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COST ALLOCATION AND RATE DESIGN FOR WATER UTILITIES

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EXECUTIVE SUMMARY

Cost allocation and rate design are fundamental and closely related parts of the utility ratemaking process. Their many complexities raise a variety of theoretical and practical issues. Though not a practitioner's manual, this report lays a foundation for further exploration of cost allocation and rate design for water utilities at a time when these concerns are increasingly salient. While the report focuses generally on commission-regulated water utilities, it has wider applicability.

The public water supply sector today is operating in an environment of dramatic change. Increasing public concern about economic growth and drinking water quality have complicated the provision of public water service. Per-capita water usage has continued to increase with rising affluence and urbanization. Potential reservoir sites for surface sources and available ground sources have become more scarce. Federal and state legislation and regulations have resulted in more stringent water quality standards. Traditional solutions to supply problems focused on augmenting existing supply sources; however, nontraditional methods including conservation, recycling, and programs designed to improve water system efficiency (for example, least-cost planning and incentive regulation) are now under consideration.

In the current environment of change, water utility issues are attaining a more prominent place on the public and governmental agendas. This growing interest can be attributed to health concerns, occasional droughts, and increased water rates, the latter being a chief concern of public utility regulators. Rising costs in water supply are the result of more stringent drinking water standards and the need to install costly treatment technologies, capacity additions required to accommodate demand growth, and the replacement and upgrading of aging water system infrastructures. The potential for water rates to rival those for energy utilities has increased regulatory concern, particularly with regard to the problem of rate shock and consumers' continued willingness and ability to pay for water service. Water utilities and regulators alike may need to reconsider cost allocation and rate design alternatives when responding to these issues.

Cost allocation is inexact; no single correct approach or method exists. Much depends on the criteria used by analysts. All cost studies involve judgments and should be viewed as a starting point. The choice of a cost allocation approach depends largely on utility management objectives and regulatory policy considerations. In the context of increasing pressure on water rates, a comparison of fully allocated (also known as fully distributed or embedded) cost analysis and marginal-cost analysis is warranted. Fully allocated and marginal-cost calculations both can provide decisionmakers with useful benchmarks for ratemaking as well as planning. These methods can produce divergent results. As a method of compromise, fully allocated costs can be used to determine revenue requirements while marginal costs can be used to design rates. Incremental least-cost analysis is proposed in this report as a marginal-cost ratemaking approach that emphasizes the practical application of least-cost planning criteria to ratemaking.

The theoretical pricing standard is to set rates equal to the cost of service; that is, rate differentials are based on cost differentials. However, to maintain this standard, cost differentials must be sufficiently defined. For example, if there are no marked differences in the cost of providing different volumes of service, it may be more appropriate to adopt a uniform commodity rate than a decreasing-block or increasing-block rate.

Despite the availability of many alternatives, water rate design leaves much discretion to decisionmakers. As in selecting a cost allocation method, the choice of rate design involves tradeoffs among the goals of efficiency, equity, revenue adequacy, and administrative feasibility. Rates that are equitable may not be efficient or perceived as affordable; rates that are perceived as affordable may not be efficient or generate sufficient revenues; rates that are efficient may not be administratively practical. The inclination to promote economic development or conservation policies through rate design must be considered within the context of basic ratemaking objectives and the tradeoffs among them. Decisionmakers may find it increasingly difficult to balance the competing perspectives that are inherent in the ratemaking process.

Finally, it is important to recognize that improved costing and pricing of water utility service, though essential to economic efficiency, is not a panacea for all the problems confronting water utilities and their regulators. Other issues and solutions merit further study as well.

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FOREWORD

A decade ago, Professor Patrick C. Mann of West Virginia University authored *Water Service: Regulation and Rate Reform,* the Institute's first publication on the subject. These issues are revisited and expanded upon in this report, which also is the Institute's first product funded in part by a grant from the American Water Works Association Research Foundation.

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CHAPTER 1

INTRODUCTION

Cost allocation and rate design for water utilities are comparatively new areas of inquiry. Historically, water supply economics has focused on the benefits and costs of large-scale water supply projects, such as reservoirs and dams, while often circumventing issues of cost and price in the public water supply sector.[1] In the public utility realm, the greater attention to other utility services (such as electricity and natural gas) can be attributed to several factors, including the relatively static nature of water industry technology, the relatively small size of the water industry within the United States economy, the dominance of water quality and quantity issues over economic and financial concerns, and the limited debate over issues such as public versus private provision of water service and the appropriate role of competition.[2] A case in point is that geographically localized water shortages tend to heighten awareness of the need to ensure long-term water supplies. However, the predominant response has been to appeal for conservation through voluntary and sometimes mandatory rationing rather than through pricing reform.[3]

One of the more important reasons for the eclipse of water supply by other utility sectors is that in the past, water service has been supplied at a lower cost than other utility services and has generally constituted a relatively small proportion of residential consumer budgets and business expenditures. The relative abundance of inexpensive water supplies has helped keep water prices low. In addition, water rates have generally been increasing at a slower rate than prices for other public utility services. However, low water rates for many publicly owned and privately owned water utilities in the United

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[1] These points are made in Patrick C. Mann, *Water Service: Regulation and Rate Reform* (Columbus, OH: The National Regulatory Research Institute, 1981).

[2] Jerome W. Milliman, "Policy Horizons for Future Urban Water Supply," *Land Economics* 39 (May 1963): 109-32.

[3] According to the economic paradigm, pricing is the preferred rationing and allocation tool.

States can be explained in part by underpricing.[4] The consequences of underpricing include deferring system maintenance and postponing capital replacement of obsolete or aging system facilities.

Underpricing of water service is a function of the need for more refined cost-of-service standards, the use of historical accounting costs (rather than present or near-term future costs) in the ratemaking process, the use of average embedded (rather than incremental) cost as the primary pricing standard in the context of increasing real unit costs of water provision, inadequate provisions for depreciation, maintenance, and other expenses, and consumer pressure to keep rates low. Another explanation for underpricing by some municipal water systems is the political nature of ratemaking at the local level. Although structured differently, many state regulated and privately owned water utilities suffer from many of the same problems. The lack of uniformity in water pricing in general can be partly attributed to the ownership and regulatory dichotomy between public and private water providers.

Forces of change are emerging.[5] In the early 1990s, water issues in general appear to be moving higher on the public and governmental agendas. Issues of economic growth and environmental quality have greatly complicated the provision of water service. Per-capita water usage has continued to increase with rising affluence and urbanization. Potential reservoir sites for surface sources have become more scarce while ground sources have become of limited availability. The traditional solution to supply problems has been to expand or augment supplies; however, nontraditional methods such as conservation, recycling, and programs designed to improve system efficiency (for example, least-cost planning and incentive regulation) are at present under serious consideration. The numerous forces affecting all utilities and their regulation have begun to affect water supply.

Although water quality and quantity issues continue to be prominent, increasing attention is being paid to rising water utility costs, which are primarily related to safe drinking water regulations and the need to install

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[4] On this issues, see James Goldstein, "Full-Cost Water Pricing," *American Water Works Association Journal* 78 no. 2 (February 1986): 52-61.

[5] Patrick C. Mann, "Reform in Costing and Pricing Water," *American Water Works Association Journal* 79 no. 3 (March 1987): 43-45.

costly new treatment technologies, additions to capacity to accommodate growth, and replacement and upgrading of aging infrastructure. Secondary factors include rising energy costs and inflation. Today, the potential for substantial water rate increases and accompanying rate shock looms large, rivaling the past experience of the nation's energy utilities. Changes in pricing policies to encourage conservation and the wise use of water may add to the upward pressure on water rates. As rates rise, so does concern about consumer willingness and ability to pay for water service. All of these issues place demands on water supply managers and regulators as they evaluate cost allocation and rate design alternatives.

Cost allocation and rate design are distinct but intrinsically related processes. The usual purpose of analyzing costs is to provide a basis for setting rates. Likewise, contemporary rate design emphasizes the determination of *cost-based* rates; indeed this objective has become fundamental to utility ratemaking. This report provides essentially a status report on cost allocation and rate design for water utilities. It draws upon theoretical as well as practical knowledge about these topics and provides a basis for evaluating some of the available alternatives. While the focus is mainly on privately owned and state regulated water utilities, the study has broader applicability to other water service providers, all of whom are confronted with cost allocation and rate design issues.

This chapter provides an overview of the issues of value, cost, and price, and a framework for the remainder of the analysis. Chapter 2 provides a description of the water supply industry. Chapter 3 reviews cost allocation, focusing on the embedded cost approach, while chapter 4 reviews conceptual and application issues related to marginal (incremental) cost pricing. Chapter 5 turns to issues of rate design. Chapter 6 offers concluding remarks and is followed by a series of technical appendices, including a glossary of terms and a bibliography. Though not a practitioner's manual, this report lays a foundation for further exploration of cost allocation and rate design for water utilities at a time when these concerns are increasingly salient.

Value, Cost, and Price[6]

Value, cost, and price are intrinsically related and highly interdependent concepts. Although understanding each concept greatly helps in understanding the others, they are distinct in that each evokes a different set of considerations in the water supply field.

Water is a value-added commodity. Its value raises issues of scarcity, competition, and the need for integrated water resource planning. An increasing awareness of water's value has led some to adopt a wise-use approach to its consumption, including--but not limited to--conservation. The cost of supplying water is increasing, especially the expense of complying with safe drinking water regulations. Cost issues also raise questions related to economies of scale and the structural character of the water supply industry. Finally, pricing deals with sending appropriate signals to customers about the value and cost of water. Value-of-service and cost-of-service pricing are contrasting (but not necessarily incompatible) approaches. In the regulatory context, pricing is a part of the process by which revenue requirements are determined, costs allocated, and tariffs designed.

The Value of Water

Of the approximately 340 billion gallons of water withdrawn daily in the United States from surface and ground sources, only about 11 percent is used by public water suppliers. Public suppliers "compete" for water withdrawals mainly against water use in agriculture and electricity generation. The value of water used by public utilities is somewhat dependent on the value society places on other water uses. Over the past several decades, competition for water has intensified greatly, partly because some water sources have reached their carrying capacities or have become impaired either by natural or manmade causes.

Globally, water in its natural state is abundant and renewable, but remains finite and nonrenewable in some respects. For instance, water is nonrenewable when it comes from a severely depleted or contaminated groundwater source. Water

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[6] See Janice A. Beecher, "Value, Cost, and Price: Essay on Emerging Water Utility Issues," *NRRI Quarterly Bulletin* 11 no. 2 (June 1990): 177-181.

withdrawals also require the expenditure of nonrenewable and usually expensive energy resources.

For water users of any type, the cost of water itself (the unprocessed variety) is negligible. All water used by human beings has value principally because its natural characteristics have been altered through withdrawal, transportation, treatment, and/or distribution. Water is a good example of a "value-added" commodity. Indeed, water utilities are in the business of adding value to water, particularly when it comes to safe drinking water.

Several books and articles in recent years have used the terms "scarcity" and "crisis" with respect to water.[7] With globally abundant supplies, it is hard for many to believe that water shortages are a relevant concern. Economists, in fact, prefer the more neutral terminology of supply and demand rather than the concept of scarcity. A "shortage," then, is manifested in higher prices for limited supplies of a good. Higher prices may cause usage to subside, lead to a reallocation of existing supplies in the short term, and stimulate the production of more supplies in the long term.

Because water is vital to human life and because it is not always where we need it when we need it, concerns about scarcity are very real. The North American continental drought of 1988 fueled fears about water shortages in much the same way that the energy crisis of the 1970s dramatized the prospect of energy shortages. In particular, we know more today about the importance of adequate drought planning than before 1988. It may be a well-known truism, but water shortages are not caused by nature but instead are caused by people.

The issue of water scarcity has contributed to an emerging philosophy known as the "wise use of water." Wise use emphasizes, above all else, reducing the wasteful use of water. It is applicable to all types of water (such as treated and untreated water) and all types of water users (such as irrigators, hydroelectric power producers, public suppliers, and consumers). Wise use can take the form of better supply management (such as leak detection and repair) and better demand management (such as pricing reform). Implementing wise-use strategies should be a prerequisite to any large-scale investment in new water supplies, and certainly to any serious consideration of constructing a multi-billion-dollar intercontinental canal

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[7] See Janice A. Beecher and Ann P. Laubach, *Compendium on Water Supply, Drought and Conservation* (Columbus, OH: The National Regulatory Research Institute, 1989).

system, as has been proposed. Pricing, along with integrated resource planning and other policy approaches, is an integral part of most allocation solutions associated with this essential value-added commodity.

The Cost of Water

Perceptions about water's value clearly are enhanced when it costs more. The cost of water is a function both of quality and quantity (that is, availability). Water that is safe to drink tends to cost more. So does water from sources difficult to secure.

Without doubt, the greatest pressure today on the cost of water in the United States is the implementation of the 1986 amendments to the Safe Drinking Water Act (SDWA). Nationally, implementation of the SDWA before the turn of the century may require $30 to $40 billion in capital expenditures alone.[8] Added operation and maintenance costs (including those related to the disposal of contaminants) may substantially increase the total cost of compliance with the act. For individual utilities, the cost of complying with these regulations (both capital and operating) is estimated to be as high as $2,062 per revenue-producing million gallons (RPMG).[9]

SDWA compliance costs for public water suppliers vary across systems as a function of site-specific factors, including system size and, of course, type of treatment required. Smaller systems--and their customers--will be hardest hit by the new regulations. However, because the very smallest systems have a chance for exemption from SDWA requirements (at least in the short term) and because large systems tend to benefit from economies of scale, medium-sized water utilities may be the first to feel the effect of SDWA compliance and thus the first to seek recovery of those costs.

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[8] James P. McFarland, John E. Cromwell, Elizabeth L. Tam, and David W. Schnare, "Assessment of the Total National Cost of Implementing the 1986 SDWA Amendments," a paper presented at the NRRI Biennial Regulatory Information Conference in Columbus, Ohio (September 1990).

[9] Patrick C. Mann and Janice A. Beecher, *Cost Impact of the Safe Drinking Water Act on Commission Regulated Water Utilities* (Columbus, OH: The National Regulatory Research Institute, 1989).

Because of economies of scale in water supply, there is a growing interest in structural options for water utilities (such as regionalization, mergers, and acquisitions) particularly when very small systems can be absorbed by larger ones that are more financially viable. There is also a growing interest in "nonproliferation" of small systems, that is, in preventing these very small (and often eventually troubled) systems from coming into existence in the first place.

For water utilities that fall under the jurisdiction of regulators, cost recovery is closely related to the issue of management prudence. Regulators will want assurances that least-cost alternatives are being pursued, including improvements both to supply and demand management. Keeping costs down may emerge as the first priority of water suppliers and their regulators. On the other hand, for consumers to value water service accurately, they must realize its true economic costs. This raises the issue of price.

The Price of Water

Prices that accurately reflect costs send correct signals to consumers about the value and cost of water, and thereby encourage wise use and discourage wasteful consumption. Nevertheless, prices in many areas may not adequately reflect the cost of providing water service. Further, the absence of metering, the use of rates unrelated to usage, and subsidization to or from nonutility functions are especially problematic. So is the use of embedded accounting costs in setting rates. Many contemporary pricing strategies are based on the idea of marginal cost, which is the additional cost of producing or selling a single incremental unit.[10] Not everyone agrees with marginal-cost pricing and (not surprisingly) the biggest difficulty in applying it is estimating marginal costs, which depend on assumptions about when the next increment of supply will be added, where it will come from, and how much it will cost. Marginal-cost estimation requires detailed and accurate cost data as well as extra effort on the part of water suppliers and their regulators. For small utilities, it may be a highly impractical approach.

Setting prices also entails assessing the potential effect of a change in price on consumption. The conservation of centrally supplied water through pricing is

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[10] See Patrick C. Mann, and Donald L. Schlenger, "Marginal Cost and Seasonal Pricing of Water Service," *American Water Works Association Journal* 74 no. 1 (January 1982): 6-11.

largely a function of the price elasticity of water demand, which is somewhat variable. Outdoor use, for example, is more price-elastic than indoor use. Some water rate structures--such as increasing block and seasonal rates--are specifically designed for conservation purposes, although disagreement exists over their use. As the cost of water treatment increases, greater attention must be paid to the issue of rate design and alternative rate structures, such as seasonal pricing. It also may be necessary to reconcile value-based and cost-based pricing through less conventional rate structures, such as scarcity pricing or excess-use charges.

Finally, one potential result of higher costs for water treatment is rate shock, especially for consumers served by utilities whose rates are currently very low.[11] Water suppliers and regulators may need to look for ways to mitigate rate shock, including rate phase-in plans similar to those that have been applied to nuclear plants in the electricity sector.[12] For any pricing scheme, however, the effects on utility investors in the regulatory context must be examined.

For a water supplier, generating revenues may be the primary consideration. For the ratepayer, the critical issue is price. As prices rise, some customers will seek substitutes, such as bottled water and reliance on their own wells. Others will seek technological solutions--recycling and low-use devices. Still others simply will change their water use habits. In the worst case, some may be unable to afford water that is safe to drink. Policymakers then will have to deal with the implications of such cases. If higher prices accurately reflect water service cost, however, many customer complaints will be difficult to resolve.

Pricing and resource conservation are inseparable issues because of the relationships of price to quantity demanded. From the viewpoint of economic theory, price is essential to the appropriate valuation, consumption, and conservation of resources. Without correct price signals, consumers may overconsume or underconsume water. Historically, weak price signals characterized by low water prices may be associated with too little conservation. In the future, that situation is likely to change.

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[11] See Mann and Beecher, *Cost Impact.*

[12] Another view is that rate shock is necessary and even desirable for sending accurate pricing signals that lead to changes in consumption behavior. In this view, the effects of rate increases should not be mitigated through phase-in plans or other measures.

The philosopher David Hume once asserted that if all goods were free, as are air and water, anyone could get as much as he wanted without harming others.[13] Today, we know that breathable air and drinkable water are not free. Indeed, they are precious resources that must be protected with diligence, allocated with considerable care, and used wisely. Water has intrinsic value because it is life sustaining. Public water utilities add substantial value by extracting water from its source, carrying it over long distances, and delivering it to our homes ready for safe consumption. The cost of doing so is not insignificant. As the price of water service increases, consumers will appreciate its real cost more than ever before.

The Ratemaking Process

Whether regulated or unregulated, all public utilities charge rates for the services they provide. Rates charged by most publicly owned utilities are determined by governing boards or local authorities. Rates charged by most investor-owned utilities are determined by state regulatory commissions. Water utilities, consumers, and society as a whole have different perspectives on ratemaking, as summarized in table 1-1. These perspectives apply not only to utility rates, but also to the process from which rates emerge.

Three Perspectives on Ratemaking

Utilities expect to be fully compensated for the cost of providing service; that is, revenue requirements must be met. Revenues to the utility must be sufficient to cover capital and operating expenses. Investor-owned utilities also want rates to incorporate a reasonable return on their capital investment. Similarly, publicly owned utilities want to be financially self-sufficient, and not rely on subsidization from other revenue sources. From the utility's perspective, ratemaking is also strategic with regard to the ability to provide its service using existing capacity as well as plan for future additions to capacity. Predictable revenues and flexible rate

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[13] As quoted in William Ophuls, *Ecology and the Politics of Scarcity* (San Francisco: W. H. Freeman and Company, 1977), 8.

TABLE 1-1

THREE PERSPECTIVES ON RATEMAKING

Utility's Perspective

- Does the rate structure fully compensate the utility so that revenue requirements are met?
- Does the rate structure allow the utility to earn a fair return on its investment?
- Is the rate structure strategically sound for load management, competition, and long-term planning?

Consumer's Perspective

- Are both the ratemaking process and the rate structure equitable?
- Are utility rates perceived to be affordable?
- Are both the ratemaking process and the rate structure understandable?

Society's Perspective

- Does the rate structure promote economic efficiency?
- Does the rate structure promote the appropriate valuation and conservation of resources?
- Does the ratemaking process take into account priority uses of water?
- Are both the ratemaking process and the rate structure just and reasonable?

Source: Authors' construct.

structures are strategically advantageous to the public utility, particularly if the utility faces any form of competition, including bypass and self supply.

For consumers, the ratemaking process and resultant rates should be equitable or fair to all types of consumers. This usually means that charges to specific types or classes of customers should be based on the costs of serving those customers, and not on arbitrary or discriminatory criteria. Consumers also prefer rates they perceive to be affordable, which is becoming an increasingly difficult expectation to meet. They also fare better with a rate structure that is understandable, which presumably improves consumption decisions. Consumer understanding and acceptance of utility rates make the job of ratemaking much easier.

Society's perspective differs from that of utilities or consumers. Economic or allocative efficiency is a societal goal having to do with costing and pricing. Rates based on efficiency goals encourage appropriate levels of production and consumption and discourage the misallocation of societal resources. Efficiency also dictates rates that are not unduly discriminatory from an economic standpoint.[14] In the context of efficiency, society has an interest in conserving (that is, not wasting) resources. Conservation emphasizes the correct valuation and allocation of resources. Ratemaking can send signals about priorities. Society may place a priority, for example, on water for human consumption over water for agricultural or industrial uses, and this may be reflected in pricing schemes in the form of subsidization. Finally, society may judge ratemaking in terms of whether it is just and reasonable, a time-honored standard in utility regulation. Good intentions can result in unjust or unreasonable outcomes, as when the cost of regulation itself outweighs its benefits. Many ratemaking practices exist that are accepted as reasonable from the societal standpoint. Creating customer classes and employing averaging to allocate cost among them, for example, may be a form of price discrimination considered reasonable on the basis of regulatory cost savings.

Ratemaking is a continual balancing act among the divergent and often competing perspectives of utilities, consumers, and society. Rates that are perceived by consumers to be affordable do not necessarily meet revenue requirements; rates that are equitable are not necessarily efficient; rates that are

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[14] See J. Stephen Henderson and Robert E. Burns, *An Economic and Legal Analysis of Undue Price Discrimination* (Columbus, OH: The National Regulatory Research Institute, 1989).

economically efficient are not necessarily administratively feasible because of practical application issues.

In balancing perspectives, the key objectives of rate regulation emerge. Although there are many different conceptualizations, the objectives identified tend to be similar. Bonbright, Danielson, and Kamerschen emphasize capital attraction (the utility perspective), fairness to ratepayers (the consumer perspective), and rationing (the societal perspective) as regulation's principal objectives.[15] Their assessment also includes what is referred to as the "ten attributes of a sound rate structure," reported in table 1-2. These attributes can be used to evaluate rate structures as well as the methodologies used to design them. As the authors explain, "Lists of this nature are useful in reminding the ratemaker of considerations that might otherwise be neglected, and also useful in suggesting important reasons why problems of practical rate design do not yield readily to scientific principles of optimum pricing."[16]

Decision Areas in Cost Allocation and Rate Design

Cost allocation and rate design can be dissected into several distinct (though highly interrelated) decision areas, each of which can be further dissected into principal considerations, as identified in table 1-3. The first is the identification of the utility's revenue requirement, which is a function of its capital investment (rate base), allowed rate of return, operation and maintenance expenses, depreciation, and taxes.[17] Costs next can be divided into functional categories of water supply, such as source development, pumping, transmission, treatment, storage, and distribution. Functional cost categories can also be established for nontraditional sources of capacity (such as leak detection and repair, purchased water, or conservation). The next step is to classify costs in terms of customer, capacity (demand), and commodity (operating) costs, distinctions which also are used in rate design. Many methods also emphasize the separate classification of fire protection costs.

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[15] James C. Bonbright, Albert L. Danielsen, and David R. Kamerschen, *Principles of Public Utility Rates* (Arlington, VA: Public Utilities Reports, 1988), 382-84.

[16] Ibid., 384.

[17] See chapter 4.

TABLE 1-2

ATTRIBUTES OF A SOUND RATE STRUCTURE

Revenue-related Attributes

1. Effectiveness in yielding total revenue requirements under the fair-return standard without any socially undesirable expansion of the rate base or socially undesirable level of product quality and safety.
2. Revenue stability and predictability, with a minimum of unexpected changes seriously adverse to utility companies.
3. Stability and predictability of the rates themselves, with a minimum of unexpected changes seriously adverse to ratepayers and with a sense of historical continuity.

Cost-related Attributes

4. Static efficiency of the rate classes and rate blocks in discouraging wasteful use of service while promoting all justified types and amounts of use:
   (a) in the control of the total amounts of service supplied by the company;
   (b) in the control of the relative uses of alternative types of service by ratepayers (on-peak versus off-peak service or higher quality versus lower quality service).
5. Reflection of all of the present and future private and social costs and benefits occasioned by a service's provision (i.e., all internalities and externalities).
6. Fairness of the specific rates in the apportionment of total costs of service among the different ratepayers so as to avoid arbitrariness and capriciousness and to attain equity in three dimensions: (1) *horizontal* (i.e., equals treated equally); (2) *vertical* (i.e., unequals treated unequally); and (3) *anonymous* (i.e., no ratepayer's demands can be diverted away uneconomically from an incumbent by a potential entrant).
7. Avoidance of undue discrimination in rate relationships so as to be, if possible, compensatory (i.e., subsidy free with no intercustomer burdens).
8. Dynamic efficiency in promoting innovation and responding economically to changing demand and supply patterns.

Practical-related Attributes

9. The related, practical attributes of simplicity, certainty, convenience of payment, economy in collection, understand-ability, public acceptability, and feasibility of application.
10. Freedom from controversies as to proper interpretation.

Source: James C. Bonbright, Albert L. Danielsen, and David R. Kamerschen, *Principles of Public Utility Rates* (Arlington, VA: Public Utilities Reports, 1988), 382-84.

TABLE 1-3

COST ALLOCATION AND RATE DESIGN FOR WATER UTILITIES: DECISION AREAS AND PRINCIPAL CONSIDERATIONS

Decision Areas	Principal Considerations
Identification of Revenue Requirement	Capital investments/rate base Return on rate base Operation and maintenance expenses Depreciation Taxes
Cost Functionalization	Source development Pumping Transmission Treatment Storage Distribution Nontraditional supply
Cost Classification	Customer costs Capacity (demand) costs Commodity (operating) costs
Cost Allocation	Functional cost Commodity demand Base-extra capacity Embedded direct Fully distributed Marginal/incremental
Cost Assignment	Residential Commercial Industrial Wholesale Institutional Public authorities Fire protection

TABLE 1-3 (continued)

Decision Areas	Principal Considerations
Rate Design	Flat fees Fixture rates Uniform rates Decreasing block pricing Increasing block pricing Seasonal rates Excess use charges Indoor/outdoor rates Lifeline rates Sliding scale pricing Scarcity pricing Spatial pricing
Tariff Design	Customer charges Capacity (demand) charges Commodity (operating) charges Dedicated-capacity charges Capital contributions Fire protection charges Ancillary charges

Source: Authors' construct.

The analyst then chooses a cost allocation method for attributing costs to their respectives causes. Some of the methods used are functional cost, commodity demand, base-extra capacity, embedded direct, fully distributed, and marginal (or incremental). Next is the assignment of costs to classes of service. Some typical service classes in water supply are residential, commercial, industrial, wholesale, institutional, public authorities, and fire protection. Finally, rates for each customer class presumably based on the cost of serving them are established. There are many potential water rate structures, some of which appear in table 1-3. The resulting tariff, or authorized list of water service charges, may consist of customer, capacity, and commodity charges as well as special charges for dedicated capacity, capital contributions, fire protection, and ancillary services. Some charges (such as customer charges) are fixed, meaning they do not vary with water usage; others (such as commodity charges) are variable, meaning they do vary with water usage.

The decision areas in cost allocation and rate design are distinct but overlap considerably. Decisions about costs may affect the choice of methodology; decisions about customer classes may affect the choice of a rate structure. The resulting rates should allow the utility to meet its revenue requirements. There are also many subtle and not-so-subtle issues that emerge in the course of ratemaking that require an analyst's judgment. Because there is no such thing as a typical water utility, there may be few precedents or rules of thumb on which to rely. In practice, convenience, expedience, and tradition probably affect ratemaking for water utilities as much as economic analysis.

Generally, the cost-of-service standard has prevailed in setting water rates. This means setting rates that generate revenues from each user group equal to the cost of serving that group. That is, the user class that causes the expense absorbs the cost in rates paid for water service. The cost-of-service concept implies equal treatment for users with equal costs and rate differentials reflecting cost differences. This presumes, however, that water service costs are easily ascertainable for specific user groups. In many cases, cost-of-service analyses ignore the distinction between average (unit) costs and marginal (incremental) costs, between short-run and long-run costs, and between peak and off-peak costs of services. Water rates, as with other public utility rates, are based on averaging (that is, the average users having an average load factor); price discrimination is inherent.

Although cost-based, water utility ratemaking generally has not made use of sophisticated cost allocation methodologies (to identify cost causers) and rate design alternatives (to assign costs to customers).[18] Limited regulatory resources are the leading explanation for why this is so. Moreover, water rates have been affected by other factors, such as political considerations, tradition, value of service, and legal constraints. For example, many water rates have been adopted on the basis of either minimal customer complaint or consistency with the rates of adjacent communities. In brief, setting water rates involves a combination of analysis and expedience as well as a desire to balance competing policy goals. However, in the increasingly complex realm of water utility ratemaking, particularly in light of rising costs and prices, these issues are worth exploring.

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[18] There are exceptions. Articles appearing in the *American Water Works Association Journal* are a good source on new approaches.

CHAPTER 2

CHARACTERISTICS OF WATER UTILITIES

The water supply industry is both "mature and conservative."[1] Its maturity accounts for a relatively low rate of technological innovation. As a consequence, few radical changes have occurred in the methods of delivering drinking water by central suppliers over the past few decades. The rate of technological change may be stimulated by the stringent drinking water regulations promulgated by the U.S. Environmental Protection Agency under the amended Safe Drinking Water Act and administered by the states through environmental or public health agencies. Increased water prices may also bring about technological, structural, managerial, and regulatory changes. However, there persists a tendency for water supply planners to rely on proven facility designs and standard operating procedures. Thus, the industry's operating characteristics remain relatively constant.

The Water Service Industry

The U.S. Environmental Protection Agency (EPA) estimates that there are more than 50,000 water systems in the United States, as reported in table 2-1. All community water systems must comply with safe drinking water regulations set by the EPA and administered through state agencies. About half of the systems are owned by governmental entities, usually municipalities. The rest are nearly equally divided between privately owned systems and ancillary systems (such as those found in mobile home parks).

Water utilities are somewhat distinct from other types of public utilities in that many small systems serve a relatively small (but not insignificant) portion of the United States' population, as seen in table 2-2. Most of these small systems serve fewer than five hundred persons each. The financial and operating characteristics of water systems vary substantially according to system size. Small water systems are generally defined by the U.S. Environmental Protection Agency as those serving fewer than 3,300 people (approximately 1,000 connections). The

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[1] Wade Miller Associates, *The Nation's Public Works: Report on Water Supply* (Washington, DC: National Council on Public Works Improvement, 1987), 22-24.

TABLE 2-1

WATER SYSTEMS IN THE UNITED STATES, 1986

Ownership Structure*	Number of Utilities	Percent of All Systems
Public		
Local, municipal government	23,248	44.3%
Federal government	528	1.0
On Indian land	127	.2
Subtotal	23,903	45.5
Private		
Investor-owned		
Financially independent	6,716	12.8
Financially dependent on parent company	986	1.9
Homeowners' association or subdivision	6,163	11.7
Other	661	1.3
Not available	178	.3
Subtotal	14,703	28.0
Ancillary		
Mobile home parks	10,150	19.3
Institutions	535	1.0
Schools	458	.9
Hospitals	91	.2
Other	2,638	5.0
Not available	31	.1
Subtotal	13,903	26.5
Total	52,509	100.0%

Source: Frederick W. Immerman, *Financial Descriptive Summary: 1986 Survey of Community Water Systems* (Washington, DC: Office of Drinking Water, U.S. Environmental Protection Agency, 1987), table 2-2.

* This table is organized according to ownership, without regard to whether different types of systems are regulated by state public utility commissions.

TABLE 2-2

WATER SYSTEMS IN THE UNITED STATES BY OWNERSHIP STRUCTURE AND POPULATION CATEGORY, 1986

Community Size (persons)	Number of Systems				Average Daily Production	
	Public (a)	Private (b)	Ancillary (c)	Total	Percent	MGD(d)
25-100	1,525	4,544	8,264	14,333	27.2	.025
101-500	5,416	5,129	4,743	15,288	29.1	.057
501-1,000	3,777	1,655	600	6,032	11.5	.623
1,101-3,300	5,831	1,933	286	8,050	15.3	.714
3,301-10,000	3,950	904	5	4,860	9.2	1.240
10,001-25,000	1,828	237	5	2,070	3.9	4.240
25,001-50,000	897	158	0	1,055	2.0	9.911
50,001-75,000	227	38	0	265	0.5	10.150
75,001-100,000	145	22	0	167	0.3	10.472
100,001-500,000	261	52	0	313	0.6	36.593
500,001-1,000,000	33	29	0	62	0.1	104.422
Over 1,000,000	13	1	0	14	0.03	442.197
Total	23,903	14,703	13,903	52,509	-	-
Percent	45.5%	28.0%	26.5%	100%	-	-

Source: Frederick W. Immerman, *Financial Descriptive Summary: 1986 Survey of Community Water Systems* (Washington, DC: Office of Drinking Water, U.S. Environmental Protection Agency, 1987), table 2-2 and 3-1.

(a) Local, municipal government, federal government, and on Indian land.
(b) Investor-owned (both financially independent systems and systems financially dependent on parent companies), homeowners' associations or subdivisions, other, and don't know/refused.
(c) Mobile home parks, institutions, schools, hospitals, other, and information not available.
(d) Millions of gallons daily for 1985.

problems of these systems are well documented.[2] Policymakers at the federal and state levels continue to be greatly concerned about the proliferation of new small, nonviable systems as well as the future of existing nonviable systems.

Water systems have many of the characteristics of monopolies. They typically face little or no competition at the operating level because duplicating service would be costly and inefficient. Their product has no substitute, although there are alternative methods of delivery as well as alternative levels of water quality. Perceptions of market failure--for technological, economic or public health reasons--reinforce the provision of water service mainly by publicly owned or regulated privately owned water utilities.

Forty-six state public utility commissions have the authority to regulate water systems in the United States; nearly 10,000 systems fall under this jurisdiction, and about one-half of these are investor-owned. Fifteen commissions have some jurisdiction over publicly owned water systems. Economic regulation by state commissions is aimed at giving monopolistic utility providers an opportunity to earn a "fair return" on their investment through "just and reasonable" rates. In return, regulated utilities must meet certain obligations to serve, which is to say they cannot discriminate in providing service within their franchised territory and must meet standards of quantity, quality, safety, and reliability. In short, a "regulatory compact" exists between the states and their jurisdictional public utilities. It is an imperfect but essential institutional arrangement.

The economic regulation of water utilities has often been subordinate to the regulation of electric, gas, and telecommunications utilities, mainly because the regulated portion of these other utility sectors consists of much larger firms serving more customers and accounting for a much greater share of economic activity as well as consumers' expenditures on utility services. Even so, many commissions report spending a disproportionate amount of resources on oversight of water utilities.

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[2] See Raymond W. Lawton and Vivian Witkind Davis, *Commission Regulation of Small Water Utilities: Some Issues and Solutions* (Columbus, OH: The National Regulatory Research Institute, 1983), 5-6. A forthcoming NRRI report on the nonproliferation of nonviable water systems also will address these issues.

Although deregulating water utilities is sometimes discussed, an economic rationale for such a policy is not readily apparent.[3] Strategies to improve regulatory efficiency and effectiveness, while reducing costs, are more realistic and urgently needed.

A typical water utility does not exist. The smallest systems are substantially different from the largest in practically all respects. However, some general observations about the cost characteristics, financial characteristics, scale and scope economies, demand characteristics, price elasticity of water demand, and water conservation are appropriate to the later analysis of cost allocation and rate design for water utilities.

Cost Characteristics

Selected operating characteristics of water suppliers according to the size of community served are presented in table 2-3. As would be expected, average net assets and average operating revenues are largely a function of water system size. Using the standard of capital investment per revenue dollar, the water utility industry is possibly the most capital intensive of all utility sectors. Using these data, water systems require $7.80 in assets for every dollar of revenue generated; the ratios range from 5.2 to 19.6. One study found that large water systems required as much $10 to $12 in capital for every dollar of revenue generated and compared this to ratios of 1:1 for the airline industry, 2:1 for railroads, 3:1 for telephone companies, and 3-4:1 for electric utilities.[4] Thus, even in the capital-intense public utility sector, water supply has particularly significant capital requirements.

The high capital intensity in water supply is mostly a function of the capital investment necessary for maintaining production capacity, maintaining a complex distribution network that ties the utility system directly to the consumer, and the necessity of meeting both fire protection and peak demands. The capital intensity

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[3] Janice A. Beecher and Patrick C. Mann, *Deregulation and Regulatory Alternatives for Water Utilities* (Columbus, OH: The National Regulatory Research Institute, 1990).

[4] Science Management Engineering and TBS, Inc., *Urban Water System Characterization* (1979), 15, as reported in Wade Miller Associates, *Report on Water Supply.*

TABLE 2-3

SELECTED CHARACTERISTICS OF THE WATER SUPPLY INDUSTRY IN THE UNITED STATES

Community Size (persons)	Average Net Assets ($000) (a)	Average Operating Revenues ($000) (b)	Ratios			
			Assets/ Revenues (c)	Assets/ Water Output (d)	Expenses/ Water Output (e)	Revenues/ Water Sold (f)
25-100	$490	$25	19.6	$24.9	$278	$198
101-500	426	45	9.5	16.5	259	243
501-1,000	792	103	7.7	8.4	164	184
1,101-3,300	3,193	475	6.7	7.2	164	204
3,301-10,000	3,471	514	6.8	4.6	141	150
10,001-25,000	13,970	1,999	7.0	4.1	139	180
25,001-50,000	15,185	2,795	5.4	2.4	83	114
50,001-75,000	31,721	3,824	8.3	2.2	83	103
75,001-100,000	53,392	8,461	6.3	3.2	108	109
100,001-500,000	98,311	14,861	6.6	2.2	80	115
500,001-1,000,000	206,616	39,971	5.2	2.0	68	113
Over 1,000,000	659,491	108,318	6.1	1.8	51	82
For all systems	$5,784	$745	7.8	$10.5	$188	$196

Source: Frederick W. Immerman, *Financial Descriptive Summary: 1986 Survey of Community Water Systems* (Washington, DC: Office of Drinking Water, U.S. Environmental Protection Agency, 1987), tables 5-1, 4-1, 5-5, 4-9 and 4-5. The data represent publicly-owned and privately-owned water systems.

(a) Current assets, net plant and equipment (gross plant and equipment less accumulated depreciation), and other assets in thousands ($000).
(b) Water operation revenues in thousands ($000).
(c) The ratio of (a) to (b), as calculated by authors.
(d) Gross plant and equipment (before depreciation) divided by average daily production ($/gallons per day).
(e) Operating expenses in cents/1,000 gallons produced.
(f) Water operation revenue (excluding other sources of revenue or municipal fund transfers) in cents/1,000 gallons delivered. Only systems that charge for water are included in the analysis.

is reflected in high capital investment/revenue ratios and low capital turnover rates; that is, low revenue/capital investment ratios.

In examining water utilities, the concepts of variable and fixed costs are relevant. The important classifications are short-term variable costs that change with output supplied (such as treatment chemicals and purchased water), and short-term fixed costs that do not vary with the volume of service (such as depreciation of distribution mains).

The characteristic of high fixed costs relative to variable costs for water utilities has important pricing implications. Conceptually, for reasons of economic efficiency discussed in chapter 3, fixed costs should be incorporated in service or customer charges rather than in commodity (usage) charges. In other words, commodity charges should only include those costs that tend to vary with the volume of services; costs that do not vary with service volume are more appropriately incorporated in service charges, which are at fixed levels. A related costing implication of the high fixed-cost-to-variable-cost ratio for water utilities is that customer load factors can play an important role in rate design. Large users with better load factors can argue that their usage patterns are associated with lower unit costs than lower load factor customers.

Financial Characteristics

The high capital intensity of water supply also has financial implications. Many water utilities have aging capital facilities that need to be replaced during this decade; others must upgrade plant facilities to meet the requirements of the Safe Drinking Water Act. This has forced water utilities to examine options for financing the replacement of aging and/or obsolete facilities. In most cases, the cost of replacement will exceed original costs by a substantial amount.

Investments in water supply tend to be large and indivisible; the "lumpiness" feature that is also typical of other public utility sectors. Many of these investments, including treatment plants and the transmission and distribution infrastructure, may have very long service lives. Because capacity is added in large increments, there may be periods of underutilization (or excess capacity), which can pose significant financial problems in terms of cost recovery. Of course, the utility with plentiful capacity is also in a good financial position to accommodate demand growth.

Because of their small size and weak financial structure, many water systems lack the ability to attract capital through the same mechanisms as larger utilities.[5] Many small water utilities lack a substantial rate base because their original capital costs were recovered through the purchase price of houses in a residential subdivision. Furthermore, the ratemaking process does not consider contributed plant an asset that can placed into rate base (for earning a return) or depreciated (an expense). Without a sufficient rate base, equity, or physical assets to serve as collateral, small water utilities find it difficult and expensive to raise capital. Tales of the very small water utility owner using a home or car for financing collateral are widely circulated. Also, many water systems with ownership of physical plant do not adequately provide for system depreciation, and thus are in a poor position to replace or upgrade infrastructure. The need to make capital improvements to comply with more stringent drinking water standards adds to the financial stress on small water systems.

Some common patterns can be noted in water system financing.[6] Capital investment in reservoirs, transmission, and treatment are generally financed by debt (for both investor-owned and publicly owned systems) and equity borrowing (for investor-owned systems only). Distribution system expansion is generally financed by developer and user hook-up charges with some reliance on borrowing. Operation costs and minor system improvements are generally financed by commodity rates; however, in the case of municipally owned systems, rate revenues are occasionally supplemented by subsidies from the local government.

Scale and Scope Economies

Both economies of scale and economies of scope, though different concepts, have applicability to water supply. A natural monopoly is thought to exist if a service or services can be supplied more efficiently by a single utility than by two or more utilities. Economies of scale should be viewed in the context of a single product or service firm; for example, a water utility providing only general water service. In this case, economies of scale are associated with the concept of natural

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[5] Lawton and Davis, *Commission Regulation of Small Water Utilities.*

[6] Patrick C. Mann, *Water Service: Regulation and Rate Reform* (Columbus, OH: The National Regulatory Research Institute, 1981), 7.

monopoly, but are not a necessary condition of natural monopoly. Economies of scope should be viewed in the context of a multiproduct or multiservice firm; for example, a water utility providing general water service as well as fire protection. In the multiple product/service case, the concept of natural monopoly requires economies of scope.

Economies of scale are often expected to occur in monopolies and are apparent when the average cost of providing a single product or service decreases as output or volume of service increases.[7] In other words, the unit cost of providing water service is expected to decline as system capacity is expanded. Many analysts contend that water utilities enjoy significant economies of scale.[8] According to recent research, economies of scale exist for treatment cost, but are somewhat less apparent for total system cost.[9] By comparison, some diseconomies of scale are apparent regarding the distribution system.[10]

As noted, table 2-3 reports ratios of assets to revenues generated for water systems according to the size of the community served. For the industry as a whole, economies of scale are indicated. This characteristic is also reflected in the ratios of assets per output of water, operating expenses per output of water, and revenues per sale of water, all of which decline as system size increases. The implication is that larger systems can produce water at a lower cost (in terms of both capital and operating expenses) and sell it at a lower price than smaller systems. More study is needed to determine whether declining ratios are related to the size or density of the population in utility service territories.

Another approach to the issue of scale economies is to examine assets per connection, as displayed in table 2-4. Such assets for production and treatment do not exhibit economies, even though there are scale economies in these areas with regard to water produced. Per-connection economies are not apparent for

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[7] Another measure of economies of scale is the ratio of average total cost to marginal cost (the cost of producing more units of output); economies exist if this value exceeds one.

[8] Robert M. Clark and J. M. Morand, "Package Plants: A Cost-Effective Solution to Small Water System Treatment Needs," *American Water Works Association Journal* 73 (January 1981): 24.

[9] Robert M. Clark, "Applying Economic Principles to Small Water Systems," *American Water Works Association Journal* 79 (May 1989): 57-61.

[10] Ibid.

TABLE 2-4

ASSETS PER CONNECTION FOR WATER SYSTEMS IN THE UNITED STATES

	Assets($)/Connection					
Community Size (persons)	Production and Treatment	Distribution	Other Plant and Equipment	Total Gross Plant	Total Net Plant	Total Net Assets
25-100	$43	$18,446	$5,934	$13,605	$19,756	$11,711
101-500	308	3,251	451	3,948	3,961	4,053
501-1,000	124	2,019	629	2,626	1,730	1,889
1,101-3,300	285	1,222	239	6,405	4,623	6,710
3,301-10,000	328	926	192	2,159*	1,185	1,583
10,001-25,000	211	750	173	1,879	1,437	1,758
25,001-50,000	212	873	102	1,437	1,083	1,639
50,001-75,000	222	839	95	1,272	925	2,041
75,001-100,000	452	1,140	97	2,186	1,850	2,353
100,001-500,000	206	1,069	213	1,553	1,212	1,766
500,001-1,000,000	171	1,414	472	1,615	1,267	1,662
Over 1,000,000	389	1,194	352	1,857	1,332	1,693
For all systems	$247	$3,409	$829	$7,336	$4,329	$4,660

Source: Frederick W. Immerman, *Financial Descriptive Summary: 1986 Survey of Community Water Systems* (Washington, DC: Office of Drinking Water, U.S. Environmental Protection Agency, 1987), table 5-3 .

* Authors' correction/estimation; source reports $21,590.

distribution and other plant and equipment categories as well. For total gross plant, total net plant, and total net assets, the ratio of assets to connections appears to decline somewhat, but not in a conclusive pattern. Thus, scale economies in water supply are more likely to be found in terms of water production than in terms of customer connections.

Although there is little research on this point, water utilities probably also enjoy economies of scope, which exist when the average cost of providing two or more products or services (in combination with one another) are less when provided by a single water utility than when two or more firms provide each of the services separately. An example is a single utility providing both general water service and fire protection service. If economies of scope exist, the unit cost of providing both services is less than if the services were provided by separate water utilities.

The water utility can be viewed as a multiproduct firm providing different types of water service. Kim and Clark found that significant economies of scale do not exist in overall water utility operation.[11] However, the typical water utility experiences substantial economies in providing residential service. The economies of scale achieved in water treatment are offset or negated by the diseconomies in water distribution. In contrast, water utilities in the aggregate experience economies of scope associated with the joint provision of residential and nonresidential service. Since their analysis incorporated a sample of sixty utilities that could be characterized as medium-sized water suppliers, the authors acknowledged that their empirical results did not preclude the possibility of substantial economies of scale for small utilities and moderate diseconomies of scale for large utilities.

Though independent, economies of scale and economies of scope interact to the extent that larger systems may be more capable of keeping unit costs down in their various areas of service. The desire to take advantage of scale and scope economies is central to the issue of water industry restructuring as envisioned by many federal and state policymakers.

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[11] H. Youn Kim and Robert M. Clark, "Economies of Scale and Scope in Water Supply," *Regional Science and Urban Economics* 18 (November 1988): 479-502.

Demand Characteristics

Water systems are designed to meet both peak and off-peak (base) demand. The peak demand (peak load) for a water system is the maximum demand imposed on the system. Water service presents two basic types of peak demands: time-of-day peak demand and maximum-day (or seasonal) peak demand. The time-of-day peak demand is the specific hour or hours within the day that maximum-system demand is experienced. It is not simply a single hour within a day but instead is the hours within a day in which the water system experiences its peak demand. The maximum-day or seasonal peak demand is the specific day or days within the year that maximum-system demand is incurred. For some water systems, a time-of-week peak load may also be important; for example, weekends may produce increased residential use and decreased commercial-industrial use. The resulting compensating effect varies with the mix of commercial-industrial users as well as with residential spatial and usage patterns; therefore, the weekend effect and its impact on system peak loads can be unpredictable.[12]

The load factor for a water system is the ratio of average demand to peak demand. The load factor must be defined with reference to a specific time period or type of peak load, such as maximum-hour or maximum-day. Thus, the load factor is operationalized as the ratio of actual consumption over a period to the maximum (peak) demand multiplied by the length of a period (the period can be hourly, daily, monthly, or annually). The capacity utilization factor for a water system is closely related to the load factor in that it refers to the average system demand as a percentage of designed or rated system capacity. Given relatively high capacity costs, water systems tend to experience declining unit costs with increasing load factors and capacity utilization factors. Since most water systems maintain some reserve capacity beyond that necessary to meet peak demands, the difference between the capacity utilization factor and the load factor for a specific water system is determined by the amount of reserve capacity.

Peak demands are important parameters in the design and construction of water systems. Given that water systems must be capable of servicing peak demands and given the existence of time-of-day, time-of-week, and seasonal

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[12] W. R. Derrick Sewell and Leonard Roueche, "Peak Load Pricing and Urban Water Management: Victoria, B.C., A Case Study," *Natural Resources Journal* 14 (July 1974): 383-400.

consumption patterns, the result is intermittent and varying degrees of unused system capacity. To further complicate matters, water system components are generally designed to meet different types of demands. For example, raw water storage facilities, such as reservoirs, are generally designed to meet average annual demand; transmission and treatment facilities as well as major feeder mains are generally designed to absorb maximum-day demand; and distribution mains, pumping stations, and local storage facilities are designed to meet maximum-hour demand, or maximum-day demand plus fire protection flow requirements, whichever is greatest.[13] Thus water systems with identical average demands are designed differently if their peak demands differ.

The primary contributor to residential peak demands (which cause most system peak demands) is lawn and garden sprinkling. Since sprinkling is used to compensate for deficiencies in rainfall, its occurrence is influenced by temperature, precipitation, and the evapotranspiration rate.[14] Landscaping preferences and even cultural norms also may affect sprinkling demand. During dry periods, sprinkling probably accounts for a large share of residential peak demands. Also, from a load management perspective, there is little possibility that new types of winter water use will emerge to offset summer peak loads created by sprinkling demand.

Price Elasticity of Water Demand

In economics, demand is viewed as the inverse relationship between price and quantity consumed. The price elasticity of demand measures the percentage change in quantity demanded in response to a percentage change in price. That is, price elasticity measures the sensitivity of quantity consumed to price changes. Estimating price elasticity is an important component of demand forecasting and revenue projection. If a rate change is anticipated, its effect on demand and revenues must also be anticipated by utilities and their regulators.

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[13] F. Pierce Linaweaver and John C. Geyer, "Use of Peak Demands in Determination of Residential Rates," *American Water Works Association Journal* 56 (April 1964); and Charles W. Howe and F. Pierce Linaweaver, "The Impact of Price on Residential Water Demand and its Relationship to System Design and Price Structure," *Water Resources Research* 3 (First Quarter 1967): 13-32.

[14] W. Douglas Morgan, "Climatic Indicators in the Estimation of Municipal Water Demand," *Water Resources Bulletin* 12 (June 1976): 511-518.

In a demand model, the price elasticity of demand (n) is calculated as:[15]

$$n = \frac{\text{change in quantity/mean quantity}}{\text{change in price/mean price}}$$

where:

n	= 0.0	Perfectly inelastic demand
0.0	> n > -1.0	Relative inelastic demand
-1.0	> n > -infinity	Relatively elastic demand
n	= -infinity	Perfectly elastic demand

Water, since it is used in a wide variety of ways, is likely to be characterized by a number of different demand curves and each may reflect a different price elasticity. For some types of water use, a change in price is likely to bring about a substantial change in the quantity consumed. Water for swimming pools and landscapes may have price-elastic demands. In contrast, demand for water used for drinking, bathing, laundering, and other more fundamental needs may be more price-inelastic.

The principal research findings about price elasticity of water demand can be summarized as follows:[16]

- Aggregate municipal demand is relatively price-inelastic.
- Price elasticity appears to vary positively with water price levels; that is, there is more usage-price sensitivity with higher rates than with lower rates.
- The price elasticity of residential demand is similar to aggregate municipal demand except when disaggregated into seasonal and nonseasonal components, in which case seasonal demand is more elastic than nonseasonal demand.
- Commercial and industrial demands appear to be more sensitive to price changes than residential demand.

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[15] A linear model is appropriately applied to water demand. But it is relevant only in the range for which the analyst has data and results cannot be assumed valid for segments of the demand curve where prices are markedly different.

[16] Mann, *Water Service,* iii.

- The price-elasticity coefficients associated with water demand generally indicate that water rates changes can alter usage levels.

- The relatively low coefficients associated with residential demand along with evidence that average sprinkling demand is more sensitive to price than maximum sprinkling demand suggests that time-differentiated rates may be more effective than general rate increases in altering consumption patterns.

Estimates of price elasticities vary widely.[17] According to Baumann, the literature as a whole suggests that a likely range of elasticity for residential demand is between -0.20 and -0.40, which is relatively price-inelastic.[18] Although its statistical significance is questionable, an estimate of elasticity for industrial demand ranges between -0.50 and -0.80, somewhat less price-inelastic than the residential demand. The implication is that industrial users will tend to reduce consumption in response to price increases by a larger quantity than residential users. Presumably, a large enough increase will cause some of these users to seek alternative water supplies.

As part of a comprehensive analysis of water pricing in Tucson, Arizona, William E. Martin and others conducted a longitudinal analysis of changes in prices and quantities of water pumped in order to assess price elasticity.[19] In eleven of sixteen years studied, the researchers found the implied elasticity to be negative, as expected. While people appeared to respond to higher prices by cutting back consumption, the authors concluded that major cutbacks could only be expected when a rate increase was accompanied by enough publicity to increase public awareness. Further, price was only one of several variables, including weather, that

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[17] For a summary, see U.S. Army Corps of Engineers as adapted by William O. Maddaus, *Water Conservation* (Denver, CO: American Water Works Association, 1987), 66; reprinted in Janice A. Beecher and Ann P. Laubach, *Compendium on Water Supply, Drought, and Conservation,* (Columbus, OH: The National Regulatory Research Institute, 1989), 242.

[18] Duane D. Baumann, "Issues in Water Pricing," in Arizona Corporation Commission, *Water Pricing and Water Demand,* papers presented at a Water Pricing Workshop, Utilities Division, August 21, 1986, 7.

[19] William E. Martin, et al., *Saving Water in a Desert City* (Washington, DC: Resources for the Future, 1984).

appeared to affect consumption significantly. In periods of drought, changes in water practices, perhaps induced by public information campaigns, actually may prove to be more influential than the simple price-quantity relationship.

Positive price-elasticity coefficients indicate that water rate changes have some potential for altering water usage levels and patterns. However, given findings that water price changes affect average sprinkling demand substantially more than maximum sprinkling demands, extreme demand patterns may be minimally affected by rate changes. Thus, a seasonal increase in price may provide an incentive to reduce average use during the summer, but not peak use on especially dry days.

The statistical findings regarding the price elasticity of water demand have several implications. The relationship of the quantity demanded of water service and price complicates the task of water system design. Water system design is a function of average and peak demands, which are a function of water price, which is a function of the cost of service, which is a function of system design, and so on, as illustrated in figure 2-1. Therefore, price-elasticity coefficients exceeding zero produce a circularity problem that can be difficult to resolve in the context of traditional public utility regulation.[20]

It has been said that since water is essential to life and no other good can be substituted for it, some small essential amount of water will always have a perfectly inelastic demand; that is, consumers will be willing to pay any price for it. Because water is necessary for human survival, some have argued that price should not be the principal allocation method during a severe water shortage.[21] However, while water itself cannot be substituted, its method of delivery can for most uses. Drinking water, for example, can come from the faucet, be brought home from the supermarket, or delivered in bottles. Some users can substitute publicly supplied water with water from their own wells and thus bypass the water utility. Industrial users may not require treated water at all. Some large users may relocate to areas with water service more suited to their needs. Recycling, as

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[20] In the electricity sector, this circularity problem is sometimes referred to as a "death spiral," meaning that rate shock leads to reduced consumption which leads to the need for another rate increase with more rate shock, and so on.

[21] David R. Dawdy, L. Douglas James, and J. Anthony Young, "Demand Oriented Measures," in Vujica Yevjevich, Luis da Cunha, and Evan Vlachos, eds., *Coping with Droughts* (Littleton, CO: Water Resources Publications, 1983).

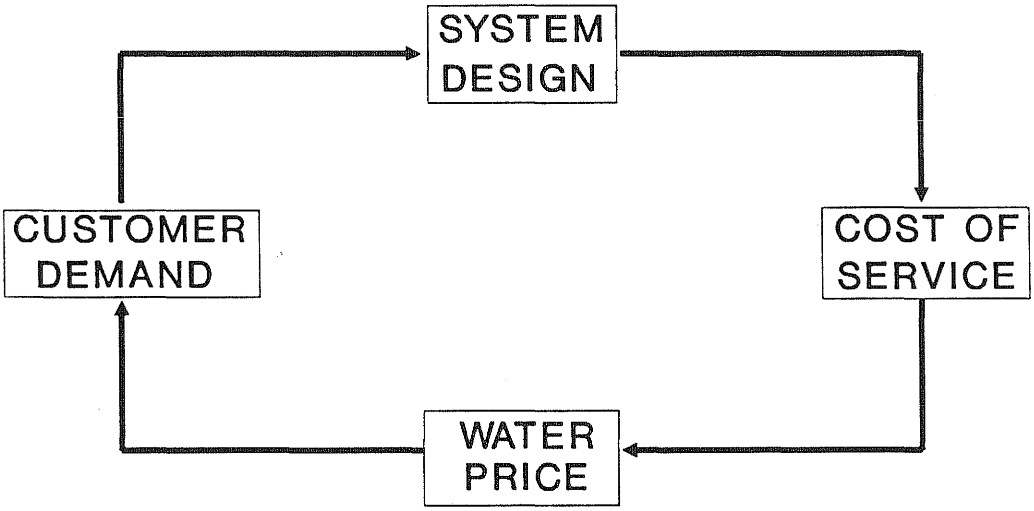

Fig. 2-1. The circularity of system design, cost of service, water price, and customer demand.

another example, substitutes "used" water for new withdrawals. In some instances, conservation in response to drought or other water shortages may have a permanent effect on water consumption habits.[22] These factors should be taken into account when estimating price elasticities of water demand.

Water Conservation

Water demand elasticities determine how much conservation occurs in response to a price change.[23] In some cases, conservation may occur naturally as prices edge upward due to increased costs and as consumers use more water-efficient appliances and change their behavior.[24] In other cases, sharp price increases may induce sudden usage reductions by moving consumers into a more price-elastic part of the demand curve. Any further price increase to remedy the revenue shortfall that results may not be appropriate since it may lead to further revenue losses.

When conservation measures or water use prohibitions are in full force absent an accompanying rate increase, utility revenues will be reduced. Some utilities may have difficulty covering their fixed costs. A rate increase, though unpopular, may mitigate this problem. According to one no-growth model, doubling the price of water results in a 32 percent reduction in demand but a 36 percent increase in revenue for the water utility.[25] Without a price increase, the revenue loss caused by the same level of conservation would be about $585,000 (32 percent). Since

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[22] Frank H. Bollman and Melinda A. Merritt, "Community Response and Change in Residential Water Use to Conservation and Rationing Measures: A Case Study--Marin Municipal Water District," in James E. Crews and James Tang, eds., *Selected Works in Water Supply, Water Conservation and Water Quality Planning* (Fort Belvoir, VA: Institute for Water Resources, U.S. Army Corps of Engineers, 1981), 393.

[23] These effects depend in part on the time lag inherent in the billing cycle. More frequent bills, received closer to the period of consumption, provide consumers with better information for changing their consumption behavior in response to the price for water service. For conservation purposes, monthly, bimonthly, or quarterly billing are preferable to semiannual or annual billing.

[24] Darryll Olsen and Alan L. Highstreet," Socioeconomic Factors Affecting Water Conservation in Southern Texas," *American Water Works Association Journal* 79 no. 3 (March 1987): 68.

[25] J. Ernest Flack, "Increasing Efficiency of Non-Agricultural Water Use," in Ernest A. Engelbert and Ann Foley Scheuring, eds., *Water Scarcity: Impacts on Western Agriculture* (Berkeley, CA: University of California Press, 1984), 147.

conservation can have an adverse effect on utility revenues, it may be necessary for a price increase when implementing a nonprice conservation strategy, such as a retrofit program, to meet the water supplier's revenue requirements. Thus a careful consideration of water price (including the billing cycle) is critical to any utility conservation effort, even if price itself is not the principal conservation tool.

Conservation through pricing can be an effective tool for managing demand when the objective is to avoid the need for additional capacity. In 1977, Dallas became one of the first major cities to adopt a pricing policy that imposed a surcharge on peak residential use. Although large peak-time users (more than 20,000 gallons in the summer) experienced a 58 percent rate increase, the overall increase in the revenue requirement was 12 percent. A preliminary assessment attributed a reduction in demand to the new pricing system, with water savings equivalent to the construction of a 50 to 75-million-gallon-a-day treatment plant.[26]

The elasticity of water demand is an important measure, but elasticity estimates do not always encompass all the variables that may affect water consumption behavior and reactions to price changes. As prices escalate, affordability becomes an issue for water service as it does for all public utility services. Price increases also bring about political reactions that may affect ratemaking and other regulatory processes. Further, these variables are dynamic rather than static. Thus estimates of elasticities and their effects cannot be made in a vacuum or without recognizing the effects of time.

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[26] I. M. Rice and L. G. Shaw, "Water Conservation--A Practical Approach," in American Water Works Association, *Water Conservation Strategies* (Denver, CO: American Water Works Association, 1980), 73.

CHAPTER 3

COST ALLOCATION FOR WATER UTILITIES

Cost allocation is an inexact but essential part of ratemaking for public utilities. Put simply, it involves the disaggregation of costs according to functions or services to which they can be attributed. Costs are allocated to the extent the analyst is able to attribute causality. The rate structure, then, is typically used to recover costs from those who cause them. Done well, rate structures mean that utilities are able to meet revenue requirements and consumers are sent appropriate pricing signals.

The application of cost-of-service criteria to water utility ratemaking is not a simple task. One significant problem with the cost approach is the subjectivity in cost measurement for specific services and user groups. The degree of subjectivity is a function of the lack of knowledge regarding the cost of specific water services, the costs of supplying specific consumer groups, and the cost of peak versus off-peak consumption. The cost-of-service principle can also generate a conflict between efficiency and simplicity. A rate structure or level based on costs of service may not be publicly acceptable and may not be easy to administer. Given the many participants (for example, city administrators, utility managers, customer groups, special users, bondholders, stockholders, and regulators) who can influence utility ratemaking, it is easy to understand why water ratemaking incorporates noncost elements. A wide variation in rates across water systems in the United States can generally be observed even within categories of the same size, ownership, and source of supply.[1]

It is readily acknowledged, then, that cost-of-service studies cannot provide definitive results since they unavoidably involve analyst judgment and other considerations. Yet there is an underlying presumption that utility rates should correspond to costs and that even rough methods for accomplishing this goal are better than methods that make no attempt to do so. This chapter describes the steps used in cost allocation, with an emphasis on the fully allocated (also referred

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[1] Patrick C. Mann, "The Water Industry: Economic and Policy Issues," in Charles F. Phillips, ed., *Regulation, Competition and Deregulation--An Economic Grab Bag* (Lexington, VA: Washington and Lee University, 1979), 105-6.

to as fully distributed or embedded) cost approach while the next considers marginal cost pricing. Chapter 5 turns to issues of rate design.

Revenue Requirements

The first step in utility ratemaking is to determine revenue requirements. An example of projected revenue requirements for a publicly owned water utility appears in table 3-1. Alternative methods exist for measuring (or forecasting) revenue requirements. In the regulation of privately owned utilities by state commissions, the utility or rate base/rate of return method prevails. An alternative approach emphasizes the utility's cash needs. The cash and utility bases for determining an identical total revenue requirement are compared in table 3-2. Although for public policy reasons there are differences between these approaches (and the utility and regulatory structures that underlie them), for ratemaking purposes the differences between the utility and cash bases should not be overstated because results may not vary significantly.

Methods

Rate Base/Rate of Return Method

The cost-of-service standard is at the heart of the rate base/rate of return method of determining revenue requirements, which specifies a return on the utility's capital investment and is depicted with the following formula:

$$RR = O\&M + D + T + r(RB)$$

where:
RR = annual revenue requirement
$O\&M$ = annual operation and maintenance expenses
D = annual depreciation expense
T = annual taxes (sales and income)
r = rate of return
RB = rate base (adjusted for accumulated depreciation).

Although it is an integral part of traditional public utility regulation and is supported by a broad base of expertise, the limitations of the rate base/rate of return method have been well documented. In sum, rate-of-return regulation may: (1) cause regulated firms to overinvest in capital, sometimes labeled "gold-plating,"

TABLE 3-1

PROJECTED REVENUE REQUIREMENTS FOR A PUBLICLY OWNED UTILITY

Expenditure Component	Expenditures Year 1	 Year 2	 Year 3
Operation-and-maintenance expense			
Source of Supply	$16,300	$17,700	$17,000
Pumping			
Power	145,500	159,900	152,700
Other	103,800	111,000	107,400
Treatment			
Chemicals	95,200	104,600	99,900
Other	67,300	71,900	69,600
Transmission and distribution			
Distribution reservoirs	13,600	14,400	14,000
Transmission mains	52,300	55,900	54,100
Distribution mains	34,000	36,400	35,200
Meters	92,500	100,700	96,600
Services	33,800	36,800	35,300
Fire hydrants	16,000	17,000	16,500
Other	58,000	62,000	60,000
Customer billing and collecting			
Meter reading	106,000	115,600	110,800
Billing and collecting	196,800	210,600	203,700
Other	11,400	12,200	11,800
Administration and general			
Fringe benefits	79,100	84,500	81,800
Other	293,400	313,800	303,600
Total O&M expense	1,415,000	1,525,000	1,470,000
Debt service requirements	462,000	458,000	460,000
Payment in lieu of taxes	175,000	175,000	175,000
Annual requirements for replacements, extensions, and improvements	189,000	201,000	195,000
Total revenue requirements	2,241,000	2,359,000	2,300,000

Source: American Water Works Association, *Water Rates* (Denver, CO: American Water Works Association, Manual M1, 1983), 6.

TABLE 3-2

COMPARISON OF UTILITY AND CASH BASES FOR EXPRESSING REVENUE REQUIREMENTS

Utility Basis	
Operation and maintenance expense	$259,000
Payment in lieu of taxes	189,000
Capital related costs:	
Depreciation	$126,000
Return	378,000
Total capital related costs	$504,000
Total revenue requirements	$952,000
Cash Basis	
Operation and maintenance expense	$259,000
Payment in lieu of taxes	189,000
Capital related costs:	
Bond debt service	214,000
Major capital improvements	150,000
Recurring improvements, replacements, and extensions	140,000
Total capital related costs	$504,000
Total revenue requirements	$952,000

Source: Robert F. Banker, "Distribution of Costs of Water Service to Customer Classes," in *AWWA Seminar on Developing Water Rates* (Denver, CO: American Water Works Association, 1973), III-17.

in order to inflate the rate base or otherwise use a suboptimal combination of inputs; (2) provide little or no incentive to minimize production costs, be technologically innovative, or respond to changes in consumer preferences; (3) encourage cost shifts (that is, cross subsidies) from unregulated to regulated parts of multifaceted firms; (4) create a real or perceived asymmetric risk to shareholders because of ex-post prudence reviews and other proceedings; and (5) be administratively costly because of extensive hearings, appeals, prudence reviews, oversight, and (in the extreme) micromanagement of the public utility.[2] High administrative or transaction costs often are cited as particularly problematic for small water utilities. Despite these issues, public utility regulation in the United States is a tradition well founded on legal and economic principles. To many, the advantages of regulation in curtailing the potential abuses of monopoly power far outweigh its limitations.

Cash-Needs Methods

Although rate base/rate of return regulation dominates, other methods for determining revenue requirements exist that emphasize the cash needs of the utility.[3] The simplest method may be the use of the utility's balance sheet, perhaps establishing a mechanism for reconciling surpluses and deficits on a year-to-year basis. Rates are used mainly to keep the utility financially viable.

The use of operating ratios has at times been suggested as an alternative method for determining revenue requirements. The operating-ratio technique (which has traditionally been used in motor carrier regulation) is a means of simplifying the regulatory process, particularly in the context of small water utilities having little or no capital investment or rate base. This approach also has appeal because of the chance that an operating margin will not be appropriately designated as a reserve to improve the utility's financial viability. Thus, the purpose of the operating ratio method is not to provide an adequate return on capital invested, but

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[2] Kenneth Rose, "Regulated Utility Pricing Incentives with Price Cap Regulation: Can It Correct Rate of Return Regulation's Limitations?," a paper presented at the Forum on Alternatives to Rate Base/Rate of Return Regulation, sponsored by the Michigan Public Service Commission in East Lansing, Michigan (May 24, 1990).

[3] American Water Works Association, *Revenue Requirements* (Denver, CO: American Water Works Association, Manual M35, 1990), 2-7.

rather to provide an adequate margin of revenues over expenses.[4] Operating ratios have been used by the commissions in North and South Carolina for small water systems.

Using operation and maintenance expenses as a substitute for the rate base, revenue requirements can be expressed by the following formula:

$$RR = O\&M + D + T + r(O\&M+D).$$

Using the operating ratio technique for rate base regulation does not eliminate the need for commission regulation. Regulators must set eligibility requirements for use of the method, determine appropriate operating ratios, and closely monitor the operating data for the utilities to which the method is applied. This method also may provide an incentive to inflate expenses, more so than rate-of-return regulation where expenses are passed through. Finally, as they mature, the investment profile of some water systems will change enough so that the operating ratio method may be an inappropriate tool for determining revenue requirements.

Still another substitute for rate of return regulation based on cash needs is the debt-service method, which shifts attention to the utility's debt. Revenue requirements are based on the sum of operating expenses and the amount necessary to service the utility's debt, both principal and interest. A variation of the debt-service approach is the "times-interest-earned ratio" (TIER), through which revenue requirements equal operating expenses plus a multiple of interest on long-term debt.[5] This method is frequently used by utilities having little equity investment, especially cooperatives and publicly owned utilities. At present, many small utilities have little debt because they have such difficulty securing it.[6] However, compliance with more stringent drinking water standards may increase the reliance on debt financing and thus stimulate interest in debt-service approaches, particularly for small systems.

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[4] Robert M. Clark, "Regulation Through Operating Revenues--An Alternative for Small Water Utilities," *NRRI Quarterly Bulletin,* 9 no. 3 (July 1988), 347.

[5] Deloitte Haskins & Sells, *Public Utilities Manual* (USA: Deloitte Haskins & Sells, 1984).

[6] An unexpected consequence of having little debt is that these small utilities sometime appear "less risky" according to certain debt-based measures of risk.

Factors Affecting Revenues

Water utility revenues--and revenue requirements--can be highly variable. Ratemaking must take this into account. A variety of factors affect revenues, including:[7]

- Number of customers served
- Customer mix
- Customer water use
- Nonrecurring sales
- Weather
- Conservation
- Use restrictions
- Rate changes
- Price elasticity

In addition to these factors, water utility revenue requirements also are affected by:[8]

- Inflation
- Interest rates
- Capital financing needs
- Tax laws and regulations
- Changes in economic conditions
- Changes in utility operations

The cost-of-service analyst must take these influences into account in estimating revenue requirements. Some factors, such as weather, can be accounted for with "normalization" techniques that use long-term historical averages to adjust for extreme cases in the short term. Others, such as conservation and price elasticity, can be analyzed using econometric methods. More difficult to account for because of problems in prediction and quantification are changes in tax laws, economic conditions, and utility operations. The choice of a test year may determine the need to make projections for these variables.

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[7] Adapted from American Water Works Association, *Revenue Requirements* (Denver, CO: American Water Works Association, Manual M35, 1990), 3.

[8] Ibid.

Test Year

Regardless of the method for determining revenue requirements, cost analysis requires the choice of a test year or test period, which is the annualized period for which costs are to be analyzed and rates established.[9] The test year may be an historical year, a future year, or a mixture of the two. The choice of an appropriate test year often is controversial because it involves a tradeoff between the certain nature of historic costs and the speculative nature of future costs. Accounting theory may be more compatible with historic data while economic theory--marginal-cost pricing in particular--is forward looking. Some state commissions may have statutory or regulatory constraints on the test year choice.

As reported in table 3-3, a majority of state regulatory commissions use an historic test year in water utility rate cases. Only a few state commissions use a future test year in water utility rate cases, while somewhat more mix historic and future data. Three states reported using an historic test year with some qualification. In Delaware, utilities may use either an historic test year or a test year with up to nine months of projected data. Illinois and Ohio indicated that an historic test year is allowed, provided the water utility is small. Illinois requires larger systems to use a future test year, while small water systems use an historic test year with an option to forecast. Ohio provides abbreviated filings for very small water systems in which they use an historic test year. All other water systems are required to develop a test year mixing historical data with projections. In a unique response, staff of the Michigan commission indicated that water utilities may choose any method to develop a test year.

Once revenue requirements are established for the test year of choice, the next step in ratemaking is to allocate the costs associated with those requirements to particular functional areas and to customer classes.

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[9] Ibid.

TABLE 3-3

TEST YEAR USED IN WATER UTILITY RATE CASES

State	Test Year Used			State	Test Year Used		
Commission	Historic	Future	Mixed	Commission	Historic	Future	Mixed
Alabama	X	-	-	New Hampshire	X	-	-
Alaska	X	-	-	New Jersey	-	-	X
Arizona	X	-	-	New Mexico	-	-	X
Arkansas	-	-	X	New York(d)	-	-	X
California	-	X	-	North Carolina	X	-	-
Colorado	X	-	-	Ohio(e)	X	-	X
Connecticut	X	-	-	Oklahoma	X	-	-
Delaware(a)	X	X	-	Oregon	-	-	X
Florida	-	-	X	Pennsylvania(f)	X	-	-
Hawaii	-	-	X	Rhode Island	X	-	-
Idaho	X	-	-	South Carolina	X	-	-
Illinois(b)	X	X	-	Tennessee	-	-	X
Indiana	X	-	-	Texas	X	-	-
Iowa	X	-	-	Utah	-	-	X
Kansas	X	-	-	Vermont	X	-	-
Kentucky	X	-	-	Virginia	X	-	-
Louisiana	X	-	-	Washington	X	-	-
Maine	X	-	-	West Virginia	-	-	X
Maryland	X	-	-	Wisconsin	-	X	-
Massachusetts	X	-	-	Wyoming	X	-	-
Michigan(c)	X	X	X	Virgin Islands	-	-	X
Mississippi	-	-	X				
Missouri	X	-	-				
Montana	X	-	-				
Nevada	X	-	-	**Number of Commissions**	32	5	14

Source: 1990 NRRI Survey on Commission Regulation of Water Systems.

(a) Utilities may use an historic test year or a test year with up to 9 months projected.
(b) Small systems use historical test year with the option of forecasting; large systems use a future test year.
(c) At the utility's option.
(d) Projections for 12 months.
(e) Abbreviated filing for very small systems with historical test year. Other systems use a mixed test year.
(f) Not beyond a 12-month forecast for mixed historical and future test years.

Key Steps in Embedded-Cost Allocation

Embedded-cost allocation depends, first, on the availability of accurate and fairly detailed cost data. This may be facilitated by a uniform system of accounts. Most state regulatory commissions rely on the systems developed by the National Association of Regulatory Utility Commissioners (NARUC) for Class A utilities (revenues exceeding $750,000), Class B utilities (revenues between $150,000 and $750,000) and Class C utilities (revenues less than $150,000). Hawaii and Montana do not use the NARUC system while California, Massachusetts, and New York have developed their own systems of accounts for water utilities.[10] The NARUC accounting system for Class A water utilities appears in appendix A of this report. In addition to accounting information, cost allocation depends on system design and load data as well as any other information required to develop cost allocators.

Assuming that the necessary data are available, the allocation of water utility costs begins with functionalization. For water service, this involves categorizing costs into areas such as source development, pumping, transmission, treatment, storage, and distribution. Since functionalization is essentially based on engineering system design, there is relatively little controversy in this step. However, alternative sources of supply (such as purchased water) and nontraditional sources of capacity (such as leak detection and repair, and conservation programs), may require special attention in the development of functional categories. A more difficult area of cost functionalization is the treatment of joint or common costs, which requires development of allocation criteria. Finally, projections of future costs can be tricky, and care must be taken to place them in the appropriate functional categories.

As mentioned earlier, the next step involves classifying the cost of utility service according to customer, capacity (demand), and commodity (operating) costs. Fire protection costs can be classified separately as well. Customer costs are those associated with metering, billing, collections, and customer service. Capacity costs are those generally associated with the physical plant required to meet peak demands for water service. Because cost allocation is sensitive to how peak

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[10] National Association of Regulatory Utility Commissioners, *NARUC Annual Report on Utility and Carrier Regulation 1988* (Washington, DC: National Association of Regulatory Utility Commissioners, 1989), 746.

demands are defined, care must be taken in their definition. Some of the available methods are:[11]

- Correlation analysis to determine those daily and seasonal periods that most appropriately reflect the margins of cost for the rating periods.
- Judgment to specify when the safe-yield of any capacity element must maintain a certain temporal reliability.
- Statistical and mathematical modeling to determine the intertemporal homogeneity of marginal costs.
- Practical considerations can be used based on rough and ready principles of calculating the probability of exceeding available system capacity, which may vary significantly for different periods.

Commodity costs vary directly with levels of production or consumption, such as those associated with treatment chemicals and energy. Fire protection costs are those associated with the flow requirements needed to fight fires. In classification, all costs must be appropriately accounted for (that is, "fully allocated") and particular attention should be paid to the effects of some costs on others.

Once total costs are functionalized and classified, the final step is to assign costs to service (or customer) classes. Although many water utilities serve only one or two service classes, the possibilities include residential, commercial, industrial, wholesale, institutional, public authorities, and fire protection. Cost assignment to customer classes, for the purpose of generating rates, usually involves assigning customer costs on the basis of service connections, assigning commodity costs on the basis of usage, and the difficult (and sometimes arbitrary) assignment of capacity costs. While some costs, such as fire protection and system development, are directly assignable to customers, most require the use of cost allocators.

A simple example of the allocation of unit costs appears in table 3-4. In this case, revenue requirements are defined for an investor-owned utility and costs are allocated between general water service and fire protection service. Fire protection costs are treated as incremental costs, and they affect virtually all of the other functional cost areas. Other approaches may be taken to allocating fire protection

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[11] Stephen L. Feldman, Robert Obeiter, Michael Abrash, and Martin Holdrich, *An Operational Approach to Estimating the Marginal Costs of Urban Water Supply with Illustrative Applications* (Unpublished report to the Wisconsin Public Service Commission, October 21, 1980), 28.

TABLE 3-4

ALLOCATION OF REVENUE REQUIREMENTS

Expense Function	Total Unit Costs (cents)	Allocation to: General Service (cents)	Fire Service (cents)
Operation and maintenance			
Source of supply	8.9	8.8	0.1
Pumping	7.7	7.6	0.1
Water treatment	3.3	3.3	0.0
Transmission and Distribution	6.7	5.0	1.7
Administration and General	13.0	11.3	1.7
Customer accounts	3.4	3.3	0.1
Taxes			
Federal	11.3	9.1	2.2
Local & state revenue	15.2	13.1	2.1
Real estate	1.1	1.0	0.1
Depreciation	4.9	4.0	0.9
Total operation and maintenance	75.5	66.5	9.0
Interest and carrying charges	10.8	8.6	2.2
Stockholder payments	11.9	9.5	2.4
Balance for capital additions	1.8	1.4	0.4
Total revenue requirement	100.0	86.0	14.0

Source: J. Richard Tompkins, "Fire Protection Charges," in *AWWA Seminar on the Ratemaking Process: Going Beyond the Cost of Service* (Denver, CO: American Water Works Association, 1986), 25.

costs.[12] One is to allocate primary costs to fire service and incremental costs to general service; another is to allocate costs on a proportional basis. However, the allocation of incremental cost to fire service may be a least-cost approach to this issue. The allocation of fire service costs to customer classes can be based on population, service connections, fire hydrants, hydrants per inch-foot, acreage, housing stock, fire-flow factors, or other criteria. For example, fire demand requirements for the different customer classes can yield fire-flow factors as depicted in table 3-5. In this case, the water system serves mainly residential and commercial customers and requires an average fire flow of about 2,400 gallons per minute (gpm). These factors can be used to allocate the cost of transmission facilities among service classes as well as among service territories, such as different municipalities served by one utility.

TABLE 3-5

COST ALLOCATION BASED ON FIRE-FLOW REQUIREMENTS

Customer Classification	Area Acres	Flow Assigned (gpm)	Fire Flow Factor
Residential	11,000	1,000	11,000
Commercial	6,300	3,000	18,900
Industrial	4,700	5,000	23,500
Total	22,000	2,400	53,400

Source: J. Richard Tompkins, "Fire Protection Charges," in *AWWA Seminar on the Ratemaking Process: Going Beyond the Cost of Service* (Denver, CO: American Water Works Association, 1986), 23.

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[12] J. Richard Tompkins, "Fire Protection Charges," in *AWWA Seminar on the Ratemaking Process: Going Beyond the Cost of Service* (Denver, CO: American Water Works Association, 1986), 19-28.

Cost allocation is a prerequisite to rate design (addressed in the next chapter). Rates generated from a cost study should be analyzed in terms of revenue implications. Rates that depart significantly from current levels or have unexpected effects on revenues should lead the analyst to verify the parameters of the cost study, including allocation criteria and methods, to check for possible errors. However, the reconciliation of costs and revenues ultimately is the responsbility of decisionmakers who may wish to take into account additional regulatory principles and public policy considerations.

Criteria

Cost allocation is made less arbitrary with the development of appropriate criteria on which cost analysts may rely. Several cost assignment criteria may be appropriate in allocating water utility costs:[13]

- Cost causation
- Traceability
- Variability
- Capacity required
- Beneficiality

The first criterion--and perhaps the most important--is cost causation. This emphasizes that costs should be assigned to the revenue generating customers or services that cause the costs to be incurred. A closely related criterion, traceability, means that costs to be assigned must be identified with a revenue generating unit, that is, a customer class. Traceability (a primary test of cost causation) implies that costs and their causes either are empirically observable or conceptually logical. Variability suggests that costs, although not necessarily traceable, can vary with the usage volume associated with the revenue generating unit. This criterion (a secondary test of cost causation) implies that certain costs exhibit a systematic relationship with specific measures of output. A fourth criterion is capacity required, which means that costs are assigned according to whether the service could have been rendered if the specific costs had not been

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[13] William Pollard, *A Peak-Responsibility Cost-of-Service Manual for Intrastate Telephone Services: A Review Draft* (Columbus, OH: The National Regulatory Research Institute, August 1986).

incurred. (This also may be a secondary criterion that can be applied in cases where both the traceability and variability criteria fail to be instructive in cost allocation.) The criterion of last resort is beneficiality, which suggests that costs are assigned to customers or services that benefit from the costs; that is, incurring the cost is necessary to providing the service. This criterion implies that without the cost being incurred, the service would be provided inefficiently. Perhaps the most prominent application of the beneficiality criterion in water supply is in the allocation of fire protection costs.

Methods

An early approach to water utility cost allocation is known as the functional-cost method.[14] It emphasizes the separation of costs into those associated with: (1) production and transmission, (2) distribution, (3) customer costs, and (4) hydrants and connections. Customer costs could be divided further into (a) meters and services and (b) customer billing and collections. The method has been criticized for its overreliance on analyst judgment and its failure to account fully for those costs driven by capacity or demand.[15] However, the functional-cost approach laid the groundwork for more sophisticated methods that are more responsive to these criticisms. Also, for the very smallest water utilities a functional-cost analysis may be better than no cost analysis at all.

Today, the cost-of service approach is usually associated with what are known as fully allocated or fully distributed methods that involve cost allocation based on variations in demand for utility services. Although there are many variations, two distinct approaches can be found to the full allocation of costs: the peak responsibility method and the noncoincidental-peak responsibility method.[16]

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[14] American Water Works Association, *Water Rates,* 21-22.

[15] Ibid.

[16] National Economic Research Associates, "An Overview of Regulated Rate-Making in the United States" (February 1977); and Robert J. Malko, Darrell Smith, and Robert G. Uhler, "Topic Paper No. 2: Costing for Rate-Making" (August 1981), in *Electric Utility Rate Design Study Report to the National Association of Regulatory Utility Commissioners* (Palo Alto, CA: Electric Utility Rate Design Study Group).

The peak responsibility method is also known as the coincident peak or Wright method. It considers both the magnitude of peak demand and its timing but does not incorporate average demand or volume of usage in the allocation of capacity costs. The allocation basis is the user class contribution to system peak demand. Its conceptual base is that those users who cause peak demand should pay for the capacity required to supply it. Off-peak users are presumed not to affect capacity requirements and capacity costs.

Several criticisms have been leveled at the peak responsibility method. Primarily, it assigns no capacity costs to off-peak users thus producing the criticism that such users should not be relieved entirely of the capacity cost burden. For example, off-peak usage contributes to the incremental capacity required to permit the scheduling of routine system maintenance. Another criticism is that the assignment of all capacity costs to peak services creates the potential for unstable (shifting) peaks. A criticism, however, that has less merit is that users with 100 percent load factors do not contribute to system peak demand and therefore should be assigned no capacity costs. This argument ignores the concept that all users at system peak demand are coresponsible for the peak demand; that is, if the 100 percent load-factor-user shifts consumption from peak to off-peak, less system capacity is required.

The noncoincidental peak method is also known as the class maximum demand or Hopkinson method. In the American Water Works Association's rates manual, the commodity-demand method is an example of this approach.[17] It distinguishes between customer costs, commodity costs, and demand (capacity) costs. An example of this method appears in appendix B.

Noncoincidental methods such as this consider the magnitude of peak demand but do not incorporate either the timing of peak demand or usage (average demand) in the allocation of capacity costs. The allocation basis is the customer class contribution to the sum of the maximum demands for all user classes. By ignoring direct responsibility for system peaks, the method allocates some capacity costs to all user classes. Criticisms of the method include an insufficient adherence to the cost causation standard and inadequate recognition of the benefits of off-peak demand.

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[17] American Water Works Association, *Water Rates* (Denver, Colorado: American Water Works Association, 1983).

Many fully allocated or fully distributed cost methods have capacity cost allocations based on both demand and consumption. Most of these methods are variations of the average-and-excess demand method, also described by the American Water Works Association as the base-extra capacity method.[18] An example appears in appendix C.

The base-extra capacity method, or Greene method, distinguishes between customer costs, base capacity costs, and extra capacity costs, meaning capacity needed to meet hourly, daily, or other peak demands. Thus it considers both peak demand and average demand but does not directly incorporate the timing of demand in the allocation of capacity costs. The approach involves an initial estimation of capacity costs assuming all users are operating at a 100 percent load factor. These estimated base capacity costs are allocated to user classes on the basis of usage. The extra or excess capacity costs then are allocated on the basis of the excess of maximum demand over average demand for each user class. The noncoincident-peak responsibility method is generally used in calculating the class maximum demand. Examples of the determination of allocation bases for facilities designed for maximum-day use and maximum-hour use are depicted in table 3-6.

TABLE 3-6

EXAMPLE OF DETERMINATION OF ALLOCATORS USING BASE-EXTRA CAPACITY METHOD

						Allocation Percentages		
							Extra Capacity	
Type of Use		Quantities		Ratio		Base	Maximum Day	Maximum Hour
Average Day Use	=	10 mgd	=	1.0	=	66.7	-	-
Maximum Day Use		15 mgd		1.5		-	33.3	-
Average Day Use	=	10 mgd	=	1.0	=	40.0	-	-
Maximum Hour Use		25 mgd		2.5		-	-	60.0

Source: Joseph M. Spaulding, "Revenue Requirements and Allocation to Functional Cost Components," in *AWWA Seminar on Developing Water Rates* (Denver, CO: American Water Works Association, 1973), II-19.

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[18] Ibid.

The base-extra capacity method makes little distinction between peak and off-peak demand thus violating the cost causation standard. However, it does have validity in apportioning some capacity costs on the basis of usage; that is, higher load-factor customers have higher probabilities of system peak contribution than lower load-factor customers. In brief, base-extra capacity implicitly employs class load factors as a measure of peak responsibility; thus, certain benefits flow to low load-factor classes. The average-and-excess demand method implies that peak demand is only responsible for the incremental costs incurred because of increased demand levels. That is, peak demand is not responsible for all system capacity costs.

In general, fully allocated cost methods suffer from certain deficiencies. All methods other than the peak responsibility method permit user classes to shift usage from off-peak to peak (thus increasing capacity costs) without increasing their class cost allocation. This occurs particularly when class peak demand at system peak is less than class average demand. The application of the various noncoincident peak responsibility methods can result in the inefficient utilization of existing capacity and increased system capacity requirements. There is also a tendency to channel difficult to allocate costs (for example, administrative costs) into the customer category. In these somewhat arbitrary cost assignments, value of service criteria may prevail.

Commission Staff Perspectives on Cost Analysis

As reported in table 3-7, twenty-four of the state commissions require some form of cost analysis in conjunction with water rate proceedings. Eighteen commissions require cost analysis of all water utilities in all rate cases. The New Jersey Commission requires the completion of a cost analysis on a case-by-case basis, while in six states the requirement depends on company size defined either by annual revenues or number of customers. For example, the commissions in Montana and Pennsylvania reported that cost analysis requirements applied only to companies having annual revenues exceeding $50,000 and $700,000, respectively. The other states with size stipulations reported only that larger companies were subject to cost analysis requirements.

TABLE 3-7

WATER UTILITY COST ANALYSIS

State Commission	Are cost studies required?	Who performs the cost analysis?	Characterization of cost analysis used by regulated water systems (a)						
			FC	CD	BX	FA	MI	O	U
Alabama	no	staff	-	-	-	-	-	(b)	-
Alaska	yes	utility	-	-	-	X	-	-	-
Arizona	no	staff	-	-	X	-	-	-	-
Arkansas	yes	both	-	X	-	X	-	-	-
California	yes	both	-	-	-	-	-	(c)	-
Colorado	no	n/a	-	-	-	X	-	-	-
Connecticut	yes	utility	-	X	X	X	-	-	-
Delaware	yes	both	-	-	-	X	-	-	-
Florida	no	staff	-	-	-	-	-	(d)	-
Hawaii	no	n/a	-	-	-	-	-	(e)	-
Idaho	no	n/a	-	-	-	X	-	-	-
Illinois	no	both	-	-	(f)	-	-	-	-
Indiana	no	both	X	X	X	X	X	-	-
Iowa	no	n/a	-	-	-	X	-	-	-
Kansas	yes	utility(g)	-	-	-	X	-	-	-
Kentucky	yes(h)	utility	X	-	-	X	X	-	-
Louisiana	no	n/a	-	-	-	X	-	-	-
Maine	no	utility	-	-	-	-	-	(i)	-
Maryland	no	n/a	-	-	-	-	-	(j)	-
Massachusetts	no	utility	-	-	-	X	X	-	-
Michigan	yes	utility	-	-	-	-	-	(k)	-
Mississippi	yes	staff	X	-	-	-	-	-	-
Missouri	yes	both	X	X	X	X	-	-	-
Montana	yes(l)	utility	-	-	-	X	-	-	-
Nevada	yes(h)	both	X	X	X	X	X	-	-
New Hampshire	no	utility	-	-	X	-	-	-	-
New Jersey	yes(m)	utility	-	X	X	-	X	-	-
New Mexico	yes	both	-	-	-	X	X	-	-
New York	yes	both	-	-	-	X	-	-	-
North Carolina	no	staff	-	-	-	-	-	(n)	-
Ohio	yes(o)	both	-	-	X	-	-	-	-
Oklahoma	no	n/a	-	-	-	X	-	-	-
Oregon	yes	staff	-	X	-	X	-	-	-
Pennsylvania	yes(p)	utility	-	-	X	-	-	-	-
Rhode Island	yes	utility	-	-	-	X	X	-	-

TABLE 3-7 (continued)

State Commission	Are cost studies required?	Who performs the cost analysis?	Characterization of cost analysis used by regulated water systems(a)						
			FC	CD	BX	FA	MI	O	U
South Carolina	no	n/a	-	-	-	-	-	-	X
Tennessee	no	n/a	-	-	-	-	-	-	X
Texas	yes(q)	utility	-	(r)	X	-	-	-	-
Utah	no	n/a	-	-	-	-	-	(b)	-
Vermont	yes	both	-	-	-	X	-	-	-
Virginia	no	n/a	-	-	-	-	-	-	X
Washington	no	utility	-	-	-	X	-	-	-
West Virginia	yes	both	X	X	-	-	-	-	-
Wisconsin	yes	both	-	-	X	-	-	-	-
Wyoming	yes	both	-	-	-	X	-	-	-
Virgin Islands	yes	staff	-	-	-	-	-	-	X
Times mentioned			6	9	12	23	7	9	4

Source: 1990 NRRI Survey on Commission Regulation of Water Systems.

(a) FC = Functional-cost
CD = Commodity demand
BX = Base-extra capacity
ED = Embedded direct
FA = Fully allocated/distributed/embedded
MI = Marginal/incremental
O = Other (as noted)
U = Unknown
(b) Accrual basis.
(c) Fixed cost and commodity cost.
(d) Fixed cost and variable cost.
(e) Original cost.
(f) On an embedded basis.
(g) Commission staff may assist smaller systems.
(h) Requirement for large systems only.
(i) Wisconsin method.
(j) Original cost or fair value.
(k) Actual book cost (accrual method).
(l) Requirement for systems with revenues in excess of $50,000 annually.
(m) On a case-by-case basis.
(n) Rate base method; operating ratios or cost plus.
(o) Requirement for large systems (in excess of 15,000 customers) and medium sized systems (5,000 to 15,000 customers).
(p) Requirement for systems having revenues in excess of $700,000 annually.
(q) Depending on size of system.
(r) Commodity-demand (fixed costs and variable costs).

The survey revealed that cost analysis is performed in its entirety by commission staff in seven jurisdictions and by the utility in fourteen jurisdictions. In the remaining commissions, the responsibility for performing a cost analysis is split between the utility and the commission staff. The Kansas Corporation Commission reported that although water utilities are required to perform cost analyses, the commission staff may assist smaller water utilities in completing cost studies. Interestingly, not all the commissions mandating cost studies shift the entire burden of performing such analysis onto the water utility. In twelve jurisdictions, the commission and the utility share the responsibility. In three of the states that mandate cost analysis, the commission staff performs the cost study. Altogether, commission staffs are involved in developing cost studies in their entirety or on a shared basis in twenty-one of the jurisdictions surveyed.

Regarding methods of cost analysis, also reported in table 3-7, the survey revealed that a variety of approaches are used by regulated water systems for purposes of cost analysis. Many state commission staff members characterize water utility cost studies as fully allocated costing (including fully distributed and embedded cost analysis). Several jurisdictions indicated that regulated water utilities use two or more methods of cost analysis. Indiana, Missouri, and Nevada are noteworthy for the variety of cost studies that come before them.

Results of the survey indicate a rather widespread use of the ratemaking manuals produced by the American Water Works Association, as reported in table 3-8. Over half of the jurisdictions surveyed reported the use of American Water Works manuals; seven jurisdictions indicated they used the manuals primarily as a general reference tool. Additional comments provided on the survey indicated that most found the manuals to be highly useful. However, it was noted that further attention could be paid to specific types of costs and charges, with more detail provided on the different steps in cost analysis. Another comment was that many small water system managers lack the expertise or resources to use the manuals effectively.

Finally, reported in table 3-9, the survey responses expose a variety of concerns about specific cost allocation issues affecting water provision. Commission staff in the jurisdictions under survey detailed twenty-one separate costing issues affecting water utilities. It appears that in terms of costs and their effects on water utilities, commission staff overwhelmingly are concerned with the impact of

TABLE 3-8

USE OF AMERICAN WATER WORKS ASSOCIATION RATEMAKING MANUALS

State Commission	Used by Commission	Used by Utilities	State Commission	Used by Commission	Used by Utilities
Alabama	yes	nk	New Hampshire	yes	yes
Alaska	yes*	nk	New Jersey	yes	nk
Arizona	yes	nk	New Mexico	yes	nk
Arkansas	no	nk	New York	yes	nk
California	yes*	nk	North Carolina	no	nk
Colorado	no	nk	Ohio	yes	yes
Connecticut	yes	yes	Oklahoma	yes*	yes(a)
Delaware	yes	yes(a)	Oregon	yes	yes
Florida	yes*	nk	Pennsylvania	yes	yes
Hawaii	no	nk	Rhode Island	yes	nk
Idaho	no	nk	South Carolina	no	nk
Illinois	yes	nk	Tennessee	no	nk
Indiana	yes	yes	Texas	yes*	nk
Iowa	no	yes	Utah	yes*	no
Kansas	nk	nk	Vermont	no	nk
Kentucky	yes	nk	Virginia	no	nk
Louisiana	no	nk	Washington	yes	nk
Maine	yes	nk	West Virginia	yes	yes
Maryland	no	nk	Wisconsin	yes	nk
Massachusetts	no	yes(b)	Wyoming	no	nk
Michigan	no	nk	Virgin Islands	no	nk
Mississippi	no	nk			
Missouri	yes	nk	**Number of commissions responding yes**	**28**	**12**
Montana	yes	yes			
Nevada	yes*	nk			

Source: 1990 NRRI Survey on Commission Regulation of Water Systems.

* Primarily as a general reference.

nk = not known.
(a) = some systems.
(b) = large systems.

TABLE 3-9

MOST IMPORTANT COST ALLOCATION ISSUES AFFECTING WATER UTILITIES ACCORDING TO STATE COMMISSION STAFF MEMBERS

Issue	Number of Times Mentioned
SDWA compliance/water quality improvements	24
System upgrade/infrastructure improvements	8
Financial viability of small systems	5
Capital costs/debt	4
Supply/water source costs	4
Conservation related steps	4
Labor costs/professional services/salaries	4
Payment and allocation of fire protection costs	3
Resale rates/price discrimination	2
Taxes/federal taxes on contributed plant	2
Appropriate rates of return for subsidiaries	1
Marginal versus embedded cost analysis for new supplies	1
Importance of rate design in cost recovery	1
Obtaining load data	1
Administrative costs	1
Pumping costs (energy)	1
Chemical costs	1
Maintenance costs	1
Metering costs	1
Insurance and liability	1
Water rights	1

Source: 1990 NRRI Survey on Commission Regulation of Water Systems.

safe drinking water requirements on the cost of water provision. The next most frequently mentioned issue of concern related to the cost of system upgrade or infrastructure improvements. Costing issues relating to financial viability of small systems, capital costs and debt, water supplies, conservation, and professional and labor related costs each were mentioned by roughly 10 percent of the responding jurisdictions. Furthermore, a host of costing issues ranging from pumping and chemical costs to rate design and load data concerns were mentioned. The results clearly indicate that a wide range of cost allocation issues affecting water utilities are making their way onto commission agendas.

Conclusion

Costing analysis is not an exact science. Traditional or conventional cost allocation has the potential for arbitrary cost assignments with no definitive scientific, economic, or accounting basis. Much depends on the analyst devising the cost-of-service analysis. Thus, the cost results are, at best, only estimates of actual costs of service. In brief, all cost studies involve judgments and should be viewed as starting points rather than presumptive determinants of rate design. In sum, there is no single "correct" costing method, particularly for the allocation of system capacity cost. In this context, a range of cost studies is desirable (including marginal and incremental cost analyses), since substantially divergent results can be achieved depending on the judgments involved. A range of studies is highly desirable for planning purposes as well.

CHAPTER 4

MARGINAL-COST PRICING APPLIED TO WATER UTILITIES[1]

Central to the issues of cost allocation and rate design is contemporary economic theory, which is used by decisionmakers to understand certain consequences of policy choices. Among other things, theories raise expectations that certain decisions will have certain outcomes. This chapter reviews marginal-cost pricing theory as applied to the case of water supply utilities. Attention is paid to the theoretical and applied aspects of the theory as well as to specific formulations for its use. Also included is a presentation of a method for calculating simple incremental costs based on a least-cost planning perspective and a comparison of the fully allocated and marginal cost approaches.

Marginal Cost in Theory and Practice

Economic theory argues for pricing resources at marginal costs to ensure their efficient allocation, thus maximizing consumer welfare. Marginal cost is among the prevailing standards by which achievement of the competitive ideal is measured, not just by economists but by regulators and judges as well. Prices that accurately reflect marginal or incremental costs send a signal to consumers about consumption, which in turn sends a signal to producers about production.

Marginal cost is defined in economic theory as the derivation of the total cost function with respect to output. Unfortunately, this definition obscures both the conceptual and pragmatic problems that can be experienced in estimating the marginal cost of water service.

Put more simply, marginal cost is the additional cost of producing or selling a single incremental unit.[2] The marginal cost of water service is the cost incurred in providing more water service. In practical terms, the two essential components

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[1] This chapter is based in part on Patrick C. Mann, *Water Service: Regulation and Rate Reform* (Columbus, OH: The National Regulatory Research Institute, 1981).

[2] See Patrick C. Mann and Donald L. Schlenger, "Marginal Cost and Seasonal Pricing of Water Service," *American Water Works Association Journal* 74 no. 1 (January 1982): 6.

of marginal cost are, first, the change in operating costs caused by changing the utilization rate for existing capacity and, second, the cost of expanding capacity, including the operating costs associated with the increased capacity. If the water utility is operating below capacity, marginal cost involves the incremental operating cost of producing more product units within the existing system capacity. In contrast, if a capacity increment is required, marginal cost involves the new capacity costs as well as the operating cost associated with the capacity increment. Calculating marginal costs involves projecting capacity and operating costs for a specified time span given a particular demand forecast. Such projections must take into account certain characteristics of water utilities themselves as well as potential influences on demand, including price.

The welfare principles that underlie marginal-cost pricing theory, as well as the allocative implications of the marginal-cost pricing rule, were set forth by Ruggles.[3] Works by Vickrey and Wiseman are excellent sources for some of the key theoretical objections to marginal-cost pricing.[4] These objections include the theory's limited value in selecting among alternative investments, the distortion effects on income distribution, and the value judgments implicit in applying marginal-cost pricing. Works by Steiner and Hirshleifer provide the early theoretical discussion of peak-load pricing, that is, its marginal-cost aspects and the pricing efficiency implications posed by variations in demand over time.[5]

The arguments for marginal-cost pricing involve economic efficiency and correct price signals. Prices for water service that equal marginal cost generate an efficient allocation of resources. The logic is that consumers are being induced to use water efficiently since the value they place on additional units of water is equal to the value they place on additional units of alternative or sacrificed goods. If water rates are unequal to marginal cost, consumers are receiving incorrect

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[3] Nancy Ruggles, "The Welfare Basis of the Marginal Cost Pricing Principle," and "Recent Developments in the Theory of Marginal Cost Pricing," *Review of Economic Studies* 17(1949-1950): 29 and 107, respectively.

[4] William Vickrey, "Some Objections to Marginal Cost Pricing," *Journal of Political Economy* 56 (June 1948): 218-238; and J. Wiseman, "The Theory of Public Utility Price," *Oxford Economic Papers* 18 (February 1957): 56-74.

[5] Peter O. Steiner, "Peak Loads and Efficient Pricing," *Quarterly Journal of Economics* 71 (November 1957): 585-610; and Jack Hirshleifer, "Peak Loads and Efficient Pricing: Comment," *Quarterly Journal of Economics* 72 (August 1958): 451-62.

signals regarding the resources used in water production; therefore, they will tend to consume either too little or too much water. Conservation is incorporated into the economic efficiency concept but economists generally do not view decreasing consumption in itself as a meaningful goal. That is, conservation is not decreasing usage per se, but instead involves the operation cost and capacity savings from efficient (marginal-cost) pricing.

Water rates based on marginal cost provide the foundation both for attaining an efficient utilization of water system capacity and attaining efficiency in capacity investment. Marginal-cost prices send signals to consumers about the resource cost consequences of their consumption decisions and, conversely, reflect the cost savings if consumers forego the consumption of additional units of water service. The ultimate purpose of marginal-cost pricing is to provide correct price signals for consumption decisions. Thus, when consumers affect water system costs by altering their consumption patterns, their bills change accordingly. In brief, marginal-cost prices reflect the immediate and near-term future cost consequences of usage decisions rather than the historical cost consequences of consumption decisions. Since pricing affects future usage decisions, not past usage decisions, future costs are those relevant for pricing.

In simple terms, economic efficiency is a standard which signals that no further reallocation of resources (either to or from the provision of water service) would enhance consumer satisfaction. The price equal to marginal-cost equation is the best available measure of attaining this standard. For example, price is the best proxy for the value placed on additional units of water service; marginal cost is the best proxy for the value placed on additional units of alternative goods. By water prices reflecting the immediate and near-term future costs of resources used or saved in water consumption, the marginal-cost approach implies a concept of equity in which consumers pay for these costs. In contrast, water prices based on average historical costs create the illusion that resources that can be used or saved at present or in the near-term future cost as much or as little as in the past. The approach implies a concept of equity in which consumers pay for the past costs of consumption decisions.

There are numerous ways of conceptualizing marginal costs: avoidable costs, product-specific costs, single and multiproduct costs, total service incremental costs, and average incremental costs are among the choices.[6] Incremental cost is a concept similar to marginal cost. While theoretical marginal cost refers to one-unit changes in output (such as a gallon of water), incremental cost can refer to larger changes in output (such as a million gallons of water), but also can refer to nonoutput changes (such as a change in water quality or system reliability). In addition, incremental costs can reflect changes in total cost over time. Economic purists prefer to use one gallon rather than a million gallons because it is truer to the theoretical idea of change at the margin. The incrementalist perspective is less rigorous but more practical. Nonetheless, for most purposes the concepts of marginal and incremental cost are virtually interchangeable.

There are also alternative ways of estimating marginal costs.[7] The three basic approaches are engineering process models, econometric models, and optimization or simulation models. Engineering process models emphasize engineering estimates about the cost of alternative supply options. Econometric models use statistical techniques to estimate costs on the basis of the behavior of key cost-causing variables. Such models are frequently used in predicting demand as well. Optimization models combine engineering and economic constraints to achieve an equilibrium, as depicted in figure 4-1. Some alternative ways of measuring marginal costs in water supply are summarized in table 4-1.

Not everyone subscribes to the economist's social welfare paradigm, with its accompanying faith in the competitive ideal. Nor does everyone agree on its application to cost allocation and rate design decisionmaking or the appropriate method for doing so. Yet even if one does not see marginal-cost pricing as a means to economic efficiency, it still can be counted among the most important tools for cost allocation, rate design, and planning. At the very least, an understanding of marginal costs is helpful in evaluating other prospective analytical methods. What other goals the method achieves depends on one's perspective and policy goals.

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[6] For an overview, see William Pollard, "Economic Theory Relevant to Marginal and Incremental Cost Estimation," a paper presented at The National Regulatory Research Institute's Telephone Cost-of-Service Symposium in Columbus, Ohio (August 12-17, 1990).

[7] Ibid.

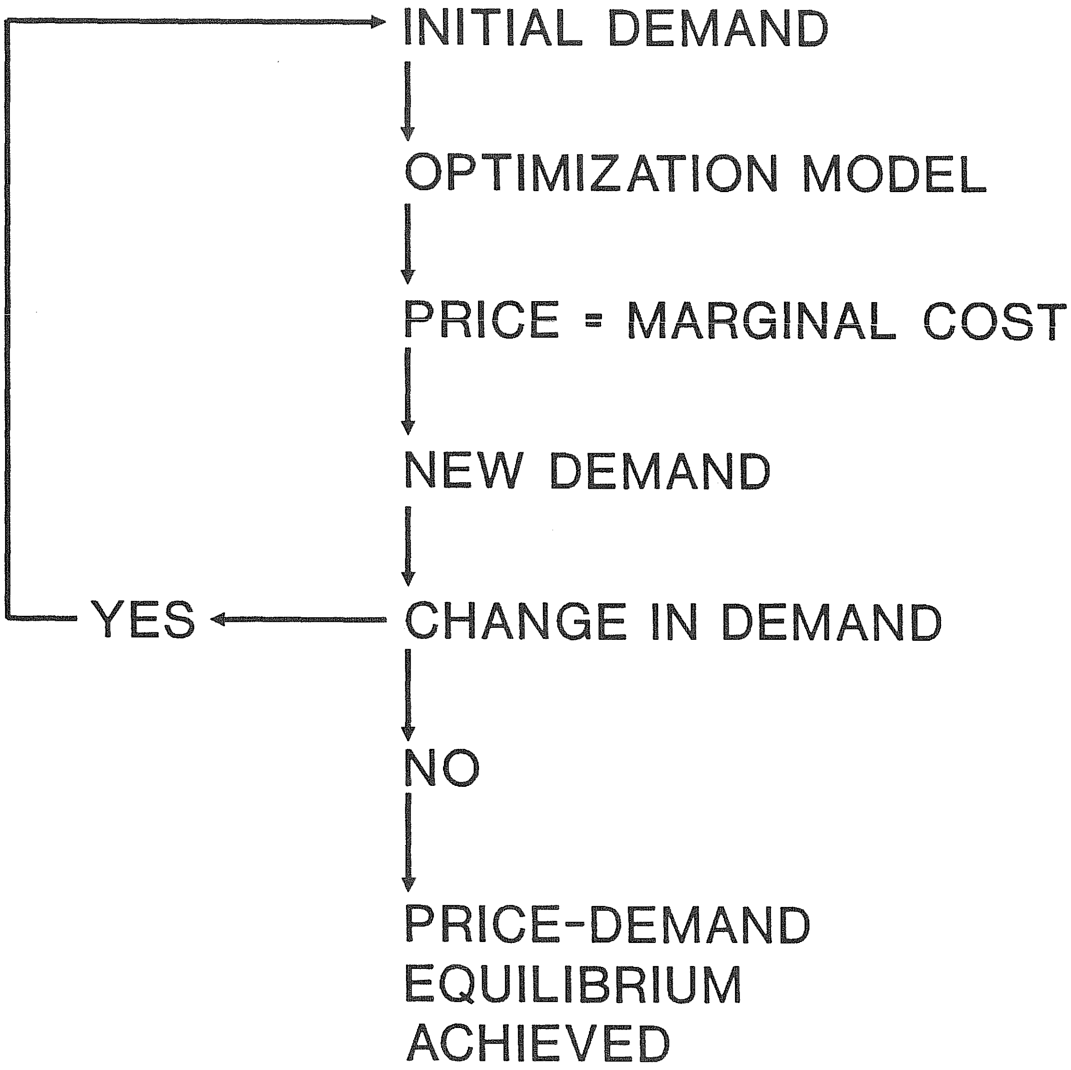

Fig. 4-1. Price-demand equilibrium analysis.

TABLE 4-1

SOME ALTERNATIVE METHODS FOR CALCULATING MARGINAL COSTS

Short-run Costs

- Estimate the average of past observed operating costs for each of the rating (such as, peak and off-peak) periods. These costs are then averaged for each rating period.
- Take some average of hourly operating costs for a given rating period from an economy dispatch model--that is, optimizing the dispatch of pumping stations and water tower discharge.
- Examine short-run operating costs and certain fixed costs with respect to meeting load requirements for any given hour.
- Determine the change on the long-run total cost function with varying load conditions. The change in costs can be calculated using the cost difference from one optimal system design to another as a result of a new load duration curve.
- Derive a set of hourly operating costs from an economy dispatch model. Rating periods can be chosen on the basis of the cost data.
- Derive the operating cost of the peaking plant or a hypothetical plant, simulated with a change in load conditions.
- Derive the operating costs of a rating period subject to a safe yield or reliability constraint.

Source-related Capacity Costs

- Derive the difference between hypothetical expansion plans that are totally peak related and calculate the cost in present value terms. (Some system expansions, such as reservoirs or wells, may be used for peak capacity only).
- Derive the annual incremental cost of any added capacity cost as a result of an expected increase or change in load, allocating these costs to the rating periods on the basis of the ratio of loads between periods.
- Determine the incremental capital costs of all new units and allocate them to the appropriate rating period.
- Calculate the annual capacity cost of any increment of capacity for peak usage and adjust that cost for safe yield or other relevant criteria. These costs can be allocated to rating periods on the basis of comparing the safe yields for different rating periods.

TABLE 4-1 (continued)

Transmission and Distribution Costs

- Treat incremental transmission investment which is related to the incremental peak load growth as a residual to ensure the equality of a revenue requirement to projected revenue collections.
- Use either linear regression or simple division so that additions in transmission and distribution are related to some measure of peak load growth.
- Use regression analysis to relate the levelized transmission and distribution sales and other costs to either off-peak, peak, administrative short-run, or variable costs.
- Use changes in transmission investment cost related to changes in peak demand.
- Relate transmission costs to a price leveled series of cost to peak demand. Distribution costs can be based on a minimum distribution system.
- Use transmission-line losses. Distribution line losses plus average of the incremental connecting charges for new customers can be calculated.
- Use embedded average cost for distribution if it is too difficult to calculate marginal distribution cost.

Source: Adapted from Stephen L. Feldman, Robert Obeiter, Michael Abrash, and Martin Holdrich, *An Operational Approach to Estimating the Marginal Costs of Urban Water Supply With Illustrative Applications* (Unpublished report to the Wisconsin Public Service Commission, October 21, 1980), 24-28.

Estimating the Marginal Cost of Water

Marginal-cost estimation in water service involves forecasting future cost and output streams. These projections require information on several variables, including technology, input price behavior, and price elasticity of water demand. In addition, a planning horizon must be specified as well as appropriate capital recovery and annuitization rates. Marginal-cost estimation is forward looking; that is, marginal operating cost, marginal capacity cost, marginal purchased water cost, and marginal customer cost involve engineering forecasts of costs incurred or avoided if usage, capacity, or the number of customers change. Finally, the marginal cost of water service varies both with time (for example, peak demand as compared with off-peak demand) and with space (for example, locational variations within the utility service area).

Naturally, the biggest difficulty in applying marginal-cost pricing is estimating marginal costs, which depends on assumptions about where the next increment of supply will come from and, of course, its cost. Several different supply options providing different increments of capacity may be available. A new well, for example, adds a much smaller increment of capacity than a new reservoir and probably at a substantially lower overall cost. However, the per-unit incremental cost of the reservoir may be lower than that of the well because of the reservoir's larger capacity. Choosing between the two supply options depends on the forecast of water demand along with hydrological and water quality considerations.

Marginal-cost theory is typically operationalized through the development of time-differentiated rates, an example of which appears in table 4-2. Although time-differentiated pricing logically flows from marginal-cost pricing, seasonal rates can be based on average or embedded cost as well as on marginal cost. In water service, the emphasis on seasonal rather than time-of-day pricing is essentially a function of water system design.[8] Distribution systems are generally designed to meet the maximum instantaneous flows anticipated from fire protection. The hourly peak demands of consumers are therefore not essential in the design of the distribution system. Thus, for most water systems there is minimal variation in

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[8] Steve H. Hanke, "A Method for Integrating Engineering and Economic Planning," *American Water Works Association Journal* 71 (September 1978): 487-91.

TABLE 4-2

EXAMPLE OF MARGINAL-COST FUNCTIONALIZATION FOR DEVELOPMENT OF SEASONAL RATES

Marginal annual cost of capacity ($/mgd/year)	
Source	19,361
Treatment	0
Transmission	27,669
Distribution	12,912
Short-run costs ($/1,000 gallons)	
Electricity	0.111
Chemicals	0.010
Maintenance	0.373
Definition of peak periods	
Number of days in peak season	153
Number of peak hours per day	10
Number of peak days per week	7
Number of peak hours in peak season	1,530
Marginal cost of water ($/1,000 gallons)	
Off-peak season, all hours	
Short-run costs	0.494
Source	0.053
Total	0.558
Peak season, off-peak hours	
Short-run costs	0.494
Source	0.053
Treatment	0.000
Transmission	0.181
Total	0.743
Peak season, peak hours	
Short-run costs	0.494
Source	0.053
Treatment	0.000
Transmission	0.181
Distribution	0.203
Total	0.949
Seasonal rates ($/1,000 gallons)	
Off-peak season	0.558
Peak season	0.829

Source: Stephen L. Feldman, Robert Obeiter, Michael Abrash, and Martin Holdrich, *An Operational Approach to Estimating the Marginal Costs of Urban Water Supply With Illustrative Applications* (Unpublished report to the Wisconsin Public Service Commission, October 21, 1980), 68. Adjusted marginal prices also are reported.

incremental cost associated with daily demand cycles. Similar to the distribution system, storage capacity is determined more by fire protection considerations than by anticipated peak hour demands. Elevated storage can also partially accommodate the daily use cycle (peak and off-peak hours) as well as peak demand for transmission capacity. In contrast, major supply sources and major transmission, pumping, and treatment facilities are generally designed to meet seasonal variations in demand. For many water systems, the capacity costs of these facilities primarily reflect summer peak demands. Thus, for most water systems there is substantial variation in the incremental cost associated with their seasonal demand cycles. Regarding time-differentiated pricing in water service, the emphasis thus should be on long-term (maximum day) demand rather than on short-term (maximum hour) demand. Chapter 5 contains a more detailed discussion of seasonal rates.

Application Issues

Several obstacles can impede the effective application of marginal-cost pricing to water service. For example, Harbeson questioned whether economists actually comprehend the magnitude of divergence between estimated and theoretical marginal cost.[9] Similarly, Turvey asserted that the textbook concept of marginal cost was too simplistic to be useful.[10]

The application of marginal-cost theory in the water sector involves many tradeoffs among competing concerns.[11] The manner in which this complex set of constraints is handled in any particular circumstance depends on how marginal cost is perceived. The conclusions that may be reached will differ to the extent that different conceptions of marginal cost exist. The application of marginal-cost pricing theory to water utilities raises four general issues: (1) allocative efficiency, (2) cost and rate stability, (3) financial viability, and (4) administrative feasibility. As seen in table 4-3, each of the general application issues is associated with some specific application issues.

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[9] Robert Harbeson, "A Critique of Marginal Cost Pricing," *Land Economics* 31 (February 1955): 54-74.

[10] Ralph Turvey, "Marginal Cost," *Economic Journal* 78 (June 1969): 282-94.

[11] Steve H. Hanke and Robert K. Davis, "Potential for Marginal Cost Pricing in Water Resource Management," *Water Resources Research* 9 (August 1973): 808-25.

TABLE 4-3

GENERAL AND SPECIFIC APPLICATION ISSUES ASSOCIATED WITH MARGINAL-COST PRICING

General Issues	Specific Issues
Allocative Efficiency	Income distribution effects Barriers to economic efficiency Ineffectiveness Competing policy goals
Cost and Rate Stability	Needle peaking and shifting peaks Distribution and customer costs Fire protection costs Purchased water costs
Financial Viability	Excess revenues Inadequate revenues Bypass Arbitrary remedies
Administrative Feasibility	Data requirements Predictive accuracy Time lags Public opposition

Source: Authors' construct.

Allocative Efficiency

Externalities pose a limitation to marginal-cost pricing theory in terms of economic efficiency. The observed willingness of consumers to pay incremental costs should not be the sole criterion for supplying them with water service. Externalities are associated with water service. For example, an external benefit that may result from the consumption of potable water is that the health of the consumer may improve with use of improved supplies; as a result, the consumer may not infect another consumer whose future health also will be enhanced. However, since the first consumer does not take the health of the second into consideration in decisions to consume water, willingness to pay incremental costs tends to understate the benefits to the community. In addition, consumers may not sufficiently understand the linkage between water quality and public health. Another example is the provision of water service for fire protection which, when afforded to one resident, also benefits neighbors by stopping the spread of fires and holding down fire insurance rates. Consumers may not understand implicitly the linkage between water service reliability and fire protection.

With respect to output, costs tend to be marginal only intermittently, depending on system utilization. If water system capacity is less than fully utilized, the only costs immediately attributable to additional water usage are certain operating costs (including the cost of purchased water). These costs are referred to as short-run marginal cost (SRMC). Long-run marginal cost (LRMC), in contrast, refers to the sum of SRMC and marginal capacity cost (MCC)--the cost of extending capacity to accommodate additional usage. The two definitions of marginal cost--one applicable in the short run and the other in the long run--must be reconciled since a pricing policy which is associated with the efficient use of existing capacity can result in nonoptimal investment decisions, and vice versa.

Strictly interpreted, the marginal-cost approach requires that price equal SRMC when capacity is not fully utilized, but, as full capacity utilization is attained, price should be increased to ration existing capacity. Once a capacity increment is completed, price should fall again to SRMC, for then the only real incremental costs are operating costs. In brief, prices theoretically should be increased with increasing demand in the period before a capacity increment is necessary; then when the capacity increment becomes available (and excess capacity exists), prices should be decreased, as illustrated in figure 4-2.[12] Water price, therefore, has the twin objectives of (a) attaining an efficient allocation of resources when the system is operating at less than full capacity, and (b) providing signals for when to invest in additional capacity.[13]

Some analysts have addressed the "second best" problem; that is, the issue of marginal-cost pricing not necessarily being optimal for the water sector given significant divergences from optimal pricing and optimal resource allocation in other sectors of the economy.[14] Marginal-cost pricing in one sector may still produce allocative inefficiency if the remaining sectors (through monopoly, taxation, and so on) have prices unequal to marginal cost. Water itself is not priced systematically in each of the major use sectors--agriculture, industry, and public supply. Allocation problems may be particularly apparent during periods of drought or when water supplies are otherwise impaired. Finally, allocative efficiency may not be achievable if other policy goals--such as equity--take precedence.

In addition, some specific application issues related to allocative efficiency include income distribution effects, barriers to economic efficiency, ineffectiveness, and competing policy goals. First, marginal-cost pricing, as with any pricing scheme, has distributive effects on income, a public policy consideration that will generally arise in its implementation. Second, the anticipated economic efficiency gains from marginal-cost pricing may not materialize if, for example, technical or cost efficiencies are not achieved. Moreover, these efficiencies will remain elusive given deviations from efficient pricing in other sectors of the economy, including water use sectors other than public supply. Third, implementation of marginal-cost pricing through seasonal rates or other rate structures may have little or no effect on water consumption patterns which will be a disappointment for those who seek to use the rate structure to induce operational changes, such as load factor improvement. Fourth, policy goals other than allocative efficiency, such as affordability and equity, play a role in cost allocation and rate design.

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[12] William Goolsby, "Optimal Pricing and Investment in Community Water Supply," *American Water Works Association Journal* 67 (May 1975): 220-24.

[13] William Vickrey, "Responsive Pricing of Public Utility Services," *Bell Journal of Economics* 2 (Spring 1971): 337-46.

[14] William Vickrey, "Some Implications of Marginal Cost Pricing for Public Utilities," *American Economic Review* 45 (May 1955): 605-620; and Robert Harbeson, "A Critique of Marginal Cost Pricing," *Land Economics* 31 (February 1955): 54-74.

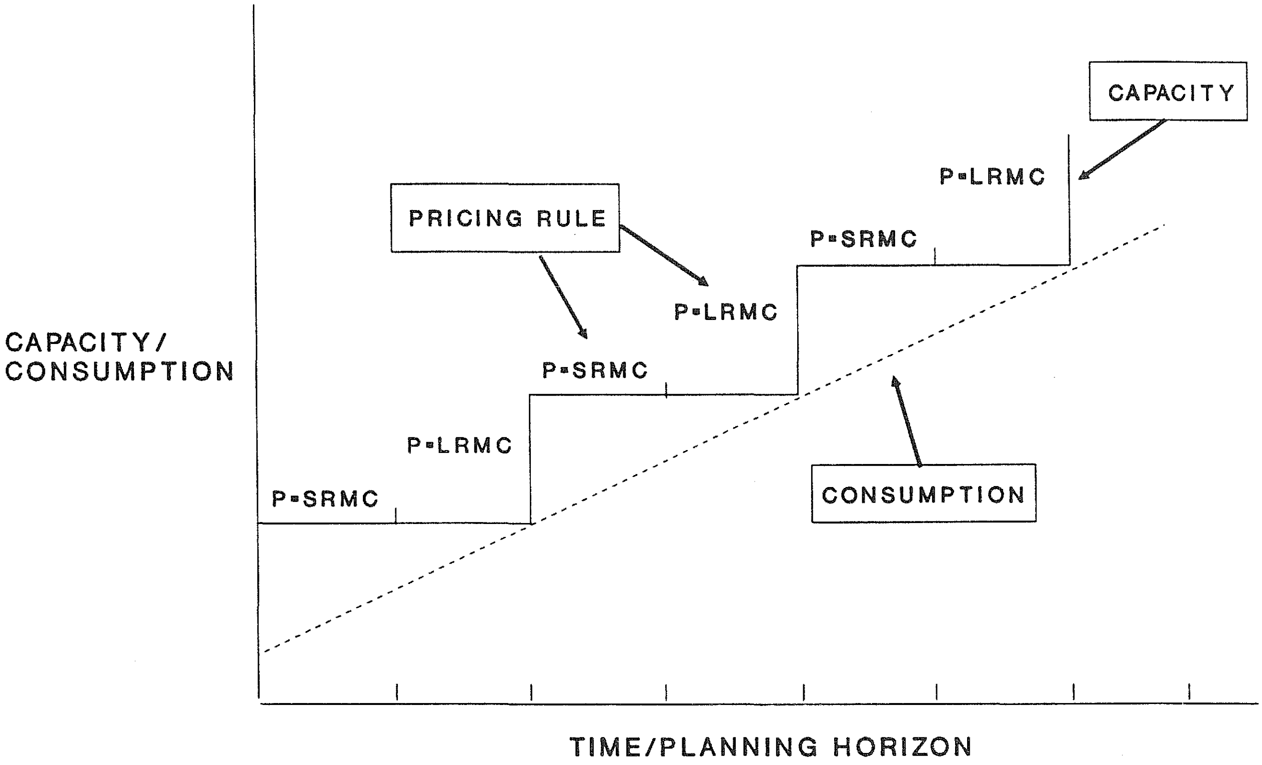

Fig. 4-2. Long-run marginal cost (LRMC) and short-run marginal cost (SRMC) pricing applications for lumpy capacity additions.

Cost and Rate Stability

Cost and rate stability problems associated with strict application of marginal-cost pricing theory are especially apparent in the presence of capital indivisibility (also known as investment "lumpiness"), meaning that capacity is typically added in large increments, some of which have a relatively long service life. By contrast, the rate of capacity utilization changes gradually. In fact, lumpiness is a trait that can apply to operation and maintenance expenses as well, perhaps especially for very small systems.[15] The indivisibility condition is particularly applicable to new water authorities which have a relatively small existing capital stock, and in which large investments are required to place a central system into full operation. Given initial capacity costs which are high relative to operation costs, strict marginal-cost pricing (as well as the strict use of embedded costs) will result in significant fluctuations in price creating a considerable source of uncertainty for consumers and creating problems (including rate shock) both for water utility managements and regulators. Even where it is technologically possible to extend capacity in relatively small increments, fluctuations in financing availability may result in capacity being extended in large increments. The exception is the already established water system with its large existing capital stock; in this case, if demand increments are relatively small and systematic, the indivisibility problem can be minimal.

Another aspect of capital indivisibility is found in the water distribution network. Prior to its construction, distribution costs would be characterized as incremental costs. However, the distribution network is generally designed to meet demands placed upon it for many future years, during which time additional usage causes negligible incremental distribution capacity costs. Economic theory suggests that the price charged for this element of service also should be negligible. This, however, presents a conflict between economic efficiency and the financial viability of the water utility.

Some specific application issues related to cost and rate stability are needle peaking and shifting peaks, distribution and customer costs, fire protection costs,

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[15] Contrast, for example, the addition of another licensed operator to a small one-operator system as compared with a system already employing ten operators (all with comparable salaries, etc). Relative expenses would increase by 100% to the small system and by only 10% to the larger system.

and purchased water costs. First, for a summer-peaking utility (because of lawn sprinkling), peak demand may not be substantially reduced by seasonal pricing, even though average demand declines. Results include the deterioration in annual load factors and revenue erosion. Seasonal rates may induce consumption that shifts the time of peaks but not their overall magnitude. Second, unstable rates can result from inappropriate cost allocation rules. Distribution costs (which vary with main size, number of customers, and location of mains) and customer costs (which are independent of capital expansion) can be handled through service charges. Third, capacity increments may or may not include capacity for meeting fire flow requirements. The joint nature of water service for consumption and fire protection makes it difficult to calculate the marginal cost of fire protection; thus, there has been a tendency to avoid the calculation of marginal fire protection cost. Fourth, the calculation of marginal costs should fully account for wholesale purchases of treated or untreated water.

Financial Viability

The strict application of marginal-cost pricing theory will result in insufficient revenues to the water utility if average cost exceeds marginal cost and excess revenues if average cost is less than marginal cost. In other words, marginal-cost pricing may lead to a mismatch of costs and revenues. This is one of the chief concerns about the marginal-cost pricing approach expressed by the American Water Works Association.[16] Accordingly, "it may be necessary to structure customer charges to achieve a balance of revenues and costs or to diverge from marginal-cost pricing somewhat" in order to align costs and revenues.[17] Of course in doing so, the economic efficiency gains of the marginal-cost pricing method may be lost. There is also concern that high prices will lead to consumption reductions that in turn reduce revenues and threaten the financial viability of the water utility. For these reasons, it may not be possible to achieve the most efficient allocation of water supplies.

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[16] American Water Works Association, *Water Rates* (Denver, CO: American Water Works Association, Manual M1, Third Edition, 1983), 57.

[17] Mark Day, "A Discussion of Empirical Evidence of the Conservation Impact of Water Rates," in Arizona Corporation Commission, *Water Pricing and Water Demand* (1986): 38.

Some specific financial viability issues that are in the implementation of marginal-cost pricing include excess revenues, inadequate revenues, bypass, and arbitrary remedies. First, water rates set equal to marginal cost may generate revenues in excess of revenue requirements for the water utility, primarily because historical accounting costs tend to underestimate the actual value of resources. Second, if prices based on marginal costs are below prices based on average costs, utility revenues will be inadequate. In particular, utilities with plentiful capacity may have difficulty recovering costs under marginal-cost pricing. Third, confronted with higher water rates, and based on price elasticities for water demand, some large industrial and commercial customers may bypass the local water utility in favor of self supply, which may have adverse effects on the utility's revenue stream. Fourth, methods to treat the problems of excess revenues, inadequate revenues, and bypass can be arbitrary and atheoretical, and many produce ambiguous price signals that undermine the potential for efficiency gains. Subsidization (in either direction) is more likely when revenues do not match costs.

Administrative Feasibility

Sophisticated analyses of utility costs require substantial resources for data collection and cost calculation, affecting both utilities and their regulators. There are measurement difficulties associated with the way cost data are collected and stored in utility accounting systems and with the higher metering and administrative costs required for the collection of certain types of data. Long-run marginal-cost estimations are highly subjective and the use of large data bases and elaborate calculations may not always improve decisionmaking by utilities and their regulators.

There is also the possibility that a well-executed average-cost pricing methodology will result in a close approximation of marginal costs, and do so in a simpler, more understandable way. In fact, some fully distributed cost studies may look much like marginal-cost studies. Decisionmakers may prefer the status quo analysis of historical costs, particularly if it is perceived to be less costly. The problem is in deciding whether the benefits of using marginal-cost analysis--including efficiency gains--outweigh these administrative costs.

Some specific application issues related to administrative feasibility include: data requirements, predictive accuracy, time lags, and public opposition. First, cost analysis requires substantial, accurate cost and demand data. Further, a rate structure can be no more sophisticated than the capability of measuring the water consumption to which the rate structure is applied. Thus water metering is essential and changes in cost accounting and billing practices may be necessary as well. Second, the cost forecasting necessary for marginal-cost estimation is imprecise and alternative calculation techniques yield different results. The approach also requires reliable data on the price elasticity of peak water demand. Without reliable elasticity estimates, price changes will have uncertain effects on revenues, load factors, operation costs, and capacity requirements. Third, billing cycles and time lags between the occurrence of peak demands, meter reading, and the customer's receipt of the water bill increase the uncertainty of consumer response to price. Fourth, the public and regulators may have difficulty accepting a radical change in the establishment of water rates, particularly if consumers perceive that a new rate structure is inequitable, unaffordable, or confusing.

Most of these application problems can be addressed, if not resolved. For example, probably the most problematic issue is the potential for marginal-cost pricing to result in excess revenues for the water utility. Stephen Feldman and his colleagues proposed several alternative tactics for addressing this problem.[18] One could decide not to reconcile the resulting rates with the revenue requirement. Assuming this is not desirable, costs can be adjusted while maintaining peak to off-peak ratios. Alternatively, marginal-cost components (short-run and long-run) can be adjusted proportionately. Overcollections can be rebated or taxed. Intramarginal discounts can be used to lower rates. Rates also could be adjusted by treating distribution cost as a residual. Finally, the inverse elasticity rule can be used in rate design to treat different customer classes differently (Ramsey pricing).

In sum, the application of marginal-cost pricing involves substantial problems, complicating its implementation. Interestingly, however, opponents of marginal-cost pricing stress these conceptual and applicational problems, rather than the possible superiority of conventional average-cost pricing. Many analysts recognize that the problems associated with marginal-cost pricing also apply to average-cost pricing. Of course, analysts' judgment plays a role in any method.

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[18] Stephen L. Feldman, Robert Obeiter, Michael Abrash, and Martin Holdrich, *An Operational Approach to Estimating the Marginal Costs of Urban Water Supply with Illustrative Applications* (Unpublished report to the Wisconsin Public Service Commission, October 21, 1980), 28.

However, conceptual and applicational problems should not stifle ratemaking innovation. Perhaps the most serious difficulty in using marginal-cost pricing lies not in the theory itself or even in the calculation of marginal costs but in the actual translation of cost estimates into water rates. The potential beneficial effects on costs, price stability, and economic efficiency under a marginal-cost or incremental-cost approach would appear to tip the scales in favor of considering including this approach among other tools of the trade.

Four Formulations of Marginal Cost[19]

Most definitions of marginal cost are similar in that they are forward looking; that is, they focus on immediate and near-term-future costs and output. Definitions differ in the extent to which they stress the importance of short-run as opposed to long-run costs, operation as opposed to capacity costs, and changes in consumption in different time periods. Thus, the definitions vary to the extent to which they focus on short-run versus long-run allocative efficiency and by the extent to which they attempt to minimize price fluctuations. Four marginal-cost formulations are discussed below:

- Simple Marginal Cost (SMC)
- Textbook Marginal Cost (TMC)
- Turvey Marginal Cost (TVMC)
- Average Marginal Cost (AMC)

All four formulations are presented for completeness, but while the first two lay the foundation for marginal-cost pricing, severe weaknesses preclude their application in the regulatory context. The other formulations are less true to pure economic theory but more pragmatic.

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[19] See also, Patrick C. Mann, Robert J. Saunders, and Jeremy J. Warford, "A Note on Capital Indivisibility and the Definition of Marginal Cost," *Water Resources Research* 16 no. 3 (June 1980): 602-4.

Simple Marginal Cost

Simple marginal cost (SMC) is defined as:

$$SMC_t = \frac{(R_t - R_{t-1}) + I_t}{(Q_t - Q_{t-1})}$$

where:

t = the year for which the calculation is being made,
R = operating and maintenance expenditures,
I = capital investment becoming operational, and
Q = water output.

If capacity increments are uneven, SMC generates cost estimations having significant volatility; thus the primary objection to this particular definition of marginal cost is that it precludes any averaging of future capacity increment. In this context, the remaining three formulations of marginal cost incorporate varying degrees of averaging or "smoothing" capital expenditures. It is stressed here that SMC, and similar formulations which focus primarily on short-run marginal cost, cannot be considered as practical cost estimation methods for water service. In brief, SMC, by focusing on the short-run, essentially fails to recognize the averaging of capacity increments, and the desirability of averaging to meet certain regulatory objectives.

Textbook Marginal Cost

Textbook marginal cost (TMC) consists of two components: short-run marginal cost (SRMC), reflecting operating cost increments, and marginal capital cost (MCC), reflecting capital expenditure increments. Similar to SMC, TMC reflects a relatively short planning horizon. TMC is defined as:

$$\begin{aligned} TMC_t &= SRMC_t + MCC_t \\ &= \frac{(R_t - R_{t-1}) + rI_t}{(Q_t - Q_{t-1})} \end{aligned}$$

where: r = the capital recovery factor or the annual payment that would repay a unit loan over the economic life, n years, of the capital expenditure with compound interest of i on the unpaid balance; that is:

$$r = \frac{i\,(1+i)^n}{(1+i)^n - 1} .$$

Given uneven capacity increments, TMC reflects both SRMC and MCC in the years in which capacity becomes operational and reflects only short-run marginal costs in the years in which no capital investment becomes operational. TMC, therefore, generates cost estimations exhibiting substantial fluctuations. However, the application of the annuitization factor (r) to capital expenditures produces some averaging of capacity costs.

Turvey Marginal Cost

Turvey marginal cost (TVMC) is an estimation method advocated by Ralph Turvey for application in water supply.[20] Similar techniques have been advocated for application to electric utilities.[21] TVMC can be defined as the present worth of the cost increment resulting from the same permanent increment in demand starting at the beginning of year t-1 *minus* the present worth of the cost increment resulting from the same permanent increment in demand starting at the beginning in year t. That is, TVMC reflects the difference in the present values of the future cost streams by shifting (for example, postponing or accelerating) a specified capacity increment by one year. The focus is not on the total costs of capacity expansion but on the cost effects of postponement or acceleration of expansion. In this context, marginal cost is the cost saving from postponing a capacity increment and not the cost saving from abandoning the capacity increment entirely.

TVMC considers marginal capacity costs with marginal operating costs defined as annual operating cost divided by the annual amount of water consumption. TVMC differs from the textbook conception of marginal cost in that it varies both

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[20] Ralph Turvey, "Analyzing the Marginal Cost of Water Supply," *Land Economics* 52 (May 1976): 158-68.

[21] Charles J. Cicchetti, William J. Gillen, and Paul Smolensky," *The Marginal Cost and Pricing of Electricity* (Cambridge, MA: Ballinger Publishing Company, 1977).

upward and downward and is positive only in those years when demand is at or near existing capacity; in between capacity increments, TVMC is generally zero. TVMC is affected when capacity increments are pushed forward or backward in time. Given an increment to projected demand growth, TVMC measures the effect on the present value of total system costs from the acceleration in capacity expansion. Given a decrement to projected demand growth, TVMC measures the effect on the present value of total system costs from the postponement in capacity expansion. In brief, TVMC reflects the difference in total system costs caused by changes in projected permanent demand growth. The TVMC method does not generally look beyond the next capacity increment; thus it ignores the effect of changing unit costs associated with subsequent changes in output. It does, however, incorporate an adjustment for system water loss.

Hanke developed marginal-cost estimates employing a version of TVMC.[22] In his calculation, MCC for a specific year y equals the present worth in y of planned system costs associated with the incremental annual demand starting in year y *minus* the present worth in y of planned system costs with the increment in annual demand starting in year y + 1, divided by the annual increment in usage. Thus, marginal capital cost is calculated on the premise of a postponement in capacity expansion. Total marginal cost is the composite for marginal capital costs and marginal operating costs (projected operation costs divided by projected annual water usage). To calculate marginal capital costs for annual use, the relevant capacity investment is aggregated; to calculate costs on a seasonal basis, the relevant planned investment are disaggregated into summer capacity and winter (base) capacity.

Average Marginal Cost

Average marginal cost (AMC) can be viewed as an attempt to reach a compromise between short-run allocative efficiency and the need for correct capacity investment signals by going beyond the traditional definition of the long run by including all future capital expenditures for a specified planning period. Of course, the longer the time frame, the greater the uncertainty of the capital cost

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[22] Steve H. Hanke, "On the Marginal Cost of Water Supply," *Water Engineering and Management* 120 (February 1981): 60-63, 69.

estimates. Given its emphasis on a planning horizon, AMC avoids the problem of defining the magnitude of the very next capacity increment, which is invariably difficult to specify, particularly for large water systems in which several different capacity investments may become operational simultaneously.

Mann, Saunders, and Warford presented a relatively sophisticated version of AMC labeled as average incremental cost (AIC).[23] In essence, AIC is calculated by discounting the future incremental costs which will be incurred in providing the incremental water demanded and dividing that by the discounted value of incremental water output over the planning period, as follows:

$$\text{AIC} = \frac{\text{Present worth of the least-cost investment stream}}{\begin{array}{l}\text{Present worth of the incremental output stream}\\ \text{resulting from the capacity investment}\end{array}}$$

Hanke presented a somewhat more pragmatic version of average marginal cost.[24] Capital expenditures are categorized into those capacity increments associated with water volume (such as treatment plants, service reservoirs, trunk mains, and source of supply facilities) and those not associated with water volume (such as distribution mains, meters, and customer services). The latter capital expenditures are primarily related to the number of customers served and should not be included in marginal capital cost calculations to be used as a basis for commodity charges; they are more appropriate for connection and service charges. Since investment increments often change abruptly, the capacity increments are averaged over several years. Therefore, marginal capital cost is formulated as the annuitized value of planned capacity expenditures becoming operational divided by the forecasted increment in total water usage for the planning period (say, five years). Marginal operation and maintenance costs are categorized into those related to volume and those not related to volume and are also averaged over the planning horizon. The resulting average marginal cost, then, consists of averages for both capital costs and the appropriate operation and maintenance costs.

The AMC method recognizes that different increments of capacity have different life spans. It also provides cost estimates that reflect future cost trends

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[23] Mann, Saunders, and Warford, "A Note on Capital Indivisibility."

[24] Steve H. Hanke, "A Method for Integrating Engineering and Economic Planning," *American Water Works Association Journal* 71 (September 1978): 487-91.

to be incurred as water usage changes. Finally, the method recognizes that with capacity increment lumpiness and the associated abrupt changes in operating costs when capacity increments become operational, it is essential that both capacity and operating costs be averaged over a specified planning period. Given the nature of its averaging process, AMC tends to generate cost estimates that exceed short-run marginal costs but that are less than long-run marginal costs in the TMC formulation. AMC generates cost estimates that smooth out capital expenditures while reflecting the trend of future costs that will be incurred as usage increases.

Hanke also suggested a modified cost categorization in calculating marginal capital costs.[25] He divided capacity costs into those associated with facilities designed to meet maximum-day demand (such as treatment plants), those related to average-day demand (such as reservoirs), and those related to customers and population growth (such as meters). Marginal capital cost in this case consists of separate components for supplying maximum-day demand and average-day demand. In essence, one can calculate peak and off-peak marginal capital costs according to these components. This categorization is important if there is substantial cost variation over the annual demand cycle, which could justify seasonal water rates. If consumers are to receive correct price signals, then the peak period should involve a price reflecting peak and off-peak costs; the off-peak price should reflect only off-peak costs. Hanke and Smart extended marginal-cost analysis to incorporate a demand simulation model.[26] Such models are useful in projecting consumer responses to changes in rate design, such as the implementation of a uniform rate based on marginal cost or seasonal rates based on peak and off-peak marginal costs.

Feldman, Breese, and Obeiter offer another version of average marginal cost.[27] Their version incorporates the calculation of the marginal costs of source capacity, transmission capacity, distribution capacity, treatment capacity, as well as marginal

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[25] Steve H. Hanke, "Water Rates: An Assessment of Current Issues," *American Water Works Association Journal* 67 (May 1975): 215-19.

[26] Steve H. Hanke and A. C. Smart, "Water Pricing as a Conservation Tool: A Practical Management Option," in *Environmental Economics* (Canberra, Australia: Australian Government Publishing Service, 1979).

[27] Stephen L. Feldman, John Breese, and Robert Obeiter, "The Search for Equity and Efficiency in the Pricing of A Public Service: Urban Water," *Economic Geography* 57 (January 1981): 78-92.

operating cost. As with other marginal-cost methods, the data employed in the calculations are engineering's best estimates. Customer costs are excluded from the analysis because they are presumed to be unchanged with system expansion. Finally, in this version, marginal costs are adjusted upward for system water losses.

Evaluating Estimation Techniques

In the abstract, marginal cost is a simple concept. In practice, different definitions of marginal cost exist. The version selected for actual implementation may be determined by factors such as the size of the projected demand increment, the relevant planning horizon, data availability, the preference for short-run allocative efficiency as opposed to long-run resource allocation, the potential impact of technology on production costs, the extent to which price stability is desired, prevailing prices, and the revenue consequences of each particular formulation of marginal cost.

The definitions of marginal cost described above cover the spectrum of tradeoffs among most of these factors. For example, even though TMC is the method that adheres most strictly to theoretical marginal cost, in certain cases both it and SMC can be rejected on technical grounds because they incorporate an insufficient planning horizon (therefore providing inadequate price signals to water consumers regarding the marginal capital cost of water service). The two methods can also be rejected on practical grounds since the potential price volatility associated with each creates regulatory, political, as well as administrative and financial management problems for the water utility. TVMC and AMC are marginal-cost formulations which average the costs of capacity expansion; that is, they incorporate marginal capital cost in price even when capacity increments are not imminent. AMC and TVMC incorporate a longer view of water costs than do SMC and TMC, thus minimizing cost-price fluctuations.

A framework is essential for selecting the most appropriate marginal-cost definition for any particular application. As discussed above, four essential evaluation criteria are:

- Allocative efficiency
- Cost and rate stability
- Revenue adequacy
- Administrative feasibility

The first criterion involves the issue of which marginal-cost definition will satisfy the criterion of minimum divergence from textbook marginal cost (TMC), which represents an approximation of a price that induces short-run allocative efficiency and correctly signals the justification of capacity increments. TMC may not be an absolute representation of marginal cost as defined in economic theory, but it does approximate the theoretical specification of marginal cost. This criterion implies that alternative methods be examined for both absolute differences and ratios between their marginal-cost estimations and comparable TMC estimations. One anticipates that the alternative formulations will tend to converge toward TMC as the capital investment pattern becomes smoother. Even if one does not accept economic efficiency in the broadest sense as a reasonable policy goal, the choice of a marginal-cost pricing method can bring about improvements in price and investment signals as well as the development of a practical cost estimation tool.

The second criterion involves the issue of which marginal-cost definition will best satisfy the criterion of minimizing the volatility of estimations; that is, which technique tends to generate cost estimations having the property of relative stability even under conditions of extreme lumpiness in capacity investment. This criterion implies that marginal-cost estimations be examined for properties of direction (behavior patterns), magnitude, and volatility. This criterion recognizes that marginal-cost pricing has not been feasible in some cases since, under conditions of lumpy investment, prices can be extremely volatile creating both political and financial management problems.

The third criterion concerns the issue of which marginal-cost definition will best satisfy the criterion of providing adequate revenues to cover revenue requirements; that is, which technique minimizes the potential for revenue erosion as well as excess revenues. This criterion indicates that the estimation methods be examined for the property of revenue flows and whether those flows will match incurred costs or revenue requirements.

The fourth criterion is administrative feasibility. The operationalization of marginal costs can be more or less complex. Some of the more sophisticated approaches may be closer to the textbook ideal and yet be very costly to implement. In some cases, the cost of generating data may outweigh the benefits, even the efficiency gains, of the marginal-cost method. A related point is that customer confusion about changes in rate design may create administrative and regulatory problems for the water system. On the other hand, administrative costs are associated with all methods.

The relative importance of the four criteria is essentially a function of judgment. For example, since the typical sale of water is in the nature of a short-term agreement, those who advocate prices based on short-run marginal cost accept price volatility as less important than economic efficiency. That is, the potential exists for continually changing water prices. However, a rational pricing scheme cannot incorporate one criterion such as efficiency and totally ignore price stability and financial considerations. Conversely, a rational pricing scheme cannot incorporate price stability and adequate revenue generation and overlook allocative efficiency as a relevant consideration.

The selection of one definition of marginal cost results in accepting various tradeoffs among allocative efficiency, cost and rate stability, revenue adequacy, and administrative feasibility. The magnitude and nature of these tradeoffs will vary with investment conditions, price horizons, capital recovery factors, economies of scale, and system growth. The ambiguous nature of the marginal-cost concept permits significant latitude in its actual estimation with the outcome being cost estimates diverging from theoretical marginal cost. For example, the averaging process implicit in the average marginal cost and Turvey marginal-cost formulations, even though desirable, can produce cost estimates having little resemblance to the marginal-cost concept portrayed in microeconomic theory. In sum, there are several ways in which marginal cost can be defined for pricing purposes, each having theoretical and practical disadvantages as well as advantages.

Incremental Least-Cost Analysis

The development of a marginal-cost method for application in water is made easier with the use of an appropriate policy framework. Proposed here is a method for calculating average incremental costs that builds substantially on the estimation techniques discussed above while incorporating several practical solutions to some of the more troublesome conceptual and application problems. The general steps in the incremental least-cost (ILC) approach are compared with a marginal-cost pricing approach in table 4-4.

The proposed ILC method defines the next increment of capacity in terms of least-cost planning criteria. The rationale is that cost allocation and rate design

TABLE 4-4

COMPARISON OF MARGINAL-COST ANALYSIS AND INCREMENTAL LEAST-COST ANALYSIS

Key Steps in a Marginal-Cost Analysis

STEP 1: Identify all potential supply options.
STEP 2: Choose the most viable supply option.
STEP 3: Develop cost-allocation assumptions and methodology.
STEP 4: Perform the cost estimation for the most viable supply option.
STEP 5: Use the cost estimation in rate design.

Key Steps in an Incremental Least-Cost Analysis

STEP 1: Identify all potential supply options using planning criteria.
STEP 2: Develop cost-allocation assumptions and methodology.
STEP 3: Perform the cost estimation for each supply option.
STEP 4: Choose the most viable least-cost supply option.
STEP 5: Use the cost estimation in rate design and planning.

Source: Authors' construct

are an integral part of supply planning and such a methodology helps reinforce these relationships. A planning approach confines the number of capacity increment alternatives to those that meet a priori planning criteria within a specified planning time frame. Planning criteria need not be confined to least-cost principles or even to cost considerations. For example, most water supply plans would require systems to maintain basic engineering and health standards related to system reliability and water quality where cost is a subordinate consideration. The planning framework can span any length of time, and potential capacity increments can be either small or large and have either a short or long service life. One need not assume that the next capacity increment will be added within the next year or even in the next few years. Absent a highly technical analysis, water system engineers essentially can make an educated forecast about a select number of potential capacity sources.

Methodology

The incremental least-cost methodology is summarized in table 4-5. The first step is the identification of appropriate supply alternatives (including changes in output levels using existing capacity as well as nontraditional supply options) consistent with relevant planning criteria. Each supply increment will involve different types of costs in the different functional areas of public water supply: source development (including raw water storage), pumping, transmission, treatment, and storage (for treated water). Some options, such as purchased water, require a separate functional category. Which cost categories are affected by each option depends on the system's existing capacity configuration. Some, for example, may entail additional incremental costs in only select areas without affecting costs in others.

TABLE 4-5

STEPS IN AN INCREMENTAL LEAST-COST ANALYSIS

- Identification of incremental capacity alternatives.
- Feasibility analysis of incremental capacity alternatives.
- Estimation of capital and operation and maintenance costs.
- Cost allocation to functional categories of water supply.
- Cost allocation to off-peak and peak demand.
- Cost allocation to service classes.
- Calculation of total annualized incremental costs (TAIC).
- Calculation of average incremental costs (AIC).
- Identification of incremental least-cost (ILC) alternative.
- Use of estimates in rate design and planning.

Source: Authors' construct.

For purposes of comparison, the incremental capital costs (k) associated with each supply alternative are operationalized as the annual payment over the useful service life of the capital expenditure necessary to pay interest and fully recover capital costs, as follows:[28]

$$k = \frac{Ci(1 + i)^n}{(1 + i)^n - 1}$$

where:
k = annualized capital costs,
C = the total capital expenditure required,
n = the useful service life of the capital expenditure (a proxy for the consumer payback period), and
i = the appropriate interest (financing) rate.

For each capacity alternative, the analyst must also estimate operation and maintenance expenses (OM). A pragmatic approach is to use the projected annual OM for the first year that the capacity addition is expected to be operational. Knowing both k and OM for each option allows the calculation of total annualized incremental costs (TAIC) for each capacity option according to the general formula:

$$TAIC = k + OM.$$

Allocating costs to each of the identified functional areas of water supply yields the more detailed formula:

$$TAIC = (k+OM)_d + (k+OM)_p + (k+OM)_r + (k+OM)_t + (k+OM)_s + (k+OM)_o$$

where:
k = annualized capital costs,
OM = additional annual operation and maintenance costs,
d = source development,
p = pumping,
r = transmission,
t = treatment,
s = storage, and
o = nontraditional supply.

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[28] Jack Hirshleifer, James C. Dehaven, and Jerome W. Milliman, *Water Supply: Economics, Technology, and Policy* (Chicago: University of Chicago Press, 1960).

This calculation of TAIC can be performed for unallocated additions to system capacity, for additions that meet off-peak or peak capacity needs, or for capacity requirements for different customer classes (which also may be divided into off-peak and peak needs). Analysts must develop allocation rules for the assignment of costs. Although in theory all costs can be allocated to a functional area of water supply, some analysts may choose to use a separate category for joint or common costs, such as general office expenses. The customer categories that apply depend on characteristics of the water service area. Cost allocation can be facilitated by the use of an incremental cost allocation matrix, an example of which appears in table 4-6.

The next step in the analysis is the choice of an appropriate denominator for comparing costs on a per-unit basis in terms of what is known as average incremental cost (AIC). Some of the available alternatives are summarized in table 4-7. As always, analyst judgment plays an important role. One approach is to calculate AIC by dividing simple annual costs (TAIC) by the amount of designed capacity added in millions of gallons per annum (mg):

$$AIC_{mg} = \frac{TAIC}{W_{mg}}$$

where: W = additional increment of water capacity, and
mg = million gallons per annum.

The problem with this formulation of AIC is that it does not take into account the difference between designed capacity and utilized capacity or the magnitude of water losses. As a result, AIC_{mg} may tend to underrepresent unit costs. An alternative denominator can be used to reflect the expected utilization of the capacity increment. A utilization factor is the ratio of the maximum demand of a system to the installed capacity of the system. Thus, an alternative AIC calculation can be represented by:

$$AIC_{umg} = \frac{TAIC}{u * W_{mg}}$$

where: u = utilization factor for the capacity increment.

TABLE 4-6

INCREMENTAL COST ALLOCATION MATRIX

					Allocation of Costs to Service Classes by Demand													
		Total Incremental	Allocation of Costs to Demand		Residential		Commercial		Industrial		Wholesale		Institutional		Public Authorities		Fire Protection	
Functional Areas		Costs	Base	Peak	Base	Peak	Base	Peak	Base	Peak	Base	Peak	Base	Peak	Base	Peak	Base	Peak
Source Development	k																	
	OM																	
	k+OM																	
Pumping	k																	
	OM																	
	k+OM																	
Transmission	k																	
	OM																	
	k+OM																	
Treatment	k																	
	OM																	
	k+OM																	
Storage	k																	
	OM																	
	k+OM																	
Nontraditional Supply	k																	
	OM																	
	k+OM																	
Total incremental cost*																		

* Assumes allocation of general plant, administration, joint/common, and other costs.

TABLE 4-7

NOTATION USED IN CALCULATING AVERAGE INCREMENTAL COSTS

Notation	Definition
k	Incremental capital costs (annualized).
OM	Incremental operation and maintenance costs (annualized).
$k+OM$	Total annualized incremental cost (TAIC).
$\frac{k+OM}{W_{mg}}$	Average incremental cost (AIC) per system design capacity.
$\frac{k+OM}{u * W_{mg}}$	Average incremental cost (AIC) per utilized capacity, where u = a utilization factor based on system output.
$\frac{k+OM}{W_{rpmg}}$	Average incremental cost (AIC) per revenue producing water.
$\frac{k}{W_{mg}} + \frac{OM}{u * W_{mg}}$	An average incremental cost (AIC) hybrid where unit capital costs are based on added design capacity and unit O&M costs are based on output using a utilization factor.

Source: Authors' construct.

There is another approach for dealing with the issue of water losses, water that is provided free-of-charge, or otherwise unaccounted-for water. Caused by a variety of conditions, "nonaccount water" is not billed and therefore generates no revenues for the utility.[29] The greater the system water loss, the more AIC will underestimate the actual incremental cost of water. Although historical records can be used, care should be taken in estimating revenue producing water because water losses do not necessarily increase linearly with output. Given an estimate of expected annual revenue producing water (rpmg), another calculation of AIC can be made as follows:

$$AIC_{rpmg} = \frac{TAIC}{W_{rpmg}}$$

where: rpmg = revenue producing million gallons per annum.

It follows that the incremental cost of water losses can be estimated by calculating the difference between the incremental cost of the gross additional increment of capacity and the incremental cost of revenue producing capacity. Because mg is always greater than rpmg, this number will always be positive. Water system managers and their regulators will certainly take note of the magnitude of this amount. For some utilities, leak detection and repair may itself be a cost effective (if not least cost) source of additional capacity. Indeed, the incremental least-cost method incorporates a variable (o) to address this potential source of supply. Other supply options, such as purchased water and conservation programs, also can be considered in the nontraditional category, as long as their cost impacts on other functional areas (such as transmission and distribution) also are identified.

Assuming that AIC is calculated for more than one potential source of additional capacity, incremental least cost (ILC) is simply the lowest value that results from the comparative analysis. The option identified should be reanalyzed in terms of feasibility and desirability. If the least-cost alternative is not preferable, it is incumbent on the analyst to explain why. Finally, the least-cost estimate should be compared with cost estimates using other methodologies, including traditional methods used to determine revenue requirements. The divergence

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[29] On the issue of water losses, see Lynn P. Wallace, *Water and Revenue Losses: Unaccounted-For Water* (Denver, CO: American Water Works Association, 1987).

between estimates should be evaluated with care, particularly if the analysis is used for pricing decisions.

Assumptions

It is important to clarify the several assumptions underlying the application of the incremental least-cost method described here. These apply to other approaches as well and may present application limitations when certain conditions cannot be assumed. First, it is assumed that operating and cost data on potential supply capacity increments (including changes in existing levels of output) are either readily available or can be easily estimated. Second, operating and cost data on nontraditional supply alternatives, such as wholesale purchases, source-of-supply leasing, leak detection and repair, conservation technology, and so on, can also be estimated. Third, service lives and financing rates associated with alternative capacity increments can be identified with reliability. Fourth, reasonable estimates can be made of the amount of water capacity added to the water system as well as revenue producing water and unaccounted-for water. Fifth, the cost of incremental additions to the distribution system can be directly recovered and therefore are not properly included in a marginal-cost analysis. Sixth, it is assumed that the water utility experiences a positive growth rate in water output and usage along with increased costs of service during the planning period. This assumption precludes the generation of negative marginal-cost values that can occur under this and other cost calculation techniques.

Perhaps most importantly, similar to the average marginal-cost method previously discussed, it is assumed that the use of the incremental least-cost method as described places more importance on the evaluative criteria of cost and rate stability, revenue adequacy, and administrative feasibility than on the criterion of economic efficiency. The method is principally a least-cost planning and general ratemaking tool, and one that should be used in conjunction with others available to the analyst, including historical cost studies.

Discussion

An important part of the ILC method is that incremental capital and operation costs are estimated for each potential capacity increment on an annualized basis. Average incremental costs can be calculated by determining annualized costs and dividing this amount by the amount of capacity added. Capital and operating costs can be estimated separately for each of the principal cost categories (that is, source development, storage, transmission, treatment, and so on) and, at the analyst's discretion, separately for capacity needed to meet off-peak and peak demand. The analysis can be taken a step further by estimating these costs for different customer classes. Still, the method does not require more data than most other cost allocation analyses.

The method, as described, allows analysts to consider alternative measures of average incremental cost based on the denominator of choice. For example, the method recognizes both the incremental cost of added capacity and the incremental cost of revenue-producing water.[30] The difference between the two is a reasonable estimate of the incremental cost of water loss on a per-unit basis. Water suppliers and regulators obviously have an interest in the amount of a system's unaccounted-for or nonaccount water and the incremental cost of these water losses. A reasonable estimate of this cost may induce some water supply managers to implement leak detection and repair programs as essentially a source of additional capacity.

Finally, the method allows for the calculation of more than one average incremental-cost estimate, based on the existence of more than one capacity alternative. These can be used to identify the least-cost alternative for planning purposes as well as ratemaking. If an estimate other than the least-cost amount is selected, the rationale for doing so should be made clear. More complicated analyses can incorporate sensitivity tests using different technology and system growth assumptions. At a minimum, water suppliers (and arguably their regulators)

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[30] The importance of revenue-producing water as the denominator in calculating per-unit costs was emphasized in Patrick C. Mann and Janice A. Beecher, *Cost Impact of Safe Drinking Water Act Compliance for Commission-Regulated Water Utilities* (Columbus, OH: The National Regulatory Research Institute, 1989).

should be able to conduct a rudimentary analysis of future capacity needs within a planning framework.

The key benefits of the incremental least-cost method, then, are that it establishes a principle for choosing the next capacity increment and eliminates many of the concerns related to time frame, simplifies the calculation of annualized costs, provides for the assessment of the incremental costs of revenue-producing water, and sets forth an array of alternatives from which to choose. One of the chief benefits of the least-cost approach is that it encourages the analysis of nontraditional capacity increments, such as purchased water, leasing, water loss reduction, and conservation, within a planning framework.

Incremental least cost has analytical value as a reasonable proxy for marginal costs in a planning framework, even though it departs significantly from the textbook definition with regard to economic efficiency. It offers pragmatic solutions to some of the problems of marginal-cost estimation. Whether or not the value of ILC actually becomes the estimate used for rate design and planning decisions may involve a variety of other considerations.

The choice of any approach depends largely on policy goals and preferences about how to achieve them. Marginal-cost pricing has been advanced by economic theory to make more efficient the allocation of water supply resources. Although marginal-cost or incremental pricing is an imperfect approach to water utility ratemaking, substantial benefits may be gained from its use. At the very least, the results of such an analysis can be used for comparison with more traditional cost allocation and pricing methods in the context of least-cost planning.

Fully Allocated Costs and Marginal Costs Compared

In the regulatory context, an important difference between fully allocated methods and marginal or incremental cost methods is the sequence of procedures. With fully allocated cost methods, revenue requirement determination is followed by cost functionalization (using historic or embedded accounting costs), cost classification, interclass cost allocation, unit cost calculation, and, finally, rate design. One starts with the premise of the equality of revenues and costs followed by an interclass cost allocation that achieves the matching of costs and revenues. Obviously, there can be elements of arbitrariness in the transition from cost allocation to rate design. For example, an allocation method can be selected on the basis of producing allocations that justify a predetermined rate structure rather than on the basis of cost causation principles.

With marginal-cost methods, selection of the planning horizon is followed by the estimation of marginal unit costs (possibly on a functionalized basis), cost classification, rate design, and finally the reconciliation of costs and revenues. One starts with the premise of the equality of price and marginal cost followed by cost adjustments to insure compatibility with revenue requirements. Since unit costs are directly calculated as the bases for rate structure, incremental methods generally do not involve interclass cost allocations.

The differences between fully allocated and marginal-cost methods may be overstated. For example, average cost calculations often are used as approximations of incremental distribution cost and incremental customer cost since incremental cost calculations for these components tend to be less precise than for production (that is, treatment). Both fully allocated and marginal-cost estimations may be adjusted in the rate design process for competition differences across markets. Both methods can be employed to provide a sophisticated rationale for value of service pricing. Both methods do not automatically generate cost-revenue equality. That is, marginal-cost estimations can create rates needing adjustment prior to implementation; fully allocated costs can lead to rates needing adjustment after implementation.

Both fully allocated cost and marginal-cost methods involve value judgments. In fully allocated cost methods, judgments occur in cost assignments, capacity cost allocations, and in the allocation of administrative and general expense. Value judgments also occur in selecting a marginal-cost estimation method, in determining the planning horizon and the timing of new capacity, in defining incremental output, and in reconciling costs and revenues. It is quite possible that the same approximate rate structure can be obtained either by a fully allocated or a marginal-cost method.

Cost concepts have emerged that incorporate elements of both fully allocated cost and marginal-cost methods. For example, the concept of attributable cost is viewed as the direct cost of providing a service plus a portion of other costs which are influenced by the provision of the service, but which would not necessarily be avoidable if the service were not provided. In brief, attributable cost is a melding of embedded and incremental cost. In contrast, the concept of avoidable cost is virtually synonymous with marginal cost. The mixed test year is another concept that, in theory at least, combines the use of embedded and incremental costs. Many commissions prefer this approach to exclusive reliance on either historic or projected data.

Few attempts, however, have been made in the regulatory process to integrate fully allocated cost methods with incremental cost methods. William Melody must be considered a pioneer in assessing the potential for combining these approaches.[31] He suggested that fully allocated cost methods could be employed in allocating revenue requirements to customer classes and specific services. Thus, fully allocated costs would determine the overall revenue requirements attributable to individual customer classes, blocks of use, and other services. Incremental cost estimates could then be employed for designing rates for these classes and services (such as different usage blocks). Thus, incremental cost would assist (along with demand and market factors) in structuring rates. Therefore, fully allocated cost emerges as the revenue requirement standard while incremental cost remains an important factor in rate design.

The Wisconsin Public Service Commission is one of the few commissions that has attempted the actual integration of fully allocated cost and incremental cost methods.[32] The Commission in recent years has employed embedded cost studies to determine the range for cost allocation; embedded cost becomes the primary basis for determining revenue targets for individual classes of service. The Commission then employs incremental cost studies to indicate the point within the range for interclass allocations; incremental cost becomes the primary basis for rate design within classes of service. Further research on the integration of these approaches is probably overdue.[33] However, another issue requiring attention is the criticism

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[31] William H. Melody, "Interservice Subsidy: Regulatory Standards and Applied Economics," in Harry M. Trebing, ed., *Essays on Public Utility Regulation* (East Lansing, MI: Institute of Public Utilities, Michigan State University, 1971), 167-210.

[32] Robert J. Malko and Terrance B. Nicolai, "Using Accounting Cost and Marginal Cost in Electricity Rate Design," Eleventh Annual Rate Symposium on Pricing Electric, Gas, and Telecommunications Services (Columbia, MO: University of Missouri, 1985), 168-82.

[33] Patrick C. Mann, "Costing Method Selection: Rhetoric and Substance," in Patrick C. Mann and Harry M. Trebing, eds., *Public Utility Regulation in an Environment of Change* (East Lansing, MI: Institute of Public Utilities, Michigan State University, 1987), 519-28.

that combining fully allocated and marginal-cost approaches undermines the goals of both methods and produces meaningless results.

In sum, both fully allocated cost and marginal-cost estimations can provide regulators with important benchmarks for rate design. Since these methods can generate divergent results, an option available to regulators is to conduct multiple costing analyses thus producing several pricing benchmarks rather than singular cost values. For example, the results of fully allocated cost studies can be supplemented with incremental cost estimations thus providing both minimum and maximum standards for specific rates. Many of the rate design alternatives available today, and discussed in the following chapter, incorporate elements of fully allocated and marginal-cost analysis.

CHAPTER 5

RATE DESIGN FOR WATER UTILITIES

As already mentioned, the theoretical pricing ideal is to set rates equal to the cost of service; in other words, water prices should track water provision costs. However, a perfect match of water utility costs and water rates is not attainable. Noncost influences on rates include politics, past customs and practices, public (consumer) acceptance, adjacent community rates, and (in the case of publicly owned systems) the existing degree or extent of subsidization, taxation, and free service. An example of multiple objectives in designing water rates is the use of a rate structure combining increasing-block rates for residential service (to promote conservation) and decreasing-block rates for commercial and industrial service (to promote economic development). As water prices are increasingly affected by more stringent drinking water regulations, the policy objective of affordability may emerge, for example, in an increasing interest in lifeline rates.

There is a strong tradition in utility regulation that the fairness of rate differentials depends on differences in costs. However, to maintain this tradition these cost differentials must be defined or specified within reasonable limits. For example, cost differentials must be shown to exist to justify decreasing-block rates. If it cannot be established that there are marked differences in the cost of providing different volumes of water service, it would be appropriate to adopt a uniform rate even if this strategy does not track water supply costs with precision.

A recent survey commissioned by the U. S. Environmental Protection Agency provides a general overview of water rate structures according to utility ownership, as reported in table 5-1.[1] In the aggregate, many systems have rates that vary with the amount of water use. However, a significant proportion of systems use flat fees for water service. According to this source, few systems impose only a uniform rate (where the price per unit is constant as consumption increases) or a nonwater use measure (where charges are tied to something other than direct water use). The data are least specific about rate structures for ancillary systems,

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[1] Frederick W. Immerman, *Final Descriptive Summary: 1986 Survey of Community Water Systems* (Washington, DC: Office of Drinking Water, U.S. Environmental Protection Agency, 1987).

TABLE 5-1

WATER RATE STRUCTURES BY UTILITY OWNERSHIP

Type of Rate	Publicly Owned(a)	Privately Owned(b)	Ancillary(c)	All Systems
	Percent of Systems			
Variable rate(d)	58.5%	43.1%	16.7%	50.7%
Flat fee(e)	19.5	34.8	25.2	25.4
Uniform rate(f)	5.2	4.3	0.0	4.6
Nonwater use measure(g)	3.1	3.4	6.6	3.4
Other(h)	13.8	14.4	51.5	15.9
Total	100.0%	100.0%	100.0%	100.0%

Source: Frederick W. Immerman, *Final Descriptive Summary: 1986 Survey of Community Water Systems* (Washington, DC: Office of Drinking Water, U.S. Environmental Protection Agency, 1987), tables 5-6 and 5-7.

(a) Based on a sample of 434 utilities.
(b) Based on a sample of 209 utilities.
(c) Based on a sample of 18 utilities.
(d) A rate based on water use, varying with amount of water used.
(e) A fee paid monthly, quarterly, or annually, not based on water use.
(f) A constant rate per unit of water use.
(g) A charge based on something other than direct water use, such as service connection size, lot size, etc.
(h) A rate structure not described by any of the above. Many of these are combinations of fees and rates, or different types of rate structures for different customer classes.

where a combination of charges (reported as "other") may be the norm. Appendix E provides more detailed information on water rates for more than one-hundred United States cities, based on a 1990 survey by Ernst and Young.[2] This chapter explores rates design alternatives for water utilities.

Water Rate Structures

Most water bills consist of a combination of fixed charges (which do not vary with water consumption) and variable charges (which do vary with water consumption). One very basic ratemaking approach, designed specifically for small water systems, results in a fixed charge based on the utility's monthly fixed costs (debt service, reserves, and depreciation) coupled with a variable charge based on the utility's annual operation and maintenance costs, adjusted for inflation and anticipated changes in expenses (such as salary increases).[3]

Fixed charges can take the form of service charges, system development charges, capacity (demand) charges, and access fees. Water systems vary in whether they use fixed or variable charges to cover capacity costs. A fixed charge makes sense if a particular cost of service is associated with a specific customer (that is, if the customer withdraws from the water system the cost can be avoided). In brief, an access or fixed charge makes economic and financial sense if it reflects a connection used exclusively by the consumer, if the cost associated with the connection is independent of the consumer's volume of usage, and if the connection or access cost is essentially independent of production and delivery system design.

Choices about fixed and variable charges must be made in the context of tradeoffs among policy goals, including cost-of-service standards as well as consumer acceptance. For example, it is common in water service to employ a single rate structure for all retail consumers. The singular rate structure is simple to administer, easy to understand, and should recover the costs of service allocated

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[2] *Ernst & Young's 1990 National Water and Wastewater Rate Survey* (Charlotte, NC: National Environmental Consulting Group, Ernst & Young, 1990).

[3] John Regnier, "Case Study: Alabama Rate-Setting Study," presentation at the Annual Meeting of the American Water Works Association in Cincinnati, Ohio (June 1990).

to service classes via proper design of usage blocks. The rate design alternatives discussed herein mainly address the issue of defining usage blocks.

A variety of rate structures are used by water utilities. Illustrated in table 5-2 and summarized below are flat fees, fixture rates, uniform rates, decreasing-block pricing, increasing-block pricing, seasonal rates, excess-use charges, indoor/outdoor rates, lifeline rates, sliding scale pricing, scarcity pricing, and spatial pricing. A subsequent section reviews other water charges.

Flat Fees

The simplest way to bill customers for water service is to use a flat rate or fee with all customers charged the same amount for service regardless of usage levels. No metering is required and fees may be collected according to any desired schedule, even annually. Flat fees can be considered cost-based to a degree because relatively high fixed costs characterize the water supply industry and may be appropriate if all members of the service class can be assumed to have uniform usage. They also insulate utilities from fluctuations in use caused by weather or other factors. However, most analysts reject the idea of flat fees because they send a poor price signal to customers about the cost of water service; nor do they provide an incentive to conserve. Flat fees, in fact, tend to encourage waste.

Fixed charges on the water bill, such as customer charges, also constitute a type of flat fee. These may be used in conjunction with a variable rate based on water consumption. Customer charges are appropriately collected as a flat fee because costs vary with the number of service connections. A variation on this idea is presented in table 5-3, which demonstrates the conversion of customer charges based on meter size. This type of approach presumes that customer costs vary in proportion to meter size and, thus, that customers with large-meter service (such as industrial users) should pay a higher charge than 5/8-inch-meter residential customers. Still, the customer charge is a per-meter charge that is fixed from month to month, as compared to a variable rate based on water usage.

A type of flat fee that does require water metering is the minimum bill, which is sometimes used to establish a basic usage block. This approach establishes a fixed fee linked to a minimal amount of water use; water consumption above this amount is charged at the established per-unit rate. An example of a minimum bill

TABLE 5-2
RATE DESIGN ALTERNATIVES

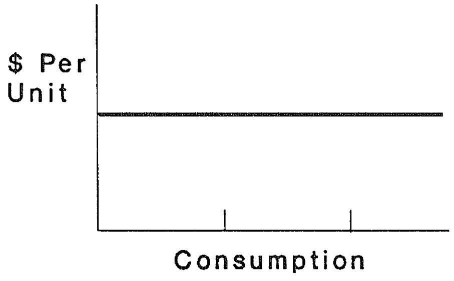
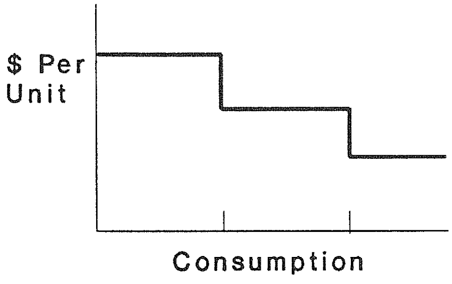
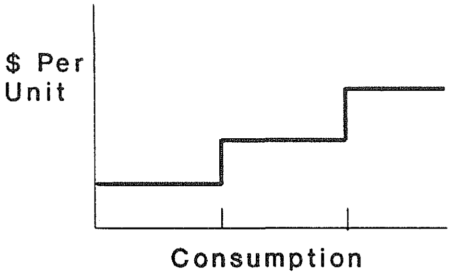
FLAT FEE* $/time period	Definition: A periodic fixed charge for water service that is unrelated to the amount of water consumed. Best used for: Only preferable when metering costs outweigh benefits. Considerations: Consumers are not sent price signals and may overconsume.
FIXTURE RATE* $/fixture	Definition: A periodic fixed charge for water service related to water-using fixtures on the customer's premises. Best used for: Only preferable when metering costs outweigh benefits. Considerations: May reflect the cost of service better than a flat fee.
UNIFORM RATE 	Definition: Price per unit is constant as consumption increases. Best used for: May be somewhat effective in reducing average use. Considerations: Large-volume users consider this structure equitable.
DECREASING BLOCK 	Definition: Price per unit decreases as consumption increases. Best used for: Retaining large-volume customers. Considerations: Large-volume users prefer this structure. When there is sufficient supply, the cost of supplying water will probably decrease as consumption increases.

TABLE 5-2 (Continued)

INCREASING BLOCK

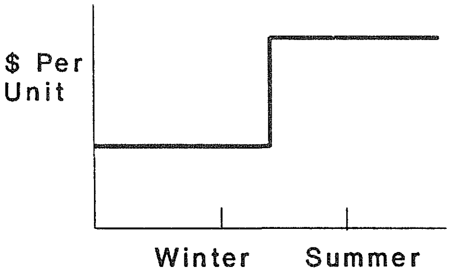


Definition: Price per block increases as consumption increases.

Best used for: Reducing average (and sometimes peak) use.

Considerations: Large-volume users consider this structure inequitable.

SEASONAL

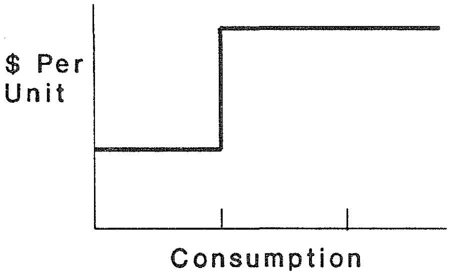


Definition: Price level during season of peak use (summer) is higher than the level during winter.

Best used for: Reducing peak use.

Considerations: Large-volume users consider this structure equitable. Effective for summer tourist community.

EXCESS USE

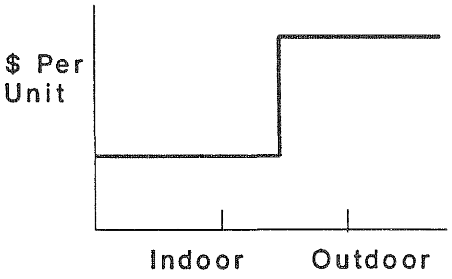


Definition: Price level is significantly higher for all water used above average, usually determined by winter use.

Best used for: Reducing peak use.

Considerations: Large-volume users consider this structure equitable.

INDOOR/OUTDOOR*

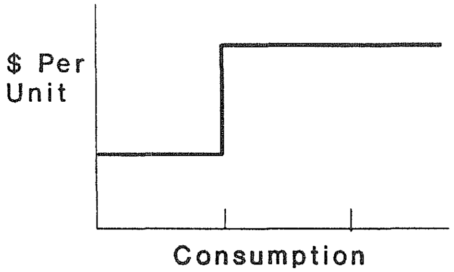
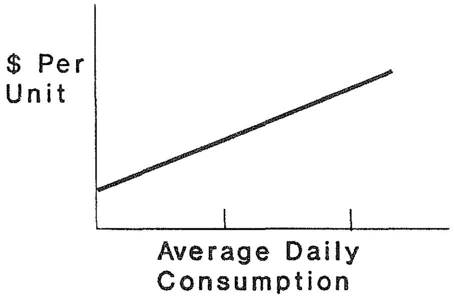
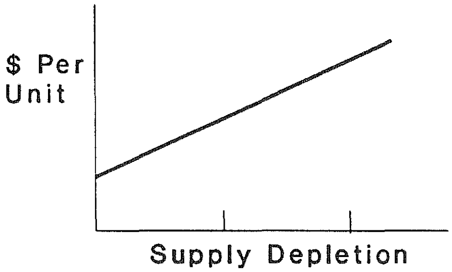
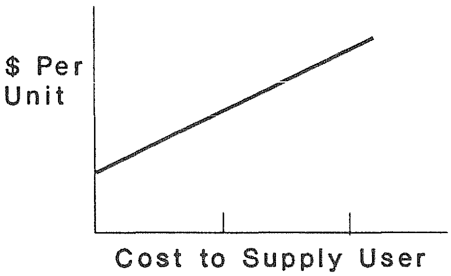


Definition: Price level for indoor use is lower than for outdoor use.

Best used for: Reducing peak use, defined by outdoor use, which is more elastic.

Considerations: Requires either two meters or detailed data and a somewhat sophisticated methodology.

TABLE 5-2 (Continued)

LIFELINE RATE  	Definition: Price for "necessary" water use is kept low. Best used for: Reducing average use. Considerations: Usually used to ensure that low-income users are not unduly burdened by high prices.
SLIDING SCALE  	Definition: Price level per unit for all water used increases based on average daily consumption. Best used for: Reducing average (and sometimes peak) use. Considerations: Large-volume users consider this structure inequitable.
SCARCITY PRICING  	Definition: Cost of developing new supply is attached to existing use. Best used for: Reducing average use. Considerations: Used where supplies are diminishing (i.e., a finite supply) so that the costs of developing new supplies are paid for by current users.
SPATIAL PRICING  	Definition: User pays for actual cost of supplying water to its establishment. Best used for: Discouraging new or difficult to serve connections. Considerations: Used in areas where the distribution system is being expanded rapidly and in difficult to serve areas.

Source: Adapted from American Water Works Association, Before the Well Runs Dry: Volume I--A Handbook for Designing a Local Conservation Plan (Denver, CO: American Water Works Association, 1984), 61-63. *Authors' construct.

TABLE 5-3

DEVELOPMENT OF CUSTOMER COSTS PER METER

Annual Customer Costs

Inside city = $145,390/17,025 unit = $8.54/unit
Outside city = $19,250/1,810 units = $10.64/unit

Meter size	Ratios	Annual Cost Per Meter
Inside City		
5/8-inch	1.00	$ 8.54
3/5-inch	1.25	10.68
1-inch	1.60	13.66
1-1/2-inch	2.60	22.20
2-inch	3.60	30.74
3-inch	7.00	59.78
5-inch	12.50	106.75
6-inch	25.50	217.77
Outside City		
5/8-inch	1.00	10.64
3/5-inch	1.25	13.30
1-inch	1.60	17.02
2-inch	3.60	38.30

Source: Paul J. Hartman, "Development and Design of Water Rate Schedules," in *AWWA Seminar on Developing Water Rates* (Denver, CO: American Water Works Association, 1973), IV-23.

based on the base-extra capacity method of cost allocation appears in table 5-4. In this example, minimum use is defined as 1,000 gallons a month. The fixed monthly charge covers not only customer costs but minimal base and extra capacity costs as well.

Fixture Rates

A rudimentary method for linking water rates to consumption, without metering actual use, is the fixture rate, illustrated in table 5-5. A fixture rate depends on accurate knowledge of water-using fixtures on the premises of each customer served--the number of faucets, toilets, bathtubs, showers, and so on. To the extent that water use varies with the presence of fixtures and the cost of service varies with water use, a fixture rate can be considered cost based. (It is certainly more so than a flat fee.) Fixture rates may be justified in instances when the cost of metering outweighs its benefits. However, fixture rates rely on highly imperfect and imprecise information and provide no incentive to conserve actual water use. For most systems, metering and variable rates are much preferred.

Uniform Rates

The simplest rate structure for metered customers is the uniform rate, under which all customers are charged the same amount for every unit of water consumed, regardless of consumption levels. Because the rate does not provide a volume discount and customers can minimize their total bill by avoiding excessive use, uniform rates provide an incentive to conserve. There is some evidence that metering alone can stimulate conservation, particularly with regard to outdoor water use.[4] Thus metering may lower peak demands.

Obviously, the uniform rate may not track costs with precision. In particular, uniform rates create a form of temporal cross-subsidization between peak and off-peak users. This rate averaging results in prices exceeding the costs of off-peak service and prices less than the costs of peak service; that is, off-peak users subsidize peak users. Uniform rates also create spatial cross-subsidization by

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[4] Brown and Caldwell, *Residential Water Conservation Projects, Summary Report* (Washington, DC: U.S. Department of Housing and Urban Development, 1984), chapter 7.

TABLE 5-4

MINIMUM BILL DESIGN BASED ON THE BASE-EXTRA CAPACITY COST ALLOCATION METHOD

	Monthly Cost: Inside-City/ 2-inch meter
Customer costs	
Meters and service-related costs ($1.6441/meter) x 2.9 equivalent meter and service ratio	$4.77
Billing and collection costs	2.29
Assume 1.0 thousand gallons monthly allowance, 150% maximum-day extra capacity factor, and 300% maximum-hour extra capacity factor	
Base costs	
$0.2984/thousand gallons x 1.0 thousand gallons	0.30
Extra capacity costs	
Maximum day at $19.0561/year/thousand gallons per day equals $0.0522/thousand gallons $0.0522/thousand gallons x 1.5 extra capacity factor x 1.0 thousand gallons	0.08
Maximum hour at $17.4545/year/thousand gallons per day equals $0.0478/thousand gallons $0.0478/thousand gallons x 3.0 extra capacity factor x 1.0 thousand gallons	0.14
Total minimum charge for 1.0 thousand gallon allowance	$ 7.58

Source: American Water Works Association, *Water Rates* (Denver, CO: American Water Works Association, Manual M1, 1983), 52.

TABLE 5-5

ILLUSTRATION OF A FIXTURE RATE

	Per Annum
Dwelling House, House occupied by one family supplied by one faucet	$20.85
Each additional faucet	3.50
One water closet of appropriate kind	6.30
Each additional water closet	3.80
One bath tub	4.85
Each additional bath tub	3.15
One self-closing urinal, none other allowed	4.15
Dishwasher	5.55
One set tub or automatic washer	5.55
Each additional set tub	1.75
Shower separate from tub at bath tub rate	
Outside shower	4.85
Turn on	8.00
Turn off	8.00

Source: Tisbury Water Works, "Rates and Regulations 1979/80," as reported in Charles F. Phillips, Jr., *The Regulation of Public Utilities* (Arlington, VA: Public Utilities Reports, Inc., 1984), 699. Tisbury Water Works is located in Vineyard Haven, Massachusetts.

ignoring geographic differentials in cost. However, the appeal of the uniform rate structure is linked to its simplicity and the deficiencies associated with multiple block rates. A variation of the uniform rate approach is standard tariff pricing in which the same rate structure is applied to a broad geographical area. In sum, the strengths of the uniform rate include relative simplicity, low administration costs, and ease of consumer understanding; compatibility with prevailing notions of fairness and equity; absence of volume discounts that discourage conservation; and conformity with the behavior of certain unit costs of water provision (for example, treatment) given increasing usage. Limitations of the uniform rate include an inability to track unit costs of water provision with precision (that is, some water provision costs, such as administrative and general costs, are fixed in nature and thus automatically decline with increasing water volume); and a lack of recognition that certain price-elastic users (for example, industrial) may resort to self-supply in the absence of a low tail-block rate, thus creating the serious regulatory problem of stranded capital investment.

Decreasing-Block Pricing

Decreasing (or declining) block rates, compared with uniform rates, provide a discount for large-volume use. An illustration based on the commodity-demand cost allocation method is provided in table 5-6. Proponents of decreasing-block rates contend that large users are entitled to lower per-unit prices because of the economies of scale in serving them. Ramsey pricing theory would argue that these customers should get a price break because their demand is more price-elastic, and reasonable substitutes for the method of water delivery may entice them to leave

TABLE 5-6

SIMPLE DECREASING-BLOCK-RATE SCHEDULE BASED ON THE COMMODITY-DEMAND COST ALLOCATION METHOD

		Rate Block	
	Total	First	Second
Actual water sales			
Thousand gallons	220,000	170,000	50,000
Percent	100.00	77.3	22.7
Weighted water sales (for demand allocation)			
Thousand gallons	390,000	340,000	50,000
Percent	100.00	87.2	12.8
Allocation of volumetric costs			
Commodity	$25,000	$19,300	$5,700
Demand	131,000	114,200	16,800
Total	$156,000	$133,500	$22,500
Rate per thousand gallons		$0.79	$0.45

Source: American Water Works Association, *Water Rates* (Denver, CO: American Water Works Association, Manual M1, 1983), 68.

the water utility system. Critics argue that decreasing-block rates encourage waste and in some cases subsidize large users. With decreasing-block rates, the incentive to conserve *declines* with greater consumption.[5]

The decreasing-block-rate schedule involves decreasing marginal or incremental rates with higher usage blocks. The decreasing-block-rate form recognizes that:

- Certain costs of water provision are fixed (such as depreciation of distribution mains) and thus automatically decline with increasing water usage.
- Certain users (such as industrial users) with relatively more price-elastic demands require lower rates to induce them to remain on the system. Lower rates can avoid forcing the remaining users to bear a larger portion of system costs.
- Certain large users have better load factors than residential and commercial users lowering the short-term unit capacity cost of supplying these users.
- Noncost objectives such as economic development, past practices, and adjacent community rates can be factors in ratemaking.

The original justification for the decreasing-block-rate structure was the pattern of decreasing unit costs with increasing usage (such as economies of scale with capacity expansion and improved capacity or load factors with existing capacity). The decreasing-block-rate structure passes these cost savings on to the consumer. Moreover, decreasing-block rates can be legitimized by carefully developing customer classes, so that the costs assigned to each class reflect load factors, fixed and variable cost proportions, and other appropriate variables. Arguably, the most important reason that decreasing-block rates have been retained is their revenue stability effect. Price-elastic demands tend to fall in the lower-priced tail blocks while price-inelastic demands tend to fall in the higher-priced initial blocks. The appeal of revenue stability is enhanced by the existence of excess capacity.

Another rationale for choosing decreasing-block schedules over uniform rates involves load factors. Larger users tend to have higher load factors (lower ratios

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[5] Duane Baumann, "Issues in Water Pricing," in Arizona Corporation Commission, *Water Pricing and Water Demand* (Phoenix, AZ: Arizona Corporation Commission, 1986), 9.

of peak demand to average demand) than smaller users, resulting in lower required extra capacities than with lower-load-factor smaller users. However, this rationale overlooks the critical issue of timing of demand (actual contribution to peak demand or peak responsibility), which causes the extra capacity to be built and the incremental capacity costs to be incurred.

Despite the reasoning in favor of decreasing-block-rate structures, significant limitations to this approach exist, including:

- The inability (particularly with the use of many blocks) to track costs with precision, given that some unit costs (such as pumping) tend to increase with increasing volume while other unit costs (treatment) tend to remain constant with increasing volume.
- The possibility that the volume discounts in the schedule exceed any discount defensible on cost-of-service principles; that is, there may be little cost justification for the magnitude of the intrablock rate differentials.
- Justification by costing methods that are questionable in their ability to determine cost causality.

A major criticism of decreasing-block rates is their possible failure to track costs with the result that smaller users subsidize larger users. In addition, block design exercises can be relatively crude with the number of blocks, usage breakpoint, and intrablock rate differentials not being cost justified. Although many argue that decreasing-block schedules for water service are justified by declining unit costs in both the short term and in the long term, substantial confusion continues regarding the circumstances under which decreasing-block rates are cost justified.

In the short term, larger volumes of usage on average tend to involve lower unit costs than smaller volumes, particularly since distribution costs tend to be fixed on a per-customer basis. However, declining unit costs do not necessarily justify declining marginal rates. Furthermore, while high fixed customer costs may provide the rationale for a flat service or customer charge, they do not necessarily provide the rationale for declining marginal commodity charges. In the long term, system expansion may involve some economies of scale. However, simply because incremental costs historically may have been below unit costs does not necessarily justify offering lower marginal rates to higher-volume users than to lower-volume users. That is, long-term incremental costs may be increasing and in the near-term or immediate future may be substantially above long-term unit costs. Also, the decreasing-block schedule tends to ignore the specific peak demands which cause the building of system peak capacity. Lower prices for higher volumes can exacerbate the peaking problem with regard to future capacity needs.

Decreasing-block rates cannot be justified in instances where economies of scale are exhausted. In other words, these rates may be appropriate only when a utility experiences decreasing unit costs with increased usage. Decreasing unit costs are attributable in the short term to improvements in capacity utilization and in the long term to economies of scale. There is reason to believe that many water systems have exhausted these scale economies. A contributing factor is the increase in system expansion costs caused by, among other things, the exhaustion of economies of scale in treatment, the depletion of more accessible sources of supply, and diseconomies in distribution. Therefore, increasing use in the short run may justify declining charges given load factor improvements. If this increased usage triggers an increase in required system capacity with the elevation of unit costs, then the promotion of use in the short run conflicts with increasing use in the long run.[6]

Finally, decreasing-block rates conflict with the policy goal of resource conservation. Because they promote consumption rather than conservation, decreasing-block rates may be particularly undesirable during periods of water scarcity. Low-volume customers may be especially resentful of high-volume price discounts. According to Phillips, "The ultimate effects of both a single rate structure for all users and a declining block rate structure not cost justified are price discrimination among customers and a failure to encourage water conservation."[7]

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[6] Patrick C. Mann, "The Water Industry: Economic and Policy Issues," in Charles F. Phillips, Jr., ed., *Regulation, Competition and Deregulation--An Economic Grab Bag* (Lexington, VA: Washington and Lee University, 1979), 104.

[7] Charles F. Phillips, *The Regulation of Public Utilities: Theory and Practice* (Arlington, VA: Public Utilities Reports, Inc., 1984), 703.

Increasing-Block Pricing

Under increasing (or inverted or inclining) block rates, the per-unit price increases with consumption. This rate structure is advocated as a method for reducing average and peak water usage. Large users bear the burden of costs associated with providing large quantities of water. With increasing-block rates, the incentive to conserve increases with greater consumption. Thus, increasing-block rates are a method of demand management. Although long-term effects are not certain, raising prices may be one method of inducing water conservation in the short term. What's more, while many alternative rate schedules may induce conservation, some, such as increasing-block rates, have been implemented for this very purpose in several major United States cities.[8]

The increasing-block-rate schedule involves increasing rates with increasing usage levels. This rate structure has been advocated as one form of conservation pricing. Its justification has been based on the existence of increasing incremental costs with capacity expansion and the goal of reducing income inequalities, both of which are debatable rationales. If increasing-block rates do not track costs, the result is that larger users subsidize smaller users. Increasing-block rates can cause decreasing average demand without corresponding decreases in peak demands; that is, the results include decreased load factors, needle peaking, and revenue erosion. Another problem is revenue instability associated with the potential loss of large customers who resort to self-supply.

The cost argument underlying increasing-block rates is that with incremental costs of new capacity increasing, price signals should discourage increasing usage. However, the cost causers are peak demand contributors who are not necessarily large users. One critic generally rejects the use of an increasing-block rate because it "unduly penalizes large customers who may have very favorable annual consumption characteristics."[9] There also may be other factors differentiating costs that are not accounted for by an increasing-block rate.

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[8] *Ernst & Young's 1990 National Water and Wastewater Rate Survey.*

[9] John D. Russell, "Seasonal and Time of Day Pricing," in American Water Works Association, *Water Rates: An Equitability Challenge* (Denver, CO: American Water Works Association, 1983), 96.

Several other potential problems exist with increasing-block rates. First, they are efficient only under unique circumstances. Second, prices that are below incremental costs in the initial blocks and prices that exceed costs in the tail blocks promote neither conservation nor efficient water use. Third, like decreasing-block rates, increasing-block rates pose problems associated with determining the number of blocks, consumption breakpoints, and rate differentials. Finally, a potentially serious problem is their potential impact on utility costs and revenues because of consumer conservation in response to higher water prices.

Nonetheless, a cost-justified increasing-block-rate schedule is feasible. According to the American Water Works Association (AWWA), "It is possible to use some elements of a cost-of-service study as a guide in the design of inverted rates."[10] Accordingly, a peak-use increasing-block-rate structure could be used to alleviate the poor load factor caused by summer residential use. The AWWA cautions, however, that increasing-block rates can be considered cost-of-service related only under special circumstances.

Seasonal Pricing

Time-differentiated, or seasonal, pricing takes notice of the cost differences between peak and off-peak usage and thus mitigates the temporal cross-subsidization between users. Excess-use rates and indoor/outdoor rates, discussed below, are variations of seasonal rates. Also, seasonal pricing may be combined with other rate structures; table 5-7 provides seasonal increasing-block rates adopted in Tucson, Arizona to encourage water conservation.

Most water utilities experience distinct seasonal peaks, due to weather-sensitive demands. The seasonal load pattern indicates that incremental costs may vary substantially over the water utility's annual demand cycle. Over time, given the peak-load problem, uniform pricing results in allocative inefficiency, an involuntary subsidy to peak users by off-peak users, and an inducement to increase system capacity to meet peak demands. Given the premise that water rates should track costs, seasonal rates provide consumers correct price signals that in turn may allow them to change usage patterns.

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[10] American Water Works Association, *Water Rates,* 58.

TABLE 5-7

SEASONAL INCREASING-BLOCK WATER RATES FOR TUCSON, ARIZONA

Charges	Winter	Summer
April 1977		
Monthly service charge	$1.40	$1.40
Commodity charge		
First 1,000 cubic feet/month	0.55	0.55
Next 1,000 cubic feet/month	0.55	0.66
Next 3,000 cubic feet/month	0.55	0.77
> 5,000 cubic feet/month	0.55	0.88
May 1986		
Monthly service charge	$3.70	$3.70
Commodity charge*		
First 500 cubic feet/month	0.86	0.86
Next 500 cubic feet/month	0.97	0.97
Next 1,000 cubic feet/month	1.15	1.33
Next 1,000 cubic feet/month	1.31	1.64
Next 2,000 cubic feet/month	1.45	1.85
> 5,000 cubic feet/month	1.61	2.08

Source: Reported in Richard W. Cuthbert, "Effectiveness of Conservation-Oriented Water Rates in Tucson," *American Water Works Association Journal* 81 no. 33 (March 1989): 67 and 69.

Seasonal pricing, as well as daily peak load (or time-of-day) pricing are time-differentiation methods that follow marginal-cost pricing theory. Seasonal rates recognize that the unit operating cost of providing water varies between peak and off-peak days, that capacity requirements essentially are determined by peak demands, and that peak users essentially are responsible for the capacity required to serve the peak demand, while off-peak users bear little responsibility. Therefore, seasonal rate design involves assigning lower costs to usage on off-peak days. Seasonal rates impose higher prices during periods of peak use (in the warm-weather months) to recover costs associated with the higher capacity needs caused by lawn sprinkling and landscaping. Daily peak-load rates are infrequently used by water utilities because, unlike electricity, the ability to store water mitigates the daily peaking problem, the cost of water does not vary significantly on an hourly basis, and the investment required for metering under these rates could outweigh the benefits.[11] Time-of-day pricing may, however, be an appropriate load management tool for regulating water pressures. Better load management may help some water utilities avoid building (and paying for) water supply capacity, a tendency exacerbated by occasional drought conditions when peak demand levels are elevated. Also, maximum-hour peaks are appropriately considered in designing fire protection rates (discussed below).

The prerequisites to effective seasonal pricing are several.[12] First, there must be substantial variation in demand between peak and off-peak periods. Second, installed capacity requirements must be determined primarily by the peak demand confronting the water system. Third, the water utility must have peak demands that occur consistently during the same season. Finally, the utility must be able to estimate the cost differences between meeting peak and off-peak demands. Russell provides some guidelines for utilities contemplating the use of seasonal rates:[13]

> - Detailed planning, complete and adequate information programs for customers, and careful administrative and computer procedures are essential for a successful program.
>
> - Any seasonal rate introduced should be relatively modest in price as compared with winter rates at the outset, with later adjustments to increase the differential.
>
> - The summer excess-charge method appears to be the superior method for matching revenues with costs and for discouraging maximum summer demands.
>
> - Any type of summer seasonal rate can cause more variations in revenue than a uniform annual rate.

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[11] John D. Russell, "Seasonal and Time of Day Pricing," in American Water Works Association, *Water Rates: An Equitability Challenge,* 91.

[12] Mann and Schlenger, "Marginal Cost and Seasonal Pricing," 7.

[13] Russell, "Seasonal and Time of Day Pricing," 96.

- A seasonal rate may not be appropriate for all water systems. Where annual supplies are more than adequate and system capacity is adequate or possibly excessive, a seasonal rate may discourage water sales and thus increase the cost of water for the remaining sales, without any substantial benefit to the water system except possibly to better recover costs from summer peaking customers.

The potential benefits of seasonal rates include increased production efficiency (through annual load factor improvements) and reduced peak demands, both of which should enhance the water utility's financial condition. Seasonal rates can be an effective tool for reflecting intertemporal cost differentials without elaborate metering (as required by time-of-day pricing). Reducing peak demands may help extend available water supplies and postpone or eliminate the need for capacity additions.[14] Also, seasonal rates promote conservation while avoiding a problem associated with purely voluntary conservation--that is, declining average usage (but not peak usage) resulting in deteriorating load factors and revenue shortfalls. Finally, for water consumers who are willing and able to modify usage patterns, seasonal rates can result in decreased water bills. In sum, the reasons for considering seasonal pricing--namely conservation and marginal-cost theory--may be compelling for some water systems and their regulators.

Excess-Use Charges

Some analysts prefer the excess-charge form of seasonal pricing (even though the summer/winter form may be easier to administer and easier for customers to understand) because it is more effective for purposes of cost recovery and conservation.[15] The excess-use charge essentially is an increasing-block schedule with two blocks. It requires the determination of "base" and "excess" consumption, with corresponding prices. Excess charges are applied to usage in excess of average winter or base usage. Although some consumers may view this method as arbitrary, the imposition of excess use charges or penalty fees is not uncommon during periods of water shortage, and evidence suggests that the public is supportive of their

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[14] Ibid., 92.

[15] Ibid.

use.[16] However, as a general tool of rate design, this approach is hampered by the difficulty in defining excess use and perceptions that the chosen definition is arbitrary, capricious, or inequitable.

Indoor/Outdoor Rates

A variation on the seasonal rate structure not mentioned in the AWWA discussion of rate schedules is the indoor/outdoor rate schedule.[17] This approach is specifically tailored to household consumption levels, as compared to excess-use charges which are based on averages. This approach is designed to address the problem of inequity occurring when large households with water-efficient landscaping pay more for water than small households with inefficient landscaping, even though the latter contributes "more than its fair share" to the summer peak. Rates for indoor and outdoor use can be charged by installing two meters in each household. This not only is costly, it also could be bypassed by the mischievous homeowner who runs a garden hose from the kitchen sink.

A methodological solution exists to this problem: household consumption during the off-peak season can be used to estimate basic indoor usage during the year. Amounts in excess of this can be billed at the outdoor water rate. Most water suppliers have the data necessary to make this calculation and may use it at present to estimate bills. While the method is slightly inferior to a dual metering system, it may be more equitable among households than simple seasonal rates or excess-use charges.

One potential issue is that treatment costs associated with safe drinking water standards should generally be assigned to indoor water use, or more specifically, to human consumption. However, there are significant economies of scale for water treatment and without a redundant distribution system the differentiation of costs on an indoor/outdoor basis is largely irrelevant. An even more difficult issue is that lower indoor rates provide a disincentive for indoor water conservation. In fact, customers with high outdoor use levels may have an

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[16] Edward F. Renshaw, "Conserving Water Through Pricing," *American Water Works Association Journal* 74 no. 1 (January 1982): 5.

[17] Gary C. Woodard, "A Summary of Research on Municipal Water Demand and Conservation Methodologies," in Arizona Corporation Commission, *Water Pricing and Water Demand* (Phoenix, AZ: Arizona Corporation Commission, 1986), 43-47.

incentive to use indoor water to excess during the winter inflating their base level. The result could be an increase in average use and only slight reductions in peak (summer) use.

Lifeline Pricing

Lifeline pricing can be viewed as another variation of the increasing-block theme. It provides a lower per-unit price for a specified level of consumption so that low-income consumers can receive water service for basic needs at a reasonable cost. In most formulations, the lowest block is priced below the cost of service. Thus the rate is policy-based, not cost-based.

Other than social and humanitarian benefits, some of the key rationales for lifeline rates are that they make it possible to retain customers on the utility system; that they reduce the frequency and cost of disconnections, collections, and bad debt because of nonpayment; and that by providing an affordable bill, many customers can meet the payments rather than continue to be served without paying anything. One of the key drawbacks is that lifeline rates send inappropriate pricing signals, and thus may not encourage conservation.

Lifeline rates in energy are normally provided only to qualifying individuals according to specified poverty indicators. Such rates have been infrequently considered by water utilities or their regulators, probably in large part due to the relative affordability of water. Also, opponents of lifeline programs generally focus on the problem of cross-subsidization and the belief that lifeline policies essentially provide social welfare benefits that are more appropriately administered by governments and funded by general tax revenues.[18] Many also prefer volunteer contributions by some customers that establish special funds for needy customers, with the utility assisting in the process.[19] One fact that mitigates the need for lifeline rates in water supply is that low-income citizens often live in public housing or apartment buildings that are master-metered. Thus, individuals are not

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[18] John F. Guastella, "Lifeline and Social Policy Pricing," in American Water Works Association, *Water Rates: An Equitability Challenge,* AWWA Seminar Proceedings (Denver, CO: American Water Works Association, 1983), 82-87.

[19] "Project Water Help Meets with Success," *Water* (Winter 1987), 25.

directly responsible for the water bill. However, higher water prices are paid indirectly through higher rents.

As the cost of drinking water escalates because of more stringent water quality regulations and as the issue of affordability continues to be debated, lifeline rates may receive more attention. The affordability issue is intrinsically related to the issue of water quality and willingness and ability to pay for it. It also is appropriate to consider conservation programs in conjunction with lifeline rates to minimize waste and heighten consumer awareness of water's increasing value.

Sliding-Scale Pricing

Sliding-scale pricing (like increasing-block rates) assigns higher prices to higher consumption levels, but ties prices to average daily consumption rather than total consumption. Therefore, the strengths and limitations of sliding scale rates are similar to those of increasing-block rates. That is, sliding scale pricing may encourage water conservation, but may also cause larger users to bypass the water system in favor of self supply.

Scarcity Pricing

Another variation of increasing-block rates, similar to sliding scale rates, is scarcity pricing. Water supplies are increasingly threatened both by natural and artificial causes.[20] Scarcity pricing stems from marginal-cost theory and assigns higher prices in accordance with the depletion of existing supplies. It may be appropriate for pricing finite water supplies where it is desirable to have current users pay for developing new supplies.

Spatial Pricing

Another pricing innovation is zonal or spatially differentiated rates. Spatial rates complement time-differentiated rates and may be appropriate for utilities with core and satellite areas than for interconnected systems. Requiring satellite systems

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[20] Janice A. Beecher and Ann P. Laubach *Compendium on Water Supply, Drought, and Conservation* (Columbus, OH: The National Regulatory Research Institute, 1989).

to pay full development costs may discourage water system expansion, a result which may or may not be consistent with local development and land-use planning considerations. Contributions-in-aid-of-construction for new developments are a form of spatial pricing. In addition, hook-up fees can be assessed to cover the cost of initiating service for new customers. If these fees are high, some prospective customers may be discouraged from connecting to the system. Spatial pricing and hook-up fees are designed to recover the ongoing costs of water service.

Uniform rates over geographic space involve cross-subsidization. The rate averaging results in prices exceeding costs for some users and failing to meet costs for others. It is possible that at current rate levels, design and administrative costs may exceed the efficiency gains from spatial pricing. An example of imperfect spatial rates is the urban/suburban variances associated with publicly owned systems. Some of these differentials are justified by capacity and pumping costs while others are motivated by annexation policies and the objective of taxing nonvoters.

Some rate design proposals would have new customers paying higher rates than existing customers. Little economic justification exists, however, for such a distinction between old and new customers. Both groups are jointly responsible for water system expansion and the development of higher-cost supplies; that is, each group contributes to the total system cost associated with meeting average demand. A rational basis for differential treatment between old and new customers is unequal contributions to peak demands. If new customers impose specific costs upon the system that would not be avoided if existing consumers decreased their usage (such as the cost of extending distribution lines), price variances between old and new customers are justified via service connection charges. Again, it may be necessary to take local development and land-use planning considerations into account.

Other Water Charges

Discussed briefly here (and in detail by the American Water Works Association) are four other types of water service charges: dedicated-capacity charges, capital contributions, fire protection charges, and ancillary charges.[21]

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[21] See American Water Works Association, *Water Rates and Related Charges* (Denver, CO: American Water Works Association, Manual M26, 1986).

Table 5-8 provides a summary of the specific types of charges that fall within these general categories.

Dedicated-Capacity Charges

Dedicated-capacity charges are designed to recover capacity costs from those potential future customers for whom the capacity is being installed. The two principal approaches are availability charges and demand-contract charges, compared in table 5-9. Both methods are cost-based and result in the calculation of fixed charges. Availability charges allow the utility to pay for construction. When facilities are complete, they usually are replaced by regular water rates charged to a group of customers. A demand contract is typically entered into by a large water user and contains specific terms of service. Care must be taken that the demand-contract rate not be unduly price discriminatory.

Capital Contributions

Capital contributions by utility customers are used to support water system improvements such as:[22]

- expanding the quantity of water supply available for normal weather periods, droughts, and emergencies for existing customers;
- providing source-of-supply protection from potential or actual contaminants, and treatment facilities necessary to assure water quality compliance with new or upgraded standards;
- providing additional distribution, storage, or pumping capacity to meet system expansion needs for both fire service and general water service;
- upgrading and replacing older facilities to improve reliability, reduce maintenance and repair costs, increase capacity, and meet current standards; and
- expanding the system to provide service to new customers and developing areas.

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[22] Ibid.

TABLE 5-8

SELECTED SPECIAL WATER CHARGES

Dedicated-capacity charges
- Availability charges
- Demand-contract charges

Capital contributions
- Main extension charges
- Participation charges
- System development charges (system buy-in or incremental cost)
- Government grants and low-interest loans

Fire protection charges
- Private fire-protection charges
- Public fire-protection charges

Ancillary charges
- Field-service charges
  - Turn-on/turn-off service
  - Field collections
  - Illegal turn-ons and open meter bypass
  - Special meter readings and final meter readings
  - Meter testing, repairs, resetting, or size change
  - Installation of special or remote meter reading devices
  - Meter boot or stop box clean-out, dig-up, or replacement
  - Special appointments
- Office-service charges
  - New account or transfer charge
  - Collection related charges
  - Administrative, paperwork, and copying fees
  - Wastewater billing fees
- Jobbing and merchandise sales
- Tapping charges
- Application, engineering, and inspection fees
  - Main inspection, filing, and contracts
  - Service-connection and cross-connection inspection
  - Engineering design and water service location
- Construction-water charges
- Miscellaneous work charges
- Unauthorized water use charges
- Unit-cost development charges
- Penalties for water conservation violations
- Special permits (such as irrigation and hydrants)

Source: Derived from American Water Works Association, *Water Rates and Related Charges* (Denver, CO: American Water Works Association, 1986); and Robert M. Wilson, "Special Charges Used by the Denver Water Department," in *AWWA Seminar on the Ratemaking Process: Going Beyond the Cost of Service* (Denver, CO: American Water Works Association, 1986), 11-18.

TABLE 5-9

DEDICATED-CAPACITY CHARGES: A COMPARISON OF METHODS

Availability Charge	
Total investment in plant to be included in availability charge	$450,000
Annual costs	
Debt service	45,000
Payment in lieu of taxes	30,000
Projected annual cost for inspection, billing, and certain (fixed) operation and maintenance expenses	45,000
	$120,000
Monthly charge based on 2,000 equivalent potential customers	$5.00
Demand-Contract Charge	
KYZ Corporation Requirements	
Average daily demand	1.0 mgd
Maximum daily demand	1.5 mgd
Maximum hourly demand	2.0 mgd
Construction of 5,000 feet of 12" water main from treatment plant to site. Estimated cost is $250,000.	
ABC Water Utility	
Annual fixed cost of 2.0 mgd surface supply	$100,000
Annual fixed cost of 4.0 mgd treatment facility	150,000
Annual variable costs (primarily power and chemicals) per million gallons	200.00
Demand charge	
Dedicated construction: $250,000 at 25% (estimated)	62,500
Source of supply ($100,000/2.0 mgd) x 1.0 mgd	50,000
Treatment facility ($150,000/4.0 mgd) x 1.5 mgd	56,250
Total demand charge per year	$168,750
Commodity charge per million gallons	$200.00

Source: Adapted from Vito F. Pennacchio, "Demand and Availability Charges," in AWWA Seminar on The Ratemaking Process: Going Beyond the Cost of Service (Denver, CO: American Water Works Association, 1986), 9-10.

Four types of capital contributions are main extension charges, participation charges, system development charges, and government grants and low-interest loans. The system buy-in and incremental-cost methods for calculating system development charges are compared in table 5-10. System development charges also constitute contributions-in-aid-of-construction, which are increasingly controversial because of taxing and ratemaking implications. The growing capital needs of the water-supply industry brought about by drinking water standards, population growth, and a deteriorating infrastructure may require more attention to the use of capital contributions for system improvements.

Fire Protection Charges

Designing fire protection rates may be the most perplexing task of rate design for water utilities. Fire protection is central to the design of water distribution facilities; yet with good fortune these services can go unused for long periods of time. The cost of private fire protection clearly is assignable while the cost of public fire protection requires some method of allocation. In table 5-11, the equivalent-connection, hydrant/inch-foot, and relative fire-flow requirements methods are compared.

Fixed costs, such as the cost of fire hydrants, are easily translated into fixed charges using some kind of averaging. Capacity costs pose another problem. Cost-based rates, using marginal-cost pricing theory, actually may call for three-tiered pricing, with base costs, seasonal peak costs, and daily (fire protection) peak costs. The costs associated with these peaks can be treated as total service incremental costs.[23] This approach probably results in relatively low fire protection rates. In contrast, a standard of reasonableness for establishing maximum fire protection charges is stand-alone cost or the hypothetical cost associated with a water utility designed to provide fire protection services only, and not general water service. In between lies a price based on the joint provision of general water service and fire

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[23] On the incremental treatment of fire protection costs, see J. Richard Tompkins, "Fire Protection Charges," in *AWWA Seminar on the Ratemaking Process: Going Beyond the Cost of Service* (Denver, CO: American Water Works Association, 1986).

TABLE 5-10

SYSTEM DEVELOPMENT CHARGES: A COMPARISON OF METHODS

System Buy-in Method	Original Cost ($000)	Accumulated Depreciation ($000)	Net Cost ($000)
Source of supply	5,000	1,000	4,000
Treatment and pumping	8,000	1,200	6,800
Distribution system	12,800	1,800	11,000
Services, meters, and hydrants	4,800	800	4,000
General structures	1,400	200	1,200
	$32,000	$5,000	$27,000
Less net cost of			
Distribution system			11,000
Services, meters, and hydrants			4,000
			12,000
Net investment in backup plant less: Outstanding bonds			8,000
Total equity investment			$4,000
Number of customers			20,000
Average net equity investment per equivalent 5/8-inch-meter customer			$200
System development charge			$200

Incremental-Cost Pricing Method	
Annual revenue under existing rates for typical 5/8-inch customer	$205
Less: Annual operation and maintenance expenses ($115) and annual replacement and improvement costs ($30) to be met from rates	145
Net revenue available to service new debt	$60
Debt that can be serviced (assume 20-year debt amortization at 10% annual interest rate ($60/0.1175)	$510
Estimated total investment in backup facilities required to serve a new 5/8-inch customer	$1,300
System development charge	$790

Source: American Water Works Association, *Water Rates and Related Charges* (Denver, CO: American Water Works Association, 1986), 15 and 16.

TABLE 5-11

FIRE PROTECTION RATES: A COMPARISON OF METHODS

Equivalent-Connection Method

	Total	Public	Private
Prorated demand costs	$110,900	$85,400	$25,500
Direct: hydrants	57,000	57,000	--
Direct: private firelines	9,200	--	9,200
	$177,100	$142,400	$34,700

	Number	Size Factor	Eq. 6-inch Connection	Charge/ Connection	Revenues
Public fire services					
Town A hydrants	388	1.0	388		
Town B hydrants	255	1.0	255		
Town C hydrants	512	1.0	512		
	1,155		1,155(77%)	$123.30	$142,412
Private fire services					
5-inch service lines	100	0.44	44	44.00	$ 4,400
6-inch service lines	200	1.00	200	100.00	20,000
8-inch service lines	60	1.72	103	172.00	10,320
	360		347(23%)		34,700
Total equivalent 6-inch connections			1,502		177,132

Hydrant/Inch-Foot Method (Public Fire Protection)

	Inch-feet	Rate	Amount	Hydrants	Rate	Amount	Total
Town A	3,892,000	$0.0050	$19,910	388	$49.35	$19,148	$ 39,058
Town B	2,613,000	0.0050	13,065	255	49.35	12,585	25,650
Town C	10,485,000	0.0050	52,425	512	49.35	25,267	77,692
Total	17,080,000		$85,400	1,155		$57,000	$142,400

Relative Fire-Flow Requirements Method (Public Fire Protection)

	Service Class	Customers	Fire Flow	Equiv. Cust.	Rate	Revenues
Town A	Residential	5,700	1.0	5,700	$7.62	$ 43,434
Town B	Residential	3,700	1.0	3,700	7.62	28,194
Town C	Residential	6,620	1.0	6,620	7.62	50,444
	Commercial	1,080	2.25	2,430	17.14	18,511
	Industrial	60	4.0	240	30.48	1,829
		17,160		18,690		$142,412

Source: Adapted from American Water Works Association, *Water Rates and Related Charges* (Denver, CO: American Water Works Association, Manual M26, 1986), 9-10.

protection by a single utility, perhaps using the average incremental pricing approach.

More complex pricing schemes for fire protection take into account such factors as property values and insurance rates. While some view fire protection as a discrete service, others believe that it is essentially a public good that should be paid for through tax dollars. Obviously, many policy considerations enter into discussions of these rates. In some jurisdictions, public safety considerations may outweigh those of cost causality.

Ancillary Charges

Ancillary charges or fees are designed to recover, as closely as possible, the actual cost of providing specific services, such as tapping and inspections. A selection of these services appears in table 5-8. Water utilities should take care both to recognize the incidental costs associated with certain services they provide and to develop appropriate fee schedules that reflect them.

Rate Structures Approved by Regulatory Commissions

As reported in table 5-12, the types of water rates imposed by regulated water utilities in the reporting jurisdictions for either residential or commercial and industrial use fall predominantly into three categories: unmetered, uniform, and decreasing-block-rate structures. The results indicate that uniform rates are used in many states for both residential or commercial and industrial water service. Over half of the commissions surveyed indicated that all three types of rates were being used for residential customers, and that uniform and decreasing-block rates are under use for commercial and industrial customers. In all, unmetered charges were mentioned slightly more often than decreasing-block rates for residential water use, while the opposite was true for commercial and industrial rates. Moreover, a sizeable share of the commissions reported the use of increasing-block rates and seasonal rates for all service classes. The responses revealed further that increasing-block rates and seasonal rates were more frequently approved for residential customers than for commercial and industrial customers.

TABLE 5-12

WATER STRUCTURES APPROVED BY STATE REGULATORY COMMISSIONS

State	Residential Rates							Commercial/Industrial Rates						
Commission	FF	FX	UN	DB	IB	SE	O	FF	FX	UN	DB	IB	SE	O
Alabama	X	-	-	X	-	-	-	X	-	-	-	-	-	-
Alaska	X	-	-	-	-	-	-	X	-	-	-	-	-	-
Arizona	-	-	-	X	X	X	-	-	-	-	X	X	X	-
Arkansas	-	-	X	-	-	-	-	-	-	X	-	-	-	-
California	X	-	X	X	X	X	-	X	-	X	X	X	X	-
Colorado	-	-	X	-	-	-	-	-	-	X	-	-	-	-
Connecticut	X	X	X	X	-	X	-	X	-	X	X	-	X	-
Delaware	X	-	X	X	-	-	-	X	-	X	X	-	-	-
Florida	X	-	X	-	-	-	-	X	-	X	-	-	-	-
Hawaii	-	-	X	-	-	-	-	-	-	X	-	-	-	-
Idaho	X	-	X	-	-	(a)	-	X	-	X	-	-	(a)	-
Illinois	-	-	X	X	-	-	-	-	-	-	X	-	-	-
Indiana	X	-	-	X	-	-	-	X	-	-	X	-	-	-
Iowa	-	-	X	-	-	-	-	-	-	X	-	-	-	-
Kansas	-	-	X	-	-	-	-	X	-	-	-	-	-	-
Kentucky	X	-	X	X	-	X	-	X	-	X	X	-	X	-
Louisiana	X	-	X	X	-	-	-	-	-	X	X	-	-	-
Maine	-	X	X	X	-	-	-	-	X	X	X	-	-	-
Maryland	X	-	X	X	X	X	-	X	-	X	X	X	X	-
Massachusetts	X	X	X	X	X	X	-	X	X	X	X	X	X	-
Michigan	X	-	X	X	X	-	-	-	-	X	X	-	-	-
Mississippi	X	-	-	X	-	-	-	X	-	-	X	-	-	-
Missouri	-	-	X	-	-	X	-	-	-	X	-	-	-	-
Montana	X	X	X	-	X	-	-	-	-	X	-	-	-	-
Nevada	X	-	X	X	X	X	-	X	-	X	X	X	X	-
New Hampshire	-	-	X	-	-	-	-	-	-	X	-	-	-	-
New Jersey	X	-	X	X	X	X	-	X	-	X	X	X	X	-
New Mexico	-	-	-	X	-	-	-	-	-	X	-	-	-	-
New York	X	-	-	X	X	X	-	-	-	X	X	-	X	-
North Carolina	-	-	X	-	-	-	-	-	-	X	X	-	-	-
Ohio	X	-	X	X	-	X	-	X	-	X	X	-	X	-
Oklahoma	X	-	X	X	X	-	-	X	-	X	X	X	-	-
Oregon(b)	X	-	X	X	-	-	-	-	-	-	-	-	-	-
Pennsylvania	X	X	X	X	-	-	-	-	-	-	X	-	-	-
Rhode Island	X	-	X	-	-	X	-	X	-	X	-	-	X	-

TABLE 5-12 (continued)

State	Residential Rates							Commercial/Industrial Rates						
Commission	FF	FX	UN	DB	IB	SE	O	FF	FX	UN	DB	IB	SE	O
South Carolina	X	-	X	X	X	-	-	-	-	-	X	-	-	-
Tennessee	-	-	X	X	-	-	-	-	-	X	X	-	-	-
Texas	X	-	X	-	X	-	(c)	X	-	X	-	X	-	-
Utah	X	-	X	X	X	-	-	-	-	X	-	-	-	-
Vermont	X	-	X	-	X	-	-	X	-	X	-	X	-	-
Virginia	X	-	X	-	-	-	-	-	-	X	-	-	-	-
Washington	X	-	X	X	X	X	-	X	-	X	X	X	X	-
West Virginia	-	-	X	X	-	-	-	-	-	X	X	-	-	-
Wisconsin	X	-	-	X	-	-	-	X	-	-	X	-	-	(d)
Wyoming	X	X	X	X	-	-	-	-	X	-	-	-	-	-
Virgin Islands	-	-	X	-	-	-	-	-	-	X	-	-	-	-
Number of commissions	31	6	38	29	15	14	1	22	3	34	25	10	13	1

Source: 1990 NRRI Survey on Commission Regulation of Water Systems.

FF = Flat fee
FX = Fixture rate
UN = Uniform rate
DB = Decreasing-block rate
IB = Increasing-block rate
SE = Seasonal rate
O = Other

(a) One system adds a summer surcharge to the uniform rate.
(b) No commercial or industrial customers.
(c) Improvement surcharge.
(d) Decreasing-block with lower blocks increasing.

Conclusion

Whatever rate design is selected, it can be appropriately evaluated by how well it meets the utility's revenue requirement. A variety of methods exist to do this, ranging from sophisticated computer simulation modeling to a basic bill tabulation analysis.[24] In the end, it is not uncommon to make adjustments to the rate structure either to match revenue requirements or meet other policy goals.

Despite the many methodological alternatives, rate design tends to be as much art as science, leaving a considerable degree of discretion to regulators. For publicly owned water utilities, it may be simpler to incorporate policy goals other than cost causation into the ratemaking process. For investor-owned water utilities under the jurisdiction of the state public utility commissions, these goals must be reconciled with traditional principles of regulation. The inclination of the commissions to promote wise use or other policies may depend on legislative mandates, precedents in other utility areas, and whether outcomes are considered consistent with the public interest and other regulatory objectives.

In his critique of lifeline rates, one analyst concludes with the general observation that rate design involves a considerable degree of "informed judgment" and that:

> Specific rate structures have and will continue to incorporate features relating to particular characteristics and objectives. So long as basic cost principles are not significantly compromised, there can be room for "policy" adjustments to effect gradual trends toward such goals as conservation, fuller recognition of economies of scale and even minimizing impact on low-use customers.[25]

The harsh reality is that not every policy goal can be met within the confines of a single--or simple--rate structure.

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[24] American Water Works Association, *Water Rates* (American Water Works Association, Manual M1, 1983), Appendix.

[25] Guastella, "Lifeline and Social Policy Pricing," in American Water Association, *Water Rates: An Equitability Challenge*, 87.

CHAPTER 6

CONCLUSIONS

This report has focused mainly on the costing and pricing of water service. This focus is not intended to imply or indicate that other issues are less important. Economic arguments tend to elevate pricing above other concerns; indeed, more efficient pricing is expected to solve a myriad of production, consumption, and allocation problems. But it is important to recognize that better pricing of water, though essential, is not a panacea for all the issues facing the providers of public water service.

Some Other Issues

Among the important policy issues distinct from price is the concern for water quality both at intake treatment and sewage discharge points. A related issue is the optimal mix of treatment expenditures and water quality. Given surface sources, there is the regulatory policy issue of trading off increased sewage treatment costs upstream for decreased water treatment costs downstream. The focus on water service costing, pricing, and investment decisions for commission-regulated water utilities should not detract from the importance of making similar decisions concurrently for sewage disposal. Water and sewage systems are interrelated (for example, a decrease in household water consumption can result in a decrease in the volume of waste). Separating the decisionmaking for water and sewage pricing can negate efficient pricing and investment policies in water provision. One can argue that sewage cost recovery and pricing is at present less efficient than water service costing and pricing.

Furthermore, the efficient costing and pricing of centrally supplied water service should not be viewed as a complete solution to the efficient use and allocation of water supplies. For example, the historically inefficient pricing of irrigation water in the western United States probably more than offsets any societal gains to be derived from the increased efficiencies in pricing public water supplies. In some states, even in terms of public water service, the proportion of water supplied by commission-regulated water utilities is relatively small. The water utilities regulated by the California Public Utilities Commission, for example, provide an estimated 2 percent of the total public water supply in California. Thus, any attempts by the Commission to attain efficient water pricing and water conservation will have but a small effect on the overall use of public water supplies in that state. Pricing inconsistency among the major water use sectors and between regulated and unregulated sectors will continue to pose a problem.

One of the most difficult unresolved issues is the need to define priority uses for water, which also should be reflected in price. Unfortunately, price and priority in water use are not always consistent. During periods of drought, the burden of use restrictions can be greater for residential users than for irrigation users. Appropriate price signals can redefine priorities and encourage adoption of permanent water conservation measures in some sectors. However, priorities may also be determined by other public policies, specifically those reflected in drought contingency and long-term supply plans. Where water conservation is concerned, commissions should consider water pricing as an important tool but recognize that consumer education about the wise use of water is equally important.[1]

Long-term planning is an emerging issue in water supply. Concerns about water quality and quantity are contributing factors, and there is an increasing need to integrate the many governmental institutions involved in water. Federal, state, and local governments all make policies affecting water, yet often there is limited coordination of their efforts. State public utility commissions need to work more closely with state drinking water and environmental officials responsible for water policy, particularly as to the role of prices in water supply and demand.

There also is a growing concern about whether the structure of the water industry is suited to meet contemporary demands. In particular, the proliferation of numerous small and financially nonviable systems is a problem. In response, there are many proponents of mergers and acquisitions in water supply so that any potential economies of scope (in production or even management) are realized. Restructuring the industry may prove as important as pricing reform to its long-term viability. Included in structural issues are bypass through self supply and the purchase of bottled water.

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[1] Janice A. Beecher and Ann P. Laubach, *Compendium on Water Supply, Drought, and Conservation* (Columbus, OH: The National Regulatory Research Institute, 1989).

Even more important may be technological innovations--especially in water treatment for small systems--that improve the economic situation of individual providers faced with specific supply issues. Portable, affordable treatment systems for small water suppliers may help mitigate the impact of safe drinking water regulations. Interconnecting water systems combines structural and technological solutions that may improve the viability of some systems. However, such solutions are partially dependent on pricing and the assurance of an adequate revenue stream to the water system for adopting these innovations. Management, planning, and cost recovery policies may help promote long-term efficiency through the adoption of innovative technologies.

Regulation by state commissions is imperfect but essential to preventing the abuse of monopoly power. Efficiency and effectiveness of regulation can be improved in a variety of ways.[2] Also, price regulation may not be viewed as necessary for some water utilities. However, one possibility for improving water pricing generally is to expand regulatory authority so that some state or regional oversight is provided to municipalities and other local ratemaking bodies. Such oversight helps remove ratemaking from local political pressures, where incentives to keep prices down may dominate the goals of cost-based ratemaking. State commission regulation has the advantage of being a centralized source of technical regulatory expertise. Thus, the long-term interest in pricing may involve regulatory restructuring as well.

Some Evaluation Criteria

As alternatives in cost allocation and rate design for water utilities are considered, an analytical framework tailored to the particular needs of utilities or regulators can be a useful tool.

A simple framework was introduced in chapter 1. That framework suggested that in considering ratemaking and changes therein, the analyst may seek to compare the perspectives of utilities, consumers, and society as a whole, recognizing that each encompasses different types of goals. Often, conflicts emerge over specific issues because these goals are difficult to reconcile. Incremental-cost

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[2] Janice A. Beecher and Patrick C. Mann, *Deregulation and Regulatory Alternatives for Water Utilities* (Columbus, OH: The National Regulatory Research Institute, 1990).

pricing, for example, may meet society's criterion of economic efficiency (and more than meet utility revenue requirements) while resulting in rates perceived as "unaffordable" by consumers. Only the rarest cost allocation and rate design method will achieve a balanced solution that is actually satisfactory from all three perspectives. It is instead an exercise in optimization, with the explicit knowledge that some goals are partially sacrificed in the interest of achieving others.

On the choice of particular methods, chapter 4 developed an evaluation framework for marginal-cost pricing emphasizing four general issues: allocative efficiency, cost and rate stability, financial viability, and administrative feasibility. Associated with each are several issues related to the practical application of pricing theory. These also may be used in evaluating cost allocation and rate design alternatives. Once again, tradeoffs among competing goals are readily apparent. For example, while the uniform rate structure may be administratively simple, it may be deficient in terms of allocative efficiency or ensuring the long-term viability of the water utility. It is a matter of policy, of course, to determine which criterion is more important than another.

Perhaps most difficult to reconcile are quantitative and qualitative evaluation criteria. In the end, revenue requirements are far easier to estimate than, say, the affordability of water bills. There may be a temptation to use mainly quantifiable indicators of success or failure and avoid the less quantifiable. Yet cost allocation and rate design cannot occur in a vacuum. It may seem necessary at times to relax cost-of-service criteria in the interest of consumer understanding and acceptance, particularly if perceptions of equity are at stake. However, once the door is open to subjective criteria in ratemaking, it is difficult to keep political and other influences out of the process. Subjective criteria, then, must be used with caution.

It may be useful to develop evaluation criteria for cost allocation and rate design in the context of a planning framework. As already noted, pricing is clearly associated with planning. The interest in least-cost planning for all public utilities--water utilities included--continues to rise. The planning process not only serves to identify trends in supply and demand and future capacity options, but to identify the goals and priorities of the water utility. Pricing alternatives can be assessed in these terms. Likewise, long-term planning must take into account the role of price.

Some Research Needs

Public utility regulation clearly has not identified an ideal solution to the cost allocation and rate design puzzle, in part because no single solution exists. Further research will play a role in the evolution of approaches.

In general, the issues of value, cost, and price and their interconnections merit further analysis. Water's global abundance can be deceptive. Growing populations have placed stress on the hydrological system both in terms of quality and quantity. In theory, pricing can improve the allocation of water resources. The economic, operational, and cost characteristics of the public water supply industry could be better understood, particularly its differences and similarities compared to other public utilities. Cost allocation for water utilities requires further refinement. A pressing need exists for the development of cost allocators founded in empirical observation. Engineering process models, econometric models, optimization or simulation models, and other methods can be appropriately applied to the analysis of costs and their causes. Rate design for water utilities is an obvious choice for further research. Attention may be especially needed in understanding how well rate design alternatives meet different policy goals as well as how they satisfy revenue requirements. The issues of financial viability for water providers and affordability for water consumers may emerge as some of the most important research topics. In sum, cost allocation and rate design for water utilities now merit a prominent place on the regulatory research agenda.

APPENDIX A

NARUC UNIFORM SYSTEM OF ACCOUNTS FOR CLASS A WATER UTILITIES

NARUC UNIFORM SYSTEM OF ACCOUNTS
FOR CLASS A WATER UTILITIES

BALANCE SHEET ACCOUNTS

Assets and Other Debts

Utility Plant

101. Utility Plant in Service
102. Utility Plant Leased to Other
103. Property Held for Future Use
104. Utility Plant Purchased or Sold
105. Construction Work in Progress
106. Completed Construction Work Not Classified
108. Accumulated Depreciation
    - 108.1 Accumulated Depreciation of Utility Plant in Service
    - 108.2 Accumulated Depreciation of Utility Plant Leased to Others
    - 108.3 Accumulated Depreciation of Property Held for Future Use
110. Accumulated Amortization
    - 110.1 Accumulated Amortization of Utility Plant in Service
    - 110.2 Accumulated Amortization of Utility Plant Leased to Others
114. Utility Plant Acquisition Adjustments
115. Accumulated Amortization of Utility Plant Acquisition Adjustments
116. Other Utility Plant Adjustments

Other Property and Investments

121. Nonutility property
122. Accumulated Depreciation and Amortization of Nonutility Property
123. Investment in Associated Companies
124. Utility Investments
125. Other Investments
126. Sinking Funds
127. Other Special Funds

Current and Accrued Assets

131. Cash
    - 131.1 Cash on Hand
    - 131.2 Cash in Bank
132. Special Deposits
133. Other Special Deposits
134. Working Funds
135. Temporary Cash Investments
141. Customer Accounts Receivable
142. Other Accounts Receivable
143. Accumulated Provision for Uncollectible Accounts--Cr.

144. Notes Receivable
145. Accounts Receivable from Associated Companies
146. Notes Receivable from Associated Companies
151. Plant Material and Supplies
152. Merchandise
153. Other Material and Supplies
161. Stores Expense
162. Prepayments
171. Accrued Interest and Dividends Receivable
172. Rents Receivable
173. Accrued Utility Revenues
174. Miscellaneous Current and Accrued Assets

Deferred Debits

181. Unamortized Debt Discount and Expense
182. Extraordinary Property Losses
183. Preliminary Survey and Investigation Charges
184. Clearing Accounts
185. Temporary Facilities
186. Miscellaneous Deferred Debits
    186.1 Deferred Rate Case Expense
    186.2 Other Deferred Debits
187. Research and Development Expenditures
190. Accumulated Deferred Income Taxes
    190.1 Federal
    190.2 State
    190.3 Local

Equity Capital and Liabilities

Equity Capital

201. Common Stock Issued
202. Common Stock Subscribed
203. Common Stock Liability for Conversion
204. Preferred Stock Issued
205. Preferred Stock Subscribed
206. Preferred Stock Liability for Conversion
207. Premium on Capital Stock
209. Reduction in Par or Stated Value of Capital Stock
210. Gain on Resale or Cancellation of Reacquired Capital Stock
211. Other Paid-In Capital
212. Discount on Capital Stock
213. Capital Stock Expense
214. Appropriated Retained Earnings
215. Unappropriated Retained Earnings
216. Reacquired Capital Stock
218. Proprietary Capital (for proprietorships and partnerships only)

Long-Term Debt

221. Bonds
222. Reacquired Funds
223. Advances from Associated Companies
224. Other Long-Term Debt

Current and Accrued Liabilities

231. Accounts Payable
232. Notes Payable
233. Accounts Payable to Associated Companies
234. Notes Payable to Associated Companies
235. Customer Deposits
236. Accrued Taxes
    - 236.1 Accrued Taxes, Utility Operating Income
        - 236.11 Accrued Taxes, Taxes Other Than Income
        - 236.12 Accrued Taxes, Income Taxes
237. Accrued Interest
    - 237.1 Accrued Interest on Long-Term Debt
    - 237.2 Accrued Interest on Other Liabilities
238. Accrued Dividends
239. Matured Long-Term Debt
240. Matured Interest
241. Miscellaneous Current and Accrued Liabilities

Deferred Credits

251. Unamortized Premium on Debt
252. Advances for Construction
253. Other Deferred Credits
255. Accumulated Deferred Investment Tax Credits
    - 255.1 Accumulated Deferred Investment Tax Credits, Utility Operations
    - 255.2 Accumulated Deferred Investment Tax Credits, Nonutility Operations

Operating Reserves

261. Property Insurance Reserve
262. Injuries and Damages Reserve
263. Pensions and Benefits Reserve
265. Miscellaneous Operating Reserves

Contributions in Aid of Construction

271. Contributions in Aid of Construction
272. Accumulated Amortization of Contributions in Aid of Construction

Accumulated Deferred Income Taxes

281. Accumulated Deferred Income Taxes -- Accelerated Amortization
282. Accumulated Deferred Income Taxes -- Liberalized Depreciation
283. Accumulated Deferred Income Taxes -- Other

WATER UTILITY PLANT ACCOUNTS

301. Organization (301.1)
302. Franchises (302.1)
303. Land and Land Rights (303.2 - 303.5)
304. Structures and Improvements (304.2 - 304.5)
305. Collecting and Impounding Reservoirs (305.2)
306. Lake, River, and Other Intakes (306.2)
307. Wells and Springs (307.2)
308. Infiltration Galleries and Tunnels (308.2)
309. Supply Mains (309.2)
310. Power Generation Equipment (310.2)
311. Pumping Equipment (311.2)
320. Water Treatment Equipment (320.3)
330. Distribution Reservoirs and Standpipes (330.4)
331. Transmission and Distribution Mains (331.4)
333. Services (333.4)
334. Meters and Meter Installation (334.4)
335. Hydrants (335.4)
339. Other Plant and Miscellaneous Equipment (339.1 - 339.4)
340. Office Furniture and Equipment (340.5)
341. Transportation (341.5)
342. Stores Equipment (342.5)
343. Tools, Shop and Garage Equipment (343.5)
344. Laboratory Equipment (344.5)
345. Power Operated Equipment (345.5)
346. Communications Equipment (346.5)
347. Miscellaneous Equipment (347.5)
348. Other Tangible Plant (348.5)

Water Utility Plant Subaccounts (as applicable)

.1 Intangible Plant
.2 Source of Supply and Pumping Plant
.3 Water Treatment Plant
.4 Transmission and Distribution Plant
.5 General Plant

INCOME ACCOUNTS

Utility Operating Income

400. Operating Revenues
401. Operating Expenses
403. Depreciation Expense
406. Amortization of Utility Plant Acquisition Adjustment
407. Amortization Expense
    407.1 Amortization of Limited Term Plant
    407.2 Amortization of Property Losses
    407.3 Amortization of Other Utility Plant
408. Taxes Other Than Income
    408.10 Utility Regulatory Assessment Fees
    408.11 Property Taxes
    408.12 Payroll Taxes
    408.13 Other Taxes and Licenses
409. Income Taxes
    409.10 Federal Income Taxes, Utility Operating Income
    409.11 State Income Taxes, Utility Operating Income
    409.12 Local Income Taxes, Utility Operating Income
410. Provision for Deferred Income Taxes -- Credit
    411.10 Provision for Deferred Income Taxes -- Credit, Utility Operating Income
412. Investment Tax Credits
    412.10 Investment Tax Credits Deferred to Future Periods, Utility Operations
    412.11 Investment Tax Credits Restored to Operating Income, Utility Operations
413. Income from Utility Plant Leased to Others
414. Gains (Losses) from Disposition of Utility Property

Other Income and Deductions

415. Revenues from Merchandising, Jobbing and Contract Work
416. Costs and Expenses of Merchandising, Jobbing and Contract Work
419. Interest and Dividend Income
420. Allowance for Funds Used During Construction
421. Nonutility Income
426. Miscellaneous Nonutility Expenses

Taxes Applicable to Other Income and Deductions

408. Taxes Other Than Income
    408.20 Taxes Other Than Income, Other Income and Deductions
409. Income Taxes
    409.20 Income Taxes, Other Income and Deductions
410. Provision for Deferred Income Taxes
    410.20 Provision for Deferred Income Taxes, Other Income Deductions
411. Provision for Deferred Income Taxes -- Credit

    411.20 Provisions for Deferred Income Taxes -- Credit, Other Income and Deductions
- 412. Investment Tax Credits
    - 412.20 Investment Tax Credits -- Net, Nonutility Operations
    - 412.30 Investment Tax Credits Restored to Nonoperating Income, Utility Operations

Interest Expense

- 427. Interest Expense
    - 427.1 Interest on Debt to Associated Companies
    - 427.2 Interest on Short-Term Debt
    - 427.3 Interest on Long-Term Debt
    - 427.4 Interest on Customer Deposits
    - 427.5 Interest -- Other
- 428. Amortization of Debt Discount and Expense
- 429. Amortization of Premium on Debt

Extraordinary Items

- 433. Extraordinary Income
- 434. Extraordinary Deductions
- 409. Income Taxes
    - 409.30 Income Taxes, Extraordinary Items

RETAINED EARNINGS ACCOUNTS

- 435. Balance Transferred From Income
- 436. Appropriations of Retained Earnings
- 437. Dividends Declared -- Preferred Stock
- 438. Dividends Declared -- Common Stock
- 439. Adjustments to Retained Earnings

WATER OPERATING REVENUE ACCOUNTS

Water Sales

- 460. Unmetered Water Revenue
- 461. Metered Water Revenue
    - 461.1 Metered Sales to Residential Customers
    - 461.2 Metered Sales to Commercial Customers
    - 461.3 Metered Sales to Industrial Customers
    - 461.4 Metered Sales to Public Authorities
    - 461.5 Metered Sales to Multiple Family Dwellings
- 462. Fire Protection Revenue
    - 462.1 Public Fire Protection
    - 462.2 Private Fire Protection
- 464. Other Sales to Public Authorities

465. Sales to Irrigation Customers
466. Sales for Resale
467. Interdepartmental Sales

Other Water Revenues

470. Forfeited Discounts
471. Miscellaneous Service Revenues
472. Rents From Water Property
473. Interdepartmental Rents
474. Other Water Revenues

WATER OPERATION AND MAINTENANCE EXPENSE ACCOUNTS

601. Salaries and Wages -- Employees (601.1 - 601.8)
603. Salaries and Wages -- Officers, Directors, and Majority Stockholders (603.1 - 603.8)
604. Employee Pensions and Benefits (604.1 - 604.8)
610. Purchased Water (610.1)
615. Purchased Power (615.1, 615.3, 615.5, 615.7, 615.8)
616. Fuel for Power Production (616.1, 616.3, 616.5, 616.7, 616.8)
618. Chemicals (618.1 - 618.8)
620. Materials and Supplies (620.1 - 620.8)
631. Contractual Services -- Engineering (631.1 - 631.8)
632. Contractual Services -- Accounting (632.1 -632.8)
633. Contractual Services -- Legal (633.1 - 633.8)
634. Contractual Services -- Management Fees (634.1 - 634.8)
635. Contractual Services -- Other (635.1 - 635.8)
641. Rental of Building/Real Property (641.1 - 641.8)
642. Rental of Equipment (642.1 - 642.8)
650. Transportation Expenses (650.1 - 650.8)
656. Insurance -- Vehicle (656.1 - 656.8)
657. Insurance -- General Liability (657.1 - 657.8)
658. Insurance -- Workman's Compensation (658.1 - 658.8)
659. Insurance -- Other (659.1 - 659.8)
660. Advertising Expense (660.8)
666. Regulatory Commission Expenses -- Amortization of Rate Case Expense (666.8)
667. Regulatory Commission Expenses -- Other (667.1 - 667.8)
670. Bad Debt Expense (670.7)
675. Miscellaneous Expenses (675.1 - 675.8)

Water Operation and Maintenance Expense Subaccounts (as applicable)

.1 Source of Supply and Expenses -- Operations
.2 Source of Supply and Expenses -- Maintenance
.3 Water Treatment Expenses -- Operations
.4 Water Treatment Expenses -- Maintenance
.5 Transmission and Distribution -- Operations
.6 Transmission and Distribution -- Maintenance
.7 Customer Accounts -- Expenses
.8 Administration and General Expenses

APPENDIX B

AN EXAMPLE OF THE COMMODITY-DEMAND COST ALLOCATION METHOD

TABLE B-1. Allocation of Plant Value
Commodity-Demand Method

			Demand		Customer	Direct Fire-
Item	Total	Commodity	Maximum Day	Maximum Hour	Meters & Services	Protection Service
Source-of-supply plant:						
Land and land rights	$ 423,000	$ 423,000				
Reservoir	204,000	204,000				
Pumping plant:						
Raw water pumping and transmission lines	114,000		$ 114,000			
Treated-water pumping	425,000		425,000			
Treatment plant	1,048,000		1,048,000			
Transmission and distribution plant:						
Structures and improvements	40,000			$ 30,000	$ 9,000	$ 1,000
Distribution storage	413,000			413,000		
Transmission mains	3,112,000			3,112,000		
Distribution mains	1,830,000			1,830,000		
Meters	472,000				472,000	
Services	1,078,000				1,078,000	
Fire hydrants	248,000					248,000
General plant:						
Office	186,000	12,000	31,000	107,000	31,000	5,000
Vehicles	17,000	1,000	3,000	10,000	3,000	
Other	141,000	9,000	24,000	81,000	23,000	4,000
Total plant value	9,751,000	649,000	1,645,000	5,583,000	1,616,000	258,000
Less: Contributions in aid of construction	750,000				750,000	
Rate base	$9,001,000	$ 649,000	$1,645,000	$5,583,000	$ 866,000	$ 258,000

Source: American Water Works Association; Water Rates (Denver, CO: American Water Works Association, Manual M1, 1983), 19.

TABLE B-2. Allocation of Depreciation Expense
Commodity-Demand Method

Item	Total	Commodity	Demand		Customer Meters & Services	Direct Fire-Protection Service
			Maximum Day	Maximum Hour		
Source-of-supply plant:						
Land and land rights						
Reservoir	$ 3,200	$ 3,200				
Pumping plant:						
Raw water pumping and transmission lines	3,500		$ 3,500			
Treated-water pumping	14,200		14,200			
Treatment plant	28,000		28,000			
Transmission and distribution plant:						
Structures and improvements	1,100			$ 600	$ 400	$ 100
Distribution storage	10,300			10,300		
Transmission mains	37,500			37,500		
Distribution mains	32,500			32,500		
Meters	22,500				22,500	
Services	33,200				33,200	
Fire hydrants	8,300					8,300
General plant:						
Office	4,600	100	1,100	1,900	1,300	200
Vehicles	4,000	100	900	1,600	1,200	200
Other	10,100	200	2,400	4,200	2,900	400
Total depreciation expense	$213,000	$ 3,600	$ 50,100	$ 88,600	$ 61,500	$ 9,200

Source: American Water Works Association; Water Rates (Denver, CO: American Water Works Association, Manual M1, 1983), 20.

TABLE B-3. Allocation of Operation-and-Maintenance Expense
Commodity-Demand Method

			Demand		Customer Costs		Direct Fire
Item	Total	Commodity	Maximum Day	Maximum Hour	Meters & Services	Billing Collecting	Protection Service
Source-of-supply	$ 17,000	$ 17,000					
Pumping:							
Power	152,700	108,400	$ 44,300				
Other	107,400		107,400				
Total	260,100	108,400	151,700				
Treatment:							
Chemicals	99,900	99,900					
Other	69,600		69,600				
Total	169,500	99,900	69,600				
Transmission and distribution:							
Distribution storage	14,000			$ 14,000			
Transmission mains	54,100			54,100			
Distribution mains	35,200			35,200			
Meters	96,600				$ 96,600		
Services	35,300				35,300		
Fire hydrants	16,500						$ 16,500
Other	60,000			24,600	31,500		3,900
Total	311,700			127,900	163,400		20,400
General billing and collecting:							
Meter reading	110,800					$ 110,800	
Billing and collecting	203,700					203,700	
Other	11,800					11,800	
Total	326,300					326,300	
Administration and general:							
Fringe benefits	81,800	2,300	25,000	13,200	16,000	22,600	2,700
Other	303,600	6,400	67,100	46,900	59,600	115,900	7,700
Total	385,400	8,700	92,100	60,100	75,600	138,500	10,400
Total operation-and-maintenance expense	$1,470,000	$ 234,000	$ 313,400	$ 188,000	$ 239,000	$ 464,800	$ 30,800

Source: American Water Works Association; <u>Water Rates</u> (Denver, CO: American Water Works Association, Manual M1, 1983), 21.

TABLE B-4. Unit Costs of Service
Commodity-Demand Method

			Demand		Customer Costs		
Item	Total Cost	Commodity	Maximum Day	Maximum Hour	Meters & Services	Billing Collecting	Direct Fire Service
Total system units of service:							
Number		2,877,000	16,563	29,632	18,159	203,136	
Units		thou. gal	thou. gpd	thou. gpd	equiv. meters	bills	
Operation-and-maintenance expense:							
Total	$1,470,000	$234,00	$313,400	$188,000	$239,000	$464,800	$30,800
Unit cost ($ unit)		0.0813	18.9217	6.3445	13.1615	2.2881	
Depreciation expense:							
Total	$213,000	$3,600	$50,100	$88,600	$61,500		$9,200
Unit cost ($ unit)		0.0013	3.0248	2.9900	3.3868		
Rate Base:							
Total rate base	$9,001,000	$649,000	$1,645,000	$5,583,000	$866,000		$258,000
Unit rate base ($ unit)		0.2256	99.3178	188.4112	47.6899		
Payment in lieu of taxes:							
Total	$175,000	$12,600	$32,000	$108,600	$16,800		$5,000
Unit cost ($ unit)		0.0044	1.9320	3.6650	0.9252		
Unit return on rate base:							
Inside-city ($ unit) *		0.0107	4.6977	8.9118	2.2557		$12,000
Outside-city ($ unit) **		0.0169	7.4488	14.1308	3.5767		
Total unit costs of service:							
Inside-city ($ unit)		0.0977	28.5762	21.9113	19.7292	2.2881	
Outside-city ($ unit)		0.1039	31.3273	27.1303	21.0502	2.2881	

* At 4.73 percent return on $8,420,000 rate base.

** At 7.5 percent return on $583,000 rate base.

Source: American Water Works Association; Water Rates (Denver, CO: American Water Works Association, Manual M1, 1983), 34.

TABLE B-5. Cost Distribution to Customer Classes
Commodity-Demand Method

		Demand		Customer Costs		Direct Fire-	Total
Item	Commodity	Maximum Day	Maximum Hour	Meters & Services	Billing & Collecting	Protection Service	Cost of Service
Inside-city:							
Unit cost of service ($ unit)	0.0977 per thou. gal	28.5762 per thou. gpd	21.9113 per thou. gpd	19.7292 per equiv. meter	2.2881 per bill		
Retail service:							
Residential:							
Units of service	928,000	6,355	10,168	16,019	190,452		
Allocated cost of service	$ 90,700	$ 181,600	$ 222,800	$ 316,100	$ 435,800		$1,247,000
Commercial:							
Units of service	590,000	3,232	5,252	1,951	12,528		
Allocated cost of service	$ 57,600	$ 92,400	$ 115,100	$ 38,500	$ 28,700		$ 332,300
Industrial:							
Units of service	1,149,000	4,722	6,296	169	120		
Allocated cost of service	$ 112,300	$ 134,900	$ 138,000	$ 3,300	$ 300		$ 388,800
Fire-protection service:							
Units of service		960	5,760				
Allocated cost of service		$ 27,400	$ 126,200			$ 57,000	$ 210,600
Total inside-city allocated cost of service							$2,178,700
Outside-city:							
Unit costs of service ($ unit)	0.1039	31.32773	27.1303	21.0502	2.2881		
Wholesale:							
Units of service	210,000	1,294	2,156	20	36		
Allocated cost of service	$ 21,800	$ 40,500	$ 58,500	$ 400	$ 100		$ 121,300
Total system allocated cost of service	$ 282,400	$ 476,800	$ 660,600	$ 358,300	$ 464,900	$ 57,000	$2,300,000

Source: American Water Works Association; Water Rates (Denver, CO: American Water Works Association, Manual M1, 1983), 36.

APPENDIX C

AN EXAMPLE OF THE BASE-EXTRA CAPACITY COST ALLOCATION METHOD

TABLE C-1. Allocation of Plant Value
Base-Extra Capacity Method

Item	Total	Base	Extra Capacity		Customer Meters & Services	Direct Fire Service
			Maximum Day	Maximum Hour		
Source-of-supply plant:						
Land and land rights	$ 423,000	$ 423,000				
Reservoir	204,000	204,000				
Pumping plant:						
Raw water pumping and transmission lines	114,000	74,000	$ 40,000			
Treated-water pumping	425,000	276,000	149,000			
Treatment plant	1,048,000	681,000	367,000			
Transmission and distribution plant:						
Structures and improvements	40,000	13,000		$ 17,000	$ 9,000	$1,000
Distribution storage	413,000	41,000		372,000		
Transmission mains	3,112,000	1,400,000		1,712,000		
Distribution mains	1,830,000	824,000		1,006,000		
Meters	472,000				472,000	
Services	1,078,000				1,078,000	
Fire hydrants	248,000					248,000
General plant:						
Office	186,000	78,000	11,000	61,000	31,000	5,000
Vehicles	17,000	7,000	1,000	6,000	3,000	
Other	141,000	59,000	8,000	47,000	23,000	4,000
Total plant value	9,751,000	4,080,000	576,000	3,221,000	1,616,000	258,000
Less: Contributions in aid of construction	750,000				750,000	
Rate base	$9,001,000	$4,080,000	$ 576,000	$3,221,000	$ 866,000	$ 258,000

Source: American Water Works Association; Water Rates (Denver, CO: American Water Works Association, Manual M1, 1983), 14.

TABLE C-2. Allocation of Depreciation Expense
Base-Extra Capacity Method

Item	Total	Base	Extra Capacity		Customer Meters & Services	Direct Fire Service
			Maximum Day	Maximum Hour		
Source-of-supply plant:						
Land and land rights						
Reservoir	$ 3,200	$ 3,200				
Pumping plant:						
Raw water pumping and transmission lines	3,500	2,300	$ 1,200			
Treated-water pumping	14,200	9,200	5,000			
Treatment plant	28,000	18,200	9,800			
Transmission and distribution plant:						
Structures and improvements	1,100	200		$ 400	$ 400	$ 100
Distribution storage	10,300	1,000		9,300		
Transmission mains	37,500	16,900		20,600		
Distribution mains	32,500	14,600		17,900		
Meters	22,500				22,500	
Services	33,200				33,200	
Fire hydrants	8,300					8,300
General plant:						
Office	4,600	1,600	400	1,100	1,300	200
Vehicles	4,000	1,400	300	1,000	1,100	200
Other	10,100	3,400	800	2,500	3,000	400
Total depreciation expense	$213,000	$ 72,000	$ 17,500	$ 52,800	$ 61,500	$ 9,200

Source: American Water Works Association; <u>Water Rates</u> (Denver, CO: American Water Works Association, Manual M1, 1983), 16.

TABLE C-3. Allocation of Operation-and-Maintenance Expense
Base-Extra Capacity Method

			Extra Capacity		Customer Costs		
Item	Total	Base	Maximum Day	Maximum Hour	Meters & Services	Billing & Collecting	Direct Fire Service
Source-of-supply	$ 17,000	$ 17,000					
Pumping:	152,700	137,400	$ 15,300				
Other	107,400	69,800	37,600				
Total	260,100	207,200	52,900				
Treatment:							
Chemicals	99,900	99,900					
Other	69,600	45,200	24,400				
Total	169,500	145,100	24,400				
Transmission and distribution:							
Distribution storage	14,000	1,400		$ 12,600			
Transmission mains	54,100	24,300		29,800			
Distribution mains	35,200	15,800		19,400			
Meters	96,600				$ 96,600		
Services	35,300				35,300		
Fire hydrants	16,500						$ 16,500
Other	60,000	9,900		14,700	31,500		3,900
Total	311,700	51,400		76,500	163,400		20,400
General billing and collecting:							
Meter reading	110,800					$110,800	
Billing and collecting	203,700					203,700	
Other	11,800					11,800	
Total	326,300					326,300	
Administration and general:							
Fringe benefits	81,800	24,400	8,700	7,400	16,000	22,600	2,700
Other	303,600	69,000	23,500	27,900	59,600	115,900	7,700
Total	385,400	93,400	32,200	35,300	75,600	138,500	10,400
Total operation-and-maintenance expense	$1,470,000	$ 514,100	$ 109,500	$ 111,800	$ 239,000	$ 464,800	$ 30,800

Source: American Water Works Association; Water Rates (Denver, CO: American Water Works Association, Manual M1, 1983), 17.

TABLE C-4. Units of Service
Base-Extra Capacity Method

	Base		Maximum-Day			Maximum-Hour				
Customer Class	Annual Use thou. gal	Average Rate thou. gpd	Capacity Factor %	Total Capacity thou. gpd	Extra Capacity thou. gpd	Capacity Factor %	Total Capacity thou. gpd	Extra Capacity thou. gpd	Equivalent Meters and Services	Bills
Inside-city:										
Retail service										
Residential	928,000	2,542	250	6,355	3,813	400	10,168	7,626	16,019	190,452
Commercial	590,000	1,616	200	3,232	1,616	325	5,252	3,636	1,951	12,528
Industrial	1,149,000	3,148	150	4,722	1,574	200	6,296	3,148	169	120
Fire-protection service				960	960		5,760	5,760		
Total inside-city	2,667,000	7,306		15,269	7,963		27,476	20,170	18,139	203,100
Outside-city:										
Wholesale service	210,000	575	225	1,294	719	375	2,156	1,581	20	36
Total system	2,877,000	7,881		16,563	8,682		29,632	21,751	18,159	203,136

Source: American Water Works Association; Water Rates (Denver, CO: American Water Works Association, Manual M1, 1983), 29.

TABLE C-5. Cost Distribution to Customer Classes
Base-Extra Capacity Method

		Extra Capacity		Customer Costs		Direct Fire-	Total
Item	Base	Maximum Day	Maximum Hour	Meters & Services	Billing Collecting	Protection Service	Cost of Service
Inside-city:							
Unit costs of service ($/unit)	0.2984 per thou. gal	19.0561 per thou. gpd	17.4545 per thou. gpd	19.7292 per equiv. meter	2.2881 per bill		
Retail service:							
Residential:							
Units of service	928,000	3,813	7,626	16,019	190,452		
Allocated cost of service	$ 276,900	$ 72,700	$ 133,100	$ 316,100	$ 435,800		$1,234,600
Commercial:							
Units of service	590,000	1,616	3,636	1,951	12,528		
Allocated cost of service	$ 176,100	$ 30,800	$ 63,500	$ 38,500	$ 28,700		$ 337,600
Industrial:							
Units of service	1,149,000	1,574	3,148	169	120		
Allocated cost of service	$ 342,900	$ 30,000	$ 54,900	$ 3,300	$ 300		$ 431,400
Fire-protection service:							
Units of service		960	5,760				
Allocated cost of service		$ 18,300	$ 100,600			$ 57,000	$ 175,900
Total inside-city allocated cost of service							$2,179,500
Outside-city:							
Unit cost of service ($/unit)	0.3377	20.8938	21.5565	21.0502	2.2881		
Wholesale:							
Units of service	210,000	719	1,581	20	36		
Allocated cost of service	$ 70,900	$ 15,000	$ 34,100	$ 400	$ 100		$ 120,500
Total system allocated cost of service	$ 866,800	$ 166,800	$ 386,200	$ 358,300	$ 464,900	$ 57,000	$2,300,000

Source: American Water Works Association; Water Rates (Denver, CO: American Water Works Association, Manual M1, 1983), 35.

APPENDIX D

AN EXAMPLE OF MARGINAL-COST ANALYSIS

TABLE D-1

UNIT MARGINAL COST BY CUSTOMER CLASSIFICATION

	Annual Marginal Cost	Effective Sales (TG's)	Unit Marginal Cost
Residential:			
A. Supply	$106,129	118,443	$0.90
B. Pumping	50,134	118,443	0.42
C. Treatment	22,143	118,443	0.19
D. Storage	48,079	84,607	0.57
TOTAL	$226,486		$2.08
Commercial:			
A. Supply	$106,129	148,081	$0.72
B. Pumping	50,134	148,081	0.34
C. Treatment	22,143	148,081	0.15
D. Storage	48,079	105,777	0.45
TOTAL	$226,486		$1.66
Other Industrial:			
A. Supply	$106,129	169,214	$0.63
B. Pumping	50,134	169,214	0.30
C. Treatment	22,143	169,214	0.13
D. Storage	48,079	131,619	0.37
TOTAL	$226,486		$1.43
Large Industrial:			
A. Supply	$106,129	211,518	$0.50
B. Pumping	50,134	211,518	0.24
C. Treatment	22,143	211,518	0.10
D. Storage	48,079	164,506	0.29
TOTAL	$226,486		$1.13
Public Authorities:			
A. Supply	$106,129	148,081	$0.72
B. Pumping	50,134	148,081	0.34
C. Treatment	22,143	148,081	0.15
D. Storage	48,079	105,777	0.45
TOTAL	$226,486		$1.66

Source: Massachusetts-American Water Company Exhibit SBA-4 in a rate hearing before the Massachusetts Department of Public Utilities (June 1990).

TABLE D-2

EFFECTIVE SALES AND PRODUCTION DATA FOR MARGINAL-COST STUDY

Effective Sales By Class	Demand Ratio	Sales Ratio	Annual Sales Per MGD of Capacity
Residential			
Max Day	2.50	0.3245	118,443
Peak Hour	3.50	0.2318	84,607
Commercial			
Max Day	2.00	0.4057	148,081
Peak Hour	2.80	0.2898	105,777
Other Industrial			
Max Day	1.75	0.4636	169,214
Peak Hour	2.25	0.3606	131,619
Large Industrial			
Max Day	1.40	0.5795	211,518
Peak Hour	1.80	0.4507	164,506
Public Authorities			
Max Day	2.00	0.4057	148,081
Peak Hour	2.80	0.2898	105,777

TOTAL PRODUCTION:	Average Day	5.51	mgd
	Annual Volume	2,011,150	TGs
Company Use & Unaccounted For		379,483	TGs
Effective Total System Sales		1,631,667	TGs

Calculation of System Sales per 1.0 MGD of Additional Capacity

Ratio of Total System Sales to Total Production:		0.8113
System Demand Ratio	2.00	
System Sales Ratio	0.4057	
Annual System Sales per MGD of Capacity (TGs per year)		148,081

Source: Massachusetts-American Water Company Exhibit SBA-4 in a rate hearing before the Massachusetts Department of Public Utilities (June 1990).

TABLE D-3

ESTIMATED COST OF FACILITIES REQUIRED TO PROVIDE 1 MGD OF NEW CAPACITY

Facilities Required			Capital Costs
1.	Well:	Exploration & Development	$150,000
		Mass. DEP Permitting	25,000
		Structures & Appurtenances	25,000
			$200,000
2.	Pumping:	Structure	$100,000
		Equipment	50,000
			$150,000
3.	Treatment:	Equipment	$50,000
4.	Storage:	250,000 gallons (1)	$250,000
5.	Transmission Mains Required to connect new well and storage facilities to existing distribution network (2):		
		a. Well	$250,000
		b. Storage Tank (3)	$60,000
6.	Land for well site		$250,000
7.	Land for tank site (4)		$12,500

Notes:

(1) Based on 1 MG Structure costing $1,000,000. Volume required to equalize 1 MGD of maximum day demand is assumed to be 250,000 gallons or 25 percent of the total.

(2) Based on 2,500 ft. of 12" main at $100 per foot.

(3) Based on 25% of $250,000 for transmission main.

(4) Based on 25% of $50,000 for land.

Source: Massachusetts-American Water Company Exhibit SBA-4 in a rate hearing before the Massachusetts Department of Public Utilities (June 1990).

TABLE D-4

CALCULATION OF ANNUAL MARGINAL COST FOR FACILITIES REQUIRED TO PROVIDE ADDITIONAL CAPACITY

A. **Supply**	Capital Cost	Life Cycle	Present Value	Equal Periodic Payment
Well	$200,000	40	$264,449	$29,569
Transmission Main	250,000	100	343,418	37,811
Land	250,000	-	351,931	38,749
Total Fixed Costs	$700,000		$959,799	
Annual Marginal Cost - Supply				$106,129

B. **Pumping**	Capital Cost	Life Cycle	Present Value	Equal Periodic Payment
Structure	$100,000	50	$133,939	$14,827
Equipment	50,000	25	63,305	7,522
Total Fixed Costs	$150,000		$197,244	$22,349
Variable Costs:				
Power Purchased			$ 282,249	
Maintenance of Equipment			23,906	
Total System			$306,155	
Effective Total System Sales (TG/YR)			1,631,667	
Unit Variable Cost				27,785
Annual Marginal Cost - Pumping				$50,134

TABLE D-4 (continued)

C. **Treatment**	Capital Cost	Life Cycle	Present Value	Equal Periodic Payment
Equipment	$50,000			
Total Fixed Costs	$50,000	20	$62,276	$7,825
Variable Costs:				
Chemicals			$147,649	
Maintenance of Equipment			10,116	
Total System			$157,765	
Effective Total System Sales (TG/YR)			1,631,667	
Unit Variable Cost			$0.10	
System Sales for IMGD Capacity			148,081	
Annual Variable Cost				14,318
Annual Marginal Cost - Treatment				$22,143

D. **Storage**	Capital Cost	Life Cycle	Present Value	Equal Periodic Payment
Storage Tank	$250,000	50	$334,847	$37,067
Transmission Main	60,000	100	82,420	9,075
Land	12,500	-	17,597	1,937
Total Fixed Costs	$322,500		$434,864	
Annual Marginal Cost - Storage				$48,079

TABLE D-4 (continued)

Supporting calculations:

Land cost required for increased well capacity:	$250,000
Return at 11.01%	$27,525
Property Taxes at 1.147%	2,868
Income Taxes at 30.36%	8,356
Total Annual Cost (Equal Periodic Payment)	$38,749
Land cost required for increased storage capacity:	$12,500
Return at 11.01%	$1,376
Property Taxes at 1.147%	143
Income Taxes at 30.36%	418
Total Annual Cost (Equal Periodic Payment)	$1,937

Source: Massachusetts-American Water Company Exhibit SBA-4 in a rate hearing before the Massachusetts Department of Public Utilities (June 1990).

APPENDIX E

ERNST & YOUNG'S 1990 NATIONAL WATER RATE SURVEY

ERNST & YOUNG'S 1990 NATIONAL WATER RATE SURVEY

State City/ Effective Date	Bill- ing Cycle (a)	Rate Struc- ture (b)	Rates (cubic feet and thousand gallons)							Connec- tion Charge (c)
			5/8 meter				2 inch	4 inch	8 inch	
			0	500	1,000	3,000	50,000	1 mil	1.5 mil	
			0	3.74	7.48	22.44	374	7,480	11,220	
ALABAMA										
Birmingham	M	D5	$3.46	$7.71	$11.96	$28.84	$425	$7,887	$11,937	$145
Mobile (1/90)	M	D9	3.78	4.69	9.66	28.86	436	5,776	7,921	281
ARIZONA										
Phoenix (7/89)										
Summer	M	I3	4.70	6.80	8.90	25.30	445	7,264	na	varies
Winter	M	I3	4.70	6.80	8.90	22.20	387	7,264	na	varies
Tuscon (5/89)										
Summer	M	I7	4.10	9.05	15.00	52.15	564	9,533	14,336	400
Winter	M	I7	4.10	9.05	14.70	44.75	564	9,533	14,336	400
ARKANSAS										
Little Rock (2/85)	M	D5	3.60	5.82	9.52	24.32	318	3,168	4,684	120
CALIFORNIA										
Anaheim (9/89)	B,M	U	9.60	11.64	13.68	22.49	237	4,169	6,389	2,500
Bakersfield (1/89)	M	U	4.85	6.88	8.90	17.00	218	4,089	6,170	none
Fresno (12/89)	B	U	3.23	4.43	5.63	10.43	129	2,420	3,649	1,760
Los Angeles (10/88)										
Summer	M,B	U	5.30	7.52	12.65	33.15	525	10,297	15,540	1,455
Winter	M,B	U	5.30	6.85	11.30	29.10	457	8,947	13,515	1,455
Oakland (7/89)	B	U	4.20	7.20	12.20	28.20	424	8,080	12,264	1,480-7,820
Sacremento (1/89)	M	R: U C: D3	5.17	5.17	5.17	10.20	158	2,543	3,793	2,214
San Diego (1/89)	B	R: I2 C: U	3.12	7.64	12.16	31.92	504	9,749	14,846	1,651
San Francisco (7/89)	B,M	U	1.50	4.05	6.60	16.80	257	5,102	7,650	1,600
San Jose (7/89)										
City of San Jose	M	I	4.00	8.09	12.84	31.84	486	9,529	14,320	3,250
San Jose Water Co.	M	I	4.35	8.66	13.62	33.41	507	9,930	14,953	na
Stockton (8/89)	M	D2	5.75	7.35	8.95	15.35	167	2,757	4,165	359
Ventura (6/89)	B	I3	1.36	4.69	8.45	26.11	441	8,830	13,245	699
COLORADO										
Col. Springs (1/86)	M	U	2.74	9.67	16.59	44.30	695	13,856	20,782	3,807
Denver (4/87)	B	D4	2.15	5.25	8.36	19.58	208	3,571	5,358	2,730

APPENDIX E (continued)

State City/ Effective Date	Billing Cycle (a)	Rate Structure (b)	Rates (cubic feet and thousand gallons)							Connection Charge (c)
			5/8 meter				2 inch	4 inch	8 inch	
			0	500	1,000	3,000	50,000	1 mil	1.5 mil	
			0	3.74	7.48	22.44	374	7,480	11,220	
CONNECTICUT										
Hartford (3/89)	M,Q	I2	6.16	10.81	15.46	34.06	474	7,257	10,757	2,654
New Haven (11/88)	Q	D3	6.52	13.97	21.42	51.22	653	11,309	16,733	485
Bridgeport (6/89)	M,Q	D3	10.27	14.84	22.45	52.91	507	6,399	9,918	50
DISTRICT OF COLUMBIA										
Washington (10/86)	Q,M	U	0.00	5.02	10.04	30.12	502	10,040	15,060	78
FLORIDA										
Ft.Lauderdale (10/89)	B	U	2.73	6.81	10.88	27.19	425	8,206	12,397	426
Jacksonville (12/81)	M	I2	5.54	5.54	8.20	15.80	212	2,848	4,337	290
Lakeland (10/84)	M	D3	3.10	4.80	7.35	20.10	307	5,880	8,902	530
Miami (10/89)	Q	U	4.29	4.29	7.13	21.38	356	7,125	10,689	315+
Orlando (2/90)	M	D2	2.35	3.93	6.05	13.97	200	3,893	5,854	985
St. Petersburg (9/88)	M	R: I3 C: U	4.38	8.05	11.71	26.37	411	7,510	11,713	505
Tampa (10/89)	M	U	1.50	3.85	7.70	23.10	385	7,700	11,550	1,345
Palm Beach Co.(11/89)	M	R: I3 C: U	3.50	5.90	9.20	20.20	300	4,786	na	1,700
GEORGIA										
Atlanta (3/84)	B,M	D4	3.35	6.75	15.25	49.25	564	7,459	11,059	400+/ 620+
Augusta (1/80)	M	D5	2.88	3.59	7.18	21.54	301	4,195	6,065	425
HAWAII										
Honolulu (7/89)	B,M	U	1.63	5.51	9.95	26.60	418	8,306	12,457	2,325
ILLINOIS										
Chicago (5/89)	B,M,S	U	0.00	3.35	6.69	20.07	335	6,690	10,035	450
Joliet (4/85)	M	D3	2.55	6.96	14.31	41.51	587	11,607	17,407	110
Peoria (3/86)	M,Q	D4	5.00	13.15	21.30	53.90	427	6,412	9,668	0
INDIANA										
Gary (12/89)	B,M	D6	7.08	8.83	17.05	46.22	587	6,190	9,069	varies
Indianapolis (7/88)	M	D5	3.25	8.05	12.85	30.25	395	4,320	6,241	varies
Fort Wayne (8/86)	M	D3	3.59	7.13	10.67	24.83	346	4,427	6,557	412/ 587

APPENDIX E (continued)

State City/ Effective Date	Billing Cycle (a)	Rate Structure (b)	Rates (cubic feet and thousand gallons)							Connection Charge (c)
			5/8 meter				2 inch	4 inch	8 inch	
			0	500	1,000	3,000	50,000	1 mil	1.5 mil	
			0	3.74	7.48	22.44	374	7,480	11,220	
IOWA										
Davenport (7/87)	Q	D4	3.35	7.96	12.57	31.01	368	6,179	8,728	0
Des Moines (1/88)	M	D	5.00	6.32	12.64	37.92	516	7,428	11,051	70+
KANSAS										
Wichita (1/87)	B	D	3.97	5.01	8.60	22.96	220	3,528	4,897	300
KENTUCKY										
Louisville (1/88)	M,B	I6	3.15	6.98	11.36	30.06	478	7,935	11,777	425
LOUISIANA										
Baton Rouge (6/89)	M	D5	7.23	8.98	13.37	30.91	344	4,147	5,867	74
New Orleans (1/87)	M	D3	2.80	9.57	16.53	40.54	628	9,848	14,630	0
Shreveport (1/89)	M	U	2.10	7.22	12.35	26.78	370	7,283	10,963	600
MARYLAND										
Baltimore (5/89)	Q	D3	2.33	3.50	7.00	17.40	175	2,977	4,452	0
MASSACHUSETTS										
Boston (1/90)	Q	I10	0.00	7.55	15.12	45.49	765	15,408	23,118	125
Salem (7/84)	Q	U	10.50	10.50	10.50	31.50	525	10,500	15,750	45+
Springfield (7/89)	Q	U	5.00	5.45	10.90	32.70	545	10,900	16,350	75+ 10/ft.
Lawrence (7/88)	Q	U	3.17	6.75	13.50	40.50	68	13,500	20,250	315
Worchester (7/89)	S	U	1.50	6.85	13.70	41.10	685	13,700	20,550	50
MICHIGAN										
Ann Arbor (7/85)	Q,M	U	2.10	4.10	8.19	24.57	410	8,190	12,285	1,005
Detroit (7/89)	Q,M	D3	0.88	3.02	5.17	13.75	191	3,341	5,039	0
Flint (7/89)	M	D3	3.40	9.35	15.30	45.35	604	9,676	14,401	70
Grand Rapids (1/89)	QM	U	6.05	9.05	12.05	24.05	337	6,145	9,324	3,538+
Lansing (11/86)	Q,M	U	4.15	8.38	12.60	29.50	462	8,616	13,256	1,836
Saginaw (11/89)	Q,M	D3	1.83	3.73	5.64	13.25	210	3,550	5,497	307
MINNESOTA										
Minneapolis (1/84)	Q	U	1.00	4.25	8.50	25.50	425	8,500	12,750	357
St. Paul (1/88)	Q,M	D3	1.07	5.57	10.07	28.07	460	8,757	13,182	1,096

APPENDIX E (continued)

State City/ Effective Date	Billing Cycle (a)	Rate Structure (b)	Rates (cubic feet and thousand gallons)							Connection Charge (c)
			5/8 meter				2 inch	4 inch	8 inch	
			0	500	1,000	3,000	50,000	1 mil	1.5 mil	
			0	3.74	7.48	22.44	374	7,480	11,220	
MISSISSIPPI										
Jackson (6/88)	B	U	2.50	10.20	15.40	36.20	543	10,438	15,638	515
MISSOURI										
Kansas City (12/89)	B,M	D3	5.10	9.70	14.30	32.70	381	6,952	9,821	varies
St. Louis (9/89)	Q	D3	3.20	6.75	10.30	24.50	327	5,662	8,537	55
NEBRASKA										
Omaha (5/89)										
Summer	M	D2	2.10	4.71	7.72	20.18	275	4,528	6,713	613
Winter	M	D2	2.10	4.71	7.72	17.76	238	4,528	6,713	613
NEVADA										
Las Vegas (10/87)	M	U	8.66	11.39	14.12	25.04	324	5,614	8,677	400
NEW JERSEY										
Jersey City (1/82)	Q	U	1.00	4.75	8.50	23.50	383	7,530	11,340	190
Newark (2/84)	Q	D5	10.37	10.37	15.56	36.30	484	8,042	11,767	1,750
Trenton (3/84)	Q	D3	4.48	5.49	6.50	10.56	145	2,076	3,597	0
NEW MEXICO										
Albuquerque (9/88)	M	U	5.19	2.79	10.39	22.72	306	5,560	9,237	2,208
NEW YORK										
Albany (6/88)	T	I2	3.75	3.75	10.00	30.00	500	13,514	20,514	175
Buffalo (7/88)	M,Q	na	6.90	6.90	6.90	20.70	207	3,627	5,427	263
New York (1/89)	S,B	U	3.90	4.75	9.50	28.50	475	9,500	14,250	330
Syracuse (12/89)	Q,M	D4	3.59	4.15	8.30	24.90	301	5,260	7,065	235
NORTH CAROLINA										
Charlotte (7/89)	M	U	1.45	4.85	8.25	21.85	341	6,801	10,201	1,001
Greensboro (3/88)	M,Q	D3	1.98	3.30	6.60	19.80	234	2,894	4,294	1,643
Raleigh (8/89)	M	U	1.41	6.61	11.81	32.61	526	10,416	15,651	1,869

APPENDIX E (continued)

State	Bill-	Rate	Rates (cubic feet and thousand gallons)							Connec-
City/	ing	Struc-	5/8 meter				2 inch	4 inch	8 inch	tion
Effective	Cycle	ture	0	500	1,000	3,000	50,000	1 mil	1.5 mil	Charge
Date	(a)	(b)	0	3.74	7.48	22.44	374	7,480	11,220	(c)
OHIO										
Akron (1/90)	M	D3	2.02	9.37	16.72	46.12	610	11,820	18,004	785
Canton (10/88)	Q	D	2.00	4.55	9.10	27.30	313	4,038	5,738	250/ 265
Cincinnati (12/88)	Q,M	D3	3.53	5.11	9.06	23.56	341	5,974	8,978	1,500
Cleveland (2/87)	Q	I2	5.20	5.20	6.23	19.71	336	6,739	10,109	235
Columbus (1/89)	Q,M	D6	2.98	6.42	9.84	30.17	298	4,889	7,034	1,997
Dayton (10/87)	Q,M	D6	3.66	3.66	3.66	8.79	140	2,170	3,157	1,300+/-
Toledo (1/87)	Q,M	D4	4.03	4.03	6.05	18.15	295	4,822	6,703	600
Youngstown (5/88)	Q	D5	1.96	4.96	9.43	30.32	307	4,943	7,383	525
OKLAHOMA										
Oklahoma C. (7/88)	M	U	2.75	4.91	9.23	25.43	406	7,631	11,446	110+
Tulsa (1/90)	M	U	3.74	7.85	11.97	26.63	331	6.394	9,573	110+
OREGON										
Portland (7/89)	Q,M	U	2.80	6.40	10.00	24.40	369	7,221	10,857	610+
PENNSYLVANIA										
Allentown (1/89)	Q	U	2.52	6.04	9.55	23.62	362	7,068	10,648	90
Lancaster (1/89)	Q	D3	1.80	5.24	10.49	31.94	393	4,160	6,142	0
Philadelphia (7/83)	Q	D4	2.08	6.81	11.53	28.28	377	6,478	9,708	50
Pittsburgh (1/89)	Q	U	5.17	10.17	17.96	48.50	730	14,382	21,598	208
Harrisburg (1/83)	Q	U-city D5-suburb	1.28	3.66	5.94	15.56	266	4,901	7,818	107
Scranton (7/89)	Q,M	R: U C: D3	5.33	10.36	19.43	54.33	571	8,264	11,001	0
SOUTH CAROLINA										
Charleston (6/89)	M	D3	3.70	6.64	10.54	23.34	268	5,051	7,638	865
Columbia (8/89)	M	D6	2.55	4.15	8.15	24.15	387	12,610	18,472	125
Greenville (2/81)	Q	D4	2.35	3.29	6.58	18.92	193	3,117	4,613	0
TENNESSEE										
Chattanooga (3/88)	M	D5	6.59	8.35	17.14	52.32	650	7,784	11,499	0
Johnson City (7/88)	M	D8	4619	10.12	17.63	44.30	567	9,258	13,821	225
Knoxville (8/86)	M	D4	6.25	9.53	17.73	50.53	603	7,211	10,373	400

APPENDIX E (continued)

State City/ Effective Date	Bill-ing Cycle (a)	Rate Structure (b)	Rates (cubic feet and thousand gallons)							Connection Charge (c)
			5/8 meter				2 inch	4 inch	8 inch	
			0	500	1,000	3,000	50,000	1 mil	1.5 mil	
			0	3.74	7.48	22.44	374	7,480	11,220	
TENNESSEE(cont.)										
Memphis (1/90)	M	R: D3	2.49	3.29	6.58	18.93	264	3,372	5,002	125
		D5-General Power Service								
Nashville (1/90)	M		3.83	11.00	22.95	66.84	996	15,124	22,508	250
TEXAS										
Austin (11/89)	M	U	5.46	9.39	17.84	51.65	856	16,960	25,478	1,627
Beaumont (11/89)	M	U	3.16	6.94	12.10	32.75	520	10,335	15,511	175
Corpus Christi (8/88)	M	R: I6 C: D6	3.76	6.02	11.13	32.28	415	6,411	9,874	1,739
Dallas (10/89)										
Summer	M	R: I3 C: I2	1.29	4.92	9.62	19.89	337	6,690	10,107	225
Winter	M	R: I2 C: U	1.29	4.92	9.62	18.37	290	5,719	8,650	225
El Paso (3/89)	M	I6	3.13	3.59	5.89	15.09	233	4,609	6,942	777
Fort Worth (10/88)										
Summer	M	D3	3.05	9.45	15.85	53.15	849	9,831	14,368	1,610
Winter	M	D3	3.05	9.45	15.85	53.15	605	9,587	14,124	1,610
Houston (8/89)	M	I2	4.47	9.78	18.34	47.68	756	14,982	22,501	135
San Antonio (12/88)	M	R: I C: D W: U	4.72	6.92	9.54	19.01	257	5,011	7,585	varies
UTAH										
Salt Lake (7/89)	M,B	U	6.45	6.45	6.45	15.05	239	4,383	6,722	230/290
VIRGINIA										
Norfolk (7/89)	B	D2	2.13	7.76	13.38	37.20	552	10,448	15,749	525
WASHINGTON										
Seattle (1/84)										
Summer	M,B	R: I2	1.40	5.74	10.58	18.39	273	5,353	8,067	0
Winter		C: U	1.40	5.40	9.39	15.21	220	4,293	6,477	0
Tacoma (1/89)	B	R: U C: D4	6.35	9.00	11.64	20.75	291	3,914	5,838	2,625

APPENDIX E (continued)

State City/ Effective Date	Billing Cycle (a)	Rate Structure (b)	Rates (cubic feet and thousand gallons)							Connection Charge (c)
			5/8 meter				2 inch	4 inch	8 inch	
			0	500	1,000	3,000	50,000	1 mil	1.5 mil	
			0	3.74	7.48	22.44	374	7,480	11,220	
WISCONSIN										
Milwaukee (6/88)	Q,M	D4	1.93	5.08	8.23	20.83	316	5,005	7,046	245

Source: *Ernst & Young's 1990 National Water and Wastewater Rate Survey* (Charlotte, NC: National Environmental Consulting Group, Ernst & Young, 1990).

Note: Dates in parentheses following each city name indicate when the rate structure was approved or implemented.

(a) M=Monthly
B =Bimonthly
Q=Quarterly
S =Seminannually
T =Triannually
A=Annually

(b) R=Residential
C =Commercial
W=Wholesale
U=Uniform
D=Decreasing block (with number of blocks)
I =Increasing block (with number of blocks)

(c) Total one-time charges assessed for a new single-family residence to connect to the water system.

GLOSSARY OF COST ALLOCATION AND RATE DESIGN TERMS

abandonment. Retirement of a utility plant on the books without its physical removal from its installed location. NARUC(a)

above the line. Expenses incurred in operating a utility that are charged to the ratepayer. They are written above a line drawn on the income statement separating them from costs paid by investors. See also **below the line.** NARUC(a)

absorption costing. See **full costing.**

accelerated depreciation. Depreciation methods that amortize the cost of an asset at a faster rate than under the **straight-line method.** The three principal methods of accelerated depreciation are sum of the year's digits, double declining balance, and units of production. AWWA(c)

account water. All water for which an account exists, the water is metered, and the account is billed. This concept is preferable to "accounted-for water." See also, **authorized water uses** and **non-account water.** AWWA(e)

accounts. Accounts prescribed in the NARUC(b) Uniform System of Accounts for Water Utilities. NARUC(b)

accrual basis. The basis of accounting under which revenues are recorded when earned and expenditures are recorded when they become liabilities for benefits received, notwithstanding that receipt of the revenue or payments of the expenditures may take place, in whole or in part, in another accounting period. See also **cash basis.** AWWA(c)

accrued depreciation. Monetary difference between the original cost of an article and its remaining value. NARUC(a)

acquisition adjustment. The difference between the price paid to acquire an operating unit or system of a utility and the rate base of the acquired property. See also **plant acquisition adjustment.** NARUC(a)

acquisition adjustment. The difference between the cost of acquiring an **operating unit or system** and the depreciated **original cost** of the acquired property. (Note: any existing **contributions in aid of construction** are also carried through the property transfer and reinstated by the new owner, thus affecting the amount of recorded acquisition adjustment.) See also **plant acquisition adjustment.** DHS

actually issued. As applied to securities issued or assumed by the utility, those which have been sold to bona fide purchasers for a valuable consideration, those issued as dividends on stock, and those which have been issued in accordance with contractual requirements direct to trustees of sinking funds. NARUC(b)

actually outstanding. As applied to securities issued or assumed by the utility, means those which have been actually issued and are neither retired nor held by or for the utility; provided, however, that securities held by trustees shall be considered as actually outstanding. NARUC(b)

ad valorem tax. A state or local tax based on the assessed value of the real or personal property. AWWA(b)

advance for construction. Advance made by or on behalf of customers or others for the purpose of construction, which is to be refunded either wholly or in part. When applicants are refunded the entire amount to which they are entitled according to the agreement or rule under which the advance was made, the balance, if any, remaining in this account shall be credited to **contribution in aid of construction.** AWWA(b)

allowance for funds used during construction (AFUDC). A percentage amount added to **construction work in progress (CWIP)** to compensate the utility for funds used to finance new plant under construction prior to its inclusion in rate base. NARUC(a)

amortization. The gradual extinguishment of an amount in an account by distributing such amount over a fixed period, over the life of the asset or liability to which it applies, or over the period during which it is anticipated the benefit will be realized. NARUC(b)

ancillary charge. A separate charge for ancillary services that is not included in costs for general water service. These ancillary services often must be performed by the utility and benefit only the individual customer using them and have no system-wide benefit. AWWA(b)

associated companies. Companies or persons that, directly or indirectly, through one or more intermediaries, **control,** are controlled by, or are under common control with, the accounting company. NARUC(b)

attributable costing. A cost accounting method in which the cost of providing any service is the costs that could be escaped over time if that service were eliminated and capacity was adjusted accordingly. The assignment of some indirect fixed overhead is required to implement this costing method and it is a longer-run concept than **direct costing.** AUT

audit. See **water audit.**

authorized water uses. All water uses known and approved or authorized by the utility. These uses include all metered uses and reliable estimates of all other approved uses such as public, fire, system, operation, and paid-for uses. AWWA(e)

automatic adjustment clause. Allows a utility to increase or decrease its rates to cover costs of specific items without a formal hearing before a commission. The utility can automatically change its rates only when the price it pays for those specified items goes up or down. Fuel adjustment clauses are an example. NARUC(a)

availability charge. A limited-use **dedicated-capacity** charge made by a water utility to a property owner between the time when water service is made available to the property and the time when the property connects to the utility's facilities and starts using the service. See also **demand-contract charge.** AWWA(b)

average-and-excess method. A method for allocating demand costs by which total demand costs are multiplied by the system's **load factor** to arrive at a cost that can be attributed to average use and allocated to each customer class in proportion to their annual consumption. The remaining costs are generally allocated to each class on the basis of the **noncoincident-demand method.** See also **base-extra capacity method** and **commodity-demand method.** AUT

average demand. The demand on, or output of, a utility system over any interval of time. NARUC(a)

average incremental cost. For a specified time period, the addition to total cost resulting from an increase in capacity divided by the incremental output provided. See also **incremental cost** and **marginal cost.** AUT

average load. The total production for the period divided by the hours in the period. DHS

average service life. Used in determining depreciation, the average expected life of all the units in a group of assets. NARUC(a)

average variable pricing. A pricing structure in which the price per unit varies according to actual expenditures during the billing period. It does not affect use and should be used *only* where costs vary significantly between billing periods. AWWA(d)

base costs. Costs that tend to vary with the total quantity of water used plus those operation and maintenance expenses and capital costs associated with service to customers under average load conditions, without the elements of cost incurred to meet water use variations and resulting peaks in demand. AWWA(a)

base-extra capacity method. An **average-and-excess method** by which **costs of service** are separated into four primary cost components: (1) **base costs,** (2) **extra capacity costs,** (3) **customer costs,** and (4) direct **fire-protection** costs. AWWA(a)

base load. The minimum quantity of utility product delivered over a given period of time. NARUC(a)

base rate. A fixed amount charged each month for any of the classes of utility service provided to a customer. NARUC(a)

base year. The actual or test data year on which a financial model is based. It is the first year of data entry in the model. AWWA(f)

below the line. Expenses incurred in operating a utility that are charged to the investor, not the ratepayers; that is, all income statement items of revenue and expense not included in determining **net operating income.** If the item falls below the net operating income line of the income statement, it is labeled a below-the-line item. Net operating income is the "line" referred to. See also **above the line.** NARUC(a) and DHS

beneficiality. A service is said to benefit from a cost if that cost is necessary to render that service. AUT

benefit-to-cost ratio. The value derived from dividing the sum of all benefits from an activity by the sum of all costs associated with that activity. A benefit-to-cost ratio having a value of 1.0 or greater would indicate that the program is economically worthwhile. AWWA(e)

bill tabulation. A method that shows the number of customer bills rendered at various levels of water usage during a specified period of time for each customer class served by the utility. The tabulation of bills for an historical period provides the basis for identifying typical customer-class usage patterns and aids in the development of rates recognizing such usage patterns. AWWA(a)

book cost. The amount at which property is recorded in these accounts without deduction of related provisions for accrued depreciation, amortization, or for other purposes. NARUC(b)

book value. The accounting value of an asset. The book value of a capital asset equals its original cost minus accumulated depreciation. The book value of a share of common stock equals the net worth of the company divided by the number of shares of stock outstanding. NARUC(a)

budget. An estimate of proposed expenditures for a given period or purpose and a statement of the means of financing them. AWWA(c)

CCF. One-hundred cubic feet.

capacity. The ability of the water utility to have the resources available to meet the water-service needs of its customers. It is the combination of plant- and service-related activities required to provide the amount of service required by the customer. The plant facilities required are a composite of all types of facilities needed to provide service. It represents the ability of the water utility to meet the quantity, quality, peak loads, and other service needs of the various customers or classes of customers served by the utility. See also **dedicated capacity** and **future capacity.** AWWA(b)

capacity (demand) costs. As used in the **commodity-demand method,** costs associated with providing facilities to meet the peak rates of use, or demands, placed on the system by the customers, including capital-related costs on plant designed to meet peak requirements plus the associated operation and maintenance expenses. This cost component may be broken down into costs associated with meeting specific demands, such as maximum-day, maximum-hour, or other periods of time that may be appropriate to the utility. AWWA(a)

capacity required. Reflects the idea that costs or capacity are assigned according to whether they are necessary to the performance of the service. The relevant test is that if these costs were not incurred, the service could not be rendered. AUT

capital intensive. A term used to designate a condition in which a relatively large dollar investment is required to produce a dollar of revenue. DHS

capital program. A plan for capital expenditures to be incurred each year over a fixed period of years to meet capital needs arising from a long-term work program or otherwise. It sets forth each project or other contemplated expenditures in which the entity is to have a part and specifies the full resources estimated to be available to finance the projected expenditures. AWWA(c)

capital structure. The permanent long-term financing of the firm represented by long-term debt, preferred stock, and net worth. NARUC(a)

capitalized costs. Costs are capitalized when they are expected to provide benefits over a period longer than one year. Capitalized costs are considered investments and are included in rate base to be recovered from customers over a number of years. NARUC(a)

cash basis. The basis of accounting under which revenues are recorded when cash is received and expenditures are recorded when cash is disbursed. See also **accrual basis.** AWWA(c)

cash basis for rates. Rates based on cash requirements for operating expenses, capital, and debt service. Most publicly owned utilities use this basis. AWWA(f)

class A utilities. Utilities having annual water operating revenues of $750,000 or more. NARUC(b)

class B utilities. Utilities having annual water operating revenues of $150,000 or more but less than $750,000. NARUC(b)

class C utilities. Utilities having annual water operating revenues of less than $150,000. NARUC(b)

coincident-demand method. A method for allocating demand costs according to the proportion of customer class demand at the time of system peak. See also **noncoincident-demand method.** AUT

coincident peak. Any demand that occurs simultaneously with any other demand on the same utility system. See also **noncoincident peak.** NARUC(a)

collection-related charges. Service fees pertaining principally to the collection and billing functions of the water utility, including delinquency (late) fees and short-check (returned check) charges. AWWA(b)

commodity (operating) costs. Costs that tend to vary with the quantity of water produced, including costs of chemicals, a large part of power costs, and other elements that increase or decrease almost directly with the amount of water supplied. AWWA(a)

commodity-demand method. A **noncoincident demand method** by which **costs of service** are separated into four primary cost components: (1) **commodity costs,** (2) **demand costs,** (3) **customer costs,** and (4) direct **fire-protection** costs. AWWA(a)

composite depreciation rate. A percentage based on the weighted average service life of a number of units of plant, each of which may have a different individual life expectancy. Composite depreciation rates may be determined for (a) a single depreciable plant account, (b) a single rate for several depreciable accounts, or (c) a single composite rate for all depreciable plant of the utility. NARUC(b)

connection charge. The charge made by the utility to recover the cost of connecting the customer's service line to the utility's facilities. This charge is often considered as contribution of capital by the customer or other agency applying for service. AWWA(b)

construction work in progress (CWIP). A subaccount in the utility plant section of the balance sheet representing the costs of utility plant under construction but not yet placed in service. NARUC(a) The utility's investment in facilities under construction but not yet dedicated to service. The inclusion of CWIP in rate base varies from one regulatory agency to another. AWWA(c)

contract demand. Relates to an agreement between the water utility and a large-use customer who requires a significant amount of the total capacity of the utility. The agreement would fix the terms and conditions under which the water utility would provide service to the customer. Such an agreement has been called contract capacity. AWWA(b)

contribution in aid of construction. Any amount of money, services, or property received by a water utility from any person or governmental agency that is provided at no cost to the utility. It represents an addition or transfer to the capital of the utility, and is utilized to offset the acquisition, improvement, or construction costs of the utility's property, facilities, or equipment used to provide utility services to the public. It includes amounts transferred from advances for construction representing any unrefunded balances of expired refund contracts or discounts resulting from termination of refund contracts. Contributions received from governmental agencies and others for relocation of water mains or other plant facilities are also included. See also **allowance for funds used during construction** (AFUDC). AWWA(b)

control. The possession, directly or indirectly, of the power to direct or cause the direction of the management and policies of a company, whether such power is exercised through one or more intermediary companies, or alone, or in conjunction with, or pursuant to an agreement, and whether such power is established through a majority or minority ownership or voting of securities, common directors, officers, or stockholders, voting trusts, holding trusts, **associated companies**, contract, or any other direct or indirect means. NARUC(b)

cost. The amount of money actually paid for property or service. When the consideration given is other than cash, the value of such considerations hall be determined on a cash basis. NARUC(b)

cost causation. Reflects the idea that costs should be assigned to the revenue-producing objects that cause those costs to be incurred. AUT

cost of capital. A utility's cost of capital is the weighted sum of the costs of component parts of the capital structure (that is, debt, preferred equity, and common equity) weighted by their respective proportions in the capital structure. AWWA(c)

cost of removal. The cost of demolishing, dismantling, tearing down, or otherwise removing utility plant, including the cost of transportation and handling incidental thereto. NARUC(b)

cost of service. The total cost of providing utility service to the system or to a group therein (the latter is commonly referred to as an allocated cost of service). The cost components include operating expenses, depreciation, taxes, and **rate of return** adequate to service investment capital. Cost of service is synonymous with the **revenue requirements** of the system (or segment thereof). DHS

cost-of-service pricing. A method of pricing service strictly in accordance with the costs (expenses and allowable profit) that are attributable to it. Customers of services priced below cost are generally subsidized by customers paying above cost for their services. NARUC(a)

curb stop. A shut-off valve attached to a water-service line from a water main to a customer's premises, which may be operated by a valvae key to start or stop flow in the water-supply lines of a building. Also called a curb cock. AWWA(b)

customer advances for construction. A deferred credit account representing cash advances paid to the utility by customers requiring the construction of facilities on their behalf. These advances are refundable; the time or extent of refund depends on revenues from the facilities. Contrast with **contributions in aid of construction (CIAC).** NARUC(a)

customer classification. The homogeneous grouping of customers into classes. Typically, water utility customers may be classified as residential, commercial, and industrial for ratemaking and other purposes. For specific utilities, there may be a breakdown of these general classes into more specific groups. For example, the industrial class may be subdivided into small industry, large industry, and special. Some water systems have individual customers (large users) with individual water-use characteristics, service requirements, or other reasons that set them apart from other general customer classes and who may require a separate class designation. This may include large hospitals, universities, military establishments, and other such categories. AWWA(b)

customer costs. Those costs associated with serving customers, irrespective of the amount or rate of water use, including meter reading, billing, and customer accounting and collecting expense, as well as maintenance and capital costs related to meters and services. AWWA(a)

cycle billing. The process of reading a segment of the system's customers each day of a billing period. By the end of the cycle,, the complete system is read and billed, and a new cycle begins. The customer reading on each day of the cycle will reflect the use for a full period so that the only customers up to date at the end of the accounting period are those read and billed as of the last day of the cycle. All other customers will have unread and unbilled consumptions of from one to thirty days, assuming a one-month cycle. This produces an **unbilled revenue** at the end of each accounting period. DHS

daily peak load pricing. A pricing structure in which the price level is higher during hours of peak use. It can be used for reducing peak use and is expensive to implement since a sophisticated meter reading system would be necessary. AWWA(d)

debt. An obligation resulting from the borrowing of money or from the purchase of goods and services. AWWA(c)

debt expense. All expenses in connection with the issuance and initial sale of evidences of debt, such as fees for drafting mortgages and trust deeds; fees and taxes for issuing or recording evidences of debt; cost of engraving and printing bonds and certificates of indebtedness; fees paid trustees; specified costs of obtaining governmental authority; fees for legal services; fees and commissions paid underwriters, brokers, and salesmen or marketing such evidences of debt; fees and expenses of listing on exchanges; and other like costs. NARUC(b)

debt service. Expenditures for interest and principal repayment on debt instruments. AWWA(f)

debt service coverage. The ratio of net revenues to **debt service** requirements. AWWA(f)

declining block pricing. See **decreasing block pricing.**

decreasing block pricing. A pricing structure, also known as declining block pricing, in which both the average and marginal price per unit decreases as consumption increases. It can be used to retain large-volume customers, who prefer this structure. When there is sufficient supply, the cost of supplying water will probably decrease as consumption increases. AUT and AWWA(d)

dedicated capacity. The portion of the water utility's total capacity that is set aside or "dedicated" for use by an individual large-use customer or group (class) of customers whose total use is a significant part of the utility's total capacity requirement. AWWA(b)

dedicated-capacity charge. A charge to ensure that the utility will recover, from those for whom a significant portion of the total utility plant facilities capacity has been dedicated, the ongoing costs associated with this capacity. Two types of dedicated capacity charges are the **availability charge** and the **demand contract-charge.** AWWA(b)

demand. The maximum rate at which a utility product is delivered to a specific point at any given moment. See also **average demand.** NARUC(a)

demand-contract charge. The use of a **dedicated-capacity charge** incorporated into a contract whereby the water customer agrees to pay the fixed costs associated with a specific share of the utility's capacity and related investment. See also **availability charge.** AWWA(b)

demand costs. See **capacity costs.**

demand factor. The ratio of the maximum demand over a specified time period to the total connected load on any defined system. NARUC(a)

demand rate. A method of pricing under which prices vary according to differences in usage or costs. NARUC(a)

depletion. The loss in service value incurred in connection with the exhaustion of the natural resource in the course of service. NARUC(a)

depreciation. As applied to depreciable utility plant, the loss in service value not restored by current maintenance, incurred in connection with the consumption or prospective retirement of utility plant in the course of providing service from causes which are known to be in current operation and against which the utility is not protected by insurance. Among the causes to be given consideration are wear and tear, decay, action of the elements, inadequacy, obsolescence, changes in the art, changes in demand, and requirements of public authorities. NARUC(b)

direct costing. A cost accounting method that assigns only those costs that vary with short-run changes in the rate of output. The costs assigned under this method are not only the direct costs but the indirect variable overhead costs as well. It is sometimes referred to as variable costing. AUT

discount. As applied to the securities issue or assumed by the utility, the excess of the par (stated value of no-par stocks) or face value of the securities plus interest or dividends accrued at the date of the sale over the cash value of the consideration received from their sale. NARUC(b)

discounted cash-flow (DCF) model. The DCF model is often used in ratemaking for estimating the investor required rate of return on common equity. By definition, the DCF model contends that the market price of a common stock is equal to the cumulative present value of all future cash flows to investors produced by said common stock. AWWA(c)

district (or zone) measurement. A measurement of all water flow into an isolated portion (district or zone) of a distribution system to be used to determine the leakage potential for the isolated zone. Annual district measurements can be compared and used to determine changes in the level of water consumption and leakage potential. AWWA(e)

diversity factor. The sum of noncoincident demands of a group divided by the group coincident demand. See also **load factor** and **utilization factor.** DHS

economies of scale. Exist when the unit or average cost of general water service decreases with the expansion of water system capacity. Economies of scale (or size) can be defined either in the context of changes in total system capacity or changes in a single component of the water system (such as treatment). See also **economies of scope.** AUT

economies of scope. Exist when the average cost of combined general water service and fire protection service is less than the cost of providing each service separately; that is, the unit cost of providing multiple services is less than if they were provided by separate utilities. See also **economies of scale.** AUT

embedded costs. Money already spent for investment in plant and in operating expenses. NARUC(a) Those costs that are in existence at any point in time regardless of the date originally incurred and that affect current operations on a continuing basis. DHS

equity. The net worth of a business, consisting of capital stock, capital (or paid in) surplus, earned surplus (or retained earnings), and, occasionally, certain net worth reserves. AWWA(c)

equivalent customer. The means of relating large-use customers to a single family unit or other small-use customer unit, such as a 5/8-inch meter customer. It would represent a composite of all elements of cost differences between the unitary customers and the large-use customers to be served. Normally, it is expressed as a ratio of the small-use customer unit. AWWA(b)

equivalent meters. The number of 5/8-inch meters equivalent in flow to a larger meter. Used to calculate monthly service charges. AWWA(f)

estimated water quantity. The quantity derived from the process of making reliable and pertinent calculations of water volumes using an appropriate method or formula to draw reasonable conclusions about an actual quantity of water. The reliability of the estimate is enhanced whenever actual times of flow, rates of flow, or partial flow volumes are measured and recorded. AWWA(e)

excess-use pricing. A pricing structure in which the price level is significantly higher for all water used above average, usually determined by winter use. It can be used to reduce peak use, and large volume users consider its use equitable. AWWA(d)

expenditures. Amounts paid or incurred for all purposes, including expenses, provisions for retirement of debt, and capital outlays. AWWA(c)

extra capacity costs. As used in the **base-extra capacity** method, those costs associated with meeting rate of use requirements in excess of average, including operation and maintenance expenses and capital costs for system capacity beyond those required for average rate of use. These costs may be subdivided into costs necessary to meet maximum-day extra demand, maximum-hour extra demand, or other extra-demand criteria appropriate to the utility. AWWA(a)

fair market value. Generally the term applies to the amount that a willing buyer will pay a willing seller in an arm's-length transaction. Because of the predominant use of **original cost** in the **rate base** and the constraints that original-cost factors place on the rates that may be charged, the depreciated book cost of utility plant may be a prominent factor in establishing fair market value for a utility system. DHS

fair value. A term normally used in those jurisdictions that, by statute or regulatory precedent, allow the **rate base** to be expressed at a level other than the recorded **original cost** amounts. The most common measure of fair value is reflected in a composite of original cost and **trended original cost** factors. In practice the fair value has often been closer to the original cost level than the trended original cost level. DHS

field-service charges. Charges related to activities including water turn on (or turn off), meter setting or removal, special meter readings, meter testing, and temporary hydrant meter settings. AWWA(b)

fire main. Any main forming part of an integrated system used exclusively for fire protection purposes. NARUC(b)

fire-protection charges. Charges made to recover the cost of providing both public and private fire-protection service to the communities served by the utility. AWWA(b)

fixed charges. Periodic charges to customers that do not vary with water use, unlike **variable charges.** AUT

fixed costs. Business costs that remain unchanged regardless of quantity of output or traffic. See also **variable costs.** NARUC(a)

fixture rate. A pricing structure in which prices for a given time period are set for each water using fixture (that is, faucets, toilets, etc.) at the location where service is provided. Although very imprecise, it is more usage oriented than a **flat fee.** AUT

flat fee. A periodic fixed charge for water service that is unrelated to the amount of water consumed, typically used when customers are unmetered. It is not the same as a **uniform rate** (which is sometimes known as a flat commodity rate). AUT

flat rate. See **flat fee.**

forecast test year. See **future test year.**

fully distributed costing. A cost accounting method in which each job or service absorbs a share of each of the costs of rendering service. It requires the allocation of indirect fixed overhead costs in their entirety, which in turn requires the calculation of predetermined overhead rates. The method uses five cost assignment criteria: (1) **cost causation,** (2) **traceability,** (3) **variability,** (4) **capacity required,** and (5) **beneficiality.** Also known as full costing, fully allocated costing, and absorption costing. AUT

functional-cost method. A method by which **costs of service** are separated into four functions which describe the activities of a water utility: (1) production and transmission, (2) distribution, (3) **customer costs,** and (4) hydrants and connections. This method has not had wide acceptance in recent years because it requires much judgment and fails to recognize that major portions of costs are capacity or demand related. AWWA(a)

future capacity. The capacity for services somewhat in excess of immediate requirements that is built into a utility in anticipation of increased demands for service resulting from higher uses by existing customers or from growth in the service area. AWWA(b)

future test year. Use of future 12-month-period projected utility financial data to evaluate a proposed tariff revision. See also **historic test year** and **test year.** Also known as a forecast test year. NARUC(a)

historic cost. The initial cost to the person who holds the property. **Original cost** and historic cost are the same where property has not changed ownership. When utility property of an **operating unit or system** nature changes ownership, the original cost carries forward and is maintained by the new owner, although the purchase price (that is, historic cost to the new owner) may be something different. DHS

historic test year. Use of a past 12-month period (usually the immediately preceding period) utility financial data to evaluate a proposed tariff revision. See also **future test year** and **test year.** NARUC(a)

hook-up fees. A charge at the time of connection. It can be used to discourage new connections and is usually used to recover connection costs, or, if a system is nearing capacity, to discourage new hook-ups. AWWA(d)

imminence. A test to determine how soon a capital asset will be put into actual use in providing utility service; that is, how soon it will be **used and useful.** NARUC(a)

increasing block pricing. A pricing structure, also known as inverted block pricing, in which the average and marginal price per block of use increases as consumption increases. It can be used for reducing average (and sometimes peak) use, and large volume users consider its use inequitable. AWWA(d)

incremental cost. The change in total cost resulting from a change in capacity, output, or services provided. See also **average incremental cost** and **marginal cost.** AUT

incremental-cost-pricing method (for determining **system-development charges**). A method in which new customers would be responsible for their share of the cost of the last increment of defined **system-development charge facilities** and/or the increment of planned future additions to meet their needs. See also **system buy-in method.** AWWA(b)

interruptible service. Service with special rates for customers who are willing to have their utility service interrupted by the utility when necessary. This is a low-priority service with generally lower unit rates. NARUC(a)

inverted block pricing. See **increasing block pricing.**

investment advances. Advances, represented by notes or by book accounts only, with respect to which it is mutually agreed or intended between the creditor and debtor that they shall be settled by the issuance of securities or shall not be subject to current settlement. NARUC(b)

leakage. See **system leakage, unavoidable leakage,** and **recoverable leakage.**

life expectancy. The time period during which an article is expected to render efficient service. See also **remaining life.** NARUC(a)

lifeline pricing. A pricing structure in which the price for "necessary" use is kept low. It can be used to reduce average use and is usually used to ensure that low-income users are not unduly burdened by high prices. AWWA(d)

load. The amount of utility product delivered at any specified point or points on a system. NARUC(a)

load factor. The ratio of average demand to peak demand, defined with reference to a specific time period or type of peak load, such as maximum-hour or maximum-day. The load factor is operationalized as the ratio of actual consumption over a period, to the maximum (peak) demand multiplied by the length of a period (the period can be hourly, daily, monthly or annual). See also **diversity factor** and **utilization factor.** AUT

load management. Techniques designed to reduce **demand** at peak times. NARUC(a)

losses. See **system water losses** and **meter losses.**

maintenance expenses. Part of **operating expenses,** including labor, materials, and other expenses, incurred for preserving the operating efficiency and/or physical condition of **utility plant.** NARUC(a)

marginal cost. The change in total cost resulting from producing (or not producing) a single incremental unit of a product or service. It is composed of: (1) the change in operating costs caused by changing the rate of utilization of existing capacity, and (2) the cost of expanding capacity, including the operating costs associated with increased capacity. See also **average incremental cost** and **incremental cost.** AUT

master metering. The use of one bulk meter for multiple tenants. NARUC(a)

meter error. That percent of water passing through the meters of a distribution system which is not properly measured by the meter. Master meter error is the meter error for all unmeasured water passing through these source or master meters, and customer meter error is all unmeasured water passing through customer meters. These errors are discovered when meters are calibrated and the quantity of error is derived from the mathematical adjustment of recorded flows to the calibrated corrections. AWWA(e)

meter losses. Water from the total of all losses resulting from meter inaccuracies. Where meters are repaired and recalibrated, meter losses can be calculated from a ratio of meter rates before and after calibration. For meters that are stopped, meter losses can be estimated from previous records from that meter during similar times and seasons. AWWA(e)

metered ratio. The ratio of <u>all</u> corrected water use, whether sold or not, to corrected metered water production. AWWA(e)

metered service. Meters record actual use in order to accurately bill a utility customer. See also **unmetered service.** NARUC(a)

MGD. Million gallons per day.

minor items of property. The associated parts or items of which retirement units are composed. NARUC(b)

mixed test year. A combination of the **historic test year** and **future test year** approaches also know as a partial future test year. See also **test year.** AUT

multiple family dwelling. A residential structure or group of structures which is capable of separately housing more than one family unit. NARUC(b)

net operating income. The amount of revenues from utility operations that remains after the deduction of the operating and maintenance expenses, depreciation expenses, and taxes (income, property, etc.) attributable to the utility operation. The revenues and expenses that are measured to produce net operating revenue are commonly referred to as "above-the-line" items. The revenues and expenses measured apart from net operating income are referred to as "below-the-line" items. The net operating income line on the income statement is the dividing point. See also **below the line.** DHS

net original cost. **Original cost** less accumulated depreciation. DHS

net salvage value. The value of property retired less the cost of removal. NARUC(b)

nominally issued. As applied to securities issued or assumed by the utility, those which have been signed, certified, or otherwise executed, and placed with the proper officer for sale and delivery, or pledged, or otherwise place in some special fund of the utility, but which have not been sold, or issued direct to trustees of sinking funds in accordance with contractual requirements. NARUC(b)

nominally outstanding. As applied to securities issued or assumed by the utility, those which, after being actually issued, have been reacquired by or for the utility under circumstances which require them to be considered as held alive and not retired; provided, however, that securities held by trustees shall be considered as actually outstanding. NARUC(b)

nonaccount water. The sum of all water produced or purchased by a water utility that is not covered by **account water.** The term is preferable to unaccounted-for water. AWWA(e)

noncoincident-demand method. A method for allocating demand costs to each customer class on the basis of its own peak, regardless of whether it occurs at system peak demand. AUT

noncoincident peak. The sum of peak demands for all customer classes. This peak may or may not coincide with the peak for the total system. AUT

nonfirm service. See **interruptible service.**

nonoperating items. Although sometimes used interchangeably with **nonutility items,** this term may more properly be used to describe items such as construction work in progress which is not currently used in providing utility service. It has also been applied traditionally to financial items (for example, interest expense). DHS

nonutility items. All items of revenue, expense, and investment not associated, either by direct assignment or by allocation, with providing service to the utility customer. DHS

off-peak. A period of relatively low system demands. See also **on-peak.** NARUC(a)

off-peak rates. The use of separate rates or rates lower than average for water delivered during off-peak periods. AWWA(a)

on-peak. A period of relatively high system demands. See also **off-peak.** NARUC(a)

operating expenses. Expenses related to maintaining day-to-day utility functions, including operation and maintenance expenses, taxes and depreciation and amortization costs, but not interest payments or dividends. Operating costs are recovered from customers on a current basis, as opposed to capitalized costs. NARUC(a)

operating ratio. The ratio, generally expressed as a percentage, of operating expenses to operating revenues. NARUC(a)

operating revenues. Amounts collected by the utility for services rendered. NARUC(a)

operating unit or system. Although not clearly defined by the Uniform System of Accounts, this term generally relates to a complete and self-sustaining facility or to a group of facilities acquired and operated intact as a segment of a complete system. DHS

original cost. As applied to utility plant, the cost of such property to the person first devoting it to public service. NARUC(b)

outage. The period during which a generating unit, transmission line, or other facility is out of service. NARUC(a)

peak demand. The maximum level of operating requirements (that is, production) placed upon the system by customer usage during a specified period of time (instantaneous peak, thirty-minute peak, one-hour peak and one-day peak outputs are common points of reference). It may be measured by an operating segment of the company, such as a customer class, or for the entire company, depending on intended use of the data. See also **off-peak** and **on-peak.** DHS

peaking factors. A measure of the additional system capacity needed to deliver peak water volumes. The ratio of peak consumption to average consumption. AWWA(f)

peak-load pricing. A pricing structure in which charges are based on both the quantity of water used and the maximum rate at which it is used. It also recognizes two types of demand (customer's demand that is coincidental with the system peak demand and customer's non-coincidental demands) and prices each separately. AWWA(a)

peak responsibility method. A **cost of service** method proposed for application to telephone utilities that allocates costs according to how and when service is used and how this use contributes to congestion on plant and equipment required to provide service. AUT

plant acquisition adjustment. The difference between the cost to the utility of acquired plant and the original cost of the plant less the amount credited at the time of acquisition for depreciation and amortization and **contributions in aid of construction.** See also **acquisitions adjustment.** NARUC(a)

plant held for future use. Cost of land or other property acquired by a utility but not yet used for generation, transmission, or distribution purposes. See also **utility plant in service.** NARUC(a)

plant in service. See **utility plant in service.**

premium. As applied to the securities issued or assumed by the utility, the excess of the cash value of the consideration received from their sale over the sum of their par (stated value of no-par stocks) or face value and interest or dividends accrued at the date of sale. NARUC(b)

property retired. As applied to utility plant, property which has been removed, sold, abandoned, destroyed, or which for any cause has been permanently withdrawn from service. NARUC(b)

prudence. A consideration of whether investments are dishonest or obviously wasteful. NARUC(a)

rate base. The value of a water utility's property used in computing an authorized return under the applicable laws and/or regulatory policies of the agency setting rates for the utility. AWWA(b)

rate base regulation. A method of regulation in which a public utility is limited in operations to revenue at a level which will recover no more than its expenses plus an allowed **rate of return** on its **rate base.** NARUC(a)

rate of return. The *realized* rate of return is the percentage factor obtained by dividing the **net operating income** from utility operations by the **rate base.** An *adequate* rate of return is the percentage factor that, when multiplied by the rate base, produces earnings that will meet the interest and equity requirements of the capital used to support the rate base. The measure of the adequacy of the rate-of-return factor is usually based upon cost-of-capital measurements. DHS

rate structure. The design and organization of billing charges by customer class to distribute the **revenue requirement** among customer classes and rating periods. NARUC(a)

recoverable leakage. All water from breaks and leaks that are repaired or are considered to be economical to repair. AWWA(e)

reimbursement costing. A cost accounting method used to develop cost-based prices that recover the total cost of production. It employs concepts governing the measurement of costs that are negotiated by customers or their representatives. AUT

remaining life. The expected future service life of an asset at any given age. See also **life expectancy.** NARUC(a)

replacement (or replacing). The construction or installation of utility plant in place of property retired, together with the removal of the property retired. NARUC(b)

replacement cost. An estimate of the cost to replace the existing facilities (either as currently structured or as redesigned to embrace new technology) with facilities that will perform the same functions. This method recognizes the benefits of presently available technology in replacing the system. For example, a number of small generating units may be replaced with a single large unit at lower unit costs and greater efficiency. DHS

reproduction cost. The estimated cost to reproduce existing properties in their current form and capability at current cost levels. The mechanics may involve a trending the original cost dollars to reflect current costs or conducting a property appraisal with cost estimates to for reconstructing the facilities. DHS

research and development. Expenditures incurred by public utilities which represent research and development costs in the experimental or laboratory sense. The term includes generally all such costs incident to the development of an experimental or pilot model, a plant process, a product, a formula, an invention, or similar property, and the improvement of already existing property of the type mentioned. NARUC(b)

retained earnings. The accumulated net income of the utility less distributions to stockholders and transfers to other capital accounts, and other adjustments. NARUC(b)

retirement units. Those items of utility plant which, when retired, with or without replacement, are accounted for by crediting the original cost.

revenue requirements. The amount of return (rate base times rate of return) plus operating expenses. NARUC(a) The sum total of the revenues required to pay all operating and capital costs of providing service. DHS

salvage value. The amount received for property retired, less any expenses incurred in connection with the sale or in preparing the property for sale, or, if retained, the amount at which the material recoverable is chargeable to materials and supplies, or other appropriate account. NARUC(b)

scarcity pricing. A pricing structure in which the cost of developing new supplies is attached to existing use. It can be used to reduce average use and where supplies are diminishing (that is, a finite supply) so that costs for developing new supplies are paid for by current users. AWWA(d)

seasonal pricing. A pricing structure in which the price level during the season of peak use (summer) is higher that the level during the winter. It can be used to reduce peak use, and large volume users consider its use equitable. It can be effective for summer tourist communities. AWWA(d)

service connection. That portion of the service line from the utility's water main to and including the curb stop at or adjacent to the street line or the customer's property line. It includes other valves, fittings, and so on, that the utility may require at or between the main and the curb stop, but does not include the curb box. AWWA(b)

service life. The time between the date utility plant can be included in **utility plant in service,** or utility plant leased to others, and the date of its retirement. If depreciation is accounted for on a production basis rather than on a time basis, then service life should be measured in terms of the appropriate unit of production. NARUC(b)

service line. The pipe and all appurtenances that run between the utility's water main and the customer's place of use and includes fire lines. AWWA(b)

service value. The difference between the original cost and the net **salvage value** of utility plant. NARUC(b)

sliding scale pricing. A pricing structure in which the price level per unit for all water used increases based on average daily consumption. It can be used for reducing average (and sometimes peak) use and large volume users consider its use inequitable. AWWA(d)

spatial pricing. A pricing structure, also known as zonal pricing, in which users pay for the actual costs of supplying water to their establishment. Costs (and hence prices) will tend to vary regionally within the service sector. Spatial pricing can be used to discourage new or difficult to serve connections and is used in areas where the distribution system is being expanded rapidly and being expanded in difficult to serve areas (long mains, pumps, and so on). AWWA(d)

straight-line method. As applied to **depreciation** accounting, the plan under which the service value of property is charged to operating expenses (and to clearing accounts if used), and credited to the accumulated depreciation account through equal annual charges during its service life. Estimates of the service life and salvage will be reexamined periodically and depreciation rates will be corrected to reflect any changes in these estimates. NARUC(b)

straight-line remaining life method. As applied to **depreciation** accounting, the plan under which the service value of property is charged to operating expenses (and to clearing accounts if used), and credited to the accumulated depreciation account through equal annual charges during its service life. "Remaining life" implies that estimates of future life and **salvage** will be reexamined periodically and that depreciation rates will be corrected to reflect any changes in these estimates. NARUC(b)

supply main. Any main, pipe, aqueduct or canal, the primary purpose of which is to convey water from one unit to another unit in the source of supply, water treatment or pumping plant and generally providing no service connections with customers. See also **transmission and distribution main.** NARUC(b)

system buy-in method. A method of determining a **system-development charge** from new customers (or developers who represent them) based on the premise that new customers are entitled to water service at the same prices charged to existing customers. The fee to new customers is related to the embedded average-equity investment in the reserve capacity or new capacity used to serve them. See also **incremental-cost pricing method.** AWWA(b)

system-capacity charge. See **system-development** charge.

system-development charge. A contribution of capital toward recently completed or planned future backup plant facilities necessary to meet the service needs of new customers to which such fees apply. Two methods used to determine the amount of these changes are the **system buy-in method** and **incremental-cost pricing method.** Various terms have been used to describe these charges in the industry, but regardless of the term used, these charges have the purpose of providing funds to be used to finance all or part of capital improvements necessary to serve new customers and are raised outside of capital to be served from general water-use rates. Also known as a system-capacity charge. AWWA(b)

system-development charge facilities. Those facilities, or a portion of those facilities, that have been identified as being required for new customer growth. The cost of the facilities will be recovered in total or in part through a **system-development charge.** AWWA(b)

system leakage. All water that is lost from the system through leaks and breaks and includes all **unavoidable leaks,** and all **recoverable leaks** and breaks. AWWA(e)

system water losses. Water from all losses such as theft, illegal connections, unauthorized uses, malfunctioning controls, differences in use quantities caused by meter error and any other loss which is not a result of a leak or a break. AWWA(e)

tariff. The authorized list of charges for a utility's services. AUT

tax incentives. Tax credits or reductions provided to water users who have installed conservation devices. They can be used to reduce either peak or average use and allow for voluntary user choice to use conservation devices. AWWA(d)

test year. The annualized period for which costs are to be analyzed and rates established. AWWA(c) The twelve-month operating period selected to evaluate the **cost of service** and the adequacy of rates in effect or being sought. Frequently, the term "test period" is used, and may refer simply to the test year or expressly to the *adjusted* test year. See also, **historic test year, future test year,** and **mixed test year.** DHS

traceability. An attribute of costs that permits the resources represented by the costs to be identified in their entirety with a revenue-producing unit. AUT

transmission and distribution main. Any main the primary purpose of which is to convey water, requiring no further processing except incidental chlorination or pressure boosting, from a unit in the source of supply, water treatment of pumping plant and generally providing no service connections with customers. See also **supply main.** NARUC(b)

trended original cost. The result of isolating original-cost plant additions by year of placement and factoring the original amounts upward to recognize subsequent changes in the cost of constructing plant facilities. The object is usually to restate installed cost of facilities at current levels. DHS

unaccounted-for water. See **nonaccount water.**

unavoidable leakage. All water from underground leaks which, due to the small amount of actual water lost, would cost more to locate and repair than the value of the water saved over a reasonable amount of time. See also **recoverable leakage** and **system leakage.** AWWA(e)

unbilled revenues. The amount of service rendered but not recorded or billed at the end of an accounting period. Cycle meter reading practices result in unrecorded consumption between the date of last meter reading and the end of the period. If these amounts are not estimated and recorded, they reflect "unbilled" amounts. DHS

uniform rate. A pricing structure in which the price per unit is constant as consumption increases. It may be somewhat effective in reducing average use, and large volume users consider its use equitable. It is also know as a flat rate or a uniform block rate, but is not the same as a **flat fee.** AWWA(d)

uniform system of accounts (USOA). A list of accounts for the purpose of classifying all plant and expenses associated with a utility's operations. The USOA specifies a number for each account, together with a title and a description of content, and prescribes the rules and regulations governing the use of such accounts. Systems of accounts may be prescribed by federal and/or state regulatory authorities. NARUC(a)

unit cost. The cost of producing a unit of a produce or service. An example would be the cost of treating a thousand gallons potable water for use by the water utility's customers. AWWA(b)

unmetered service. Utility service used and billed without being recorded by a meter. See also **metered service.** NARUC(a)

used and useful. A test for determining the admissibility of utility plant as a component of rate base. Plant must be in use (not under construction or standing idle awaiting abandonment) and useful (actively helping the utility provide efficient service). See also **imminence.** NARUC(a)

user charges. The monthly, bimonthly, quarterly, or other periodic charges made to the users of water service through the general water-rate structures of the water utility. AWWA(b)

user fees. Amounts paid by consumers of a service that cover all or part of the cost of providing the service. In contrast, some governmental services are paid for or subsidized by taxes. AUT

utility plant in service. The land, facilities, and equipment used to generate, transmit, and/or distribute utility service. See also **plant held for future use** and **used and useful.** NARUC(a)

utility water use. That water which is removed from the distribution system by the utility for the purpose of maintaining and operating the system. This should include both metered and unmetered water removed with those unmetered uses being reliably estimated. AWWA(e)

utilization factor. The ratio of the maximum demand of a system to the installed capacity of the system. See also **diversity factor** and **load factor.** DHS

value of service. A concept in utility pricing practice whereby the usefulness or necessity of the service to a customer group replaces cost factors as a major influence on the rates charged to the group. DHS

variable charges. Periodic charges to customers that vary with water use, unlike **fixed charges.** AUT

variable costs. Costs which change with the increase or decrease of output. See also **fixed costs.** NARUC(a)

variability. An attribute of costs not traceable to a revenue-producing object based on whether it varies in total with variations in some measure of the volume of activity that is associated with the revenue-producing object. These costs can be assigned to revenue-producing objects according to an estimated rate of variability. AUT

vertical service. The utility company performs all major utility services for its customers, including production, transformation, transmittal, and distribution. This is typical of water utilities. NARUC(a)

vintage rates. A program in which customers are classified and customer rates are based on the date or period in which a customer connects to and first obtains service from the utility system. Such rates and charges can include user rates; customer contributions of capital for system development, main extension, and connection fees; or for ancillary services rendered. The concept has been used during periods of rising average costs to reflect the higher costs associated with serving new customers. AWWA(b)

water audit. A thorough accounting of all water into and out of a utility as well as an in-depth record and field examination of the distribution system that carries the water, with the intent to determine the operational efficiency of the system and identify sources of water loss and revenue loss. AWWA(e)

wheeling charge. The charge made by a utility for transmission of water to another party through its system. AWWA(c)

wholesale service. A situation in which water is sold to a customer at one or more major points of delivery for resale to individual retail customers within the wholesale customer's service area. AWWA(a)

working capital. Used broadly, the term refers to those rate-base allowances other than the utility plant in service and may include material, fuels, supplies, and so on. In the narrower use, commonly referred to as cash working capital, it relates to the investor-supplied funds necessary to meet operating expense or going-concern requirements of the business. There is normally a time lag between the point when service is rendered and the related operating costs are incurred and the point when revenues to recover such costs are received. The operating funds to bridge the lag are usually supplied by the investor and become a fixed commitment to the enterprise. DHS

zonal pricing. See **spatial pricing.**

zone measurement. See **district measurement.**

The **Glossary** was adapted from the following sources:

AUT	Authors.
AWWA(a)	American Water Works Association, *Water Rates* (Denver CO: American Water Works Association, Manual M1, 1983).
AWWA(b)	American Water Works Association, *Water Rates and Related Charges* (Denver, CO: American Water Works Association, Manual M26, 1986).
AWWA(c)	American Water Works Association, *Revenue Requirements* (Denver, CO: American Water Works Association, Manual M35, 1990).
AWWA(d)	American Water Works Association, *Before the Well Runs Dry, Volume 1* (Denver, CO: American Water Works Association, 1984).
AWWA(e)	Lynn P. Wallace, *Water and Revenue Losses: Unacccounted for Water* (Denver, CO: American Water Works Association, 1987).
AWWA(f)	Jack A. Weber and David S. Hasson, *Reference Manual: A Financial Planning Model for Small Water Utilities* (Denver, CO: American Water Works Association, 1990).
DHS	Deloitte Haskins & Sells, *Public Utilities Manual* (USA: Deloitte Haskins & Sells, 1984).
NARUC(a)	National Association of Regulatory Utility Commissioners, *NARUC Annual Report on Utility and Carrier Regulation 1988* (Washington, DC: National Association of Regulatory Utility Commissioners, 1989).
NARUC(b)	National Association of Regulatory Utility Commissioners, *Uniform System of Accounts for Class A Water Utilities 1984* (Washington, DC: National Association of Regulatory Utility Commissioners, 1984).

BIBLIOGRAPHY

Agthe, Donald E. and R. Bruce Billings. "Dynamic Models of Residential Water Demand." *Water Resources Research* 16 (June 1980): 476-80.

American Water Works Association. *Revenue Requirements.* Denver, CO: American Water Works Association, Manual M35, 1990.

__________. *The Rate Making Process: Going Beyond the Cost of Service*. AWWA Seminar Proceedings. Denver, CO: American Water Works Association, 1986.

__________. *Water Rates and Related Charges.* Denver, CO: American Water Works Association, Manual M26, 1986.

__________. *Demand Forecasting and Financial Risk Assessment*. AWWA Seminar Proceedings. Denver, CO: American Water Works Association, 1985.

__________. *Before the Well Runs Dry, Volume 1.* Denver, CO: American Water Works Association, 1984.

__________. *Water Rates*. Denver CO: American Water Works Association, Manual M1, 1983.

__________. *Water Rates: An Equitability Challenge.* AWWA Seminar Proceedings. Denver, CO: American Water Works Association, 1983.

__________. *Energy and Water Use Forecasting.* Denver, CO: American Water Works Association, 1980.

__________. *Water Conservation Strategies*. Denver, CO: American Water Works Association, 1980.

__________. *Developing Water Rates*. AWWA Seminar Proceedings. Denver, CO: American Water Works Association, 1973.

Arizona Corporation Commission. *Water Pricing and Water Demand: Papers Presented at a Water Pricing Workshop*. Utilities Division, August 21, 1986.

Arthur Young's 1988 National Water and Wastewater Rate Survey. Charlotte, NC: National Environmental Consulting Group, Arthur Young and Company, 1988.

Baumann, Duane D., et al. *The Role of Conservation in Water Supply Planning.* United States Corps of Army Engineers Contract Report 78-2. Institute for Water Resources, April 1979.

Beattie, Bruce R. and Henry S. Foster. "Can Prices Tame the Inflationary Tiger?" *American Water Works Association Journal* 72 (August 1980).

Beecher, Janice A. "Value, Cost, and Price: Essay on Emerging Water Utility Issues" *NRRI Quarterly Bulletin* 11 no. 2 (June 1990).

Billings, R. Bruce and Donald E. Agthe. "Price Elasticities for Water: A Case for Increasing Block Rates." *Land Economics* 56 (February 1980).

Boland, John J. "Forecasting the Demand for Urban Water." In *Municipal Water Supply: The Challenge for Urban Resource Management,* edited by David Holtz and Scott Sebastian. Bloomington, IN: Indiana University Press, 1978.

__________. "The Requirement for Urban Water: A Disaggregate Analysis." *1979 Annual Conference Proceedings.* Denver, CO: American Water Works Association, 1979.

Bonbright, James C., Albert L. Danielsen, and David R. Kamerschen. *Principles of Public Utility Rates*. Arlington, VA: Public Utilities Reports, 1988.

Brown, Gardner and C. B. McGuire. "A Socially Optimum Pricing Policy for a Public Water Agency." *Water Resources Research* 3 (February 1967).

Brown and Caldwell. *Residential Water Conservation Projects, Summary Report*. Washington, DC: U.S. Department of Housing and Urban Development, 1984.

Carver, Philip H. and John J. Boland. "Short-run and Long-run Effects of Price on Municipal Water Use." *Water Resources Research* 16 (August 1980).

Cassuto, Alexander E. and Stuart Ryan. "Effect of Price on the Residential Demand for Water Within an Agency." *Water Resources Bulletin* 15 (April 1979).

Cicchetti, Charles J., William J. Gillen, and Paul Smolensky. *The Marginal Cost and Pricing of Electricity.* Cambridge, MA: Ballinger Publishing Company, 1977.

Ciriacy-Wantrup, S. V. "Projections of Water Requirements in the Economics of Water Supply." *Journal of Farm Economics* 43 (May 1961).

Clark, Robert M. "Applying Economic Principles to Small Water Systems." *American Water Works Association Journal* 79 (May 1989).

__________. "Regulation Through Operating Revenues--An Alternative for Small Water Utilities." *NRRI Quarterly Bulletin* 9 no. 3 (July 1988).

__________. "Package Plants: A Cost-Effective Solution to Small Water System Treatment Needs." *American Water Works Association Journal* 73 (January 1981).

Colander, David C. and J. Haltiwanger. "Comment--Price Elasticity of Demand for Municipal Water: A Case Study of Tucson, Arizona." *Water Resources Research* 15 (October 1979).

Crew, M. A. and G. Roberts. "Some Problems of Pricing Under Stochastic Supply Conditions: The Case of Seasonal Pricing for Water Supply." *Water Resources Research* 6 (December 1970).

Crews, James E. and James Tang, eds. *Selected Works in Water Supply, Water Conservation and Water Quality Planning*. Fort Belvoir, VA: Institute for Water Resources, U.S. Army Corps of Engineers, 1981.

Cuthbert, Richard W. "Effectiveness of Conservation-Oriented Water Rates in Tucson." *American Water Works Association Journal* 81 no. 33 (March 1989).

Danielson, Leon E. "An Analysis of Residential Demand for Water Using Micro Time-Series Data." *Water Resources Research* 15 (August 1979).

De Rooy, Jacob. "Price Responsiveness of the Industrial Demand for Water." *Water Resources Research* 10 (June 1974).

Deloitte Haskins & Sells, *Public Utilities Manual.* USA: Deloitte Haskins & Sells, 1984.

Electric Utility Rate Design Study Group. *Electric Utility Rate Design Study Report to the National Association of Regulatory Utility Commissioners*. Palo Alto, CA: Electric Utility Rate Design Study Group.

Elliott, R. D. and J. A. Seagraves. *The Effects of Sewer Surcharges on the Level of Industrial Water and the Use of Water by Industry.* Raleigh, NC: Water Resources Research Institute, 1972.

Englebert, Ernest A. and Ann Foley Scheuring, eds. *Water Scarcity: Impacts on Western Agriculture*. Berkeley, CA: University of California Press, 1984.

Ernst & Young. *Ernst & Young's 1990 National Water and Wastewater Rate Survey*. Charlotte, NC: National Environmental Consulting Group, Ernst & Young, 1990.

Feldman, Stephen L. "Peak Load Pricing Through Demand Metering." *American Water Works Association Journal* 67 (September 1975).

__________. "On the Peak-Load Pricing of Urban Water Supply." *Water Resources Research* 11 (April 1975).

Feldman, Stephen L., John Breese, and Robert Obeiter. "The Search for Equity and Efficiency in the Pricing of a Public Service: Urban Water." *Economic Geography* 57, January 1981.

Feldman, Stephen L., Robert Obeiter, Michael Abrash, and Martin Holdrich. *Operational Approach to Estimating the Marginal Costs of Urban Water Supply with Illustrative Applications*. Unpublished report to the Wisconsin Public Service Commission, October 21, 1980.

Flack, J. Ernest and George J. Roussos. "Water Consumption Under Peak Responsibility Pricing." *American Water Works Association Journal* 70 (March 1978).

Foster, Henry S. and Bruce R. Beattie. "Urban Residential Demand for Water in the United States." *Land Economics* 55 (February 1979).

Fourt, Louis. "Forecasting the Urban Residential Demand for Water." Paper presented at an Agricultural Economics Seminar, University of Chicago, February 14, 1958.

Gibbs, Kenneth. "Price Variance in Residential Water Demand Models." *Water Resources Research* 14 (February 1978).

Goldstein, James. "Full-Cost Water Pricing." *American Water Works Association Journal* 78 no. 2 (February 1986).

Goolsby, William. "Optimal Pricing and Investment in Community Water Supply." *American Water Works Association Journal* 67 (May 1975).

Gottlieb, Manuel. "Urban Domestic Demand for Water: A Kansas Case Study." *Land Economics* 39 (May 1963).

Hanke, Steve H. "Demand for Water Under Dynamic Conditions." *Water Resources Research* 6 (October 1970).

__________. "Pricing Urban Water." In *Public Prices for Public Products,* edited by Selma Mushkin. Washington, D.C.: The Urban Institute, 1972.

__________. "Water Rates: An Assessment of Current Issues." *American Water Works Association Journal* 67 (May 1975).

__________. "Pricing as a Conservation Tool: An Economist's Dream Come True." In *Municipal Water Supply: The Challenge for Urban Resource Management,* edited by David Holtz and Scott Sebastian. Bloomington, IN: Indiana University Press, 1978.

__________. "A Method for Integrating Engineering and Economic Planning." *American Water Works Association Journal* 71 (September 1978).

__________. "On the Marginal Cost of Water Supply." *Water Engineering and Management* 120 (February 1981).

Hanke, Steve H. and A. C. Smart. "Water Pricing as a Conservation Tool: A Practical Management Option." In *Environmental Economics.* Canberra, Australia: Australian Government Publishing Service, 1979.

Hanke, Steve H. and Robert K. Davis. "Potential for Marginal Cost Pricing in Water Resource Management." *Water Resources Research* 9 (August 1973).

Harbeson, Robert. "A Critique of Marginal Cost Pricing." *Land Economics* 31 (February 1955).

Harunuzzaman, Mohammad and Govindarajan Iyyuni. *GCOST: A Gas Cost-of-Service Program*. Columbus, OH: The National Regulatory Research Institute, 1989.

Headley, Charles. "The Relation of Family Incomes and Use of Water for Residential and Commercial Purposes in the San Francisco-Oakland Metropolitan Area." *Land Economics* 39 (November 1963).

Henderson, J. Stephen and Robert E. Burns. *An Economic and Legal Analysis of Undue Price Discrimination*. Columbus, OH: The National Regulatory Research Institute, 1989.

Hirshleifer, Jack. "Peak Loads and Efficient Pricing: Comment." *Quarterly Journal of Economics* 72 (August 1958).

Hirshleifer, Jack, James C. Dehaven, and Jerome W. Milliman. *Water Supply: Economics, Technology, and Policy*. Chicago: University of Chicago Press. (1960).

Hogarty, Thomas F. and Robert J. MacKay. "The Impact of Price on Residential Water Demand and its Relationship to System Design and Price Structure." *Water Resources Research* 11 (December 1975).

Howe, Charles W. and F. Pierce Linaweaver. "The Impact of Price on Residential Water Demand and its Relationship to System Design and Price Structure." *Water Resources Research* 3 (1ast Quarter 1967).

Immerman, Frederick W. *Final Descriptive Summary: 1986 Survey of Community Water Systems*. Washington, DC: Office of Drinking Water, U.S. Environmental Protection Agency, 1987.

Johns Hopkins University. *Reports on Residential Water Use Research Project.* Baltimore, MD: Department of Sanitary Engineering and Water Resources, Johns Hopkins University, 1966.

Joskow, Paul L. "Public Utility Regulatory Policy Act of 1978: Electric Utility Rate Reform." *Natural Resources Journal* 19 (October 1979).

Kim, J. Youn and Robert M. Clark. "Economies of Scale and Scope in Water Supply." *Regional Science and Urban Economics* 18 (November 1988).

Kim, Jae R. and Richard H. McCuen. "Factors Predicting Commercial Water Use." *Water Resources Bulletin* 15 (August 1979).

Linaweaver, F. Pierce and John C. Geyer. "Use of Peak Demands in Determination of Residential Rates." *American Water Works Association Journal* 56 (April 1964).

Malko, Robert J. and Terrance B. Nicolai. "Using Accounting Cost and Marginal Cost in Electricity Rate Design." Eleventh Annual Rate Symposium on Pricing Electric, Gas, and Telecommunications Services. Columbia, MO: University of Missouri, 1985.

Mann, Patrick C. and Harry M. Trebing, ed. *Public Utility Regulation in an Environment of Change*. East Lansing, MI: Institute of Public Utilities, Michigan State University, 1987.

Mann, Patrick C. "Reform in Costing and Pricing Water." *American Water Works Association Journal* 79 no. 3 (March 1987).

Mann, Patrick C. and Donald L. Schlenger. "Marginal Cost and Seasonal Pricing of Water Service." *American Water Works Association Journal* 74 no. 1 (January 1982).

Mann, Patrick C., Robert J. Saunders, and Jeremy J. Warford. "A Note on Capital Indivisibility and the Definition of Marginal Cost." *Water Resources Research* 16 (June 1980).

Martin, William E., et al. *Saving Water in a Desert City*. Washington, DC: Resources for the Future, 1984.

McCuen, Richard H., Roger C. Sutherland, and Jae R. Kim. "Forecasting Urban Water Use: Commercial Establishments." *American Water Works Association Journal* 67 (May 1975).

McFarland, James P., John E. Cromwell, Elizabeth L. Tam, and David W. Schnare. "Assessment of the Total National Cost of Implementing the 1986 SDWA Amendments." A paper presented at the NRRI Biennial Regulatory Information Conference in Columbus, Ohio (September 1990).

Milliman, Jerome W. "New Price Policies for Municipal Water Service." *American Water Works Association Journal* 56 (February 1964).

Milliman, Jerome W. "Policy Horizons for Future Urban Water Supply." *Land Economics* 39 (May 1963).

Morgan, W. Douglas. "A Time Series Demand for Water Using Micro Data and Binary Variables." *Water Resources Bulletin* 10 (August 1974).

__________. "Climatic Indicators in the Estimation of Municipal Water Demand." *Water Resources Bulletin* 12 (June 1976).

National Association of Regulatory Utility Commissioners, *NARUC Annual Report on Utility and Carrier Regulation 1988.* Washington, DC: National Association of Regulatory Utility Commissioners, 1989.

National Association of Regulatory Utility Commissioners, *Uniform System of Accounts for Class A Water Utilities 1984.* Washington, DC: National Association of Regulatory Utility Commissioners, 1984.

Olsen, Darryll and Alan L. Highstreet. "Socioeconomic Factors Affecting Water Conservation in Southern Texas." *American Water Works Association Journal* 79 no. 3 (March 1987).

Ophuls, William. *Ecology and the Politics of Scarcity*. San Francisco: W. H. Freeman and Company, 1977.

Patterson, William L. "Comparison of Elements Affecting Rates in Water and Other Utilities." *American Water Works Association Journal* 57 (May 1965).

Phillips, Charles F. *The Regulation of Public Utilities: Theory and Practice*. Arlington, VA: Public Utilities Reports, Inc., 1984.

__________, ed. *Regulation, Competition, and Deregulation--An Economic Grab Bag.* Lexington, VA: Washington and Lee University, 1979.

Pollard, William. "Economic Theory Relevant to Marginal and Incremental Cost Estimation." A paper presented at The National Regulatory Research Institute's Telephone Cost-of-Service Symposium in Columbus, Ohio (August 12-17, 1990).

__________. *A Peak-Responsibility Cost-of-Service Manual for Intrastate Telephone Services: A Review Draft*. Columbus, OH: The National Regulatory Research Institute, 1986.

Regnier, John. "Case Study: Alabama Rate-Setting Study." A presentation at the Annual Meeting of the American Water Works Association in Cincinnati, Ohio (June 1990).

Renshaw, Edward F. "Conserving Water Through Pricing." *Water Works Association Journal* 74 no. 1 (January 1982).

Rose, Kenneth. "Regulated Utility Pricing Incentives with Price Cap Regulation: Can It Correct Rate of Return Regulation's Limitations?" A paper presented at the Forum on Alternatives to Rate Base/Rate of Return Regulation, sponsored by the Michigan Public Service Commission in East Lansing, Michigan (May 24, 1990).

Ruggles, Nancy. "The Welfare Basis of the Marginal Cost Pricing Principle." *Review of Economic Studies* 17 (1949-1950).

__________. "Recent Developments in the Theory of Marginal Cost Pricing." *Review of Economic Studies* 17 (1949-1950).

Saunders, Robert J. "Urban Area Water Consumption: Analysis and Projections." *Quarterly Review of Economics and Business* 9 (Summer 1969).

Seidel, Harris F. and John L. Cleasby. "A Statistical Analysis of Water Works Data for 1960." *American Water Works Association Journal* 58 (December 1966).

Sewell, W. R. Derrick and Leonard Roueche. "Peak Load Pricing and Urban Water Management: Victoria B. C., A Case Study." *Natural Resources Journal* 14 (July 1974).

Steiner, Peter O. "Peak Loads and Efficient Pricing." *Quarterly Journal of Economics* 71 (November 1957).

Trebing, Harry M. "Broadening the Objectives of Public Utility Regulation." *Land Economics* 53 (May 1977).

__________, ed. *Essays on Public Utility Regulation*. East Lansing, MI: Institute of Public Utilities, Michigan State University, 1971.

Turnovsky, Stephen J. "The Demand for Water: Some Empirical Evidence on Consumers' Response to a Commodity Uncertainty in Supply." *Water Resources Research* 5 (April 1969).

Turvey, Ralph. "Marginal Cost." *Economic Journal* 78 (June 1969).

__________. "Analyzing the Marginal Cost of Water Supply." *Land Economics* 52 (May 1976).

Vickrey, William. "Some Objections to Marginal Cost Pricing." *Journal of Political Economy* 56 (June 1948).

__________. "Some Implications of Marginal Cost Pricing for Public Utilities." *American Economic Review* 45 (May 1955).

__________. "Responsive Pricing of Public Utility Services." *Bell Journal of Economics* 2 (Spring 1971).

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

Wallace, Lynn P. *Water and Revenue Losses: Unaccounted for Water.* Denver, CO: American Water Works Association, 1987.

Weber, Jack A. and David S. Hasson. *Reference Manual: A Financial Planning Model for Small Water Utilities.* Denver, CO: American Water Works Association, 1990.

Wiseman, J. "The Theory of Public Utility Price: An Empty Box." *Journal of Industrial Economics* 18 (November 1969).

Wong, S. T. "A Model on Municipal Water Demand: A Case Study of Northeastern Illinois." *Land Economics* 48 (February 1972).

Yevjevich, Vujica, Luis da Cunha, and Evan Vlachos, eds. *Coping with Droughts* Littleton, CO: Water Resources Publications, 1983.

Young, Robert A. "Price Elasticity of Demand for Municipal Water: A Case Study of Tucson, Arizona." *Water Resources Research* 9 (August 1973).

Reports of the National Regulatory Research Institute on Water Utility Regulation

Beecher, Janice A. and Ann P. Laubach. *Compendium on Water Supply, Drought, and Conservation* (1989).

___________. *1989 Survey on State Commission Regulation of Water and Sewer Systems* (1989).

Beecher, Janice A. and Patrick C. Mann. *Deregulation and Regulatory Alternatives for Water Utilities* (1990).

Davis, Vivian Witkind, G. Richard Dreese, and Ann P. Laubach. *A Preliminary Review of Certain Costs of the Safe Drinking Water Act Amendments of 1986 for Commission-Regulated Ground Water Utilities* (1987).

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* (1984).

Davis, Vivian Witkind and Ann P. Laubach. *Surface Water Treatment Rules and Affordability: An Analysis of Selected Issues in Implementation of the 1986 Amendments to the Safe Drinking Water Act* (1988).

Dreese, G. Richard and Vivian Witkind Davis. *Briefing Paper on the Economic Impact of the Safe Drinking Water Act Amendments of 1986* (1987).

Lawton, Raymond W. and Vivian Witkind Davis. *Commission Regulation of Small Water Utilities: Some Issues and Solutions* (1983).

Mann, Patrick C. *Water Service: Regulation and Rate Reform* (1981).

Mann, Patrick C. and Janice A. Beecher. *Cost Impact of Safe Drinking Water Act Compliance on Commission-Regulated Water Utilities* (1989).

Mann, Patrick C., G. Richard Dreese, and Miriam A. Tucker. *Commission Regulation of Small Water Utilities: Mergers and Acquisitions* (1986).

Wagman, David C. and Raymond W. Lawton. *An Examination of Alternative Institutional Arrangements for Regulating Small Water Utilities in Ohio: An Abridgement* (1989).