported.

Clark, Robert M. and Richard G. Stevie, "A Regional Water Supply Cost Model," *Growth and Change* 12, no. 3 (July 1981): 9-16.

In this very important work the authors note that regionalization advocates and utility managers seem to assume that economies of scale in water delivery are unlimited. But water utility operations involve separate components (acquisition, treatment, transmission, and distribution) and each has a separate cost function. This paper examines the tradeoffs between the economies of scale in treating water and the diseconomies associated with transporting the water to points of use. Capital and operating costs are considered. Given the demand conditions of a regional market, a least-cost or optimal water utility size can be identified. A mathematical model is presented for evaluating utility size based on utility data and incorporating alternative system growth scenarios. The model can accommodate a circular or noncircular service area. Sample average and marginal unit costs for increasing distances are provided. The researchers found that the minimum cost point ranged from 8.3 to 8.5 miles from the treatment plant (depending on per capita water consumption). At longer distances, regionalization introduces inefficiency in the total water system (as measured by upward sloping average and marginal cost curves). The findings indicate that population dispersion, rather than population density or per capita consumption, is the most important variable in determining the least-cost system. Changes in population dispersion critically affect the point at which water system economies of scale are lost. The authors recommend that policymakers and water utility managers consider the insights from this analysis before committing resources to regionalization. Regulators should not advocate regionalization to minimize their own efforts, and in the process create inefficient water systems.

Clark, Robert M. and Richard G. Stevie. "A Water Supply Cost Model Incorporating Spatial Variables," *Land Economics* 57, no. 1 (February 1981): 18-33.

Clark, Robert M. and Richard G. Stevie. "Analytical Cost Model for Urban Water Supply," *Journal of Water Resources Planning and Management* 107, no. 2 (October 1981): 437-453.

Clark, Robert M. and Richard G. Stevie. *Meeting the Drinking Water Standards: The Price of Regulation.* Cincinnati, OH: U.S. Environmental Protection Agency, 1978.

In this review of the cost impact of the Safe Drinking Water Act of 1974, the authors note that industry consolidation may offer economies of scale, as well as lower the cost of regulation.

Lauria, Donald T. *Regionalization of Wastewater Collection and Treatment Location, Scale and Construction Sequence of System Components.* NTIS Report Pb-287 092. Washington, DC: National Technical Information Service, 1978.

A relatively complex mixed integer programming model for evaluating wastewater management alternatives presented. The model incorporates economic, inflation, treatment process, and salvage value functions and is demonstrated with an application to wastewater planning in Pennsylvania.

Leighton, Jeffrey P. and Christine A. Shoemaker. "An Integer Programming Analysis of the Regionalization of Large Wastewater Treatment and Collection Systems," *Water Resources Research* 20, no. 6 (June 1984): 671-682.

A mixed integer programming optimization procedure is used to screen alternatives for wastewater treatment and collection in Western Suffolk County, Long Island, New York. The procedure was adapted to handle this large region. Existing planning area designations were found not to be cost effective. Substantial saving can be generated from regionalization. Administrative feasibility, locations of effluent discharge, and treatment costs were constraints in generating available alternatives from the model.

Lejano, Raul P. and Climis A. Davos. "Cost Allocation of Multiagency Water Resource Projects: Game Theoretic Approaches and Case Study," *Water Resources Research* 31, no. 5 (May 1, 1995): 1387.

de Melo, Joao Joanaz and Antonio S. Camara. "Models for the Optimization of Regional Wastewater Treatment Systems," *European Journal of Operational Research* 73, no. 1 (February 24, 1994): 1-16.

Optimization in regional wastewater systems involves meeting water quality standards at minimum cost. Other objectives, including the reliability, environmental impacts, and effluent reuse, are considered as well. Optimization requires thorough characterization of wastewater transport and treatment in a region. The analysis is complicated by a number of factors: the difficulty of quantifying and defining optimization objectives, an exponential increase in problem complexity with the addition of a variable, and the nonlinearity and dimensionality of the applicable cost functions. Optimization models should be user-friendly and integrate the experience of engineers and other professionals who would benefit from their practical use. These models also should be designed for easy integration into existing institutional processes. Research is needed on the development of optimization techniques, interactive models, user-friendly interfaces, and automated data input systems. This article provides a brief overview of previous optimization models. Potentially important constraints and objectives of modeling, including such less frequently considered issues as equity concerns and the dynamic nature of wastewater systems, are discussed. The article also examines different methods for obtaining optimization solutions, such as nonlinear programming.

Sharp, Bruce B. "Economics of Pumping and the Utilization Factor," *Journal of Hydraulic Engineering* 113 (July 1987): 1386-96.

Voutchkov, Nikolay S. and Paul F. Boulos. "Heuristic Screening Methodology for Regional Wastewater-Treatment Planning," *Journal of Environmental Engineering* 119, no. 4 (July 1, 1993): 603.

A heuristic screening method, with limited data requirements, is used to limit the number of potential locational alternatives for regional wastewater treatment plants. The method determines whether the economies of scale achievable by the plant are greater than the cost of transporting wastewater. Nonoptimal sites (that is, sites that do not result in cost-effective regional management) are eliminated by identifying a critical distance. Design flows and elevation differences also are considered. In the example provided, which included eight communities, critical distances ranged from 5,673 to 8,039 meters. The method can be used to evaluate the cost effectiveness of regional treatment plants in comparison to separate treatment plants. Plants sites that pass the screening criteria can be studied further for actual regionalization potential.

Warrenburg, Wallace R. and Robert L. Martinez. "Who Pays For Pure Water? Cost Allocation For Regional Wastewater Systems." *Management Focus* 26 (July/August, 1979): 2-9.

Whitlatch, E. Earl. and Peggy L. Asplund. "Capital Cost of Rural Water Distribution Systems," *Water Resources Bulletin* 17, no. 2 (April 1981): 310-313

The capital and operating cost associated with serving rural water customers is high in comparison to the cost of serving urban customers. The Farmers Home Administration (FmHA) subsidizes many rural systems. Reducing costs is essential for reducing rates and making the most of limited funding. Capital data for forty-four water supply projects funded by the Ohio office of the FmHA are analyzed to derive cost equations for twenty-six components of rural water distribution systems. Ninety-two percent of distribution system capital costs can be explained by these components. Economies of scale in construction costs were observed. The authors also discuss the limitations of the model and further research needs. The analysis can be used to design more efficient water systems, but more data and analysis are needed on the combined effects of capital and operating costs.

Whitlatch, Earl and Charles S. ReVelle. "Regionalization in Water Resource Projects," *Water International* 15, no. 2 (June 1990): 70-80.

Regionalization involves integrating or coordinating the physical, economic, social, informational, or personnel structure of water resource projects for addressing national, regional, and local societal objectives and constraints. Global and societal trends (including demands for quality, rising costs, population growth, urbanization, advances in computer technology, and interest in comprehensive project planning) will promote regionalization. The potential advantages of regionalization are: cost reduction through economies of scale, internalization of external diseconomies, higher product quality, greater public participation, consideration of more alternatives and project impacts, greater certainty in development plans, easier financing, and increased political power. Potential disadvantages, which can result from lack of planning, include: greater external diseconomies, greater overall consequences of system failure, a prolonged planning process, political opposition, and cost-sharing impediments. For regional projects that have been implemented, advantages outweigh disadvantages. The seven degrees of regionalization are: over-regionalization, complete, high, intermediate, low, zero, and under-regionalization. Building public support and educating participants are essential for effective regionalization. Future needs include broadening the recognition of regionalization benefits and routine adoption of a long-run viewpoint.

1.3 Markets and Market Value

Amir, S. "The Role of Water Importation on Regional Landscape and Land Use in Israel," *Landscape and Urban Planning* 16, no. ½ (October 1, 1988): 81.

Bhattacharyya, Arunava, Thomas R. Harris, and Kambiz Raffiee. "Allocative Efficiency of Rural Nevada Water Systems: A Hedonic Shadow Cost Function Approach," *Journal Of Regional Science* 35, no. 3 (August 1, 1995): 485.

Brown, Thomas C., Benjamin L. Harding, and Elizabeth A. Payton. "Marginal Economic Value of Streamflow: A Case Study for the Colorado River Basin," *Water Resources Research* 26, no. 12 (December 1, 1990): 2845.

Crouter, Jan P. "Hedonic Estimation Applied to a Water Rights Market," *Land Economics* 63, no. 3 (August 1987): 259-71.

Haimes, Yacov Y. and W. Scott Nainis. "Coordination of Regional Water Resource Supply and Demand Planning Models," *Water Resources Research* 10, no. 6 (December 1974): 1051-59.

Hall, J. C. and C. M. Howett. "Trading in the Tar-Pamlico," *Water Environment Technology* 6, no. 7 (1994): 58-61.

This article describes the nation's first point and nonpoint source pollution credit trading program, which the authors expect to serve as a national model for regulating water quality on a watershed basis, integrating land-use and water-quality planning, improving coastal water quality and reducing the cost of compliance with standards.

Hanemann, W. Michael. "On Reconciling Different Concepts of Option Value," University of California at Berkeley Department of Agricultural and Resource Economics (CUDARE) Working Paper: 295 (March 6, 1986).

Horbulyk, Theodore M. "Integrated Water Management and the Treatment of Regulatory Takings: The Case of Canada's Water Allocation Reform," *Water Resources Update* 93 (Autumn 1993): 48.

This paper considers the effects of using marketlike mechanisms in allocating groundwater and surface water supplies. The premise is that regulatory reform is aimed primarily at economic efficiency, with a backdrop of water quality deterioration, growing shortages, and historic misallocation. The reallocation of a water resource can constitute a "regulatory taking," and thus require just compensation to landowners under the U.S. Constitution. The implications of takings in Canada and other jurisdictions without such constitutional protections is a relevant policy issue. Regulatory takings have both economic and legal effects. Three types of values related to the resource should be considered: social net benefit, changes in private property values, and other effects on the economic well-being of affected parties. Examples of policy instruments for which these issues arise are tradable permits for water use, water pricing, water access permits, water banks, and other integrated watershed management initiatives. Governments will be interested in the equity, fairness, and distributional effects of policy reforms. Moreover, as they pursue reforms, governments will have varying capabilities to provide cash compensation or in-kind compensation through enhanced economic efficiency.

Howe, Charles W., Jeffrey K. Lazo, and Kenneth R. Weber. "The Economic Impacts of Agriculture-to-Urban Water Transfers on the Area of Origin: A Case Study of the Arkansas River Valley in Colorado," *American Journal of Agricultural Economics* 72, no. 5 (December 1, 1990): 1200.

Howe, Charles W. and Mark Griffin Smith. "The Value of Water Supply Reliability in Urban Water Systems," *Journal of Environmental Economics & Management* 26, no. 1 (January 1994): 19-30.

Reliability in urban water supply is important, and water customers place a high value on reliable water service. The demand for reliable service can be measured using contingent valuation methods. Simulation models can be used to assess the costs associated with varying levels of reliability. Using contingent valuation methods, the researchers estimate the value placed on water-supply reliability by water users in three Colorado towns. It was shown that in one of the towns (Boulder), consumers were willing to accept a lower level of reliability. Boulder later decided to sell a portion of its water rights. Water officials seldom discuss the optimization of reliability as part of system design. In general, the study

demonstrates the feasibility of incorporating public views about reliability into water system planning

Kneese, Allen V. *Measuring the Benefits of Clean Air and Water.* Washington, DC: Resources for the Future, 1984.

Kulshreshtha, S.N. "Establishing the Value of Water for Different Economic Sectors Using a Regional Interindustry Model," *The Canadian Journal of Regional Science* 13, no. 1 (Spring 1990): 63.

Letson, David. *Transferable Discharge Permits for Regional Water Quality.* University of Texas, Austin, Ph.D. Dissertation (1989).

Lund, Jay R. and Morris Israel. "Optimization of Transfers in Urban Water Supply Planning," *Journal of Water Resources Planning and Management* 121, no. 1 (January-February 1995): 41 (8).

Water transfers can be integrated into urban water supply planning, but cooperation and coordination among urban, agricultural, and environmental water users is required. Water transfers have particular cost and availability characteristics. Types of water transfers include permanent transfers, contingent transfers, and spot-market transfers. Transfers to supplement existing supplies are less controversial during wet years. Transfers can be used for alternative purposes: to meet demand, to improve system reliability, to improve source water quality, and to satisfy environmental constraints. In this analysis, linear programming is used to generate least-cost water supply alternatives including both conservation and water transfers. The least-cost mix depends on cost and reliability conditions; typically, a wide range of options qualify as near-optimal solutions. The virtue of the approach is that it can be modified to incorporate changes in the problem under study.

Mercer, Lloyd J. and W. Douglas Morgan. "Welfare Effects of Alternative Water Rationing Schemes: A Case Study," *Water Resources Bulletin* 25, no. 1 (February 1, 1989): 203.

Saarinen, Phyllis and Gary D. Lynne. "Getting the Most Valuable Water Supply Pie: Economic Efficiency in Florida's Reasonable-Beneficial Use Standard," *Journal of Land Use & Environmental Law* 8, no. 2 (Summer 1993): 491.

The authors evaluate the economic efficiency of the Florida Water Resources Act and the Model Water Code and briefly describe current conditions of water scarcity in Florida. They argue that the reasonable use criterion in the Act and Code is not efficient because too much information is required to estimate the relative value of different water uses, and the value of different uses is continually changing in accordance with shifting economic conditions. The lack of compensation for unrecovered capital costs due to decreased permit durations also may hinder investment in Florida's economy. Negative economic impacts cause political resistance that may undermine water use legislation. Relying on cost-benefit analyses and the market forces is not deemed an effective remedy for negative impacts; however, limited trade in portions of water use permits is recommended a possible method of improving the legislation's economic efficiency without jeopardizing the protection of scarce water resources.

Steinnes, D. N. "Measuring The Economic Value of Water Quality. The Case of Lakeshore Land," *The Annals of Regional Science* 26, no. 2 (1992): 171.

Ward, Frank A. "Efficiently Managing Spatially Competing Water Uses: New Evidence From A Regional Recreation Demand Model," *Journal of Regional Science* 29, no. 2 (May 1, 1989): 229.

A travel-cost model, based on demand systems theory, is used to compare the recreational value of water to agricultural value. This study considered a region containing four recreational sites with water facilities in the arid west. Agriculture and recreation are competing uses of water at these sites. The travel-cost model was extended to account for unique features of arid environments related to travel time, substitution, and discretionary cost assumptions. Using a conventional travel-cost model, the recreational value of water was found to be higher than the agricultural value of water. Further, the recreational value of water was 40 to 60 percent higher under the extended demand model than under the conventional model.

Yaron, D. and A. Ratner, A. "Regional Cooperation in the Use of Irrigation Water: Efficiency and Income Distribution," *Agricultural Economics* 4, no. 1 (April 1, 1990): 45.

Zarnikau, Jay. "Spot Market Pricing of Water Resources and Efficient Means of Rationing Water During Scarcity," *Resources & Energy Economics* 16, no. 3 (August 1994): 189-210.

The marginal cost of water supply varies temporally and spatially, but water utility pricing generally does not reflect true costs. A pricing model based on short-run marginal costs, or spot-market pricing principles, is proposed as a more efficient means of rationing water during periods of short supplies or capacity constraints.

2. UTILITY OPERATIONS

2.1 Trends and Perspectives

American Water Works Association Regionalization Committee. "Regionalization of Water Utilities: A Survey," *Journal American Water Works Association* 71 (December 1979).

A survey on regionalization sent to utility members of the AWWA is described. The majority of respondents were water utilities serving suburbs and small cities; the views of smaller water utilities were not represented. Utilities that had participated or anticipated the need to participate in regionalization efforts most commonly cited the need for additional water supply as the motivating factor behind regionalization. Nonstructural issues, such as community attitudes, were the most commonly cited factors hindering regionalization. Most utilities favored a minimal governmental role in water utility regionalization and involvement at the lowest possible level of government.

American Water Works Association Management Division. "Regionalization of Water Utilities: Needs and Issues," *Journal American Water Works Association* 71, no. 12 (December 1979).

The Safe Drinking Water Act (SDWA) promotes regionalization as a means of solving water supply problems. This article expresses American Water Works Association (AWWA) views on regionalization and relates potential benefits and problems associated with regionalization. As defined by the AWWA, water supply regionalization can refer to a large physically united system or the coordinated management of two or more independent systems. The AWWA recommends that water resource management, water pollution control management, and public water supply system management be integrated only after each of these processes has been considered individually. The AWWA encourages the identification of each community's long-term water resource needs and opposes mandating regionalization because of the unique needs of different communities. The AWWA urges that all water systems should be operated in an efficient and financially sound manner, and that each system should be able to meet all water supply needs within its service area. When regionalization is implemented, all affected utilities should participate and future service areas for adjacent utilities should be delineated.

Brewer, Deborah J. "Theme Introduction--Regionalization of Water Utilities," *Journal American Water Works Association* 71 (December 1979).

Emery, Scott H. "Regionalization of Water Supplies: An Experiment," *Florida Environmental and Urban Issues* (July 1, 1988).

Hill, Len. "Regionalization: A Decade Points to More Change," *Water Engineering and Management* 132 (June 1985): 40-41.

Manwaring, J. F. "Regionalization of Water Utilities: Advantages," *Journal American Water Works Association* 71, no. 5 (May 1979): 10.

This short article states the potential advantages associated with the regionalization of water utilities, including unified operation and maintenance, capital resource pooling, increased reliability of water supplies, improvements in regulatory surveillance, and economies of scale.

Okun, Daniel A. "Drinking Water for the Future," *American Journal of Public Health* 66, no. 7 (July 1976): 639-644.

Regionalization, cooperation among water resource and pollution control authorities, and the development of dual water supplies (for drinking versus other needs) are advocated in response to issues arising under the Safe Drinking Water Act (SDWA) of 1974. The SDWA ignores the needs of people who are not served by public water systems, very small water systems, water systems with polluted supply sources, and chemical contaminants that cannot be removed by conventional treatment methods. Great Britain's experience with regionalization since 1945 is characterized as a highly successful strategy.

Rice, I. M. "Regionalization of Water Utilities: Disadvantages," *Journal American Water Works Association*, no. 5 (May 1979): 11.

This article describes the problems associated with the regionalization of water resources. Objections to regionalization might include: an increase in litigation as existing contractual relationships are altered, the lack of local control over water supplies, the inequity inherent in allowing those who did not plan adequately to gain

from the foresight of others, and the financial implications of transferring ownership to a regional organization. The article concludes that a national regionalization program is impractical. State and local governments should be allowed to assess their unique needs, resources and circumstances.

Whipple Jr., William. "Regionalization in the Water-Supply Industry," *Journal of Water Resources Planning* (July 1, 1991).

Wubbena, Robert L. "Regionalization of Water Utilities--An Interim Committee Report," *American Water Works Association Annual Conference Proceedings.* Denver, CO: American Water Works Association, 1978.

2.2 System Modeling

Basagaoglu, Hakan. "Optimal Capacity-Expansion Planning in Multiaquifer Systems," *Journal of Water Resources Planning and Management* 120, no. 6 (November-December 1994): 836 (21).

Camara, Antonio S., M. Graca Viegas, and Ana Amaro. "Interfacing System Dynamics and Multiobjective Programming for Regional Water Resources Planning," *Annals of Regional Science* 20, no. 3 (November 1986): 104-13.

This article outlines SMARTEST, a system dynamics model developed to take into account nonlinearities, as well as the frequently multidimensional, multiobjective, and dynamic nature of problems encountered in water planning. SMARTEST was designed for regional water resources planning, but should be applicable to any multiobjective, dynamic, and nonlinear planning problem. The purpose of SMARTEST is to determine the effects of different planning alternatives. In terms of systems dynamics, variables can be categorized as level, rate, or auxiliary variables. For planning, variables are grouped as control and impact variables. A given planning alternative is defined by a set of values for a given control variable. The number of control variables considered is reduced by a screening process. Evaluation of an alternative is effected by determining "promise levels" resulting from the alternative determined according to the alternative's effect on impact variables. Further development of the SMARTEST method should result in shifting from system dynamics modeling to a simulation model that accounts for qualitative considerations as well as quantitative data.

Cesario, A. Lee. "Network Analysis from Planning, Engineering, Operations, and Management Perspectives," *Journal American Water Works Association* 83, no. 2 (February 1991): 38-42.

Crawley, Philip D. and Graeme C. Dandy. "Optimal Operation Of Multiple-Reservoir System," *Journal of Water Resources Planning and Management* 119, no. 1 (January-February 1993): 1 (17).

Diba, Ali, Manouchehr Mahjoub, Philip D. Crawley, and Graeme D. Dandy. "Optimal Operation of Multiple-Reservoir System," *Journal of Water Resources Planning and Management* 120, no. 5 (September-October 1994): 742 (6).

Darabos, P. and F. Gocze. "Water Supply Network Model for Operation Control," *Periodica Polytechnica: Civil Engineering* 35, no. 1 (1991): 17.

Gengdong, Cheng and Ma Haitao. "Optimal Design of Water Distribution Systems," *Civil Engineering Systems* 6, no. 3 (1989): 111.

Heekyung, Park, and Jon C. Liebman. "Redundancy-Constrained Minimum-Cost Design of Water Distribution Nets (Discussion)," *Journal of Water Resources Planning and Management* 119, no. 1 (January-February 1993): 1-18.

A water distribution network subject to explicit reliability constraints demands a considerable amount of capital investment. A realistic measure of reliability is necessary to optimize water distribution network reliability. An ideal water distribution network should: (1) consider a time-based probabilistic measure, (2) reflect the shortfall in flow, (3) be easy to calculate, and (4) recognize the pressure dependency of demand.

Jarrige, P. A., T. Harding, T., and D. Knight. "Using Optimization For Integrated Water Network Management," *Civil Engineering Systems* 8, no. 4 (1991): 241.

Karamouz, Mohammad, Mark H. Houck and Jacque W. Delleur. "Optimization and Simulation of Multiple Reservoir Systems," *Journal of Water Resources Planning and Management* 118, no. 1 (January-February 1992): 71-82.

This study reported an investigation of a multivariate hydrological time-series analysis and a deterministic/implicitly stochastic optimization technique for determining reservoir operating rules for multiple reservoirs. An optimization technique was used to develop operating rules for a two-river system under a set of twenty-eight different conditions. The study's three-step cycle consisted of: (1) developing an optimization of reservoir operations for a set of streamflows, (2) analyzing optimal operations from the solution in a regression procedure to obtain a set of operating rules, and (3) evaluating these rules through a simulation model using another data set. Based on the test case results, monthly operating rules could be improved dramatically over standard operating rules when the operating rules were refined using the proposed algorithm.

Kessler, A., L. Ormsbee, and U. Shamir. "A Methodology for Least-Cost Design of Invulnerable Water Distribution Networks," *Civil Engineering Systems* 7, no. 1 (1990): 20.

Goulter, I.C. "Systems Analysis in Water Distribution Network Designs From Theory To Practice," *Journal of Water Resources Planning and Management* 118, no. 3 (May-June 1992): 238-249.

Although systems-analysis techniques can be used to effectively design realistic water distribution networks, these techniques have been underutilized because the algorithms used have not been adequately packaged for practical system-design environments. Thus, the packaging of these models (more than the models themselves) need retooling. Also, reliability analysis in water distribution network design has been rejected because of computational infeasibility and superficial interpretations. Further research and development is needed to develop graphically interactive decision support systems (DSS) that use optimization and classical simulation models. These improvements could lead to greater usage in the design office setting.

Hartley, J. A. and R. S. Powell. "The Development of a Combined Water Demand Prediction System," *Civil Engineering Systems* 8, no. 4 (1991): 231.

Miller, C. E., and L. Hamilton. "A Catalyst For Regionalization of Rural Water Systems," *Water Resources Bulletin* 24, no. 3 (1988): 677-683.

This case study highlights the potential role of a computerized hydraulic data management program (CHDMP) as a catalyst for water supply regionalization. The software was used in a demonstration project in Nelson County, Kentucky. Utility staff members at two rural water districts were trained in using the model for a network analysis of system facilities, flows, and pressures. The model also was used to simulate the effects of coordinated or regional operations. In the case reported, the water suppliers opted for increased cooperation, but not a merger. In the event of decreases in federal funding, the managers of the two utilities involved could foresee a possible merger.

Miles, Terence M. and Barbara J. Lence. "Optimization of the City of Winnipeg Water Distribution System," *Canadian Journal of Civil Engineering* 23, no. 1 (February 1, 1996): 42.

Miloradov, M. "Planning and Management of Water Resource Systems in Developing Countries," *Journal of Water Resources Planning and Management* 118, no. 6 (November-December 1992): 603-620.

The author asserts that complex, spatially scattered, multipurpose water systems are needed to meet the demands of all types of human activity (including industrial development and urbanization). Multidimensional mathematical formulations and complex models are necessary for planning these systems. Simplifying these models to make them more accessible yields other problems in terms of measurement weaknesses or unclear conclusions. A multiphase optimization method procedure can help eliminate the confusion and strengthen end results.

Ong, S. L. and Barry J. Adams. "Capacity Expansion for Regional Wastewater Systems," *Journal of Environmental Engineering* 116, no. 3 (May 1, 1990): 542.

Schaake, John C., Jr., and David C. Major. "Model for Estimating Regional Water Needs," *Water Resources Research* 8, no. 3 (June 1972): 755-59.

Sun, Yung-Hsin, William W-G Yeh, Nien-Sheng Hsu, and Peter W. F. Louie. "Generalized Network Algorithms for Water Supply System Optimization," *Journal of Water Resources Planning and Management* 121, no. 5 (September-October 1995): 392-399.

The basic structure of a water supply system is a network; thus, network algorithms have been used for system operation and management. Traditional algorithms were designed to solve transshipment problems in a pure network setting, with total demand equal to total supply. Non-network type constraints and variables are precluded from network models. Consequently, network models are used to perform optimization only for the network portion of the water supply system under certain overall operational guidelines. An alternative algorithm, EMNET, is introduced for solving the regional water supply system optimization that corresponds to a generalized network problem with additional non-network type constraints and variables. Results indicate that EMNET can be faster than standard linear programming codes.

Tanyimboh, T. T. and A. B. Templeman. "Optimum Design of Flexible Water Distribution Networks," *Civil Engineering Systems* 10, no. 3 (1993): 243.

Uber, James G., E. Downey Brill, Jr., and John T. Pfeffer. "Use of Mathematical Programming Methods for Complex Systems," *Journal of Water Resources Planning and Management* 118, no. 3 (May-June 1992): 281-295.

This article considers the benefits of using mathematical programming techniques, together with human decisionmaking, to improve water management systems. Programming techniques were used to generate alternative solutions for evaluation by water management system designer, allowing the human planner to integrate intuition and judgment into the decisionmaking process. In the case of designing a wastewater treatment plant, described in the article, a minimum-cost model generated by the techniques proved unsatisfactory. Yet other model formulations could be used to generate good alternatives. Through trial and error, designers can use the proposed techniques to more efficiently solve water management problems.

Vreke, J. "Optimal Allocation of Surface Water in Regional Water Management," *Water Resources Management* 8, no. 2 (1994): 137-153.

An optimization model is presented for regional surface water management, given alternative capacities and applications (including conservation), and demonstrated through a case study.

Whitlatch, Earl and Charles S. ReVelle. "Designing Regionalized Waste Water Treatment Systems," *Water Resources* 12, no. 4 (August 1976): 81-591.

This article considers the optimal number, location, and level of treatment for regional wastewater treatment plants along an estuary or river. The model is formulated to minimize the sum of treatment and transport (piping and pumping) costs to achieve water quality improvement goals for dissolved oxygen. The model can accommodate alternative treatment requirements or least-cost criteria. The optimization procedure provides a series of steps leading to progressively improved cost. The location procedure requires a degree of analyst judgment. A case study of the Delaware estuary is presented, including a cost comparison for a series of water quality management alternatives. The findings indicate that regional treatment schemes can result in considerable savings.

Wurbs, Ralph. "Reservoir-System Simulation and Optimization Models," *Journal of Water Resources Planning and Management* 119, no. 4 (July-August 1993): 455 (18).

2.3 Small Systems

Association of State Drinking Water Administrators. *Enhancing Drinking Water System Viability: Options for States.* Washington, DC: Association of State Drinking Water Administrators, 1995.

Inadequate or aging infrastructure, as well as regulatory and legislative requirements for water systems, have led to a decrease in compliance, and increase in costs, and an increase in technical and managerial needs, especially for small water systems. Some states have developed initiatives to deal with these problems. This document, the result of a collaboration between the Association of State Drinking Water Administrators and the U.S. Environmental Protection Agency, is a

compendium of options states can use to ensure small water system viability. Seventeen states provided summaries of their efforts, which are provided as attachments. The states have taken a variety of approaches including adopting statutory requirements for small systems assessments and assistance, enhancing existing authority, and initiating informal prevention and assistance programs. Specifically, some states have strengthened permitting programs, required detailed sanitary surveys, and provided technical assistance for small systems and communities.

American Water Works Association. *Proceedings of the American Water Works Association Seminar on Small Water System Problems.* Denver, CO: American Water Works Association, 1982.

Burke, C. A. "Management Training: Potential Solutions for Small Water Utility Systems," *AWWA Seminar Proceedings: Small Water System Solutions.* Denver, CO: American Water Works Association, 1982.

The importance of management training for small system operators is emphasized and guidelines for developing or choosing management training programs are provided.

Clark, Robert M. "Small Water Systems: Role of Technology," *Journal of the Environmental Engineering Division, Proceedings of the American Society of Civil Engineers,* 106 (February 1980).

Cromwell, John E. "Strategic Planning for SDWA Compliance in Small Systems," *Journal American Water Works Association* 86, no. 5 (May 1, 1994): 42.

Formal strategic planning is useful to small as well as large water supply systems in determining the total cost a given utility is likely to incur with Safe Drinking Water Act (SDWA) requirements. The use of strategic planning can help a utility identify the most efficient means of compliance. In many cases, documenting the absence of liabilities also can improve a given utility's financing opportunities. Guidance questions for strategic planning used to identify potential liabilities are grouped according to six main categories of contaminants regulated by the SDWA: microbes, disinfection by-products, corrosion by-products, natural geologic contaminants, agrochemicals, and industrial chemicals. Resources for strategic

planning are given, and the importance of consumer awareness of liability issues is emphasized.

Cromwell, John E., III, Walter L. Harner, Jay C. Africa, and J. Stephen Schmidt. "Small Water Systems at a Crossroads." *Journal of the American Water Works Association* 84 no. 5 (May 1992), 40-8.

Deb, A. K. and W. G. Richards. "Economic Evaluation of Alternative Technology for Small Water System Management," *AWWA Seminar Proceedings: Small Water System Solutions.* Denver, CO: American Water Works Association, 1982.

Small water systems (serving 100 to 10,000 people) find it difficult to provide adequate water quality at a reasonable cost, especially since they became subject to federal drinking water regulations. Typical scenarios are systems with supplies that have high concentrations of inorganic substances or synthetic trace chemicals. Compliance options for small systems are different and more limited than those available to larger systems. Small systems may have fewer source-of-supply alternatives. Treatment technologies designed for large-scale operations may not be feasible. Small-system alternatives include new supply sources, new treatment facilities, prefabricated facilities, point-of -use treatment devices, interconnection, sharing of technical or support services, bulk bottled water, and dual water systems. An evaluation model referred to as WATMAN (WATer MANagement model) includes thirty-eight unit-cost functions for water supply, treatment, and distribution processes. For this analysis, an additional twenty-six cost functions appropriate for small systems were added. Two hypothetical cases were presented. The first case involved a utility with high levels of nitrate in its groundwater supply. The second case involved a small community with wells contaminated by an inorganic substance. In both cases, the general result was that interconnection with another system (if available within a few miles), was the least-cost alternative, followed by the development of new water supplies.

Dreese, G. Richard and Janice A. Beecher. "Developing Models for Assessing the Financial Health of Small and Medium-Sized Water Utilities," *Journal American Water Works Association* 85, no. 6 (June 1993): 54-60.

Ford, W. C. "Workshop on State Support of Small Water Systems," *AWWA Seminar Proceedings: Small Water System Solutions.* Denver, CO: American Water Works Association, 1982.

A sixteen member workgroup including state public drinking water directors, U.S. Environmental Protection Agency officials, and other water industry representatives met in early 1982 to produce a "Recipe Book" of successful management practices for use by state water supply agencies in improving small water system compliance. The workgroup classified issues into four categories: training and technical assistance; state organization and administration; financial, institutional, and legal concerns; and special problems. Several problems were identified for each issue, and a range of possible solutions was developed for each problem.

Gillian, James I., Richard G. Stevie, Robert M. Clark, and Jeffrey Q. Adams. *Managing Small Water Systems: A Cost Study,* Volumes I and II. Cincinnati, OH: U.S. Environmental Protection Agency (September 1979).

Harris, Steven C. and Andrea Sklarew Maynard. "Small Water Users: Planning Crisis," *Civil Engineering* 55 (August 1985): 76-78.

Levin, A. and H. F. Hanson. "Small Water Systems: What Can Government Do for Them?" *Water/Engineering and Management* 128 no. 3 (March 1981).

McCall, Robert G., et al.. "Roundtable--Problems of Small Water Systems," *Journal American Water Works Association* 74 (February 1982).

Miller, G. Wade, John E. Cromwell III, and Frederick A. Marrocco. "The Role of the States in Solving the Small System Dilemma," *Journal American Water Works Association* 82 (August 1988).

New Jersey General Assembly. *Public Hearing: Assembly Bill No. 4365* (1989).

These proceedings concerned the ownership of water supply utilities; the proposed bill specifically would prohibit water supply utilities from being corporately related to companies that are in the real estate business.

Prendergast, John. "Fit To Drink. Small Drinking-Water Systems Are Having Big Problems Complying with New Regulations Emerging from the 1986 Amendments to the Safe Drinking Water Act," *Civil Engineering* 63, no. 5 (May 1, 1993): 52.

Rommelmann, David W., et al. "Roundtable--Economics of Small Systems," *Journal American Water Works Association* 87, no. 11 (November 1995): 20.

Sagraves, Barry R., John H. Peterson, and Paul C. Williams. "Financial Strategies for Small Systems," *Journal American Water Works Association* (August 1988).

Shanaghan, P. E. "Small Systems and SDWA Reauthorization," *Journal American Water Works Association* 86, no. 5 (May 1994): 52.

Stevie, R. G. and R. M. Clark. "Costs for Small Systems to Meet the National Interim Drinking Water Regulations," *Journal American Water Works Association* 74 (January 1982).

U.S. Environmental Protection Agency. *Developing Solutions: On the Road to Unraveling the Small Systems Dilemma.* Washington, DC: U.S. Environmental Protection Agency, 1990.

This report notes that planning can help address the small water systems problem by providing a means of identifying the location of water systems in a regional area, as well as opportunities for physical interconnection and satellite management.

U.S. Environmental Protection Agency. *Ensuring the Viability of New, Small Drinking Water Systems: A Study of State Programs.* Washington, DC: U.S. Environmental Protection Agency, 1989.

U.S. Environmental Protection Agency. *Financial Capability Guidebook.* Washington, DC: U.S. Environmental Protection Agency, 1984.

U.S. Environmental Protection Agency. *Improving the Viability of Existing Small Drinking Water Systems.* Washington, DC: U.S. Environmental Protection Agency, 1990.

U.S. Environmental Protection Agency. *Methods for Assessing Small Water System Capability: A Review of Current Techniques and Approaches.* Washington, DC: U.S. Environmental Protection Agency, 1996.

This manual reviews some methods for assessing small water system capability. The methods emphasize measures of costs and financial viability. Three methods are presented. First, PAWATER is a PC-based screening tool developed jointly by the U.S. Environmental Protection Agency and Pennsylvania drinking water regulators. The model can be used to calculate costs and assess financial capacity for new community water systems. Second, the "Dozen Questions Approach" is a query-based diagnostic tool intended to foster comprehensive strategic planning. It can be applied to existing systems to evaluate issues related to water quantity, water quality, infrastructure, management, finance, and customer awareness. Third, the Washington State Financial Viability Planning Manual outlines a program requiring a water system plan that includes a 6-year operating budget and a financial viability test considering rates, reserves, and revenues. The state can deny construction and operating permits if the viability test is not passed.

U.S. General Accounting Office. *Drinking Water: Stronger Efforts Essential for Small Communities to Comply with Standards.* Washington, DC: U.S. General Accounting Office, 1982.

This review focuses on Safe Drinking Water Act compliance problems and suggests that, in the long term, compliance could be improved with industry restructuring (namely, physical interconnection between smaller and larger systems or the formation of networks for sharing technical and managerial expertise).

U.S. General Accounting Office. *Review of the Safe Drinking Water Act.* Washington, DC: U.S. General Accounting Office, 1982.

Wade Miller Associates, Inc. *State Initiatives to Address Non-Viable Small Water Systems in Pennsylvania.* Arlington, VA: Wade Miller Associates, Inc., 1991.

3. NATURAL RESOURCE

3.1 Planning and Management

Burt, John P. "New Water Resource Challenges," *Water Resources Update* 93 (Autumn 1993): 27.

Chernin, Philip R. and Brendon O. Frederick. "Protecting Local Supplies: Perspectives from a Regional Water Purveyor," *Water Engineering and Management* 139 (October 1992): 20-22.

Dworsky, Leonard B., David J. Allee, and Ronald M. North. "Water Resources Planning and Management in the United States Federal System: Long-Term Assessment and Intergovernmental Issues for the Nineties," *Natural Resources Journal* 31, no. 3 (Summer 1991): 475.

Grigg, Neil S., Phillip Z. Kirpich, and Warren Viessman, Jr. "Water Management: Challenge and Opportunity (discussion)," *Journal of Water Resources Planning and Management* 118, no. 1 (January-February 1992): 102.

This discussion responds to a piece by Warren Viessman. According to Grigg, water management is multidimensional and requires a more holistic approach than currently is practiced. Lack of planning is identified as a key reason for water management problems. Sustainability, and recognizing the environment as a "water user" should play a role in natural resource management. Coordination is at least as important as planning in successful water management. According to Kirpich, better water management requires incentives for good performance and broader education of engineers, who often are responsible for water supply projects, so that they can better understand social, economic, and environmental issues. Finally, Viessman notes that policy continues to deal with regional problems on a local scale and that needed institutional reform is slow to come because of cultural barriers.

Hall, Warren A. "Regional Integration for Effective Water Resource Management," in David Holtz and Scott Sebastian, eds. *Municipal Water Systems--The Challenge for Urban Resource Management.* Bloomington, IN: Indiana University Press, 1978.

Quality and quantity aspects of resources are inseparable; neglect in either area contributes to the "tragedy of the commons" (the inevitable destruction of resources held as common property caused by the self-interest of individual users). The problem can be addressed by dividing and allocating the resource to individuals, regulating the resource through police powers, or creating an authority to manage the resource for the common good (the "can-do" approach). The advantages and disadvantages of each approach are reviewed. The advantages of the regional management approach are that it maintains authority at the appropriate level, promotes cost-effective quantity and quality management, and enhances achievement and maintenance of water quality standards. Regionalization for water management involves: identifying the region, developing a rationale for the agreement, drafting a charter document, and using moral persuasion to overcome mutual distrust and suspicion among parties. Strong local leadership can help transform fragmented loyalties into a common regional loyalty under which local conflicts are subordinated to common needs.

Heany, James P. "New Directions in Water Resources Planning and Management," *Water Resources Update* 93 (Autumn 1993): 3.

This author makes the point that political and hydrologic boundaries seldom coincide and suggests that comprehensive water planning is needed to meet multiple objectives and avoid policy gridlock. Watershed planning is getting renewed attention, and offers a number of technical advantages, but several factors have hindered its use. Planning options can be evaluated according to five long-standing feasibility criteria: technical, economic, financial, environmental, and sociopolitical. Planning also has evolved in terms of the methods for selecting among alternatives, including microeconomic analysis, systems analysis, and decision support systems (such as geographic information systems). In the 1980s, interest in planning waned as the federal government pursued a more aggressive regulatory approach; perceived shortcomings of the regulatory approach in the 1990s has rekindled interest in planning, but adequate funding for planning remains an issue. "Continuous improvement" is a new theme in watershed planning,

Holtz, David and Scott Sebastian, eds. *Municipal Water Systems--The Challenge for Urban Resource Management.* Bloomington, IN: Indiana University Press, 1978.

This edited volume covers a wide range of issues related to urban water system operations, management, and planning, including perspectives on the fragmentation of the water utility industry and prospects for regional integration to improve the effectiveness of water resource management.

Kneese, Allen V. and F. Lee Brown. *The Southwest Under Stress: National Resource Development Issues in a Regional Setting.* Baltimore: Johns Hopkins University Press, 1981.

Lauwaert, Alan J. "Water Quality and Regional Water Supply Planning," *Journal of Water Resources Planning and Management* 111 (July 1985): 253-67.

Miller, William. "Water Resource Planning for Maximum Benefit," *Journal American Water Works Association* 77, no. 9 (September 1985): 44-47.

Miloradov, M. "Planning and Management of Water-Resource Systems in Developing Countries," *Journal of Water Resources Planning and Management* 118, no. 6 (November 1, 1992): 603.

Peralta, R.C., R. R. A. Cantiller, and J. E. Terry. "Optimal Large-Scale Conjunctive Water-Use Planning: Case Study," *Journal of Water Resources Planning and Management* 121, no. 6 (November 1, 1995): 471.

Prasifka, David W. *Current Trends in Water-Supply Planning: Issues, Concepts and Risks* (New York: Van Nostrand Reinhold Company, 1988).

Raj, P. Anand. "Multicriteria Methods In River Basin Planning: A Case Study." *Water Science and Technology* 31, no. 8 (May 1995): 261.

Rao, P. K. "Planning and Financing Water Resource Development in the United States: A Review and Policy Perspective," *American Journal of Economics and Sociology* 47, no. 1 (January 1988): 81.

Smerdon, Ernest T., John A. Gronouski, and Judith M. Clarkson. "Approaches to Water Resource Policy and Planning in Texas," *Water Resources Bulletin* 24, no. 6 (December 1, 1988): 1257.

U.S. Environmental Protection Agency. *Federal Programs Impacting Regional Water Quality Management.* Washington, DC: Miami Valley Regional Planning Commission and Water Planning Division, U.S. Environmental Protection Agency, 1976.

This report describes federal programs related to the Federal Water Pollution Control Act Amendments of 1972. The summary was prepared to assist state and areawide agencies in using existing federal resources to develop regional water quality management programs. The federal programs discussed related to land use, wastewater management, water supply, floodplain management, nonpoint source pollution, solid waste, and transportation. The relevant federal agencies, legislation, objectives, extent of participation, eligibility requirements, and funding status are listed for each program. The potential relationship of each given program to the development of a regional water quality management programs is described. These potential relationships are derived from the opinions of federal officials and federal policies applicable at the time of the report's publication.

Whipple, William. *New Perspectives in Water Supply.* Boca Raton, FL: Lewis Publishers, 1994.

Wilhite, Donald A., ed. *Planning for Drought: Toward a Reduction of Societal Vulnerability.* Boulder, CO: Westview, 1987.

3.2 Natural Resource Modeling

Bargur, Jona. "Dynamic Multisector Programming Approach to Regional Water Resource Management, " *Water-Resources-Research* 8, no. 4 (August 1972): 801-17.

Bennett, G. D. "Regional Ground Water Systems Analysis," *Water Spectrum* 11 (Fall 1979): 36-42.

Bouzaher, Aziz and Jason F. Shogren. "An Integrated Systems Approach to Regionalization with Application to Atrazine and Water Quality," a paper presented at the Agricultural Research to Protect Water Quality Conference of the Soil and Water Conservation Society, et al., Minneapolis, Minnesota, February 21-24, 1993.

Butcher, Jonathan B., Miguel A. Medina, Jr., and Carlos M. Marin. "Empirical Bayes Regionalization Methods for Spatial Stochastic Processes," *Water Resources Research* 27, no. 1 (January 1, 1991): 8.

Cooper, A. Bryce and Adelbert B. Bottcher. "Basin-Scale Modeling as Tool for Water-Resource Planning," *Journal of Water Resources Planning and Management* 119, no. 3 (May-June 1993): 306 (18).

This article describes the development of Basin-New Zealand (BNZ), a basin-scale model used to evaluate the effects of different management practices on water quality. BNZ simulates point and nonpoint sources of pollution and stream attenuation of pollution, using a modified version of the Chemicals, Runoff, and Erosion from Agricultural Management Systems (CREAMS) model to estimate water, sediment, and nutrient run-off. BNZ determined pollutant losses within 30 percent of values estimated from empirical data, and the model successfully characterized changes in pollutant loss resulting from the institution of different pollution control methods. Stream and riparian zone processes must be considered in order to obtain accurate results from models such as BNZ. To effectively execute modeling, users of the models should understand a given model's simplifying assumptions and have a thorough knowledge of the region being studied. Research on stream attenuation of pollution is needed.

Davis, Michael J. *Conceptual Design of a Regional Water Quality Screening Model.* A Report of the Argonne National Laboratory, Washington, DC: Office of Environmental Assessments, U.S. Department of Energy, 1981.

As summarized in Section 2 of this report, a review of existing models and databases used in water quality assessment revealed that the need to develop a model that would fulfill the analytical requirements of the Office of Environmental Assessments (OEA). Section 3 discusses issues that should be considered in any effort to model the effect of given practices or policies on water quality. These issues include the limitations resulting from the spatial scale used in the model, identification of pollutants to be considered in the model, and model calibration. Section 5 describes areas of water quality modeling, such as pollutant load estimation and the dependence of pollutant concentrations on flow. Section 4 outlines an adaptable screening model for regional water quality designed for use in the Department of Energy's Strategic Environmental Assessment System (SEAS) and OEA's Regional Issue Identification Assessment program. The screening model outlined in Section 4 is comprised of a database with information on streams; a generator of pollutant loads, which can be used for describing pollutant loads in non-SEAS applications; and an input-output module describing pollutant transport. The model uses measured concentrations to describe current pollutant levels; future levels are estimated by varying load and flow rates. The model uses only stream data and focuses on energy development effects on water quality. Limitation of the model are that it is unable to describe very localized impacts, it does not consider some important pollution sources such as nonpoint sources and landfill leachate; and it only models pollutants as undergoing exponential decay or none at all.

DeLorme, Charles D., Jr., and Norman J. Wood. "Quantifying Environmental Losses from a Regional Water Development Program," *Growth and Change* 12, no. 1 (January 1981): 21-26.

Graves, Glenn W., Gordon B. Hatfield, and Andrew B. Whinston. "Mathematical Programming for Regional Water Quality Management," *Water Resources Research* 8, no. 2 (April 1972): 273-90.

Kaden, S. "Analysis of Regional Water Policies in Open-Cast Mining Areas--A Multicriteria Approach," in M. Grauer and A. P. Wierzbicki, eds., *Interactive Decision Analysis: Proceedings of an International Workshop.* Lecture Notes in Economics and Mathematical Systems, No. 229. New York: Springer, 1984.

Kao, Jehng-Jung, Jon C. Liebman. "Computer-Aided System for Ground-Water Resources Management," *Journal Of Computing in Civil Engineering* 5, no. 3 (July 1, 1993): 251.

Kirshen, Paul H. "Spatial and Temporal Aggregation Effects in a Regional Water Supply Planning Model," *Water Resources Research* 16, no. 3 (June 1980): 457-64.

Kloosterman, F. H., R. J. Stuurman, R. J., and R. Van Der Meijeden. "Groundwater Flow Systems Analysis on a Regional and Nation-Wide Scale in the Netherlands: The Use of Flow Systems Analysis In Wetland Management," *Water Science and Technology* 31, no. 8 (1995): 375.

Loucks, Daniel P. "Water Resource Systems Models: Their Role in Planning," *Journal of Water Resources Planning and Management* 118, no. 3 (May-June 1992): 214 (10).

Water resource systems models help planners understand the consequences of taking no action or one action over another. This article examines the ways models are used in the planning process, the limitations of models, and the ways planners, modelers and managers must weave expertise into the entire process. The most important part of the process is communication; water resource planners and managers must first determine what information is needed to help make a decision and articulate those needs to the modelers. In turn, modelers must be able to effectively communicate results to the end users.

Lystrom, David J., Frank A. Rinella, David A. Rickert, and Lisa Zimmermann. *Multiple Regression Modeling Approach for Regional Water Quality Management.* Springfield, VA: Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, 1978.

A statistical approach to modeling water quality is described. Although the model is specific to the Susquehanna River basin in Pennsylvania and New York, and similar adjacent areas, the general methodology should be widely applicable. The model can be used as a screening technique to estimate water quality for a basin site or the effect of basin characteristics on water quality. The model was derived from multiple linear regression equations with water quality characteristics as the dependent variables and basin characteristics as the independent variables. Water

quality characteristics included various measures of suspended sediment, dissolved solids, nitrogen, and phosphorus. Basin characteristics were included in the model based on hydrologic relevance and statistical significance, and categorized into six general classes: climate, topography, geology, soils, streamflow, and land use. Monte Carlo simulations, based on long-term stream data, indicated that the error in the results was primarily due to model error and not error in the data and methods. Limitations of the model include its applicability only to a specific region and omission of variables describing point sources and localized nonpoint sources of pollution. Background water quality as measured by the model does not take into account water pollution from precipitation and past land uses. For many regions, sufficient data may not be available for water quality and land use.

Maimone, Mark. "Using Regional Ground-Water Models in Water Resource Planning," *Journal of Water Resources Planning* 117, no. 4 (July-August 1991): 448 (12).

This article presents a personal computer-based model describing water balances for groundwater aquifers in Nassau County, New York. The model takes analysis and planning beyond what can be accomplished with field data because it can be used to simulate the effects of changes in climatic conditions and stress factors. Simulations indicate that the aquifers examined are not being overdepleted, but that withdrawals have changed predevelopment flow patterns. The model is believed to provide more precise estimates of aquifer yield than field measures. It is suggested that the model can be one element in an approach to water management planning that also includes stakeholder and public participation.

McNamara, John R. "An Optimization Model for Regional Water Quality Management," *Water Resources-Research* 12, no. 2 (April 1976): 125-34.

Musgrove, M. and J. L. Banner. "Regional Ground-Water Mixing and the Origin of Saline Fluids: Midcontinent, United States," *Science* 259, no. 5103 (March 26, 1993): 1877.

Orlob G.T. "Water Quality Modeling for Decision Making," *Journal of Water Resources Planning and Management* 118, no., 3 (May-June 1992): 295 (13).

Peralta, R. C, R. R. A. Cantiller and J. E. Terry. "Optimal Large-Scale Conjunctive Water Use Planning: Case Study," *Journal of Water Resources Planning and Management* 121, no. 6 (November-December 1995): 471-478.

The authors analyzed water-use strategies for a region in northeastern Arkansas, a heavily irrigated and groundwater-dependent area. Optimal sustained groundwater yield and conjunctive water-use strategies for the area are presented, based on water demands projected for the five decades of 1990-2039. Groundwater flow simulation and optimization models are used to satisfy temporally increasing water needs for alternative future management scenarios. The models employ a sequential steady-state embedding approach, and contain over 1,600 embedded groundwater and river-volume balance constraints per decade. The authors suggest that the most appropriate scenario is the one in which municipal and industrial demand is always satisfied, and farmers deploy improved water-conservation techniques.

Piggott, Andrew R., A. Ghosh Bobba and Kent S. Novakowski. "Regression and Inverse Analyses in Regional Ground-Water Modeling," *Journal of Water Resources Planning and Management* 122, no. 1 (January-February 1996): 1 (10).

Rossman, Lewis A. and Jon C. Liebman. *Optimal Regionalization of Wastewater Treatment for Water Quality Management.* NTIS Report Pb-236 410. Washington, DC: National Technical Information Service, 1974.

Schaeffers, Hans. "Design of Computer Support for Multicriteria and Multiperson Decisions in Regional Water Resources Planning," in G. Fandel and J. Spronk, eds., *Multiple Criteria Decision Methods and Applications: Selected Readings.* New York: Springer, 1985.

Singh, Krishan P., Sally M. Broeren and Ali Durgunoglu. "Adequacy Of Surface Water-Supply Systems: Case Study," *Journal of Water Resources Planning and Management* 118, no. 6 (November-December 1992): 620-36.

Statewide and regional models can be used to evaluate surface water supplies. Water demand changes over time with changes in a community's population density and industrial development. The combination of increases in demand with reductions of surface water reservoir capacities due to sedimentation can create

problems for water supply planners and managers. A method for calculating future reservoir capacity losses due to sedimentation is available. Various measures can be implemented to maintain adequate, reliable water supplies while taking into account the optimal use of water resources and possible adverse impacts imposed on stream and river ecology. All surface water supply systems in Illinois are investigated with respect to future demands, water source yields, supply inadequacies under specified drought frequencies, and the feasibility and cost-effectiveness of alternative measures.

Texas Department of Water Resources. *Economic Optimization and Simulation Techniques for Management of Regional Water Resource Systems: Multibasin Water Quality Simulation Model QNET-I.* Washington, DC: Office of Water Resources Research, U.S. Environmental Protection Agency, 1982.

Vreke, J. "Modelling Agriculture to Support Regional Water Management," *European Review of Agricultural Economics* 17, no. 3 (1990): 317-34.

Young, George K. and Mary A. Pisano. "A Nonlinear Programming Applied to Regional Water Resource Planning," *Water Resources Research* 6, no. 1 (February 1970): 32-42.

3.3 Watershed Management

Apogee Research, Inc. *Watershed Planning and Management: A Background Paper.* Prepared for the Water Quality 2000 Steering Committee. Bethesda, MD: Apogee, 1991.

This practical guidebook, based in part on surveys of planning agencies and water system managers, provides the scientific basis for watershed planning, an overview of watershed management practices, and technical guidance for establishing a water supply protection program.

Ballweber, Jeffrey A. "Prospects for Comprehensive, Integrated Watershed Management Under Existing Law," *Water Resources Update* 100 (Summer 1995): 19.

The author suggests that watershed management is an "elastic concept," not mandated but implemented on a relatively *ad hoc* basis. The article reviews the concept of watershed management, the role of federal agencies in implementation, and possible reforms of existing laws and institutions. Watersheds provide for holistic resource management because watershed boundaries are well-defined, ecologically important, systematically related, easily understood, and already used in some management efforts. Federal statutes relevant for watershed management can be organized into procedural, regulatory, development, and management categories. Different federal agencies, as well as state and local bodies, play roles within each of these areas. Watershed management could be improved through improvements in regulatory programs (including greater flexibility and less duplication), improvements in nonregulatory programs (such as research and planning), and expansion of partnerships. As Congress considers reauthorizing related legislation (such as the Farm Bill, the Endangered Species Act, and the Clean Water Act), a more holistic approach to watershed management is recommended.

Bulkley, Jonathan W. "Integrated Watershed Management: Past, Present, and Future," *Water Resources Update* 100 (Summer 1995): 7.

This article contrasts regional water management in the United States and Great Britain, with an emphasis on watershed management. In Great Britain, ten watershed-based regional water authorities were established in 1974, in response to growing concerns about water demand, water supply, existing governing institutions, conflict resolution, and planning. In 1989, these authorities were privatized. Legislation passed in 1995 reaffirmed a commitment to integrated environmental protection (water, air, and land), as well as watershed management and planning. In the United States, the National Water Commission was established in 1968 and it also recommended a watershed perspective. The Commission also reiterated the belief that problems should be dealt with at the lowest possible level of government. Subsequent legislation, however, undermined the movement toward watershed planning. Today, the interest in holistic, integrated approaches appears to be growing. Two examples of watershed management in Michigan are provided. The author concludes that specific incentives for a watershed approach can be provided and that the barriers to watershed management can be overcome. The benefits of watershed management are flourishing ecosystems, cost-effective solutions for

adverse impacts, and community commitment. Characteristics of an effective watershed management institution are detailed.

Burby, R. J., E. J. Kaiser, T. L. Miller, and D. H. Moreau. *Drinking Water Supplies: Protection Through Watershed Management.* Stoneham, MA: Butterworth Publishing, 1983.

Burrows, Robert and John D. Koppen. "Grass Roots Lake and Watershed Management Organization," *Lake and Reservoir Management: Proceedings of the Third Annual Conference of the North American Lake Management Society.* Washington, DC: U.S. Environmental Protection Agency, 1984: 482-486.

Clements, J. Trevor, Clayton S., Craeger, Audrey R. Beach, Jonathan B. Butcher, Michael Marcus, and Thomas R. Schueler. *Framework for Watershed Management.* Alexandria, VA: Water Environment Research Foundation, 1995.

This report concerns the development of a strategic planning approach to watershed management. The report notes that several states (including North Carolina, South Carolina, Washington, Nebraska, and Massachusetts) are implementing statewide frameworks incorporating watershed management principles. The essential elements of the continuous management cycle are described: strategic monitoring, basin assessment, prioritization and targeting, developing management strategies, management plan and documentation, and implementation (which is followed in the cycle by strategic monitoring and so on). Researchers used a fictitious community to demonstrate an application of the framework. The role of planning in providing a forum for collaboration among key stakeholders, without a regulatory mandate to participate, is emphasized. Some of the tools for facilitating watershed management identified in the report were: environmental indicators and data integration methods, quantitative risk assessment, water-use attainability analysis, procedures of setting site-specific water quality standards, ecological restoration information, pollution trading guidance, monitoring consortiums, information management and analysis, administrative structures to implement watershed approaches, and watershed zoning. Impediments to statewide watershed management include: legal, institutional, and financial impediments; uncooperative stakeholders; mistrust and cynicism; and transitional issues. Recommendations are made for implementing the watershed framework within constraints.

Culik, Martin N. "Watershed Management Through Public Policy Education," Proceedings of the American Water Resources Association Conference in Bellevue, Washington (June 27-30): 329-338.

Dodd, R. C., P. A. Cunningham, R. J. Curry, and S. J. Sticter. *Watershed Planning in the Albemarle-Pamlico Estuarine System: Report 6, Use of Information Systems for Developing Subbasin Profiles.* A report to the North Carolina Department of Environment, Health, and Natural Resources and the U.S. Environmental Protection Agency, 1995.

Dodd, R. C., and M. McCarthy. *Watershed Planning in the Albemarle-Pamlico Estuarine System: Report 7, Geographic Targeting for Nonpoint Source Programs.* A report to the North Carolina Department of Environment, Health, and Natural Resources and the U.S. Environmental Protection Agency, 1995.

Elder, John F. *Applicability of Ambient Toxicity Testing to National or Regional Water-Quality Assessment.* Denver, CO: U.S. Geological Survey, U.S. Department of the Interior, 1990.

Evans, R. O., J. O. Parsons, K. Stone and W. B. Wells. "Water Table Management on a Watershed Scale," *Journal of Soil and Water Conservation* 47, no. 1 (January-February 1992): 58.

Farrow, Daniel R. G. and Clair T. Bower. "Toward More Integrated Management of Watersheds: Some Past Efforts, Present Attempts, and Future Possibilities," *Water Resources Update* 93 (Autumn 1993): 13.

Watershed management has a long conceptual, legislative, and institutional history. From the 1930s to the 1960s, water management focused on water quantity issues (that is, supply development). Since the 1960s, water quality management in river basins has been a concern, in part because of the efforts of the Quality of the Environment Program at Resources for the Future (RfF). Research at RfF has focused on regional water quality studies, studies of individual water treatment plants, studies of incentives for influencing discharge behavior, and studies of governance (that is, how to organize a region for continuous water quality management). The RfF program has been guided by three principles: water quality

management is related to overall water resource management, water quality and water resource management are multidisciplinary, and formal linkages among disparate agencies involved in these areas is required. The Strategic Environmental Assessments (SEA) program at the National Oceanic and Atmospheric Administration emphasizes water quality management for coastal watersheds. The SEA program involves three stages: data synthesis within a consistent framework, development of management tools, and direct participation in decisionmaking. Specific recommendations are made for improving the management and decision-making processes. Better management decisions can be expected when water managers apply a continuous management framework, adopt improved planning and integration methods, alter aspects of the scientific approach to cement a partnership with management, and involve decisionmakers in analysis and planning.

Mahon, J. D. Jr., and A. Dieffenthaller. "Watershed Management and the Water Business," *Lake and Reservoir Management* 9, no. 2 (1994): 94-95.

Concerns about water quality, increasingly stringent and complex treatment requirements, and the need to protect drinking water sources from degradation provide compelling reasons for water utilities to advocate watershed management. Water and wastewater utilities, environmental agencies, and consumer groups are beginning to recognize the importance of managing water resources at the watershed level.

Margerum, Richard D. "Integrated Watershed Management: Comparing Selected Experience in the U.S. and Australia," *Water Resources Update* 100 (Summer 1995): 36.

The concept of integrated watershed management reflects the growing recognition that water systems are interrelated with other physical and socioeconomic systems. Interorganizational coordination is a key part of integrated management. Although the United States has no national watershed management policy (except for U.S. Environmental Protection Agency guidelines), states and localities are pursuing watershed planning and management. In Australia, the states are implementing the comparable concept of total catchment management. The article compares the U.S. and Australian experiences, which are similar in some features (implementation difficulties, problems with stakeholder commitment, resource availability, and limited implementation tools) and different in others (structure of decisionmaking and approaches to decisionmaking). The Australian experience suggests that involving stakeholders can create much-needed support for integrated watershed

management that cuts across political parties and philosophies. Further guidance and research in integrated approaches is needed.

Nelson, Dennis. "Water Education in Integrated Watershed Management," *Water Resources Update* 93 (Autumn 1993): 34.

Sheng, Ted. C. "Interagency Coordination in Watershed Conservation," in *Conservation Policies for Sustainable Hillslope Farming.* Ankeny, Iowa: Soil and Water Conservation Society, 1992.

Wayland, Robert H., III. "Comprehensive Watershed Management: A View from EPA," *Water Resources Update* 93 (Autumn 1993): 23.

This article reviews the official U.S. Environmental Protection Agency (EPA) position on reauthorization of the Clean Water Act, which provides an opportunity to confirm and promote comprehensive watershed-based management of water resources. A fragmented approach to water quality can no longer be afforded. The EPA's conception of water management consists of: (1) recognizing the interconnectedness of ecosystem resources, (2) identifying priorities and tailoring solutions, (3) building partnerships, (4) integrating programs, and (5) securing local commitment to implementation. Comprehensive management involves every level of government (federal, state, and local), as well as universities (including collaborationists who recognize the need to build interdisciplinary relationships). Also, a "nested" approach recognizes a progression from smaller, localized watersheds to the larger, encompassing water basin; planning and management for the smaller entities must be incorporated within planning and management for the larger entity. New umbrella institutions (such as interstate regional agreements) may be needed. Watershed teams can be used for developing a vision, building understanding, and facilitating implementation.

Wegner, Judith Welch. "Watershed Protection: Problems and Possibilities," *Carolina Planning* 16 (Fall 1990): 19-27.

4. IMPLEMENTATION

4.1 Process Guidance

Alpern, Robert. *Issues and Options in Regional Water Supply.* New York: Citizens Union Research Foundation, Inc., 1979

Advisory Commission on Intergovernmental Relations. *A Handbook for Interlocal Agreements and Contracts.* Washington, DC: Advisory Commission on Intergovernmental Relations, 1967.

Bown, George E. and Gary E. Ferguson. "Overcoming Institutional Barriers and Constraints to Water Quality Management," *Proceedings of the American Water Resources Association Water Laws and Management Conference*, Tampa, Florida (September 17-22, 1989): 2B5-2B16.

Gillies, J. A. "The Role of Advisory Boards in a Water Management Agency," *Water Resources Bulletin* 25, no. 6 (December 1989): 1243-1247.

Justus, Lucy. "A Regional Partnership That Works: The Metropolitan Atlanta Water Resources Study," *Water Spectrum* (U.S. Army Corps of Engineers); 9 (Fall 1977): 27-32.

"Local Water, Local Control," *Civil Engineering* 63, no. 7 (July 1, 1993): 46.

This article explores methods for improving the performance of local irrigation districts, including economic incentives and methods for empowering water users.

McCall, Robert G. *Institutional Alternatives for Small Water Systems.* Denver, CO: American Water Works Association, 1986.

This report reviews a myriad of institutional alternatives for water supply, including physical interconnection, as well as other formal and informal arrangements.

Morris, Robert C. "The Regionalization Process," *Proceedings of the Annual Conference of the American Water Works Association.* Denver, CO: American Water Works Association, 1981.

Nakamura, Liane and Stephen M. Born. "Substate Institutional Innovation for Managing Lakes and Watersheds: A Wisconsin Case Study," *Water Resources Bulletin* 29, no. 5 (October 1993): 807-821.

National Association of Counties Research Foundation. *A Practical Guide to Intergovernmental Agreements/Contracts for Local Officials.* Washington, DC: National Association of Counties Research Foundation, 1977.

Northeast Regional Center for Rural Development. *Community Guide To Groundwater Protection and Management: An Annotated Bibliography.* University Park, PA: Pennsylvania State University, 1985.

Plumlee, John P., Jay D. Starling, and Kenneth W. Kramer. "Citizen Participation in Water Quality Planning: A Case Study of Perceived Failure," *Administration and Society* 16, no. 4 (February 1985): 455-473.

Participants in two water quality projects requiring public participation were surveyed about satisfaction with the planning process. The projects, both in Texas, were sponsored by the U.S. Environmental Protection Agency. In general, participants were not satisfied due to unmet expectations, poor understanding of technical aspects, project delays, and interjurisdictional strife. The authors suggest that satisfaction could be increased if participants were better educated about the requirements of the process, their particular roles, the positions of other participants, and problems that might be encountered. Alternative approaches to choosing advisory groups should be considered.

Syme, G. J., D. K. Macpherson, and C. Seligman. "Factors Motivating Community Participation in Regional Water-Allocation Planning: A Test of an Expectancy-Value Model," *Environment and Planning* 23, no. 12 (December 1991): 1779-95.

Syme, Geoffrey J. and Blair E. Nancarrow. "Predicting Public Involvement in Urban Water Management and Planning," *Environment and Behavior* 24, no. 6 (November 1992): 738.

SMC Martin, Inc. *Regionalization Options for Small Water Systems.* Washington, DC: U.S. Environmental Protection Agency, 1983.

Regionalization is defined as "the administrative or physical combination of two or more community water systems for improved planning, operation, and/or management. Regionalization should be viewed in the context of a range of possible approaches, from the actual physical interconnection of systems to an administrative and management arrangement to provide common technical, operational, or financial services for two or more systems" (III-1). This report describes the problems faced by small water systems, regionalization options, analyzing and selecting an option, and implementation. Nonstructural options include informal agreements, basic service contracts, joint service contracts, and the formation of a regional council of local officials. Structural options include annexation, as well as the formation of water-supply associations, corporations, special districts, and areawide authorities. The advantages and disadvantages of each approach are described. Evaluation criteria also are provided: economic efficiency, fiscal equity, political accountability, administrative effectiveness, legal authority, costs, and policy/political constraints. A framework for implementation is presented.

Thomsen, Arvid Lee. *Public Participation in Water and Land Management.* Albany, New York: New York State Sea Grant Program, 1973.

U.S. Environmental Protection Agency. *Restructuring Manual.* Washington, DC: U.S. Environmental Protection Agency, 1991.

This guidance manual provides an overview of restructuring terminology and a step-by-step implementation process. Five "how-to" steps are described: (1) define the problem, (2) conduct a feasibility study, (3) find a "champion," (4) choose a restructuring option, and (5) develop a plan to sell the concept. The role of the drinking water regulator in promoting restructuring is described in detail. Additional materials are provided on "trouble-shooting" and "where to go for help."

U.S. Environmental Protection Agency. *Restructuring Small Drinking Water Systems.* Washington, DC: U.S. Environmental Protection Agency, 1995.

Small water systems face challenges in terms of deteriorating infrastructure, lack of access to capital, limited customer base and rate base, poor economies of scale, and inadequate technical and managerial capabilities. This manual provides options for dealing with these problems. Restructuring is presented on a continuum of five categories, from making internal changes, to establishing informal cooperation among systems, to forging contractual arrangements between systems, to establishing agencies with joint powers, and finally, to transferring ownership. The first category preserves the greatest degree of local control, while the last involves transferring responsibility through an acquisition by a larger entity (which may be existing or new, as well as public or private). Thirty case studies of small systems restructuring are presented, in hopes that they will inspire other small systems to consider the benefits of restructuring.

Williams, Normal C. and Martin J. Redfern. "The Financial Feasibility of Regionalization," *Journal American Water Works Association* 65 (March 1973).

This article discusses financial issues associated with the possible centralization of the thirteen existing independent water supply systems in Benton and Washington Counties in northwestern Arkansas. The financial feasibility of centralization was evaluated according to two criteria: the rate of return on the incremental investment in the regional system compared to the cost of capital for the water systems in the area, and the amortization period of a bond issue necessary to finance the project compared to the productive life of the system. Based on anticipated increases in regional water demand, the authors suggest that the centralized system would be more financially viable than separate, smaller suppliers.

4.2 Strategies and Incentives

Bowman, L. G. "Consolidations--FmHA's Perspective," *National Rural Water Association Journal* 11, no. 2 (Summer 1990): 32.

Capen, Charles H. "Real or Rash Regionalization," *Journal American Water Works Association* 67 (October 1975).

This article addresses the problems city-owned water systems face when trying to obtain compensation for supplying water to areas outside their municipality. The article describes the various attempts made by the thirty cities in the study to gain just compensation. The article concludes that the district or regionalization, along with the use of arbitration boards, may be viable methods for resolving this issue.

Cawley, James H. "The Takeover of Troubled Water Companies," *Proceedings of the Fourth Biennial Regulatory Information Conference, Volume 1.* Columbus, OH: The National Regulatory Research Institute, 1984, 359-69.

Cloud, Thomas A. "When a City Buys a Utility," *Water Engineering & Management* 141, 10 (October 1994): 24-26.

Water system acquisitions require a number of considerations: (1) system income and expenses, (2) level of contributions in aid of construction, (3) rate base, (4) condition of facilities, (5) reasonableness of price and terms, (6) impact on customers, (7) required additional investments, (8) alternatives to sale and impacts of no sale, (9) ability to operate facilities, and (10) public interest assessment. In evaluating whether to purchase a water or wastewater system, and designing a purchase agreement, local governments or private utilities should exercise appropriate caution.

Gallier, W. Thomas. "Planning and Implementing a Dual Distribution System," *Journal American Water Works Association* 77, no. 11 (November 1985): 40-44.

Haarmeyer, David. "Privatization of Infrastructure: Options for Municipal Systems," *Journal American Water Works Association* (March 1994): 43.

Haarmeyer, David. *Privatizing Infrastructure Options for Municipal Water-Supply Systems.* Policy Insight No. 151. Los Angeles, CA: The Reason Foundation, 1992.

Hanke, Stephen H. and Stephen J. K. Walters. "Privatization and Natural Monopoly: The Case of Waterworks," *Privatization Review* (Spring 1987).

Holmes, William D. "The Takeover of Troubled Water Companies," *Proceedings of the Fourth Biennial Regulatory Information Conference, Volume 1.* Columbus, OH: The National Regulatory Research Institute, 1984, 371-76.

Jekel, D. "Consolidation--The Right Answer?" *National Rural Water Association Journal* 11, no. 2 (Summer 1990): 9.

Kucera, Daniel J. "Privatization of Water and Wastewater Utilities: A Very Public Affair," *Water Engineering & Management* 142, no. 4 (April 1995): 15-17.

Historically, high rates and poor service associated with private ownership, the infeasibility of serving remote areas, municipal law, and nationalization movements have promoted government ownership of water and wastewater utilities. Today, a shift toward privatization (or "investorization") can be explained by the financial burdens associated with facility deterioration, the financial burden associated with high water quality standards, the revenue needs of local governments, and a political climate favoring capitalism. This movement also reflects the original principles of public utility law (investor-owned utilities affected with a public interest). Increasing water scarcity promotes water supply consolidation or regionalization, which often occurs in conjunction with privatization. Several legal issues that should be considered during privatization efforts also are considered.

Kucera, Daniel J. "Compensation for Contributed Property," *Water Engineering & Management* 141, no. 5 (May 1994): 14.

This article summarizes court cases pertaining to compensation for contributed property, which can be an issue in utility acquisition strategies and consolidation of the water utility industry. Contributed property is defined as the land or utility plant acquired by a utility without investment by the utility. In February 1993, the Supreme Court of Florida upheld an appealed ruling that ordered a county to

compensate an investor-owned water utility for contributed property that the county had condemned. The decision implies that, since a water utility is allowed to earn a return on its system, regardless of whether or not corporate funds have been invested in the system, the cost of acquired contributed property can be included in municipal rates and considered during condemnation proceedings. The established legal requirement of fair compensation for contributed property may increase the cost of acquisitions.

Limbach, Edward W. "The Future of Public/Private Partnerships for Water Infrastructure," *Proceedings of the Fourth Biennial Regulatory Information Conference.* Columbus, OH: The National Regulatory Research Institute, 1994..

Limbach, Edward W. "The Takeover of Troubled Water Companies," *Proceedings of the Fourth Biennial Regulatory Information Conference, Volume 1.* Columbus, OH: The National Regulatory Research Institute, 1984, 377-83.

Limbach, Edward W. "Single Tariff Pricing," *Journal American Water Works Association* 76, no. 9 (September 1984): 52-55.

McQueen, James R. "Takeover of Small Failing Water Systems," *Proceedings of the Annual Conference of the American Water Works Association, 1991.* Denver, CO: American Water Works Association, 1991, 341-45.

Miceli, Kenneth D. "The Problems of Small Water Companies and the Takeover as a Solution," *Proceedings of the Fifth Biennial Regulatory Information Conference, Volume 2.* Columbus, OH: The National Regulatory Research Institute, 1986: 1421-35.

4.3 Information Systems

Bailey, R. G., and H. C. Hogg. "A World Ecoregions Map for Resource Reporting," *Environment and Conservation* 13, no. 3 (1986): 195-202.

Understanding regional variations in climate, vegetation, and soil is essential for developing resource management and conservation strategies. A regional approach facilitates planning for large areas, organizing a resource inventory, and interpreting inventory data. The authors propose an international mapping project to delineate the globe's various ecoregions.

Baum, David. "Water District Fights Drought with Data Technology," *InfoWorld* 16, no. 30 (July 25, 1994): 68.

The Los Angeles-based Metropolitan Water District (MWD), which distributes water to twenty-seven member agencies, employs a relational database and a geographic information system to monitor water usage patterns, generate long-term demand forecasts, and produce reports incorporating tabulated and spatial data.

Castillo, Eloise, Sally K. Keefe, and Robert S. Raucher. *Small System Restructuring to Facilitate SDWA Compliance: An Analysis of Potential Feasibility.* Denver, CO: American Water Works Association Research Foundation, 1996.

This research study tested the hypothesis that many small systems can be physically interconnected with medium-sized or larger systems in order to enhance compliance with drinking water regulations. The potential for satellite management (without physical interconnection) also was analyzed. Using the available data, a full analysis was conducted for the water systems in seventeen states and a partial analysis was conducted for the water systems in twelve states. Screening criteria were developed to evaluate the cost effectiveness of the alternatives. For physical interconnection, the screening criteria were the interconnection costs (based on the distance between systems) and the resulting investment cost per customer (for both the acquiring and the acquired entity). Interconnection in rural areas was assumed to be half as costly as interconnections in urban areas. A geographic information system was used to screen for physical barriers (such as bodies of water and elevation changes) that could impede interconnection. For satellite management, the screening criterion was based on the driving distance (60 road miles) between systems. Computer-generated maps illustrate restructuring opportunities within each state. The researchers found that on a national scale the potential for cost-

effective restructuring was tremendous, with variations in opportunities from state to state. For implementation, restructuring also would require attention to several legal, institutional, and cultural barriers.

"Computer Model Aids Water Planning," *Civil Engineering* 62, no. 7 (July 1992): 28.

"Computer Tools Simplify Sewer Planning," *Water Environment & Technology* 7, no. 7 (July 1, 1995): 34.

Dean, Burton V.; Roger L. Salstrom, Jim Fiedler, Bill Molnar, and Kent Haake. "Statistical and Simulation Analysis Assists Santa Clara Valley Water District Planning," *Interfaces* 24, no. 6 (November/December 1994): 82-99.

Simulation software was used to project water supply and demand conditions in Santa Clara County, California. Alternatives for dealing with anticipated water shortages were evaluated. The analysis helped establish needs in terms of conservation, water purchases, out-of-county storage contracts, and additional local supplies.

Drake, Tracy. "PLCs Assigned Many Tasks in Large Water Utility," *Water Engineering & Management* 141, no. 12 (December 1994): 31-33.

This article describes the use of programmable logic controllers (PLCs) by the North Jersey District Water Supply Commission at a large regional water treatment facility.

Greene, R. G. and J. F. Cruise. "Urban Watershed Modeling Using Geographic Information Systems," *Journal of Water Resources Planning and Management* 121, no. 4 (July-August 1995): 318 (8).

He, Chansheng, James F. Riggs, and Yung-Tsung Kang. "Integration of Geographic Information Systems and a Computer Model to Evaluate Impacts of Agricultural Runoff on Water Quality," *Water Resources Bulletin* 29, no. 6 (November 1, 1993): 891.

Hren, Janet, Carolyn J. Oblinger Childress, and Norris, J. Michael. "Regional Water Quality Summary: Evaluation of Data for Assessing Conditions and Trends," *Environmental Science & Technology* 24, no. 8 (August 1, 1990): 1122.

Jacobs, P., I. C. Goulter, and J. Davidson. "Water-Distribution GIS from Fragmented and Incomplete Information. *Journal of Computing in Civil Engineering* 7, no. 3 (July 1, 1993): 372.

The City of Winnipeg has developed a Geographic Information System (GIS) including pipe characteristics, leaks, and locations. A water supply reliability study provided the impetus for creating the system The paper discusses the types of data that were needed, as well as how the data were derived from documents and computerized files and incorporated into the GIS. The analysis indicated that pipe characteristics within small areas usually are consistent, making it possible to develop reasonable assumptions for missing data.

Jankowski, Piotr and Craig ZumBrunnen. "Towards Modeling Support System for Simulation of Water Quality," *Journal of Computing in Civil Engineering* 7, no. 3 (July 1, 1993): 354.

Leipnik, Mark R., Karen K. Kemp, and Hugo A. Loaiciga. "Implementation of GIS for Water Resources Planning and Management," *Journal of Water Resources Planning and Management* 119, no. 2 (March-April 1993): 184 (22).

The key stages in implementing a geographic information system (GIS) are: (1) becoming GIS-aware, (2) defining needs, (3) system selection, (4) system implementation, and (5) operation and maintenance. Critical factors to consider at each stage are discussed.

McKinney, Daene C., David R. Maidment, and Mustafa Tanriverdi. "Expert Geographic Information System for Texas Water Planning," *Journal of Water Resources Planning and Management* 119, no. 2 (March-April 1993): 170 (14).

A geographic information system and an expert system were linked to generate alternatives for regional water management. This tool was developed to reduce the time required to update water plans in Texas. In a pilot application to Corpus Christi, for which a water deficit was projected, alternative water sources were identified over a 50-year horizon.

Norris, J. Michael. *Water-Quality Data-Collection Activities in Colorado and Ohio.* Phase III: Evaluation of Existing Data for Use in Assessing Regional Water-Quality Conditions and Trends. Denver, CO: U.S. Geological Survey, U.S. Department of the Interior, 1992.

Prewitt, Todd. "Raging Waters," *Communications* 31, no. 10 (October 1994): 58-62.

Water district managers can use user-friendly computerized Supervisory Control and Data Acquisition (SCADA) products to help control their operations.

Reitsma, Rene, Ilze Zigurs, Clayton Lewis, Vance Wilson and Anthony Sloane. "Experiment With Simulation Models In Water-Resources Negotiations," *Journal of Water Resources Planning and Management* 122, no. 1 (January-February 1996): 64.

Ross, Mark A. and Patrick D. Tara. "Integrated Hydrologic Modeling with Geographic Information Systems," *Journal of Water Resources Planning and Management* 119, no. 2 (March-April 1993): 129 (12).

Schillgalies, Joachim and Gerhard Kreiling. "Multi-Stage Control System Supports German Region's Water Needs," *Water Engineering & Management* 142 , no. 3 (March 1995): 40-43.

Shea, Conor, Walter Grayman, Douglas Darden, Richard M. Males and Peter Sushinsky. "Integrated GIS and Hydrologic Modeling for Countywide Drainage Study," *Journal of Water Resources Planning and Management* 119, no. 2 (March-April 1993): 112 (17).

Spruill, T. B. *Monitoring Regional Ground-Water Quality--Statistical Considerations and Description of a Monitoring Network in Kansas.* Denver, CO: U.S. Geological Survey, U.S. Department of the Interior, 1991.

Stalford, Richard N. and Kenneth V. Lewis. "Case Study: GIS and Facility Management," *Public Works* 124, no. 4 (April 1, 1993): 57.

This article presents a case study of how a city can use geographic information systems (GIS) to plan for future water supply needs.

"Trends in Choosing a Geographic Information System," *Water Engineering & Management* 137, no. 11 (November 1, 1990): 20.

Computer-assisted mapping, automated mapping, and geographic information systems differ in terms of data structure intelligence.

Walsh, Michael R. "Toward Spatial Decision Support Systems in Water Resources," *Journal of Water Resources Planning and Management* 119, no. 2 (March-April 1993): 158 (12).

Geographic information systems (GIS) and decision support systems (DSS) are being linked, providing a new class of systems called spatial decision support systems (SDSS). The technology is in a prototype stage. SDSSs integrate water resource models, expert models, spatial and non-spatial data, and a user interface. SDSSs allow expression of the spatial aspects of water resource problems. More work should be done to integrate the components, as well as to test and evaluate prototypes.

Ward, R. M. and R. E. A. Storm. "A Land Use Mapping Technique for City and Regional Planning," *Journal of Environmental Management* 17, no. 4 (1983): 325-332.

This article describes the use of a technique (epsilon generalization) delineating planning areas (urban, rural, and urban-rural fringe) without using political boundaries.

5. POLICIES AND INSTITUTIONS

5.1 Government Roles and Coordination

Advisory Commission on Intergovernmental Relations. *Multistate Regionalism.* Washington, DC: Advisory Commission on Intergovernmental Relations, 1972.

Advisory Commission on Intergovernmental Relations. "Intergovernmental Cooperation in Water Governance: Commission Recommendations," *Intergovernmental Perspective* 18, no. 3 (Summer 1992): 6.

Allee, David J. "Subnational Governance and the International Joint Commission: Local Management of United States and Canadian Boundary Waters," *Natural Resources Journal* 33, no. 1 (Winter 1993): 133-151.

Blase, Melvin G., Wendell Gottman, and Coy G. McNabb. "Public Water Supply Districts: Evaluation of a New Institution," *Land Economics* 48 (August 1972).

The challenges faced by rural and small-town Public Water Supply Districts are discussed. Ninety-four districts in Missouri were surveyed in 1968 about their problems. A major problem for new districts is fluctuations in the number of users, caused by customers who do not follow through on their commitment to hook up to the system and others who discontinue service. District capital requirements varied widely, depending on the number of users and miles of pipe. Operating expenses are influenced primarily by the number of users, and by the amount of time volunteered by board members. Clerical expenses also are a major cost. Solutions include providing more complete financial information to customers, penalizing customers who do not honor contracts, discontinuing the practice of refunding deposits, and forecasting capital and operating expenses based on the number of customers and miles of pipe in the system.

Blomquist, William. "Taking Federalism Underground: Managing Water Resources," *Intergovernmental Perspective* 17, no. 3 (Summer 1991): 6.

As national surface water supplies have become developed and increasingly scarce, groundwater usage has increased. A growing consensus nationally is that conjunctive management should be used to coordinate groundwater and surface

water supplies. Since the characteristics of groundwater basins and usage vary regionally, an inflexible national policy would be problematic. As a result, interorganizational arrangements and other innovative means have been developed for managing conjunctive use. Some of the types of arrangements used include special districts, private entrepreneurship, centralized state administration, and interstate and interlocal cooperation. Under these arrangements, several functions are managed, including overdraft control, storage capacity regulation, water quality protection, and cost management. The federal government should support basic and applied research, and develop ambient and drinking water standards. States should provide user incentives relating to water rights and transfers, institutional capacity for regulation and conflict resolution, and technical assistance. Local governments should price water, impose overdraft protection, and regulate underground water storage.

Boland, John J. "Clean Water Act Needs Regional Goals and Flexible Standards," *Water Environment and Technology* 5 (May 1993): 11-12.

Bumstead, John C. "Politics of Regionalization--A Public Perspective," *American Water Works Association Annual Conference Proceedings.* Denver, CO: American Water Works Association, 1978.

Delaware River Basin Commission. *Interstate Planning For Regional Water Supply And Pollution Control.* Washington, DC: U.S. Environmental Protection Agency, 1972.

"Diminishing Water Resources and International Law: U.S.-Mexico, A Case Study," *Cornell International Law Journal* 24, no. 2 (Spring 1991): 299.

Donnelly, Basil S., Stephan A. Hartman, and Cathleen M. Stryker. "Considering Comprehensive Water Legislation: Pennsylvania as a Case Study," *The Villanova Environmental Law Journal* 3, no. 2 (1992): 443.

Dworsky, Leonard B., David J. Allee, and Ronald M. North. "Water Resources Planning and Management in the United States Federal System: Long-Term Assessment and Intergovernmental Issues for the Nineties," *Natural Resources Journal* 31, no. 3 (Summer 1991): 475.

Duncan. A. "Proposal for a Columbia Basin Watershed Planning Council," *ILLAHEE* 10, no. 4 (1994): 287-303.

According to the author, the Northwest Power Planning Council should have regional responsibility for developing a unified view of the Columbia-Snake basin and implementing watershed-based management, planning, and conservation strategies.

Einsweiler, Robert C. "Lessons in Regionalization," *Proceedings of the AWRA Unified River Basin Management Symposium*, Atlanta, Georgia (October 4-8, 1981): 361.

This paper compares the authority and responsibilities of the Upper Mississippi River Basin Commission and the metropolitan council of the Twin Cities, Minnesota, suggesting that an institutional model emphasizing broad-based and policy-oriented approach has advantages over traditional basin commissions or compact authorities.

Erhardt, Carl. "The Battle Over 'The Hooch': The Federal-Interstate Water Compact and the Resolution of Rights in the Chattahoochee River," *Stanford Environmental Law Journal* 11 (1992): 200.

Francis, George. "Binational Cooperation for Great Lakes Water Quality: A Framework for the Groundwater Connection," *Chicago-Kent Law Review* 65, no. 2 (1989): 359.

The Great Lakes Water Quality Agreement can provide a comprehensive, ecosystem framework for addressing groundwater issues and promoting United States-Canadian cooperation.

Frey, Frederick W. "The Political Context of Conflict and Cooperation Over International River Basins," *Water International* 18, no. 1 (March 1, 1993): 54.

Fullerton, David. "No Magic Solutions: Without Cooperation Water Woes Won't Go Away," *California Grower* 19, no. 1 (January 1, 1995): 38.

Gellis, Ann J. "Water Supply in the Northeast: A Study of Regulatory Failure," *Ecological Law Quarterly* 12, no. 3 (1985): 429-480.

Despite plentiful supplies, water shortages in the Northeast can be attributed to inadequate institutional mechanisms. The region's numerous distribution systems and the legal environments in which they operate are highly fragmented. Consolidation and regionalization can enhance regional supply reliability, during drought periods and otherwise.

Girardot, Joseph W. "Toward a Rational Scheme of Interstate Water Compact Adjudication," *University of Michigan Journal of Law Reform* 23, no. 1 (Fall 1989): 151.

Goldmann, Kjell. "The Line in Water: International and Domestic Politics," *Cooperation and Conflict* 24, no. 3 (1989): 103.

Grigg, Neil S. "New Paradigm for Coordination in the Water Industry," *Journal of Water Resources Planning and Management* 119, no. 5 (September-October 1993): 572.

More coordination is needed to increase efficiency, reduce conflict, and prevent environmental damage in the U.S. water industry. New roles are suggested for players within existing institutions to facilitate coordination for several purposes: (1) to improve recognition of the integrated nature of the water industry, (2) to establish a national water-management reporting function, (3) to provide plans and arrangements for geographic coordination, (4) to carry out national water policy studies, (5) to coordinate water data and research, and (6) to provide education and training programs.

Grigg, Neil S. "Regionalization in the Water Supply Industry: Status and Needs," *Journal of Water Resources Planning* 115, no. 3 (May 1989): 367 (12).

The status of regionalization in the U.S. water industry is described. Many policy studies have advocated regionalization of water supply. Trends toward consolidation, including mergers and cooperative arrangements, can be seen. Regionalization potentially increases economies of scale, increases reliability of service in new areas, and benefits water quality. The major barriers to regionalization are political, but they also can be financial or technical. The states are a logical place for sustained policy attention to regionalization, since federal intervention would be unpopular and local intervention is unlikely. The author also concludes that the water industry would benefit from developing better databases with financial, facility, and performance measures and that this effort could help the industry overcome the lack of market and regulatory incentives for cost control and performance improvement.

Grigg, Neil S. and Evan C. Vlachos. "Drought and Water-Supply Management: Roles and Responsibilities," *Journal of Water Resources Planning and Management* 119, no. 5 (September-October 1993): 531 (11).

The traditional roles of local, state, and federal agencies in drought management do not result in adequate drought management. Drought management should an ongoing, not just a periodic, process. Local governments should consider variability, not just average demand in water planning. Although state governments have greatly increased drought planning efforts in the last twenty years, further analysis and coordination at the river basin level is needed. The federal government should provide more assistance in managing data, conducting regional studies, and coordinating water management activities.

Harrison, David C. "Organization of the Water Policy Process 'From the Bottom Up': The Red River Valley of the North Experiment," *Water Resources Bulletin* 22, no. 5 (October 1986): 731-743.

Hesse, Richard J. "A Regional Approach to Public Water Supply," *Journal American Water Works Association* 69 (May 1977).

This article describes the formation of the West Coast Regional Water Supply Authority (WCRWSA), which supplies water to the Tampa Bay, Florida area. The WCRWSA is authorized to construct and maintain facilities in order to meet the demand for water in the region. Under this regionalization scheme, counties and municipalities also continue to operate their own facilities. Ultimately, WCRWSA should be fully financed by water sales.

Homerosky, F., et al. *Survey of State Programs and Attitudes on Regionalization for Public Water Systems.* A Report of the Regionalization Task Committee, Water Supply and Resource Management Committee, Environmental Engineering Division. American Society of Civil Engineers, April 1977.

Hooker, Donald. "A Regional Response to Water Supply Emergencies," *Journal American Water Works Association* 73 (May 1981): 232-37.

This case study describes the creation of the Washington Water Supply Emergency Agreement (WSEA) to coordinate water conservation during water shortages in the Washington, DC, metropolitan area. Shortages can result from drought or malfunction in water supply systems. The area's Council of Governments (COG) formulated the WSEA and oversees the agreement The WSEA provides for efficient emergency planning and provides for consistent, clear communication to the public in the event of a water shortage. The WSEA encompasses the Potomac Low Flow Allocation Agreement (PLFAA) and the Water Supply Emergency Plan (WSEP). The PLFAA characterizes water shortages and details the formula for determining water allocation to area suppliers under shortage conditions. The public and affected agencies receive information according to the WSEP. The WSEP also outlines conservation measures. The WSEP provides for conservation measures under increasingly severe stages (alert, restriction, and emergency).

Hubbell, Peter G. "The Evolution of the Institution of Water Management Districts in Florida," *Proceedings of the American Water Resources Association Water Laws and Management Conference*, Tampa, Florida (September 17-22, 1989): 2A-23.

Ingram, Helen M. "The Political Economy of Regional Water Institutions," *American Journal of Agricultural Economics* 55, no. 1 (February 1973): 10-18.

This article theorizes that the effectiveness of regional water organizations depends on the political environment of the region. The political environment of regional organizations, as well as strategies for gaining the support of political entities, are described. The article concludes that cooperation from various political interests and the public are necessary to the successful operation of a regional water organization.

Kim, C. S. and Michael R. Moore. *Public Policies in Water-Resource Use: Their Effect on Groundwater Mining and Surface-Water Imports.* Technical Bulletin 1764. Washington, DC: Economic Research Service, U.S. Department of Agriculture, 1989.

Lord, William B. and Douglas S. Kenney. "Resolving Interstate Water Conflicts: The Compact Approach," *Intergovernmental Perspective* 19, no. 1 (Winter 1993): 19.

Maxwell, J. M. and Wubbena, R. L. "Developing County-Wide Management Systems and Satellite System Operations," *AWWA Seminar Proceedings: Small Water System Solutions.* Denver, CO: American Water Works Association, 1982.

A new statewide approach to dealing with small water system problems is described. Washington State's Public Water System Coordination Act encourages counties to develop management systems for water utility planning and management. In urban areas, fixed control areas are established to provide county governments and water utilities with a framework for more efficient planning and coordination. The service areas of existing utilities are permanently defined, and no new systems may be created. The act also provided for the creation of a county-wide satellite system management agency to provide support to rural areas. Support services fall under three categories: ownership transfers, contract services, and technical support.

McCool, Daniel. "Intergovernmental Conflict and Indian Water Rights: An Assessment of Negotiated Settlements," *Publius* 23, no. 1 (Winter 1993): 85.

Milliman, Jerome. "Municipal Water Systems: The Challenge for Urban Resource Management," in David Holtz and Scott Sebastian, eds. *Municipal Water Systems--The Challenge for Urban Resource Management.* Bloomington, IN: Indiana University Press, 1978.

Existing institutional structures for water planning do not adequately address the needs of metropolitan areas, produce policies that are efficient on a regional scale, or facilitate modeling and forecasting for urban resource management. The Water Pollution Control Act of 1972, for example, contains language implying that planning for water supply and water quality are independent processes. The result is fragmented and sometimes inefficient policies. To address these problems, permanent regional agencies could be created to provide needed research and expertise for implementing integrated and more efficient policies. Current forecasting techniques also are limited. Forecasts often fail to account for the full range of variables that influence water consumption behavior. Capability exists to develop more accurate models that integrate demographic, economic, and water resource variables at the regional level. Federal water agencies could assist in the development of regional models for application in metropolitan areas. Regional models should be reasonable in cost and size, and continuously monitored for internal validity. An econometric model for regional demand forecasting is presented.

Okun, Daniel A. "Fragmentation of the Water Industry in the U.S.," in David Holtz and Scott Sebastian, eds. *Municipal Water Systems--The Challenge for Urban Resource Management.* Bloomington, IN: Indiana University Press, 1978.

Fragmentation of the water industry under existing institutional arrangements undermines sound management to achieve desired goals, including economic efficiency. Federal drinking water regulations have brought thousands of water systems under the purview of the Environmental Protection Agency and the states. Many thousands of wastewater systems also operate in the United States, mostly independent of water supply operations. The Federal Water Pollution Control Act of 1972 recognized the need for regional wastewater treatment operations, but implementation has faltered. Despite much attention to and support for regionalization in the water sector, little has been accomplished in terms of overcoming local parochialism. Physical interconnection is not required. In Great Britain, regionalization reduced the number of systems from 1,200 in 1945 to 187 in 1974. Ten water authorities, defined by hydrologic boundaries and governed by appointed and elected officials, were created pursuant to the Water Act of 1973. While the United States cannot necessarily replicate the British model, a key lesson

for the United States is that the institutional context of water management must be addressed before technical and economic success can be achieved.

Okun, Daniel A. "State Initiatives for Regionalization," *Journal American Water Works Association* 73, no. 5 (May 1981): 243-246.

This article suggests that economies of scale make regionalization of water management advantageous, particularly in comparison to the highly fragmented organizational structures characterizing the U.S. water supply industry. Local governments, however, do not want to lose sovereignty over their water supply, while federal laws offer contradictory incentives for regionalization. The author concludes that state governments have the greatest ability and incentive to initiate regionalization. Examples of federal and state regionalization efforts are discussed.

Pinkham, Richard and Scott Chapin. *Water 2010: Four Scenarios for 21st Century Water Systems.* Snowmass, CO: Rocky Mountain Institute, 1996.

Considering a variety of influences on the U.S. water industry, the authors develop four future scenarios. Two underlying and critical uncertainties were used to construct the scenarios: the role of the federal government in water management and the nature of utility finances (namely, access to capital and the public's willingness to pay for maintaining, improving, and expanding water service). A dominant federal role combined with a weak financial environment produces a "mandate" future, characterized by underfunding and lacking coordination. A reduced federal role and a weak financial environment combine to produce an "apocalyptic" future, where activist federal agencies are history. A dominant role with a supportive financial environment produces a "Camelot" future, with high quality and quantity standards, a strong economy, and readily available financial support. The combination of a reduced federal role and a supportive financial environment produces a "market-oriented" future, with minimal federal standards and funding, an emphasis on partnerships, and a market that produces mixed results for different kinds of utilities. The report also describes the methodology for building the scenarios.

Roberts, Christopher M. "A Blueprint for the Basin," *Delaware Conservationist* 32, no. 2 (Summer 1989): 14.

The Delaware River Basin Commission provides a unifying role in managing water resources in the regional of the Delaware River and Bay.

Roberts, Christopher M. "Restoration Along the Delaware," *The Conservationist* 43, no. 6 (May 1, 1989): 2.

Federal, state, and local organizations making up the Delaware River Basin Commission have had a positive impact on Delaware River and its basin.

Rotival, A. H. "Beyond the Decade: A Framework for Global Cooperation," *Water Science and Technology* 23, no. 1 (1991): 211.

Sherk, George William. "Resolving Interstate Water Conflicts in the Eastern United States: The Re-Emergence of the Federal-Interstate Compact," *Water Resources Bulletin* 30, no. 3 (May 1, 1994): 397

Population growth in the Eastern U.S. has increased the demand for water. The necessity for new transbasin diversions in response to this growing demand often is at the root of interstate water conflicts. This article looks at several past and current conflicts, and evaluates the efficiency of the alternatives used in their resolution. The author concludes that interstate compacts are the most effective method for conflict resolution.

Smith, Robert G. *Public Authorities, Special Districts and Local Government.* Washington, DC: National Association of Counties, 1965.

Smith, William R. "Regional Allocation of Water Resources," *Journal American Water Works Association* 73 (May 1981): 226-31.

This case study describes the formation and structure of the Monterey (California) Peninsula Water Management District (MPWMD). In a newly created institution such as the MPWMD, it is important to maintain a historical file so that the institution's achievements can be monitored and extraneous projects can be

avoided. It also is important to identify areas where the new institution's powers may overlap with the jurisdictions of existing agencies and to maintain good public relations so that voters will support the new institution financially. The MPWMD is funded through water sales, assessments, charges, fees, and bonds. The District's responsibilities include the sale of water and water rights, flood control, the purchase of water utilities, drought rationing, water connection regulation, and planning.

U.S. House of Representatives. "Hearing on Regional Drinking Water Supplies," February 11, 1991.

5.2 Economic Regulation

"1991 State Regulators' Forum," *Public Utilities Fortnightly* (November 1, 1991): 29-37.

Beecher, Janice A. and G. Richard Dreese. *Viability Policies and Assessment Methods for Small Water Utilities* (Columbus, OH: The National Regulatory Research Institute, 1992).

This research report provides an overview of water system viability issues, focusing both on policies to address the emergence of new water systems and policies to address the viability problems of existing systems. Viability is described as a three-legged stool consisting of financial, managerial, and technical capabilities. Viability also is described as having structural, regulatory, and comprehensive components. A wide range of policy options, including regionalization, is described. For many small water systems, the least-cost solution to standards compliance and other problems is a structural solution. The report also provides an overview of viability assessment methods, including qualitative and quantitative approaches. A basic viability assessment model, drawing on the bank failure prediction models, is presented. The model uses a composite of key financial indicators to generate distress scores, which are calibrated according to a database drawn from industry sources. Efforts of the states to address viability are reported, including regulatory commission policies and new statutory authority in such areas as takeovers. The report is directed to state public utility regulators and others interested in small water system viability.

Beecher, Janice A., G. Richard Dreese, and John D. Stanford. *Regulatory Implications of Water and Wastewater Utility Privatization.* Columbus, OH: The National Regulatory Research Institute, 1995.

This research report, prepared for state pubic utility regulators, explores the rationale for privatizing water and wastewater utilities in the United States. Theoretical arguments and empirical findings on the comparative performance of publicly and privately owned utilities are reported. Case studies of privatization suggest that financial needs, regulatory compliance, and source of supply constraints are among the leading factors behind privatization. Case studies of municipalization also are reported. Regionalization of the water sector through mergers and acquisitions is considered. Regulatory issues related to water utility privatization are explored and a model of structured competition is outlined.

Jones, Douglas N., Robert E. Burns, Frank P. Darr, Mark Eifert, Robert J. Graniere, Reinier H. J., H. Lock, and Robert Poling. *Regional Regulation of Utilities: Opportunities and Obstacles.* Columbus, OH: The National Regulatory Research Institute, 1992.

Technological and organizational developments in the electricity and telecommunications sectors have heightened interest in regional economic regulation (that is, two or more state commissions acting jointly to carry out their regulatory responsibilities). These developments include mergers, transmission access and pricing, integrated planning, acid rain legislation, and open network architecture. Regional coordination can take the form of cooperative federalism, but it also can reflect defensive federalism with respect to the possibility of federal preemption. The more frequently used institutional arrangement for cooperation is the interstate compact, but joint boards or conferences also can be used if states are willing to use their legal authority to implement this approach. States may find that regional "clubs" (based on the theory of clubs) serve their interests by creating spillover benefits and minimizing and internalizing negative externalities. Four types of regional regulatory clubs, in increasing structural formality, are proposed: episodic, sequential, coordination, and consolidated. Each iteration is more costly and difficult to implement, and requires more sacrifice of state autonomy. The authors conclude that collaborative multistate action may be appropriate when one or more of the following applies: threat of federal preemption, incongruent jurisdictional and utility operational boundaries, integrated planning concerns, inconsistent regulatory rules or practices, desire to improve governmental efficiency, and the need to match technical staff resources and political power with major regional utilities.

Davis, Vivian Witkind, J. Stephen Henderson, Robert E. Burns, and Peter A. Nagler. *Commission Regulation of Small Water Utilities: Outside Resources and Their Effective Uses.* Columbus, OH: The National Regulatory Research Institute, 1984.

This research report provides an inventory of more than forty organizations that can provide technical and other assistance to small water utilities. The governmental and private agencies and organizations included can provide utilities and public utility commissions with assistance in the areas of finances, information, training, education, technical guidance, regulation, research, and legislation.

Holland, Wendell F. "Acquisition Incentive Encouraging Regionalization in the Water Industry," a paper presented at the National Association of Regulatory Utility Commissioners Great Lakes Conference, July 11, 1995.

Regionalization, according to this former regulator, stands out as a promising solution to the challenges faced by the water industry. The Pennsylvania Public Utility Commission initiated a proceeding to consider incentives for acquisitions of smaller and nonviable water systems. The regulatory incentives for regionalization include (but are not limited to): rate-of-return premiums, acquisition adjustments, deferral of acquisition improvement costs, plant-improvement surcharges, and operating ratios. To increase the number of mergers and foster regionalization, the following should be considered: whether the public interest is served, the effect of the acquisition on the viability of the acquiring company, the nonviability and noncompliance of the acquired system, service improvements for the acquired system's customers, the fairness and reasonableness of the purchase price, and the application of single-tariff pricing (possibly phased-in). The author also supports consideration of the increased risks associated with regionalization when determining the acquiring utility's return on equity. Finally, a sound viability policy for water systems includes integrated planning and incorporates land-use and development considerations. Case studies from Pennsylvania and South Africa are mentioned in support of regionalization. Regionalization and service improvements will require more effort on the part of policymakers, regulators, companies, and customers.

Jones, Douglas N., et al. *Regional Regulation of Utilities: Issues and Prospects.* Columbus, OH: The National Regulatory Research Institute, 1980.

This research report, prepared for state public utility regulators, considers the potential need for regional regulatory institutions to oversee the activities of transjurisdictional public utilities.

Lagassa, George. "State Commissions as Vestigial Organs: The Regional Context of Electric Utility Regulation," *Kansas Law Review* 28 (Winter 1980): 29.

Lawton, Raymond W. and Vivian Witkind Davis. *Commission Regulation of Small Water Utilities: Some Issues and Solutions.* Columbus, OH: The National Regulatory Research Institute, 1983.

This research report considers how the state public utility commissions are responding to the problems of small water utilities, including policies focused on economic viability, management, and rate case procedures. Specific regulatory solutions can be evaluated according to several criteria: effectiveness in preventing monopoly profits, assuring adequate service, start-up costs, cost to the commission, cost to the utility, and cost to ratepayers. A survey of forty-five state commissions revealed twenty-two traditional and non-traditional approaches. The solutions fit within four strategic approaches. The "limited adjustment" strategy focuses on those solutions not requiring statutory or institutional changes. A strategy of "aggressive improvement" involves an act of intervention to improve a system's viability. The third strategy, "reduced authority," would reduce or eliminate commission jurisdiction for small water systems. Finally, the "safe harbor" strategy would allows utilities to operate within commission-specified boundaries without explicit regulatory approval of rates or returns.

Mann, Patrick C., G. Richard Dreese, and Miriam A. Tucker. *Commission Regulation of Small Water Utilities: Mergers and Acquisitions.* Columbus, OH: The National Regulatory Research Institute, 1986.

This research report discusses the acquisition of small financially troubled water companies by larger utilities. When considering acquisitions, state public utility commissions often consider either full inclusion of costs in the rate base or complete exclusion of those costs. The authors describe a variety of alternatives to these absolute approaches. Case studies of mergers in twelve states are presented. The

report also recommends consideration of municipal ownership options for small systems. For private acquisitions, the price paid is sometimes in excess of the depreciated value of the acquired utility's plant. The report recommends a flexible approach to including these costs in the rate base. Most states do little monitoring to identify potentially troubled small water utilities. A peer analysis model, based on operating and financial ratios, is presented and recommended as a monitoring technique.

New York Department of Health. *Strategic Plan for Regulatory Reform of the Small Water Industry.* Albany, NY: New York Department of Health, 1994.

This report was prepared by the Statewide Water Initiatives Team, an interdepartmental and interdisciplinary team whose charge was to develop a new regulatory paradigm for dealing with small water companies. Phase One of the strategy focused on drafting a policy statement, reforming the ratesetting process for existing companies, continuing interagency collaborative efforts (especially on legislation), creating a detailed database plan, providing a safety net for failing systems, and reforming the initial rate filing policy for new systems. Phase Two of the strategy focused on revising service and compliance requirements, improving and targeting enforcement and auditing, developing financing options with viability tests, and supporting restructuring of the water industry (within the context of agency jurisdiction).

O'Connor, Jeremiah F. and Bharat C. Patel. "The Water Industry Needs Reform," *Public Utilities Fortnightly* 132, no. 7 (April 1, 1994): 24-27.

To promote efficiency, financial viability, and compliance with federal drinking water standards, regulatory and structural reform is needed to promote consolidation and privatization in the U.S. water industry.

Pennsylvania American Water Company. "Responsive Comments of Pennsylvania-American Water Company," testimony filed in *Comprehensive Plan for Water Industry Regulation: A Plan to Stop the Proliferation and Continued Existence of Non-Viable Systems in Pennsylvania,* a proceeding before the Pennsylvania Public Utility Commission, June 6, 1994.

This very thorough testimony addresses issues related to small water system viability in Pennsylvania. Provided are an overview of the challenges faced by the

water supply industry, a profile of the Pennsylvania-American Water Company, and a discussion of specific topical areas (regionalization, public education and outreach, technical assistance, financial and managerial guidance, and other issues). Maps, acquisition data, and other documentation also are provided. The company strongly endorses, and has actively pursued, the strategy of regionalization to achieve economies of scale (including physical interconnection and the formation of satellite service areas having enough "critical mass" to be viable). Barriers to regionalization include information and data limitations, operational issues, financial considerations, and political and legislative concerns. Proposals for legislative and/or regulatory policy changes include making market entry more difficult, changing state revolving loan funding standards, supporting the repeal of the tax on customer advances, strengthening state legislation on takeovers to include participation by municipal utilities (possibly extending commission jurisdiction to municipals), providing clearer incentives for acquisitions (including a forward-looking approach to acquisition and rate-base additions), providing tax relief for acquisitions of municipal systems, and providing advance ratemaking treatment of acquired property.

U.S. House of Representatives. "Hearing on Regional Cooperation in Utility Ratemaking," May 19, 1979.

5.3 Integrated Resource Planning

Allen, Carol J. "Planning and its Interrelationship to Regionalization and Conservation," a paper presented at the Pennsylvania Public Utility Commission Regulatory Conference on Water, September 14, 1992.

Comprehensive planning, according to the author, is the key to regionalization and to conservation. Planning is needed for improving water resource development and management, as well as water system viability. Regionalization is a flexible and important tool for addressing the problems of small water systems. Commonwealth legislation concerning takeovers, acquisition adjustments, and small systems assistance reflect the interest in regionalization. Regionalization can involve acquisitions, physical interconnection, consolidated management, and other strategies. Several success stories in Pennsylvania are cited. On an interstate regional scale, utilities in Pennsylvania also are affected by two major interstate compacts. Parochial concerns and economic realities present barriers to regionalization, but new approaches are overcoming these issues. The author also

emphasizes the role of conservation in comprehensive water resource planning and management. The commission's conservation policy addresses: customer education, metering, leak detection, unaccounted-for water, plumbing fixture standards, and contingency planning for nonessential uses. Trends in conservation include an emphasis on managing demand, conservation rates, affordability concerns, legislative solutions, and water and energy audits.

Beecher, Janice A. "Integrated Resource Planning Fundamentals," *Journal American Water Works Association* 87, no. 6 (June 1995): 34.

The author reviews the basic principles, concepts, and tools of integrated resource planning for water utilities.

Beecher, Janice A., James R. Landers, and Patrick C. Mann. *Integrated Resource Planning for Water Utilities*. Columbus, OH: The National Regulatory Research Institute, 1991.

This report considers whether integrated resource planning, as applied to electricity and natural gas utilities, is transferable to water utilities. Integrated planning subsumes the goals of least-cost planning, while also emphasizing the need to integrate the many institutions involved in water resource policy and planning and the many public policy issues they address. The fragmentation of government roles and responsibilities in water remains the greatest obstacle to a fully integrated approach. State public utility commissions can help ensure that jurisdictional utility plans are consistent with state water resource plans and policies. Commission expertise on issues of price and the least-cost utility planning framework also can be of substantial value in other water resource planning processes. The least-cost planning literature emphasizes internal coordination of utility management functions (forecasting, financial analysis, engineering, supply management, demand management, and so on). At least as important is the integration of water utility planning externally, such as with other water resource planning processes conducted by state agencies and neighboring utilities in the region. The success of integrated planning depends on the continued development of analytical tools, especially modeling applications and forecasting techniques designed to address issues specific to the water sector. Integrated resource planning is not a panacea for the water industry. A comprehensive and integrated approach should enhance other regulatory determinations, but it is not a substitute for them.

Featherstone, Jeffrey. "Conservation in the Delaware River Basin," *Journal American Water Works Association* 88, no. 1 (January 1996): 42-51.

This article describes the conservation efforts of the Delaware River Basin Commission, a multistate regulatory body created by a federally sanctioned interstate compact. Demand management and conservation have become an integral part of the commission's comprehensive water resource management strategy. Regulatory and education tools are used to promote conservation. Regulatory tools include policies related to source metering, service metering, leak detection and repair, performance standards for plumbing fixtures and fittings, conservation and drought planning, and conservation-oriented pricing. The Commission sponsors information and education events, including symposiums to promote technology transfers among major industrial and commercial water users.

Fischer, A. M. "Area-Wide Jurisdictional Planning: Toward Comprehensive and Coordinated Management Typologies," *Proceedings of the Second Annual Marine and Estuarine Shallow Water Science and Management Conference* (Philadelphia, PA: U.S. Environmental Protection Agency, 1995): 44.

The Jurisdictional Restoration Planning (JRP) model of the Liberty Bay Project is a system for sharing information, clarifying management roles, coordinating responsibilities, improving regulation, and resolving conflicts. Regional planning themes are established and used to formulate simpler and more comprehensive planning strategies.

Fiske, Gary and Anh Dong. "IRP: A Case Study From Nevada," *Journal American Water Works Association* 87, no. 6 (June 1995): 72.

This case study details the use of the integrated resource planning (IRP) framework in the development of a regional water resource plan for the Southern Nevada Water Authority. The article describes the IRP theoretical framework and emphasizes a decision analysis approach. The specific political and scientific steps taken to establish the water resource plan are recounted.

Ford, Kittie E., Karen A. Glatzel, and Rockey E. Piro. "Watershed Planning and Restoration: Achieving Holism through Interjurisdictional Solutions," *Environmental Restoration: Science and Strategies for Restoring the Earth Conference* (January 1988): 312-320.

Rabe, Barry G. and Janet B. Zimmerman. "Beyond Environmental Regulatory Fragmentation: Signs of Integration in the Case of the Great Lakes Basin," *Governance* (London) 8 (January 1995): 58-77.

Ruzicka, Denise and Bob Hartman. "Integrated Resources Planning: The Connecticut Experience," *Proceedings of Conserv 96* (Denver, CO: American Water Works Association, 1996.

Integrated resources includes attention to conservation, involvement of multiple entities, and consideration of uncertainty. Connecticut adapted these principles in the state's Coordinated Water Supply Plan. Utilities are required to incorporate conservation plans as part of their supply plans. As of July 1995, 49 of 88 water supply plans had been approved. Utility plans also must be consistent with the state's seven regional water plans. The planning process invites participation from various interests. Various planning horizons are used to deal with uncertainty and change. Planners believe that the process will help them address infrastructure needs, land-use conflicts, small system viability, competition, and other issues. Benefits of planning so far include better defined service areas, identification of potential safe yield deficits, reduction in the number of small and nonviable water systems, development of multiple interconnections, development of a statewide conservation program, and promotion of a regional ethic for water supply.

Warren, David R., Gerald T. Blain, and Jeffrey Klein. "IRP: A Case Study From Kansas," *Journal American Water Works Association* 87, no. 6 (June 1995): 57.

This case study describes the use of the integrated resource planning (IRP) framework in the development of a long-term water resource plan for the city of Wichita, Kansas. The article details the water resources unique to the region and the key steps in developing a plan to address these issues. A wide range of options are considered in a comprehensive framework. The final plan balances environmental, social and economic concerns.

6. CASE STUDIES IN REGIONALIZATION

6.1 United States

Bakken, J. Darrell. "Evolution of a Regional System," *Journal American Water Works Association* 73 (May 1981): 238-42.

This case study details the expansion of the privately-owned Indianapolis Water Company (IWC). Since its inception in 1871, the IWC and its predecessor the Water Works Company of Indianapolis, have grown from an urban utility to a regional system that provides water to all of Indianapolis and to portions of three adjacent counties. This article describes the managerial, financial, and design adaptations the IWC implemented in becoming a regional water supplier.

Baltimore Regional Planning Council. *Baltimore Region Water Quality Management Plan, Summary.* Washington, DC: U.S. Environmental Protection Agency, 1979.

This report describes the Water Quality Management Plan for the Baltimore Metropolitan Region, which recommends cooperative arrangements among local governments to address the region's water pollution problems.

Bierman, Don E. and W. Rydzkowski. "Regional Politics in Public Works Projects: The Tennessee-Tombigbee Waterway," *Transportation Quarterly* 45 (April 1991): 169-80.

"Cooperation for Enhanced Water Supply," *Fire Engineering* 148, no. 2 (February 1, 1995): 51.

"Fire and Water: Partnership Pays Dividends," *Public Works* 126, no. 4 (April 1, 1995): 84.

Gilbert, Jerome B. "Land and Water Management in the San Francisco Bay Area," *Proceedings of the Annual Meeting of the American Water Works Association.* Denver, CO: American Water Works Association, 1976: 9-2 to 9-13.

A regional approach to land and water management in the San Francisco Bay is described, along with particular issues such as water conservation, water reuse, groundwater management, and the role of utilities in regional growth.

Haller, Timothy G. "The Legislative Battle over the California-Nevada Interstate Water Compact: A Question of Might Versus Native American Right," *Nevada Historical Society Quarterly* 32, no. 3 (Fall 1989): 198.

Herman, James A. and Walten Farr. "A Case History of Making the Central City's Distribution System a Regional Facility," *Journal American Water Works Association* 68 (August 1976).

Hurd, Merna. "Regionalization Opportunities and Obstacles: A Case Study," *Journal American Water Works Association* 71 (December 1979).

This case study describes economic, legal, political, and social implications of regionalizing the water supply system in Northern New Castle County, Delaware. The project was expected to economically benefit the entire county. Obstacles to the regionalization included competition among the four existing water utilities, legal issues concerning water rights, the technical feasibility of interconnecting the systems, the allocation of costs and how these would affect rate structures, and contracts concerning the minimum and maximum amounts of water to be supplied. The author concluded that public and political support is essential for successful implementation..

Injerd, Daniel A. "Lake Michigan Water Diversion: A Case Study," *Buffalo Environmental Law Journal* 1, no. 2 (Fall 1993): 307 .

Institute for Defense Analysis. *An Analysis of Alternative Institutional Arrangements for Implementing an Integrated Water Supply and Waste Management Program in the Washington Metropolitan Area.* Arlington, VA: Institute for Defense Analysis, 1971.

Kahrl, William L. *Water and Power: The Conflict over Los Angeles' Water Supply in the Owens Valley.* Berkeley, CA: University of California, Press, 1982.

Osterman, Douglas, Frederick Steiner, Theresa Hicks, Ray Ledgerwood, and Kelsey Gray. "Coordinated Resource Management and Planning: The Case of the Missouri Flat Creek Watershed," *Journal of Soil and Water Conservation* 44, no. 5 (September-October 1989): 403-406.

The use of coordinated resource planning and management to prepare a conservation plan for a watershed area is described.

Peralta, R. and A. Peralta. "Cooperation as a Policy Initiative In Utah," *Journal of Soil and Water Conservation* 45, no. 2 (March 1, 1990): 261.

Planning Guide To Water Resource Development for East-Central Oklahoma. Symposium proceedings. Bethesda, MD: American Water Resources Association, 1984.

"Regional Facility Solves Wastewater Problems," *The American City & County* 105, no. 2 (February 1, 1990): 50.

Ritchlin, Lance. "Public-Private Effort Boosts West Virginia Water Supply," *American Water Works Association Mainstream* 139, no. 11 (November 1995): 4.

This brief article describes the funding arrangement for a regional water supply project for 20,000 customers in southern West Virginia, including 700 customers presently without service. The Mercer-Summers Regional Water Project will be jointly funded by West Virginia-American Water Company, the Economic Development Administration, the U.S. Army Corps of Engineers, and Appalachian Regional Commission, the Small Cities Block Grant, and a loan.

Schwartz, Harry E. "Joint Discussion--Northeastern U.S. Water Supply Study." *Journal American Water Works Association* 63 (May 1971).

Shiati, K. "A Regional Approach to Salinity Management in River Basins: A Case Study in Southern Iran," *Agricultural Water Management* 19, no 1 (January 1, 1991): 27.

Stecker, K. , J. Edison, D. Chestnut, and C. Lacy. "South Carolina's Watershed Water Quality Management Approach," *Lake and Reservoir Management* 9, no. 2 (1994): 116.

The South Carolina Department of Health and Environmental Control (SCDHEC) initiated watershed planning in 1991, emphasizing a coordinated and comprehensive approach to planning. modeling, monitoring, permitting, communications, as well as the use of geographic information system applications in realizing program objectives.

U.S. Army Corps of Engineers. *Harrisburg Metropolitan Area Regional Water Supply Study.* Baltimore, MD: U.S. Army Corps of Engineers, 1992.

This study focused on the water supply needs of the Harrisburg area, as well as nearby counties in Pennsylvania. The study includes: (1) an inventory of existing supplies, (2) water demand forecasts, (3) the identification of deficits and other potential supply problems, and (4) an evaluation of alternative means of meeting demand. Compliance with federal drinking water standards was a key concern. Regionalization was viewed as the best means for systems to defray costs associated with new regulations. It was recommended that regional planning focus on detailed assessment of small system compliance.

U.S. Army Corps of Engineers. *Small Systems Regionalization Study for Lebanon County, Pennsylvania.* Baltimore, MD: U.S. Army Corps of Engineers, 1995.

This study examined a range of structural and nonstructural alternatives for meeting the present and future water needs of twenty-four water systems in Lebanon County, Pennsylvania. The purpose of the study was to assist systems in the region in evaluating and optimizing their operations and to promote the most efficient use of water resources. Data were compiled for the systems in the region from existing information sources. Water quality issues played a prominent role in the analysis. The study was conducted in phases: (1) data collection and needs analysis, (2) compilation of alternatives with a view toward regionalization, and (3) economic analysis of the alternatives. The study will be followed by a market feasibility study concentrating on the economic aspects of regionalization.

U.S. Environmental Protection Agency. *Chesapeake Bay Program: Findings and Recommendations.* Washington, DC: U.S. Environmental Protection Agency, 1983.

U.S. Environmental Protection Agency. *National Capital Region Water and Waste Management Report.* Washington, DC: U.S. Environmental Protection Agency, 1971.

Walker, Robert F. "The Philadelphia Water Department: A Regional Utility," *Journal Water Pollution Control Federation* 59 (September 1987): 804-809.

Warner, John and John Kindt. "Land-Based Pollution and the Chesapeake Bay," *Washington and Lee Law Review* 42, no. 1099 (1985): 1121-22.

Weck, Egon. "Water, Water--Not Quite Everywhere," *Appalachia* 15/16 (July/October 1982): 24-31.

Woods, Howard J., Jr. "Tri-County Water Supply Project Uses State-of-the-Art Technology to Meet a Region's Water Needs," *NAWC Water* (Fall 1995): 18-19.

The water needs of Southern New Jersey are being met by the New Jersey-American Water Company's Tri-County Water Supply Project. As many as fifty-five communities could receive water from the project. A new treatment plant in the region can withdraw up to 40 million gallons daily from the Delaware River. The plant eventually will have a capacity of 100 million gallons daily. The plant was built because of the depletion of a major aquifer in the region. The project's state-of-the-art features, including treatment methods for meeting drinking water standards, are discussed.

6.2 International and Transboundary

Abebe, Mesfin. "The Nile: Source of Regional Cooperation or Conflict?" *Water International* 20, no. 1 (March 1, 1995): 32.

Agakishieva, L. S., A. S. Kasimov, and M. M. Eivazov "Water Resources Regionalization of Azerbaidzhan," *Water Resources* 15, no. 3 (May 1, 1988): 284.

Burton, Lloyd and Chris Cocklin. "Water Resource Management and Environmental Policy Reform in New Zealand: Regionalism, Allocation, Indigenous Relations," *Colorado Journal of International Environmental Law* 7, no. 1 (Winter 1996): 75.

Booker, Alan. "British Privatization: Balancing Needs," *Journal American Water Works Association* 86, no. 3 (March 1994): 56.

Datta, S. "A Decision Support System for Micro-Watershed Management in India," *Journal of the Operational Research* 46, no. 5 (May 1995): 592-603.

An integrated decision support system model for generating alternative water allocation and agricultural production scenarios is presented and tested with data from a micro-watershed in India.

Dinar, Ariel. "International Markets for Water and the Potential for Regional Cooperation: Economic and Political Perspectives in the Western Middle East," *Economic Development and Cultural Change* 43, no. 1 (October 1994): 43.

Dinar, Ariel and Aaron Wolf. "Economic Potential and Political Considerations of Regional Water Trade: The Western Middle East Example," *Resource and Energy Economics* 16, no. 4 (November 1994): 335-56.

Dingzhong, Dai, Lu Xueren, Guo Yuanyu, and XuXinji. "Research/Application of System Engineering to Water Resources Systems," *Journal of Water Resources Planning and Management* 118, no. 3 (May-June 1992): 337(13).

This article enumerates Chinese achievements in water systems engineering and specifically relates systems engineering applications and research in hydropower generation, irrigation and drainage, water-resource development and utilization, water-quality protection, flood control, and dam construction. Applications are found throughout China, where theories are applied as they are developed. Chinese resource models tend to be complex due to the diversity of China's topography and climate.

Donaldson, David. "Regional Authorities Support Small Water Systems in the Americas," *Journal American Water Works Association* 76 (June 1984): 62-67.

Fischer, R. Montgomery and Milton Potash. "Management of an International and Bi-State Watershed: The Lack Champlain Basin," in *Unified River Basin Management,* Proceedings of the American Water Resources Association and Tennessee Valley Authority Symposium (May 4-7, 1980): 199-213.

Garduno, Hector. "Large-Scale Transfers Within Master Water Planning in Mexico," *Proceedings of the International Institute for Applied Systems Analysis Water Transfers Task Force Meeting*, Austria (June 1979): 103.

This paper reviews Mexico's 1975 water management plan, which addressed regionalization and water transfers for agricultural and public supply uses.

Ghosh, Pradip K., ed. *Population, Environment and Resources, and Third World Development.* International Development Resource Books No. 5. Westport, CT: Greenwood Press, 1981 and 1984.

Gould, Michael S. and Frederick A. Zobrist. "An Overview of Water Resources Planning in West Africa," *World Development* 17, no. 11 (November 1989): 1717-22.

Hooper, Bruce. "Towards More Effective Integrated Watershed Management in Australia," *Water Resources Update* 93 (Autumn 1993): 28.

In Australia, integrated catchment (watershed) management is strongly supported by the national and state governments. It is defined as "the co-ordinated management of land and water resources within a region, with the objectives of controlling and/or conserving the water resource, ensuring biodiversity, minimizing land degradation, and achieving specified and agreed land and water management and social objectives." The article summarizes an analysis of the programs and activities associated with catchment management. Analysts found that while the philosophy and products of integrated approaches were well understood, significant process problems persisted. These problems included lacking coordination, inadequate integration of economic development and ecological management, and institutional barriers to implementation. Options for change in the process were considered. The study also found that a national strategy could be established to provide a framework for public sector investment in natural resource management. Guiding principles for a national strategy were provided. The author recommends that catchment management in Australia should be bioregional, integrated, systems-based, strategic, and stakeholder-driven with clearly identified roles and responsibilities. Best management practices require: correct scale, the best technical approach, congruence and accountability, a task force/teamwork approach, and measurable indicators of ecosystem and socioeconomic success.

Jolly, Carol and Judith Leckrone. "Managing Lake Roosevelt: An International Challenge," *Changing Roles in Water Resources Management and Policy,* Proceedings of the American Water Resources Association Conference in Bellevue, Washington (June 27-30): 587-596.

Kettani, M. Ali. "Energy and Water Needs in Arid Zones: Regionalization and Planning: the Case of Saudi Arabia," *Proceedings of the Energy Use Management International Conference,* Tucson (October 24-28, 1977): 879-895.

Liu, Philip. "Water Supply in Peril," *Free China Review* (August 1993): 34-39.

The status of water resources in Taiwan is described. Water shortages have resulted from a host of problems, including overpumping of groundwater, saltwater intrusions, seasonal droughts, poor management of surface water supplies, limited availability of reservoir sites, watershed erosion, pollution, and low water prices.

Groundwater overpumping, the most serious problem, has resulted in forced temporary industrial shutdowns, extensive land subsidence, and saline contamination of farmland. Watershed erosion is unusually high in Taiwan due to the prevalence of slope development. The high erosion rate shortens the effective life of Taiwan's reservoirs, which currently only supply one percent of water needs. Furthermore, suitable reservoir sites for future development are lacking. In response to these problems, the government has implemented temporary water rationing, instituted a policy to separate public and industrial water supplies, built several new reservoirs, and increased enforcement of groundwater pumping limits. The author recommends implementing conservation measures and more effective groundwater pumping management.

Livingstone, Andrew and Harry J. McPherson. "Management Strategies for Rural Water Development: A Case Study from Sudan," *Natural Resources Forum* 17, no. 4 (November 1, 1993): 294.

Lund, Jay R. "Regional Water Supply Development in South Sweden," *Journal of Urban Planning and Development* 114 (June 1988): 14-33.

Middle East Water Commission. "Observations Regarding Water Sharing and Management: An Intensive Analysis of the Jordan River Basin with Reference to Long-Distance Transfers," *Water Resources Development* 11, no. 4 (1995): 351-375.

Future water needs of the Jordan River Basin region have been analyzed in detail by the Middle East Water Commission. Thirteen unilateral management options, four cooperative management options, and twenty-four water management priorities were reviewed. Participatory evaluation techniques were used to identify a smaller set of feasible projects. The analysis emphasized: (1) rainfall variance and severe limitations on aquifers, (2) the importance of mixing hydrotechnologies to meet regional needs, (3) the combined production of hydroelectricity and reverse osmosis water, (4) the use of off-peak electricity for pumped storage to meet peak electricity demand, (5) the careful balancing of Dead Sea water levels using importation to accommodate hydroelectric and reverse osmosis processes, (6) the combination of short-term, mid-term, and long-term response to water shortages, (7) the need for long-range planning, and (8) the importance of cooperative regional development. These ideas are presented not as *the* answer but as a means of stimulating interest in finding the best possible comprehensive solution to the region's hydrologic needs.

McPhail, Alexander A. "Why Don't Households Connect to the Piped Water System? Observations from Tunis, Tunisia," *Land Economics* 70, no. 2 (May 1994): 189-196.

A contingent valuation case study conducted in Tunis, Tunisia found that households are discouraged from connecting to the public water supply system not because of the affordability of monthly bills but because of the utility-required cash down payment for connection.

Munasinghe, Mohan. *Water Supply and Environmental Management: Developing World Applications.* Boulder, CO: Westerview Press, 1992.

Muyibi, Suley A. "Planning Water Supply and Sanitation Projects in Developing Countries," *Journal of Water Resources Planning and Management* 118, no. 4 (July-August 1992): 351-356.

This paper discusses the issue of equity with regard to providing sanitation and water supply in developing countries. Although the International Drinking Water Supply and Sanitation Decade (IDWSSD) was launched in 1980, water supply and sanitation problems still persist in developing countries, particularly in rural and peri-urban areas. Governments often provide water supply and sanitation to urban areas but not the same level of service to outlying regions. The author proposes a sequential procedure to promote community involvement in the planning construction, and operation and maintenance processes and equitable consideration of needs in rural and peri-urban areas.

Okun, Daniel A. *Regionalization of Water Management: A Revolution in England and Wales*. London: Applied Science Publishers, 1977.

In the twenty years following World War II, water supply management in England and Wales underwent regionalization, bringing the total number of water supply systems from more than 1,200 to less than 200. Simultaneously, public water supply service was extended to more than 90 percent of the population. This book describes the institutional changes in England and Wales that facilitated regionalization. Chapter 1 provides an introduction to the subject, an overview of water issues in England and Wales, and a discussion of the basic principles of sound water management. These principles address: the uniqueness of water projects, economies of scale, integration of water supply and pollution control, sound financial practices, and the preference for pure over polluted water sources.

Chapter 2 describes the prelude to regionalization, including findings of analytical studies and key legislation. In chapter 3, the author reviews the creation of the Water Bill, as well as topics addressed in related consultant papers that played a critical role in the regionalization process. Debate over the bill in parliament is the subject of chapter 4. Chapter 5 depicts the rapid implementation of the reorganization, which took effect on April 1, 1974. The ten newly created water authorities are described in chapter 6. Chapter 7 discusses the roles and responsibilities of national governmental agencies under the new legislation. Water quality management is discussed in chapter 8 and finances are discussed in chapter 9. In chapter 10, the author considers the relevance of the British experience for the United States and compares the U.K. and U.S. according to the management principles provided in the first chapter. Finally, chapter 11 concludes with a discussion of future problems and prospects. At the time of regionalization, private water companies serving 22 percent of the population were not expected to survive; against company protestations, the government planned their integration into the water authorities (subject to funding). The Labour Party maintained that private ownership was "wrong in principle and anomalous in practice" (because they operated outside of the authorities). Detailed information on the precursors to regionalization and the reorganization timetable is provided.

Perkins, Frances. "Cost Effectiveness of Water Supply Technologies in Rural Indonesia: Evidence from Nusa Tenggara, Barat," *Bulletin of Indonesian Economic Studies* 30, no. 2 (August 1994): 91-117.

This article considers the difficulty of extending safe and adequate water supplies to rural Indonesia. Implementation problems include inadequacies in the areas of funding, administrative capability, and community involvement. Variations in cost and other features make the choice of water supply technology crucial. The author finds that improving traditional wells, installing simple piped systems, and rehabilitating larger systems have lower economic and financial costs (on a unit basis) than new large-scale piped systems. Where feasible, the simpler and smaller systems are more cost effective and sustainable for serving rural areas. The small-scale technologies also appear more desirable in terms of distributional effects.

Rowntree, Norman A. F. "Regionalization of Water Supply in England," *Proceedings of the Annual Conference of the American Water Works Association.* Denver, CO: American Water Works Association, 1978.

Rudig, Wolfgang and R. Andreas Kraemer, "Networks of Cooperation: Water Policy in Germany," *Environmental Politics* 3, no. 4 (Winter 1994): 52.

Singleton, Cynthia. "Treading Water," *Business* 5, no. 4 (April 1995): 22-25.

The tremendous rate of growth in Mexico City highlights the need to balance economic and environmental planning criteria. Strains on the city's water supplies led to a program to encourage conservation, reduce leaks, metering, and usage-based water pricing.

Shady, Aly M., Ahmad M. Adam, and Kamal Ali Mohamed. "The Nile 2002: The Vision Toward Cooperation in the Nile Basin," *Water International* 19, no. 2 (June 1, 1994): 77.

Slootweg, R. "Water Resources Management and Health: General Remarks and a Case Study from Camerron," *Landscape and Urban Planning* 20, no. 1 (April 1, 1991): 111.

Takeuchi, Keiichi. "Official And Popular Approaches to Water Resources in Japan: The Failures of an Applied Geography," *Hitotsubashi Journal of Social Studies* 24 August 1992) :1-8.

Wagner, E. G. "The Latin American Approach: Special Emphasis on Brazil," *AWWA Seminar Proceedings: Small Water System Solutions.* Denver, CO: American Water Works Association, 1982.

The organization of Brazil's small water systems differs from the organization of small systems in the United States. In Brazil, and in other Latin American countries, local governments did not develop as strongly as in the United States. Small communities do not have the resources to operate autonomous water systems and regional management is prevalent. In Brazil, most of the water systems are state owned and administered. Financing and design practices also differ in Latin America, partly because of the regional approach. A comparison of construction and operating costs between Brazilian and U.S. treatment plants indicates that the Brazilian plants operate at a much lower cost.

Yijian, Tang and Zhang Shen. "Economic Development and Water-Related Environmental Problems in China," *Chinese Geography and Environment* 3 (Fall 1990): 82-98.

7. PLANNING AND ADMINISTRATION

7.1 Urban and Regional Planning

American Society of Civil Engineers, *Urban Planning Guide* (New York: American Society for Civil Engineers, 1986).

Banks, H. O. "Comprehensive Health Planning in Relation to Environmental Problems," *American Journal of Public Health* 61, no. 10 (1971): 1972-79.

Banks, H. O. "Regional Planning for Water Supply and Sewage Treatment," *Archives of Environmental Health* 16, no. 1 (1968): 88-92.

Batey, P. W. J. and M. Madden, eds. *Integrated Analysis Of Regional Systems.* London: Methuen Inc., 1986.

Billings, Clayton H. "Master Planning and Water Conservation," *Public Works* 123 (January 1992): 72.

Cargill Samuel P., Jr. "Collaborative Planning for a Regional Wastewater Treatment System," *Economic Development Review* 12, no. 1 (Winter 1994): 46.

Cisneros, Henry. *Regionalism: The New Geography Of Opportunity.* Washington, DC: U.S. Department of Housing and Urban Development, 1995.

This brief booklet describes regional approaches to dealing with urban problems including poverty, housing, central city decay, and urban sprawl. Approaches include regional governments, special districts, annexation, regional revenue sharing, and changes in zoning policies. Regional authorities often emerge because local authorities alone cannot address major regional problems, such as air pollution and watershed protection. In the transportation sector, policies such as the Federal Intermodal Surface Transportation Efficiency Act of 1991, require regional transportation planning. According to the author, most special districts provide "things-regionalism" because they focus on public works, such as water supply. More difficult to establish is "people-regionalism" to address issues such as poverty.

The keys to people-regionalism, according to the author, are civic life and civility. Various examples of regionalism are provided.

Curbelo, Jose-Luis. *Regional Development Planning: Regional Political Economy Versus Regional Science.* Chicago: Council of Planning Librarians, 1987.

Ehrenhalt, Alan. "Cooperate or Die," *Governing* (September 1995).

The Pittsburgh region has seen discussions of regionalism for at least thirty-five years. The area is highly fragmented, with 130 different municipalities and a population of 1.3 million. Many of the small outlying communities recognize the need to cooperate for economic reasons, such as deindustrialization and the resulting loss of tax base in the region. Many small-scale initiatives such as public works consolidations, and community development consortiums have begun. Many failures can be cited as well, including attempts at combined police coverage and joint zoning ordinances. The forces preventing large-scale cooperation are political and social. Fragmentation and historical rivalries among communities have led to provincial attitudes and resistance to change. Some national urban experts believe the time is right for a new wave of regionalism in the United States. But local experts hold opposing views on whether the tide is actually turning toward regionalism in the Pittsburgh area.

Fox, Karl August. *Urban-Regional Economics, Social System Accounts, and Eco-Behavioral Science: Selected Writings*. James R. Prescott, Paul van Moeseke, and Jati K. Sengupta, eds. Ames, IA: Iowa State University Press, 1994.

Giachio, John and Carol Ferguson. "Regionalization Concept Aids Wastewater Systems," *American City and County* 101 (September 1986): 82.

Hershberg, Theodore. "The Case for Regional Cooperation," *The Regionalist* 1, no. 3 (Fall 1995).

Kemmis, Daniel. "The Rebirth of the City-State," *The Regionalist* 1, no. 3 (Fall 1995).

Kim, Tschangho John. *Integrated Urban Systems Modeling: Theory and Applications.* Boston: Kluwer Academic Publishers, 1989.

Kreines, Ted. "Water, Water Everywhere Except Where it Should Be," *American Planning Association Planning* 43 (April/May 1977): 39-41.

Levy, John M. *Contemporary Urban Planning.* Englewood Cliffs, NJ: Prentice Hall, 1991.

In this textbook, the author notes the emergence of regional and state planning in the 1920s. A comprehensive plan was drawn up for the New York City region during this time period. In defining the region, planners considered: the boundaries within which people travel from home to work, outlying recreational areas within easy reach of the metropolitan center, the boundaries of cities and counties at the periphery, and physical characteristics such as watersheds and waterways. Regional planning also emerged during this time frame in other parts of the country. Inevitably, regional planning confronts the fact that no political entity corresponds to region. In some cases, regional authorities have been created to facilitate regional planning.

Mahtesian, Charles. "The Civic Therapist," *Governing* (September 1995).

This article examines the career of Neil Pierce, a specialist in urban affairs who has authored a dozen reports analyzing the problems of specific urban regions. Pierce's analyses over the last ten years cover the gamut of urban problems, but a recurring theme is regionalism. Urban areas are often dysfunctional because of interjurisdictional competition. Pierce suggests that part of the cure would be for urban areas to find an area of economic advantage and exploit it as a unified economic unit. This would include regionalizing transportation, planning, and fiscal equity. Even cities that agree with some of Pierce's solutions have had difficulty implementing them because of the popularity of local governance. A high degree of consensus and commitment, and an incremental approach, seem to increase the likelihood of successful regional cooperation.

Metropolitan Association of Greater Indianapolis Communities. *MAGIC, Central Indiana, and the 21st Century: An Urgent Need for a Delicate Balance.* Indianapolis, IN: United Way and Community Service Council, 1995.

The report presents an analysis of regional planning and governance in central Indiana, including case studies and models of regional action related to business climate and quality of life. Brief case studies of regionalization include Newark, New Jersey; Baltimore, Maryland; Phoenix, Arizona; and Denver, Colorado. Models of regional coordination include: honeycomb (Dayton, Ohio); metropolitan (Portland, Oregon); grassroots (Tyler and Longview, Texas); institution-based (Philadelphia and the University of Pennsylvania); confederated council (Tug Hill, New York); regional council-association (Jacksonville, Florida, and M21 in northern Wisconsin); councils of government; and random universe.

Nelson, Arthur C. and James B. Duncan. *Growth Management Principles and Practices.* Chicago: American Planning Association, 1995.

Growth management policies are aimed at developing regions in an economically and environmentally sustainable manner. States with comprehensive (that is, multifunctional) growth management legislation include California, Florida, Georgia, Hawaii, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont, and Washington. This book provides a theoretical framework for growth management. Various local, regional and state approaches to growth management are described. The efficacy of specific techniques for both urban and rural development is examined. Administrative and financing concerns also are discussed. Water distribution systems briefly are considered with respect to the effects of urban sprawl on costs, operations, and uncertainty. The authors conclude by reassessing the elements necessary for the creation of an effective growth management policy.

Sekhar, M. Chandra and P. Anand Raj. "Landuse - Water Quality Modelling: A Case Study," *Water Science And Technology* 31, no., 8 (1995): 383.

Swanstrom, Todd. "Philosopher in the City: The New Regionalism Debate," *Journal of Urban Affairs* 17, no. 3 (1995): 309.

Wallis, Allan D. "Inventing Regionalism: A Two-Phase Approach," *National Civic Review* 83, no. 4 (Fall 1994): 447.

The trend toward regional governance is being accomplished by a two-stage approach. The first stage involves building consensus around a vision for the region; the second stage involves structuring institutional capacity for sustained implementation of that shared vision.

Wallis, Allan. "Regional Governance and the Post-Industrial Economy," *The Regionalist* 1, no. 3 (Fall 1995).

Wu, Ray Shyan and Douglas A. Haith. "Land Use, Climate, and Water Supply," *Journal of Water Resources Planning and Management* 119, no. 6 (November-December 1993): 685 (20).

7.2 Infrastructure and Economic Development

Andrews, K. and J. Swanson. "Does Public Infrastructure Affect Regional Performance?" *Growth and Change* 26 (Spring 1995): 204-216.

Andreassen, Arthur E. and J. Berman. "Infrastructure Alternatives for 2005: Employment and Occupations," *Monthly Labor Review* 117, no. 4 (April 1994): 22-29.

Anton, Walter F., Ronald M. Polivka, Laurel Harrington. "Seattle Plays it Safe," *Civil Engineering* 62, no. 8 (August 1, 1992): 38.

This article describes Seattle's decision to invest substantially in its metropolitan water supply infrastructure.

Bartik, Timothy J. *Who Benefits From State and Local Economic Development Policies?* Kalamazoo, MI: W. E. Upjohn Institute for Employment Research, 1991.

Beaumont, Peter. *Environmental Management and Development in Drylands.* New York: Routledge, 1989.

Congressional Research Service. *Multi-State Economic Development Commissions: History and Background.* Washington, DC: Congressional Research Service, 1979.

Cox, William E. "Water and Development: A Complex Relationship," *Journal of Water Resources Planning and Management* 114 (January 1988): 91-98.

Duffy-Deno, Kevin T. and R. Eberts. *Public Infrastructure and Regional Economic Development: A Simultaneous Equations Approach.* Working Paper 8909. Cleveland, OH: Federal Reserve Bank of Cleveland, 1989.

Eberts, Randall W. "Public Infrastructure and Regional Economic Development," *Economic Review* (Fall 1990): 15-27.

Eisner, Robert. "Infrastructure and Regional Economic Performance: Comment," *New England Economic Review* (September/October 1991): 47-49.

Holtz-Eakin, Douglas and A. Schwartz. *Infrastructure in a Structural Model of Economic Growth.* Working Paper Series. National Bureau of Economic Research, Inc., (April 1994): 1-32.

Johannson, L. "Environmental Training Fosters Bottom-Line Education and Regional Economic Development." *Total Quality Environmental Management* 4, no. 1 (1994): 85-94.

This article describes a case study of total quality environmental management, which embraces the idea of incorporating environmental performance in regional economic development.

Keating, Ann Durkin. *Invisible Networks: Exploring the History of Local Utilities and Public Works.* Malabar, FL: Krieger Publishing Company, 1994.

This historical analysis explores the role of public utility infrastructure systems (water, sewer, power, transportation and other public works) in defining communities. Utilities and public works influence how communities evolve and connect to surrounding regions. The author emphasizes how utilities form an invisible network, taken for granted yet essential for modern life. Numerous case study examples are provided, including several in the water and wastewater areas. The author also provides specific suggestions for conducting historical research about a community's utilities and public works.

Krol, Robert. "Public Infrastructure and State Economic Development," *Economic Development Quarterly* 9, no. 4 (November 1995): 331-338.

This article evaluates the literature on the economic impact of public capital investment. Some studies suggest that investing in public capital has a significant positive benefit on the local or regional economy. However, these studies generally fail to consider differences in state production functions, and thus overstate the benefits of public investment. The author uses data from previous studies but controls for production function differences. The results indicate that investments in highways and streets, as well as buildings and structures do not have a positive effect on economic development. However, the author also finds that investing in water supply and sewage treatment systems has a positive effect. According to the author, the uncertain effect of public capital on output suggests that alternative economic development strategies should be considered, including maintaining the existing infrastructure and pricing its use more efficiently.

Moomaw, Ronald L., John K. Mullen, and Martin Williams. "The Interregional Impact of Infrastructure Capital," *Southern Economic Journal* 61, no. 3 (January 1995): 830-845.

Studies have suggested that public infrastructure investment can significantly increase the productivity and output of a region, although the extent of these economic benefits varies widely. This article explored the economic effects of investing in physical infrastructures. The model incorporated state-specific labor, private capital and public capital data as inputs for 1970, 1980, and 1986. The states were grouped into census regions for a comparative analysis of the output elasticity of public capital stocks. The findings indicate that the effectiveness of

public capital varies with a region's level of development and the ratio of public to private capital. Aggregate public capital investment, highway investment, and water system investment contribute positively to a region's output. Investments in water and sewer systems have a much larger effect on state output than investments in highways or other public capital stocks. Thus, water system investments can stimulate regional economic growth and enhance a region's competitive position in attracting economic activity. Substantial variations in the magnitude of output elasticities were found across the states, indicating that some regions experience an upper limit on the economic benefit that can be derived from investments in public infrastructure.

Mullen, John K., M. Williams, and R. Moomaw. "Public Capital Stock and Interstate Variations in Manufacturing Efficiency," *Journal of Policy Analysis and Management* 15, no. 1 (Winter 1996): 51-67.

Munnell, Alicia M. 1990. "How Does Public Infrastructure Affect Regional Economic Performance?" *New England Economic Review* (September/October 1990): 11-31.

Nijkamp, Peter. "Infrastructure and Regional Development: A Multidimensional Policy Analysis," *Empirical Economics* 11 1986: 1-21.

Perry, David C. *Building the Public City.* Thousand Oaks, CA, Sage Publications, 1995.

Reitveld, Piet. "Infrastructure and Regional Development," *The Annals of Regional Science* 23 (1989): 255-274.

Rives, Janet M. and M. Heaney. "Infrastructure and Local Economic Development," *Regional Science Perspectives* 25, no. 1 (1995.): 58-73.

Sudol, Frank. "Broad Infrastructure Program Includes Capture System for CSO Floatables," *Water Engineering & Management* 142, no. 9 (September 1995): 26-28.

Controlling suburban sprawl is essential for protecting environmentally sensitive areas. Cities should invest in existing infrastructure and conserve resources. Cities, such as New York City, also should strive to comply with federal and state pollution regulations, control combined sewer overflows (CSO), and reduce the unsightly "floatables" (such as litter) discharged into combined sewers and waterways.

"Utilities and Economic Development," *Economic Development Quarterly* 9, no. 4 (November 1995).

Manufacturers can benefit greatly from partnering with utilities and governments to identify cost savings from more efficient production processes. The result can be waste minimization, lower compliance costs, mitigation of environmental impacts, and a stronger economic base. Energy utilities have begun, and should continue to, expand their role in assessment and technical assistance to companies.

Wade Miller Associates, Inc. *The Nation's Public Works: Report on Water Supply.* Washington, DC: National Council on Public Works Improvement, 1987.

This seminal report describes the status of the national water supply industry and makes recommendations to encourage capital investment and help ensure adequate infrastructure. Key findings were that: (1) a gap in funding that would justify federal subsidies is not apparent; (2) considerable infrastructure needs (especially in the northeast) do not necessarily constitute a national problem; (3) water utilities experiencing revenue shortfalls generally are not charging rates that cover full costs; (4) small water systems suffer from poor management; (5) the Safe Drinking Water Act will have significant impacts on small and medium-sized systems; (6) western states have enough water, but do not allocate it efficiently; and (7) groundwater depletion and contamination is a major national problem. Recommendations were that: (1) the Safe Drinking Water Act should require full-cost pricing; (2) states should encourage regionalization and regional management, since it will lead to more efficient allocation of water supplies; (3) the U.S. Environmental Protection Agency (EPA) and the American Water Works Association Research Foundation should increase the scope if research and technology transfer programs for small water systems; (4) the National Rural Water Association should expand to all states and coordinate with state programs; and (5) the EPA, state agencies, and utilities should expand public education efforts.

Walker, Richard A. and Matthew J. Williams. "Water From Power: Water Supply And Regional Growth in the Santa Clara Valley," *Economics and Geography* 58 (April 1982): 95-119.

Young, Robert A., and S. Lee Gray. "Input-Output Models, Economic Surplus, and the Evaluation of State or Regional Water Plans," *Water Resources Research* 21, no. 12 (December 1985): 1819-23.

The authors criticize the use of input-output models for evaluating the costs and benefits of expanding state or regional water supplies. These models, though useful in "impact analysis," should be used with care in normative applications. Agencies using the value-added concept will tend to overstate the returns to a public investment in water supply projects in comparison to investment alternatives. Specifically, using primary regional income per unit of water to measure benefits results in high estimates of value. A conceptual framework, based on the willingness-to-pay concept, is provided. Key elements of the model include the costs of primary resources used by water users (capital, labor, management and land). Many studies incorrectly account for opportunity costs faced by water users in producing sectors. Primary resources other than water also are scarce in the regional and national contexts. Analysts should not assume zero opportunity costs for primary resources in measuring the benefits of water supply projects.

7.3 Regionalization in Other Sectors

Basri, H. B. and E. I. Stentiford, E. I. "Expert Systems in Solid Waste Management," *Waste Management & Research* 13, no. 1 (February 1, 1995): 67.

Berger, David and Jim Hull. "A Case Study of Regionalization in Missouri," a paper presented at the 8th Annual Southwestern Regional Solid Waste Symposium of the Solid Waste Association of North America, Oklahoma City, Oklahoma, March 31-April 2, 1992.

In a commitment to substantially reduce solid waste disposal, Missouri enacted an integrated management strategy in 1990 that included the delineation of nineteen solid waste management districts with responsibilities for planning and implementing waste reduction, recycling, composting, public education and proper disposal. Although county participation is voluntary, most have chosen to participate in the districts.

Birnesser, Donald J., Lauren H. Moore, Jr., and Timothy P. Kaye. "Development of a Regional Integrated Solid Waste System," *Public Works* 124, no. 4 (April 1993): 52.

This article describes the regionalization of the waste disposal system in Mercer and Atlantic Counties, New Jersey. Benefits of regionalization include the ability to share implementation efforts, shorten project schedules, increase reliability, promote, self-sufficiency, and achieve economies of scale. Disadvantages include increased transportation costs.

Caruso, C., A. Colomi, and M. Paruccini. "The Regional Urban Solid Waste Management System: A Modelling Approach," *European Journal Of Operational Research* 70, no. 1 (October 8, 1993): 16.

Caruso, C., A. Colomi, and M. Paruccini. "The Regional Urban Solid Waste Management System: A Modelling Approach," *Operations Research and Management Science* 34, no. 2 (1994): 151.

Curtis, Charles B. "Maintaining a Proper Balance Between Federal and State Authority--Is Their a Place for Regional Regulation?" *The Electricity Journal* (January/February 1992): 28-33.

Criner, George K., Alan S. Kezis, and John P. O'Connor. "Regional Composting of Residential Waste: An Economic Analysis," *Compost Science & Utilization* 3, no. 4 (Fall 1995): 31.

Damadopoulos, E., Y. Koutsantonakis, and V. Zaglara. "Optimal Design of Municipal Solid Waste Recycling Systems," *Resources, Conservation, and Recycling* 14, no. 1 (July 1, 1995): 21.

Hartigan, John P. "Urban Nonpoint Pollution Management In Northern Virginia," Urban Land Institute's *Environmental Comment* (Summer 1980): 8-16.

This article describes a regional strategy for managing urban stormwater for the Occoquan River Basin in Northern Virginia.

Hollas, Daniel R. and Stanley R. Stansell. "Regulation, Ownership Form, and the Economic Efficiency of Rural Electric Distribution ," *Review of Regional Studies* 21, no. 2 (Summer 1991): 201.

Jadun, Leonora K. "Regionalization, the Key to an Integrated Solid Waste Program," a paper presented at the 30th Annual International Exposition of the Solid Waste Association of North America, Orlando, Florida, August 3-6, 1992.

This paper suggests that as landfill space becomes scarce, communities should consider pooling resources and implementing solid waste management on a regional basis. Alternative waste management techniques, a rating system for evaluating management options, and a case study of six Michigan communities are presented.

Kearney, Richard C. and John C. Stucker. "Interstate Compacts and the Management of Low-Level Radioactive Waste," *Public Administration Review* 45, no. 218 (1985).

Mestayer, Kathi A. "Regional Solid Waste Partnerships: Getting to Yes," *Waste Age* 24, no. 12 (December 1993): 89.

O'Neil, Raymond K. and Edward R. Locke. "Solid Waste Planning: Signposts on the Road to Regionalization," *Solid Waste Management* 19, no. 10 (October 1976): 24-28.

A regionalized approach to solid waste management can address disposal constraints and facilitate centralized resource recovery, but surrendering local control can be controversial. Political, institutional, and financial considerations are considered and a case study of Portland, Oregon, is presented.

Poling, Robert. "Regional Perspectives in Energy Regulation," *Bell Atlantic Quarterly* 2, no. 45 (1984).

Redd, A. "Regionalization Brings Economies of Scale to East Coast," *World Wastes* 36, no. 7 (1993): 40-65.

Successful regionalization in solid waste management is linked to statewide management strategies, strong county authority, tonnage capacity and tipping fees to ensure financial viability, and cooperation among participants through a governing council. Interstate regionalism may be constrained by interstate trade restrictions.

"Regional Systems Benefit Both Wet and Dry States," *World Wastes* 36, no. 10 (October 1, 1993): 53.

The economic, marketing, and siting benefits of regional solid waste management are examined with examples from Michigan, Minnesota, Wisconsin, Arizona, New Mexico, and Texas.

"Regionalization: A Solid Waste Solution," *American City & County* 110, no. 9 (August 1, 1995): 44.

Cities and counties can pool resources to reduce costs and provide effective solid waste management on a regional basis.

"Regions Ally In War On Waste," *World Wastes* 36, no. 6 (June 1, 1993): 110.

Solid waste planning and management can be improved through regionalization, but success may depend on adapting strategies to regional characteristics and needs.

Rokach, Joshua Z. "Antitrust in the Electric Utility Industry: Regional Transmission Groups," *Journal of Law and Commerce* 14, no. 1 (Fall 1994): 39.

Salo, M. and K. Saarikoski. *Development of Regional Solid Waste Management in Finland: A Mathematical Model in Solid Waste System Design.* Helsinki, Finland: Government Printing Center, 1982.

An optimization model is described for evaluating regional solid waste management in Finland. The computerized model is a practical planning tool that can facilitate cooperative regionalization and help reduce costs and landfill sites.

Stuntz, Linda. "Is it Time to Consider Regional Solutions to Power Planning Problems? One Federal View," *The Electricity Journal* (January/February 1992): 14-19.