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Water Resources Management in the State of Rhode Island: An Institutional Recommendation

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WATER RESOURCES MANAGEMENT

IN THE STATE OF RHODE ISLAND:

AN INSTITUTIONAL RECOMMENDATION

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ABSTRACT

Water is an indispensable resource. Modern urban areas have come to rely on extensive water supply networks which collect, store, treat, and distribute massive amounts of water from remote locations. Most systems in the northeastern United States were constructed several decades ago and still function very well. End users of such systems have become accustomed to an abundant supply of cheap, high quality water.

Rapid growth in population and economic development in recent years is placing a strain on existing water supply systems. At the same time, watershed and wellhead areas which are sources of supply are being threatened by increasing contamination sources resulting from intensified and sometimes inappropriate land use. Where the traditional solution to increasing demand is to create additional water supply sources, the fiscal and environmental impacts of such action are rapidly escalating. There is increasing interest a more comprehensive approach to the management of water, where a premium is placed on protecting surface and groundwater supplies, conservation, and the integration of the efforts of government and the water industry.

The purpose of this research project is to describe and evaluate the water resources management institutional structure in the state of Rhode Island. Using selected criteria, a comparison is made with alternative institutional approaches in Massachusetts, California and elsewhere. Based on this analysis, a recommendation for a new water resources and waste water management authority in Rhode Island is presented.

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If there is magic on this planet, it is in water.

-Loren Eisley

The order and manner in which decisions are made is critical to the effectiveness of any governmental body. This is especially true when resources vital to the public health, safety and welfare are in question. It is the basic responsibility of any government, regardless of its political, philosophical, or geographical orientation, to manage and regulate such resources as effectively as possible.

In recent years, population growth and the impact of economic development has strained traditional water supply systems. In response, government is increasingly broadening and making more regional its purview over water supply and delivery systems in acknowledgement of the many interrelated factors pertaining to water resources management.

Rhode Island's state government is presently in the process of reevaluating their institutional structure of water resources management. The first major demand forecasting study in 20 years is nearing completion. The Governor has recommended to the General Assembly a law which would place the Water Resources Board, a quasi-independent agency responsible for coordinating, regulating, and providing financial assistance for the activities of

the state's water authorities and private systems, under a new Department of the Environment.

Background

The existence of water is what differentiates the earth from all other planets. Water is essential to the support of all life forms. Water is also essential to countless human activities.

Water interacts between terrestrial and atmospheric conditions in a manner known as the hydrologic cycle. As precipitation falls to the earth's surface, it either evaporates, runs off the surface into water bodies, is absorbed by vegetation and is returned to the atmosphere in a process called evapotranspiration, or percolates through surface soils under the ground. Groundwater flows along the surface of till or bedrock and accumulates in aquifers. Residual water then flows up towards surface water bodies, where evaporation again takes place.

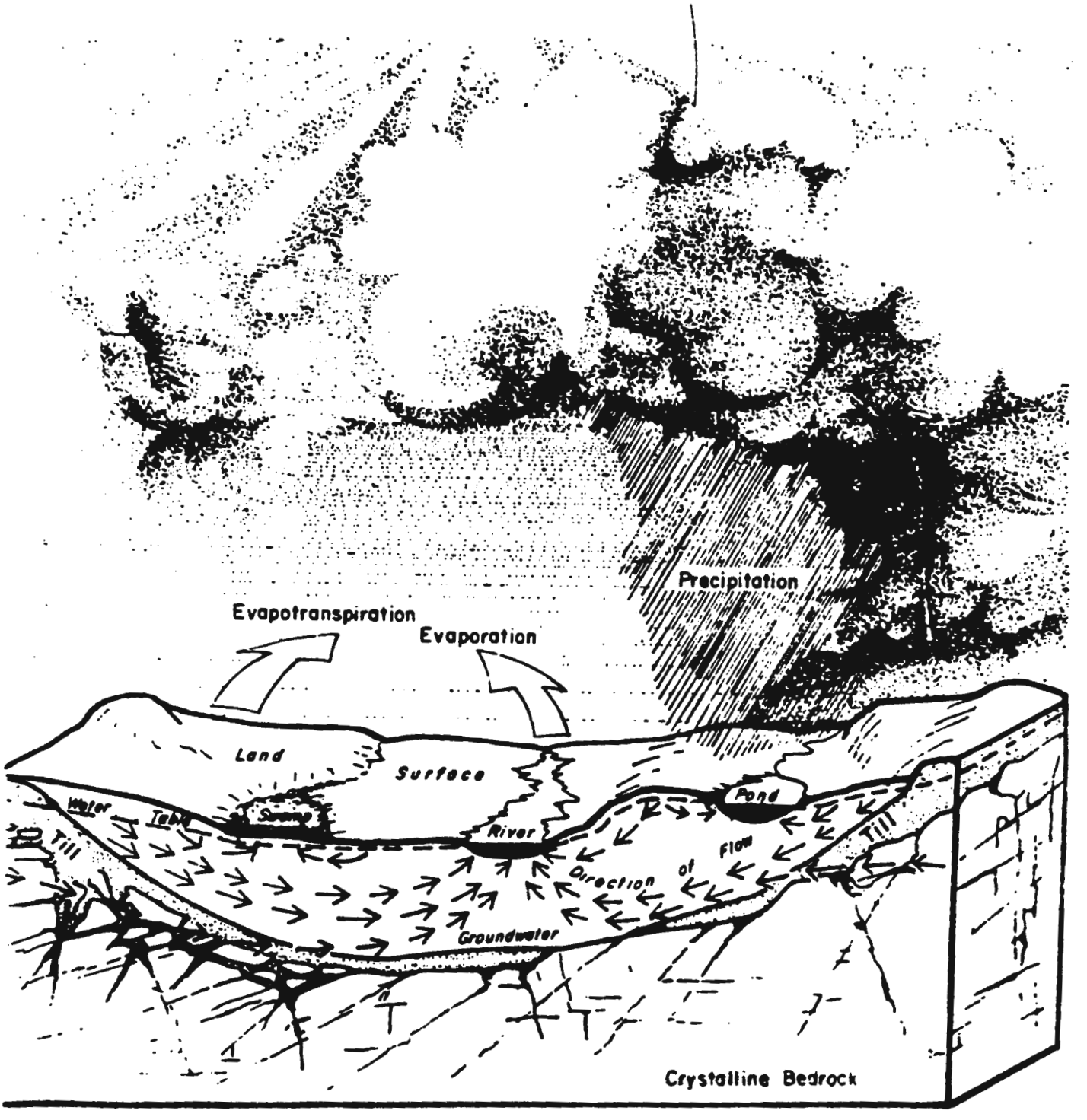
This underground movement of water is a function of soil conditions. Soils of high transmissibility closer to the surface are known as outwash. Soils of low transmissibility resting on hard bedrock are known as till. As water drains through these soils, it takes the path of least resistance, flowing through outwash, and around till and bedrock. Groundwater reservoirs exist where the soils are saturated. The adjacent area of highly transmissive soils is known as a recharge zone.

A hydrologic system is based on the flow of water within the confines of a watershed. Water drains down from higher elevations to a central water body, usually a river, and corresponding groundwater reservoir.

Over centuries, man has developed sophisticated ways of collecting, storing, treating and delivering water for use in urban areas often many miles from the original source. The Romans constructed great stone aqueducts which delivered water to the cities from the mountains in the north. In the United States, the California Water Plan and the Central Arizona Project represent the largest water storage and transmission systems in the world, diverting the Colorado River and several rivers in northern California through pipelines and aqueducts to metropolitan areas located in the desert hundreds of miles away. Treatment of raw water supplies removes sediment, impurities and kills harmful bacteria.

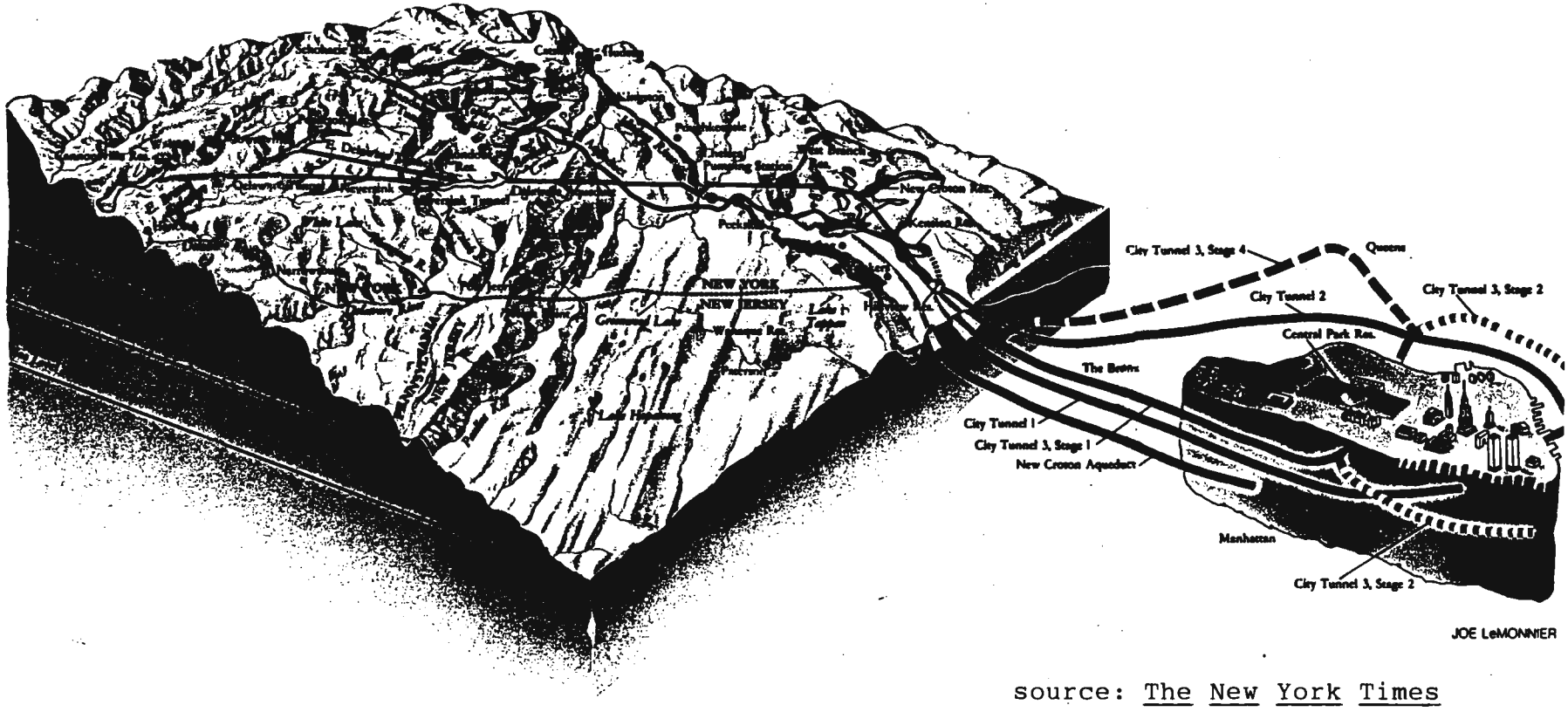
In recent decades, rapid population growth and out-migration from traditional urban centers has resulted in two dynamic conditions facing those responsible for water supply and delivery systems. The first condition is the increasing demand for additional water supply to accommodate population growth. Where water suppliers have initially relied on planning for the development of additional water supply sources, concern over environmental impacts of reservoir development has resulted in federal government discouragement of such projects. As a result, there is an increasing interest in encouraging more efficient use of existing supplies. Many feel an important conservation strategy is to price water in such a way that it becomes more

figure 1:The Hydrologic Cycle



source: RI Statewide Planning Program

figure 2: New York City Water Supply System

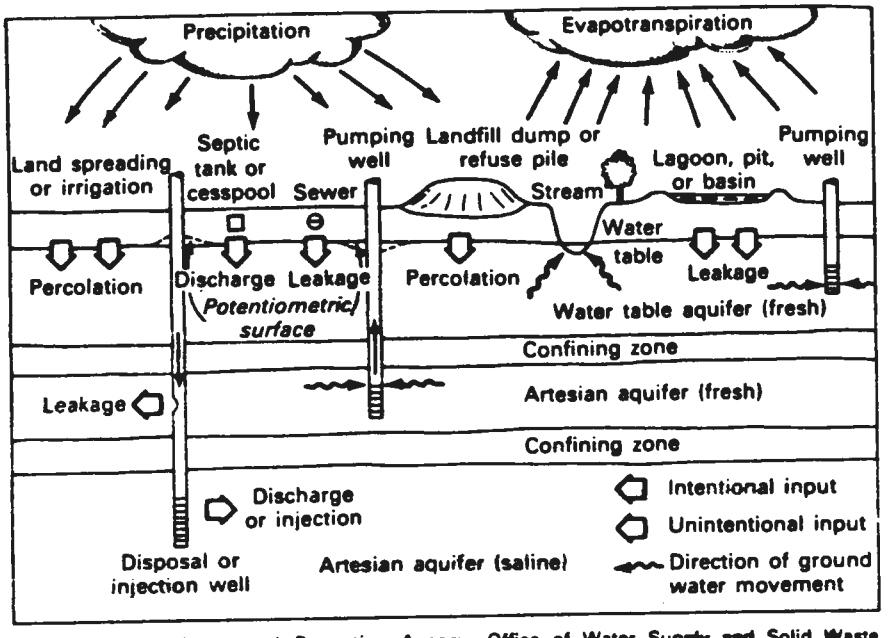


source: The New York Times

expensive with an increase in consumption, and/or during times of the year when there is peak demand.

The second condition is the accumulative impact of intensified land use practices on groundwater. Within a watershed, pollution from runoff-borne toxins and failed waste storage and disposal facilities are a common threat (figure 3). There are two classifications of contamination sources. Point sources are specific sources of discharge. Non-point sources are not easy to identify.

figure 3: Sources of Groundwater Contamination



Source: U.S. Environmental Protection Agency, Office of Water Supply and Solid Waste Management Programs, Waste Disposal Practices and Their Effects on Ground Water: Executive Summary (Washington, D.C.: U.S. Government Printing Office, 1977), p. 8.

The following man-made pollution sources constitute common threats to the quality of water resources:

1. Urban Runoff. Impervious surfaces created by buildings and pavement prevents water from percolating into the ground. Instead, water "runs off" in an accelerated fashion, carrying with it accumulated surface pollutants such as grease and petroleum, and metals such as copper, cadmium, lead, zinc and nickel. Runoff associated with storm conditions increases the likelihood of erosion and sedimentation.

2. Landfills. Leaching of toxic substances are a serious contamination threat to groundwater resources.

3. Hazardous Waste Sites. The failure of storage facilities is a significant environmental problem. However, the casual disposal of seemingly innocuous substances also has a potentially serious cumulative effect.

4. Individual Sewage Disposal Systems (ISDS). If these systems are improperly designed, are poorly maintained, or fail, there may be a significant increase in suspended solids and nutrients, resulting in a higher biochemical oxygen demand (BOD). Such conditions may starve aquatic species.

5. Underground Storage Tanks. Despite regulatory prevention programs, corrosion and leakage of storage tanks containing petroleum and other hazardous materials pose a threat to surface and groundwater bodies.

6. Underground Injection Control. Sludge, non-domestic wastes and waste water are sometimes injected through wells, pits, ponds, lagoons, cesspools, and septic systems as a permitted disposal method.

7. Agricultural Activities. The accumulation of fertilizers can load soils with excessive amounts of nitrogen and phosphorus. The accumulative effect of pesticides may threaten water resources.

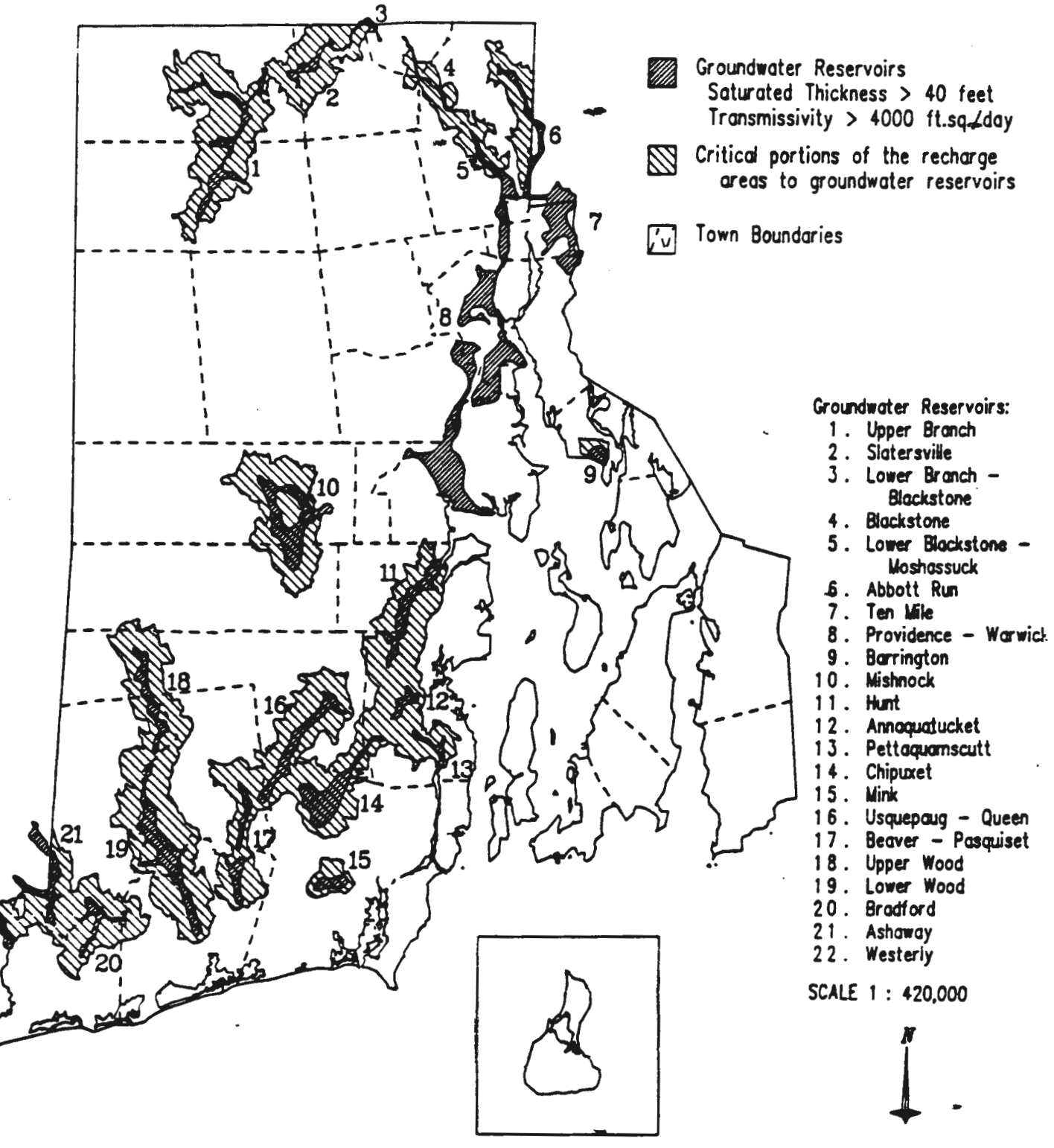
These environmental constraints are forcing states to reevaluate traditional water management approaches. Reliance on surface water storage is giving way to alternatives such as the tapping of groundwater for supply and programs which encourage conservation. As the demand for water increases and the supply and delivery systems remain fixed, the approach of government evolves from an orientation of regulating a public commodity to that of managing a limited resource.

Assumptions many Americans have held for years concerning water are no longer valid. This has always been true in vast areas of the western United States where there exists a dry, arid terrain. The way of life there has been one in which water has been considered a precious resource. It is not the water itself that is expensive, but the infrastructure needed to store, deliver and treat it. Order and control by government is widely accepted as critical to the maintenance of adequate supply and equitable distribution of water.

By national standards, Rhode Island enjoys an abundance of water resources. "The state contains 357 freshwater lakes and ponds, and 21 major groundwater aquifers within four of its river basins - Narragansett Bay, Blackstone, Pawtuxet, and Pawcatuck Rivers. An average annual rainfall of 45 inches provides ample replenishment of both surface and groundwater, except during the periods of drought conditions, when various short-term emergency

figure 4

GROUNDWATER RESERVOIRS AND THE CRITICAL PORTIONS OF THEIR RECHARGE AREAS



source:

measures are commonly used to extend water supplies" (RI Statewide Planning Program, 1988).

The current safe yield (defined as consistent and reliable minimum capacity) of public water supplies in the state is between 137.5 and 177.1 million gallons per day (MGD). Of this, between 110.1 and 149.7 MGD is drawn from surface reservoirs and 27.4 MGD (18% of the total water use in Rhode Island) is drawn from ground water wells (Arthur D. Little, Inc. 1990).

In 1980, 89.7% of Rhode Island's population received water from public suppliers (RI Statewide Planning Program, 1988). The Scituate water supply system services 600,000 residential customers, or 61% of the state's population. Of that, 36% is distributed through the PWSB system, and 25% is sold to other water authorities. Approximately 10% of the state's population relies on private water supply. Of all the water furnished from public systems, 50% is consumed for domestic purposes, approximately 33% is used for industrial, commercial and institutional purposes, and the balance is "unmetered" public and system use, and leakage (Arthur D. Little, Inc.1990).

In recent years state officials have been concerned with creating additional sources of supply, However, plans for a $300 million augmenting reservoir were vetoed this year by the US Environmental Protection Agency (EPA) because of its concern for the projected loss of sensitive wetlands. There is now more interest than ever before in a comprehensive state water resources management system.

In regard to the use of these water resources in the satisfying of public demand, Rhode Island State Guide Plan 721 makes the following observation:

> Several public water systems which formerly relied on groundwater, in whole or in part, as a supply source have recently switched to a much greater reliance on surface water supplies. This has been due to increasing problems with contamination and, in some cases, in anticipation of degradation of groundwater supplies from encroachment by intensive land use activities. The most common solution for many of these systems has been to tie into the Providence water system.
>
> This tendency to rely on the largest water system in the state, which has the most widespread and sophisticated distribution system, points out the apparent paradox of water supply issues in Rhode Island. The relative abundance of the resource is a false measure of its adequacy. The accessibility of high quality water within the economic parameters of public water system operations is a more accurate indicator of the problems which exist.

In this project I will describe the institutions responsible for the management of water resources in Rhode Island, and evaluate how the efforts of these agencies could better be integrated to carry out the goal to "provide for the cooperative development, conservation, and the use of water resources" (RIGL 45-15-2, 1967) in the state of Rhode Island.

In this project I also identify at what point on the comprehensive water resources management spectrum the state appears to be. At one end of the spectrum, water is marketed and regulated as a public commodity, and the management's orientation is on water supply and demand. At the other end of the spectrum, water is managed as a scarce resource. In this approach, water supply and distribution is highly integrated with conservation and ground water protection.

Based on my analysis and conclusions, I will recommend an institutional arrangement which would best facilitate the most efficient water resource management structure for the state of Rhode Island.

Chapter 2: The Evolution of Water Resources Management in Rhode Island

> Emotionally, people are able to look only two generations back and two generations forward. We need to see farther than that.
>
> -former Sierra Club Executive Director David Brower,
> from Encounters With the Archdruid, by John McPhee

In many ways, Rhode Island typifies the institutional water management approach of the regions of the northeastern United States. Since colonial times, urban centers have been the developers of central water supply and delivery systems. These cities most often secure supplies by the construction of reservoirs and delivery systems originating far from their geopolitical boundaries.

In recent years, the unrestricted development of water resources are coming under a progressive number of constraints. States and the federal government are enacting regulations relating to the environmental impacts of the constructing of surface water reservoirs. Population out-migration from central cities to previously undeveloped areas result in increased land values, increased threats to groundwater quality, and proportionally increased political power in areas in which potential future water supply sources for urban centers are located. In addition, water distribution systems originally developed by and for urban populations spread to become regional networks.

As a result of these developments, there is a growing interest in developing a regional approach to water resources management. States are

moving to establish some degree of control over the activities of the water supply systems within their jurisdiction. The following describes such an experience in the State of Rhode Island.

Providence Establishes the First State Water System, 1866-1955

Established within the enabling authority in Chapter 64 of the RI Public Laws of 1866, the City of Providence has ever since been the central water supply management institution in the state. The Providence Water Works developed the state's principal water supply resources, including the Scituate Reservoir (1924-29), constructed and managed an extensive distribution system, and was providing supply to at least 9 municipalities by 1964.

The modern Providence Water Supply Board (PWSB) was established per Chapter 1278 of the Public Laws of 1915. This Act also gave certain communities the right to receive from the PWSB water originating from the Scituate Watershed.

State Begins to Assert Control, 1955-67

Before 1955, the state limited its role in public water supply management. The Department of Health maintained continuous quality monitoring of public drinking water supply starting as early as the 1870's.

The Water Resources Coordinating Board (WRCB), established in 1955, created a seven member body whose function was primarily advisory. The duties and responsibilities of the Board included reviewing and evaluating

current studies and water conservation and development programs relating to state and municipal agencies, looking to a long-range ground water protection program, and to assisting in "devising and perfecting ways and means for accommodating the distribution of water supplies of the state" (P.L. 1955, ch. 3562, sect.3).

As an advisory body, the WRCB was charged with recommending legislative and other initiatives to the governor to promote a coordinated water resources program and with "making surplus water supplies in one area available to any other area in the interest of all the people and for the advancement of the economy of the state" (P.L. 1955, ch. 3562, sect. 5).

From the onset, ownership and development of the Big River Reservoir became the focal point in a fierce competition between the State and the City of Providence and the Providence Water Supply Board. When the State Fiscal Study Commission and Institute of Public Administration recommended in 1959 that the future development of water resources, pollution control and sewage disposal should be centered in the hands of the state, the city objected, stating the action might endanger its water supplies and raise rates.

A drought in 1962-66 intensified public interest in the issue. The City and the State became locked in a battle to determine which would be the developer of the Big River Reservoir project. WRCB Chairman Walter Shea announced in January 1960, that the state was planning to build the Big River and Wood River Reservoirs. The City responded in April 1962 with the assertion that if the state failed to build Big River, the City would be forced to

construct its own water source. In November 1965, Governor John Chafee authorized the condemnation of land for the first stage of the reservoir.

The City, making no secret of its willingness to develop the reservoir, commissioned a $27,000 preliminary engineering study in September 1967. Providence Mayor Joseph Doorley subsequently proposed his own $48 million plan to develop the two reservoirs. Providence Water Supply Board Chief Engineer Philip Holton went so far as to say that the State, after 16 years of struggle in planning for the new reservoirs, "has been unable to muster the drive and initiative to get the problem advanced beyond the study stage" (Providence Journal 9/20/66).

Quest For Big River Reservoir, 1967-85

In 1967, the state established the Rhode Island Water Resources Board (WRB) as a quasi-governmental state agency to replace the WRCB. By this act, the State asserted its authority to "provide for the cooperative development, conservation and use of water resources by the state, municipal agencies or departments, or privately-owned water systems" (RIGL 46-15-6(d) 1967). The Act recognized that the water industry's "capabilities and experience must be brought to bear on the total problem of water resources development in a coordinated manner if the proper development, conservation, apportionment, and use of the water resources of the state are to be realized" (RIGL 46-15-1, 1967).

Perhaps the most important feature of the Act was the provision which prohibited public or private water authorities from acquiring additional water supplies, condemning lands for additional sources of water supply, extending distribution to new service areas outside of its jurisdiction, constructing extensions of transmission lines, extending special water district boundaries, or supplying water to other municipal water districts without approval of the WRB. Such operations within the existing districts were permitted, but an enforcement provision allowed for a Superior Court injunction against any authority, upon application of the board.

The new law also gave the WRB the authority to acquire and develop properties for water supply, treatment and distribution, absorb public or private water authorities, regulate development performed by water authorities, borrow temporarily from a Water Development Fund, to make loans to public water authorities, and to "regulate, manage, or perform related functions on any lands or waters acquired under the provisions of the Big River-Wood River Reservoir Site Acquisition Act (P.L. chapter 133, 1964)" (RIGL 46-15-6, 1967).

Two years later the General Assembly passed the Administrative Procedure Water Development Fund Act establishing the WRB as a facilitator of financing of capital development for water supply and distribution system projects. This measure allowed the WRB to use the proceeds (up to a balance of $1 million) of the sale and lease of gravel mining and timber harvest rights on the Big River site as working capital for the Board's operations, debt service, and loans to water suppliers. The Water Facilities Assistance Program

Act of 1980 established a 25% grant program for public water supply systems that constructed approved water transmission facilities.

The Water Supplies Facilities Act of 1970 empowers the WRB with bonding authority based on the value of its assets. The bond funding designates for the costs of surface water supply development (especially Big River). Through the Act, the General Assembly established a sister body to the WRB, commonly known as the 'Board Corporate'.

Amendments to RIGL 46-15-6 in 1981 grants the WRB additional authority to acquire or merge with any public or private water authority, and to lease, sell or convey reservoir sites or facilities to any public or private water authority. At the same time, the WRB is relieved of the obligation to submit its transactions to the of the State Properties Committee. Previously, the WRB had no authority to perform such arrangements with public water authorities.

Additionally, the General Assembly in 1967 amended Chapter 640 of the Public Laws of 1866 by giving the State Public Utilities Commission the authority to review proposed rate increases by the Providence Water Supply Board for non-resident consumers. This measure was subsequently struck down by the Rhode Island Supreme Court in PWSB v PUC (414 A.2d 465) on April 29, 1980. The Court found that parallel statutes (P.L. 1967, ch. 156 sect. 2 and P.L. 1967, ch. 162 sect.2) were in conflict. Where the former included in its definition of a public utility only those municipal water authorities selling water outside of their territorial limits, the latter explicitly gave the PWSB the

authority to set its own rates. The Court decided chapter 162 superseded chapter 156 because it passed first, and its provisions were more specific.

Between 1968 and 1971 the competition between the WRB and the PWSB over the right to develop the Big River Reservoir took a new turn. Upon the passage of a $2.5 million Big River bond issue on April 18, 1968, the PWSB immediately introduced a $26.8 million plan to develop the project. The WRB responded by appointing two commissions to prepare to negotiate this proposal with Providence. On March 26, 1969, Governor Frank Licht announced the WRB had decided 'in principle' to allow the PWSB to develop the reservoir system, provided such details as land acquisition prices, management authority and recreational use of the site were resolved. The state set a limit on the City's land acquisition costs of $5.8 million.

After studying the State's offer at length, Mayor Doorley withdrew the City from consideration on July 9, 1971. The City cited the very 1967 statute later struck down in PWSB v PUC (1980), stating that because its rates were regulated by the PUC, the city was unable to meet the conditions necessary to sell the bonds which would finance the venture.

Subsequently, the WRB pursued the development of the Big River system in the face of growing opposition by environmental groups, the Division of Natural Resources (later to become the Department of Environmental Management), and the general public (i.e. in the failure of almost every bond referendum to pass during this period). By 1978, Governor J. Joseph Garrahy had formally requested the Army Corps of Engineers to design, and if possible,

construct the project. The Army Corps enthusiastically endorsed the project, completing several studies forecasting the need for the reservoir, and forwarding various proposals to construct the system.

In the meantime, momentum was building for more comprehensive demand management policies for the state. As early as 1973 Audubon Society of Rhode Island Executive Director Alfred Hawkes advocated a state water conservation program (including pricing strategies designed to reduce demand), as well as 'linking both ends of the pipe'- a concept embodying centralized management of both water supply and waste water treatment. In 1979 the Division of Statewide Planning urged that in the event Big River was built, municipalities receiving supply from that source would be required to submit a water conservation plan targeting a reduction in sewage flows and pollution.

Emergence of Planning and Comprehensive Resource Management, 1985-90

Starting in 1985, a number of initiatives marked a departure from the state government's past priority of engineering an increase in supply as the solution to future water needs to a more balanced approach, which includes planning and comprehensive water resource management. In the process, the WRB saw of its original policy-making authority transferred to other agencies.

That same year, the General Assembly empowered the Division of Statewide Planning to develop State Guide Plans for the management of Rhode Island's physical resources. RIGL 46-15-25 formally transfers such authority from the WRB to Statewide Planning. Such plans recommend "specific

guidelines, standards, and programs to be adopted to implement strategic planning" to the State Planning Council, whose members include the Director of the Department of Administration and his or her Assistant Director for Planning and Financial Management, the Governor's Director of Policy, the State Budget Officer, and the Director of the Office of Intergovernmental Relations.

The Division of Statewide Planning completed State Guide Plan Element 721-Water Supply Policies for Rhode Island in March, 1988. With the declared intent "to guide protection and development of water sources, promote conservation, and coordinate water system development with implementation of the land use plan and waste water disposal needs", the Guide Plan states in regard to assuring an adequate water supply that "it is no longer logical or feasible to pursue that end using only the traditional capital development program approach."

In regard to planning and institutional policies of the state, the Guide Plan recommended the following:

1. the state should develop long-range plans and improve coordination between all agencies involved in water resources,
2. more planning should take place at the state, municipal, regional and water system level,
3. approval of any development should be conditional upon the availability of adequate supplies,

4. there should be a central repository for all water resource data,
5. water system's management plans should be more comprehensive,
6. "the state should take an active role in guiding the resource management activities of public water systems through incentives, conditional financial assistance programs, and formal review procedures",
7. "in recognition of the interrelationship of waste water treatment requirements, the quantity of water made available to an area should not exceed the capacity of the treatment and/or disposal systems serving the same area", and
8. "the state should take an active role in protecting water supply watersheds, reservoirs, and groundwater aquifers."

Also in 1985, the General Assembly enacted The Ground Water Protection Act, which authorized the Department of Environmental Management to survey and classify the quality of all groundwater aquifers in the state, for the purpose of protecting existing and potential drinking water sources. The General Assembly also directed DEM to recommend strategies for the protection of groundwater.

The passage of The Public Drinking Water Protection Act of 1987 enhanced the WRB's role as a facilitator of water supply capital project funding. The measure established a "water quality protection charge" for public water suppliers of one cent per 100 gallons. The General Assembly earmarked

the proceeds from this charge for financing the acquisition of properties or development rights in critical watershed areas.

In a response to the contention of EPA that the state had failed to prepare a comprehensive water management plan, Governor DiPrete issued Executive Order no. 89-2 on January 25, 1989. This measure established the Water Resources Coordinating Council (WRCC), which was charged with the following responsibilities:

1. "to insure the implementation of a coordinated effort to preserve existing surface and underground water supplies",
2. "to insure the creation and the implementation of a comprehensive drinking water conservation program",
3. "to coordinate and review the evaluation of the need for new water supplies for the state and to advise the Governor", and
4. "to oversee the implementation of the provisions of the Federal Safe Drinking Water Act in Rhode Island".

Pursuant to this order the WRCC, using in excess of $550,000 in WRB funds, engaged the consulting firm of Arthur D. Little, Inc. of Cambridge, Massachusetts, to conduct a comprehensive water supply analysis for the state. The WRCC has also implemented several demonstration water conservation programs, and coordinated a water efficiency audit of state owned buildings.

On November 22, 1989 the Governor endorsed the proposal of the Environmental Quality Study Commission, including the recommendation that the WRB "be absorbed" into the Operations Branch of the new Department of the Environment. The Commission states "The Board's corporate existence should continue, but staff functions in water supply development should be carried out by a new Water Supply Section in the Operations Branch. This change will emphasize the resource management aspects of water supply rather than the public utility approach taken by the Board." It further states "The land acquisition and management of state-owned land for water resource protection functions of the current Water Resources Board will be vested in [the new Resource Management Branch]." Legislation establishing the new department is being considered by the 1990 General Assembly.

By 1990, the state of Rhode Island has evolved towards a more comprehensive planning approach, but the organizational framework of water resources management is still segmented. The decision-makers have shifted responsibilities between various agencies, and added environmental protection and planning responsibilities to its traditional focus on maintaining adequate water supply.

Chapter 3: Present Water Resources Management Institutions

Born in a water-rich environment, we have never really learned how important water is to us...Where it has been cheap and plentiful, we have ignored it; where it has been rare and precious, we have spent it with shameful and unbecoming haste...Everywhere we have poured filth into it.

--William Ashworth

In Rhode Island, there are presently several institutions which play a role in the management of water resources. The following is a description of these organizations, and how each functions in their respective area of responsibility.

The Suppliers

There are 30 major public water systems in Rhode Island. Each is either chartered by the state or is a department or quasi-independent agency (fire district) of a municipality.

Of the 30 systems, 10 acquire supplies from the Scituate Reservoir system managed by the Providence Water Supply Board, representing 62% of all public water resources in the state. While Providence provides its own water, the city sells supply wholesale to the Cranston Water Department, the East Providence Water Department, the East Smithfield Water District, the Greenville Water District, the Kent County Water Authority, the Lincoln Water

Table 1:
Total Water Use for Major Systems

Retail Water Department	Purchased from:	Year	Million Gallons /Year	Million Gallons /Day	Percent
Scituate System			26,875	73.6	62.3%
Providence		fy87	15,471	42.4	35.9%
Cranston	Providence	1988	338	0.9	0.8%
East Providence	Providence	1988	2,231	6.1	5.2%
East Smithfield	Providence, Smithfield*	1988	388	1.1	0.9%
Greenville	Providence	1987	327	0.9	0.8%
Johnston	Cranston*	1987	48	0.1	0.1%
Kent County	Providence, Warwick*	fy88	3,475	9.5	8.1%
Lincoln	Providence (1)	1988	914	2.5	2.1%
Smithfield	Providence	1988	191	0.5	0.4%
Warwick	Providence, Kent	fy88	3,492	9.6	8.1%
Other Interconnected Systems			10,955	30.0	25.4%
Cumberland	Pawtucket (2)	1987	783	2.1	1.8%
Narragansett	Wakefield,N Kings,S Kings	fy88	356	1.0	0.8%
Newport		fy88	2,571	7.0	6.0%
North Kingstown		1988	991	2.7	2.3%
North Tiverton	Fall River, Stonebridge	1988	156	0.4	0.4%
Pawtucket		fy88	4,655	12.8	10.8%
Portsmouth	Newport, Stonebridge	1988	445	1.2	1.0%
South Kingstown	Wakefield	fy89	126	0.3	0.3%
Stonebridge		es88	91	0.2	0.2%
Wakefield		1988	783	2.1	1.8%
Self-Contained Systems			5,309	14.5	12.3%
Block Island		1988	18	0.0	0.0%
Bristol	E Prov* (1987 & 88)	1985	1,556	4.3	3.6%
Harrisville		1988	81	0.2	0.2%
Jamestown		1988	86	0.2	0.2%
Kingston		fy88	118	0.3	0.3%
North Smithfield-Slatersville		1988	21	0.1	0.0%
Pascoag		1988	153	0.4	0.4%
Richmond		1988	6	0.0	0.0%
Westerly		1988	1,253	3.4	2.9%
Woonsocket		fy88	2,018	5.5	4.7%
Total			43,140	118.2	100.0%

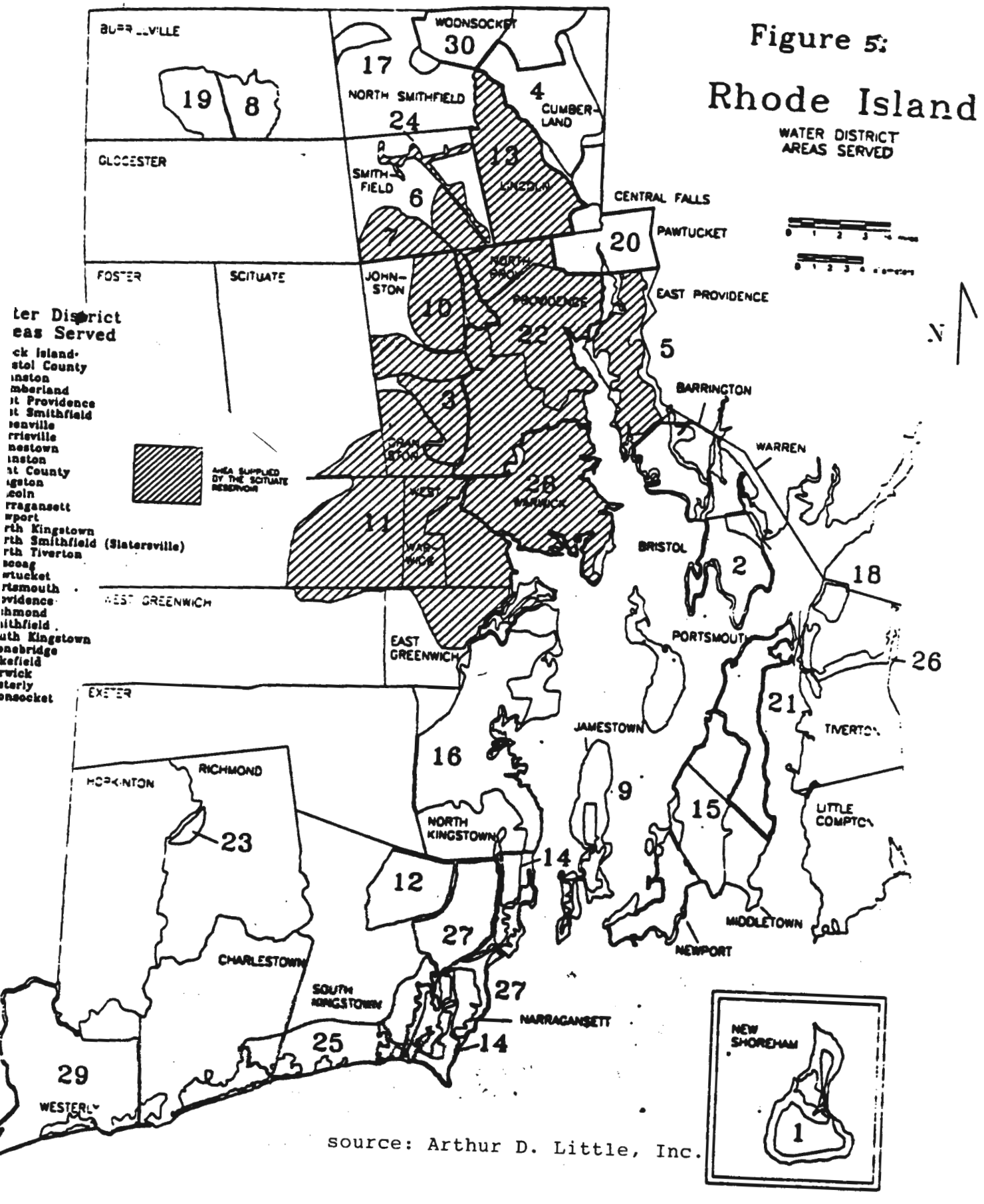
* Supplied by Providence
(1) Purchased from Pawtucket five years ago
(2) Occasional purchases from Lincoln

source: Arthur D. Little, Inc.

Figure 5:

Rhode Island

WATER DISTRICT
AREAS SERVED



source: Arthur D. Little, Inc.

Department, the Smithfield Water District, and the Warwick Water Department (table 1).

These authorities cover a contiguous area in and around metropolitan Providence (figure 5) and are connected to the Scituate system through high capacity distribution lines. There are also interconnected distribution lines between some of the systems who use Scituate water. Other authorities, including Pawtucket and Bristol County have the capacity to tap into the Scituate system under emergency conditions (RI Statewide Planning Program, 1988).

In addition to the Scituate Reservoir, other water supply sources serve more than one water authority. The Newport Water Department serves Newport and Portsmouth, the Wakefield Water Company serves North Kingstown and South Kingstown, and the Pawtucket Water Supply serves Pawtucket, the Lincoln Water Department, and the Cumberland Water Department.

Ten water authorities are self-contained systems. The Woonsocket Water Department, Westerly Water Department and Bristol County Water Authority are relatively large systems. The water authorities in New Shorham, Harrisville, Jamestown, Kingstown, North Smithfield, Pascoag and Richmond are very small by comparison.

There is a controversial proposal to link the Scituate system to the Bristol County Water Authority's transmission system. Bristol County customers pay the highest rates in the state, and the system is plagued by rusty, leaking

pipes and a seriously limited source of supply. A $30 million "Cross Bay Pipeline" has been questioned by environmental groups, state and federal environmental agencies, and municipalities already served by the Scituate Reservoir. A statewide referendum question authorizing $15 in state spending for the 10.4 mile extension failed by a 3-1 margin in November, 1989.

There are many supply management initiatives underway by the state and individual water authorities directed at protecting water supplies and upgrading distribution systems. The Rhode Island Water Works Association (RIWWA) has been instrumental in coordinating statewide water supply priorities. The Providence Water Supply Board, in November 1989 announced a $50 million, five year program to refurbish its system, including $20 million to increase the buffer around the Scituate Reservoir, $6 million to replace lead water pipes, $4 million to replace old water meters, and $4 million to replace aging water mains. The Bristol County Water Authority has had a similar capital improvement program in effect since 1987. The state Water Resources Board serves as a financing agent for the upgrading of transmission systems, providing 25% and 50% grants for capital improvements.

Leak detection is becoming a priority with some water suppliers. Arthur D. Little, Inc. estimated in November, 1989 that nearly 9 million of an estimated 147 million gallons of water every day are being lost to leaky distribution pipes. Kent County Water Authority officials estimated in May, 1990 that between 14 and 20 percent of their water is lost or unaccounted for. Programs featuring periodic leak detection and pipe repair and planned

preventative maintenance have been adopted by Kent County, Lincoln, Cumberland, Portsmouth, Pawtucket, Wakefield, Bristol County, and Westerly.

In the area of conservation, Providence, Lincoln and Newport participated in demonstration projects in the summer of 1989 to encourage residential customers to install water saving devices in their homes. In addition, Bristol County, Lincoln, Cumberland and Portsmouth charge rates which increase with consumption.

There are also a mounting efforts to protect surface water and groundwater supply sources from contamination. The 1988 Public Drinking Water Protection Act instills a one cent per hundred gallon surcharge for water authorities to acquire property and conservation easements in water supply source watersheds.

It is at the local level where ultimate responsibility for the delivery of adequate quantities of quality water supply to end users takes place. While a myriad of regulatory obligations have been incrementally imposed by state and federal authorities, suppliers are still responsible for keeping water flowing to customers 24 hours a day, 7 days a week.

The Regulators

A complex system of governmental regulatory activities is intended to provide protection for water resources. The foundation of the government's efforts is in "command and control" legislation-measures designed to prevent pollution of natural resources deemed critical to the common good.

The Federal Government

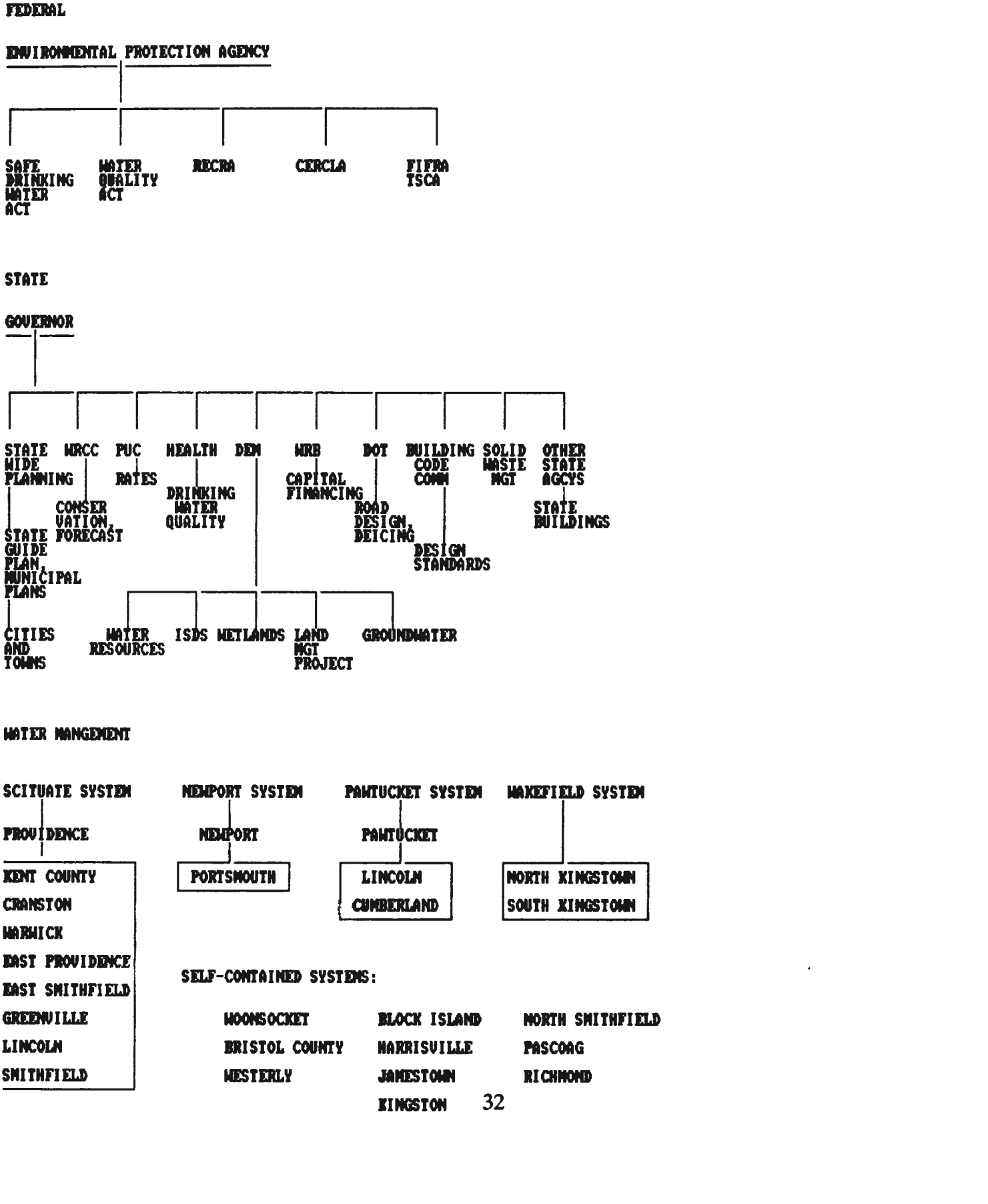
The federal government first established standards for contaminants in public drinking water supplies in the 1920's in order to control such diseases such as typhoid and cholera. For fifty years, these standards remained relatively unchanged.

In recent years, the federal government has enacted two measures which have modernized the protection of surface water supplies in the United States. Congress passed the Water Quality Act in 1965. The Safe Drinking Water Act (SDWA) was enacted in 1974 (and amended in 1986), directing the Environmental Protection Agency (EPA) to replace state standards for the quality and treatment of water supplies with national standards. Maximum contaminant levels were established for 83 substances. The Underground Injection Control Program (UIC) was created to regulate the disposal of toxic wastes into subsurface areas. The Sole Source Aquifer Demonstration Program provided for states and communities to secure EPA technical purview over federally funded projects in areas primarily serviced by groundwater. In addition, The Wellhead Protection Program was adopted to encourage prevention of contamination of areas surrounding public drinking water wells (Concern, Inc., 1988).

In 1972, the Clean Water Act (CWA) established federal jurisdiction over all surface water bodies. This measure was comprehensive in scope, regulating point and non-point pollution sources by establishing effluent standards, standards for the application of pollution control technology, requires

figure 6:

RHODE ISLAND'S PRESENT WATER RESOURCES MANAGEMENT SYSTEM



EPA to maintain a technological database on pollutants, establishing a federal permitting system for the release of pollutants, and creating the National Pollution Discharge Elimination System (NPDES), which provides for permitting of municipal and industrial storm water discharge. In addition, under this measure the EPA and the Army Corps of Engineers are directed to initiate a permitting system for dredging and filling certain wetlands.

Congress amended the Clean Water Act with the Water Quality Act of 1987. States are delegated control over toxic substance discharge and enforcement. Congress mandated EPA phase in stricter contamination standards. "These include stringent standards for 83 contaminants, filtration for most surface water sources, disinfection requirements, corrosion control, and increased monitoring and testing requirements. While imposing these requirements, the Act provides no funding for communities to carry them out" (MAPAC, 1989).

Significantly, a major feature of this Act is to require all states to initiate new non-point source pollution control plans. This measure is one of the few directed at the protection of groundwater resources.

Another area of responsibility of EPA is the administration of two measures relating to hazardous materials. The Resource Conservation Recovery Act (RCRA) requires standards be maintained for the treatment, storage, and disposal of these wastes. The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), commonly known as "Superfund", provides for the standards and administration of clean-ups of hazardous waste

sites, assigns liability to parties involved in such sites, and allows for coordination of efforts with state environmental agencies.

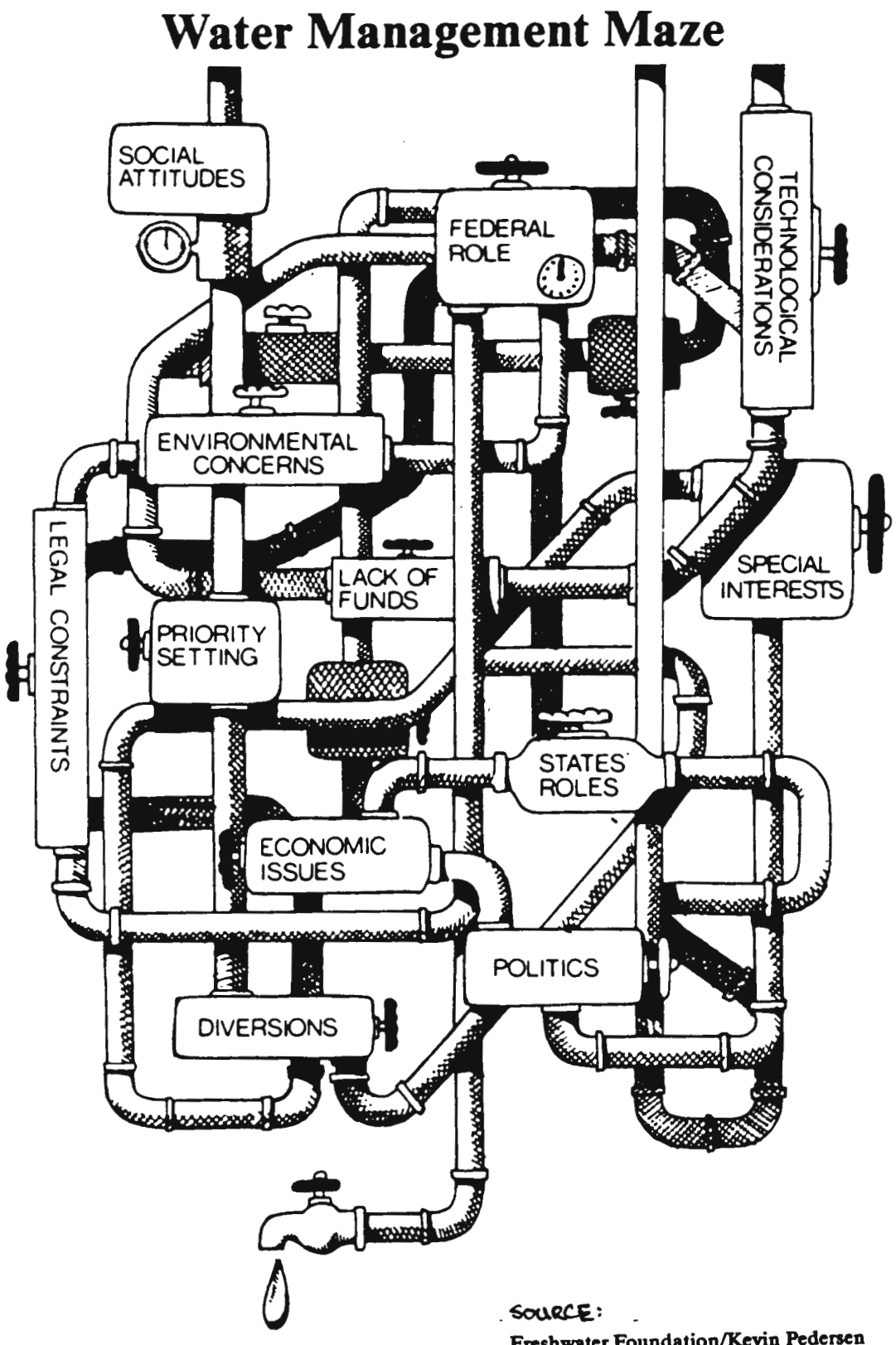
Other federal legislation relating to the potential contamination of groundwater include The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulating the production and use of pesticides and the Toxic Substances Control Act (TSCA) regulating the use of toxic materials.

The State of Rhode Island

The Department of Environmental Management (DEM) is the lead state agency in the area of command and control environmental protection administration, and coordinates most of the programs mandated by EPA.

The Division of Groundwater and Freshwater Wetlands administers regulation and enforcement efforts directed at controlling and monitoring development in hydrologically sensitive areas. The Wetlands Section regulates and enforces standards relating to bogs, swamps and freshwater marshes of three acres in size or greater, determining allowable alterations, and establishes minimum distances from water bodies and wetlands. The Individual Sewage Disposal System (ISDS) Section certifies installers, maintains standards for design, construction, and placement of systems, and determines approvals for the installation of systems. The Groundwater Section provides source location and quality standards, point source management and enforcement, and underground tank testing. This agency also responds to contamination emergencies.

figure 7.



SOURCE:
Freshwater Foundation/Kevin Pedersen
Reprinted Courtesy of Freshwater Foundation

The Division of Water Resources is responsible for regulating and permitting the controlled release of contaminants into the ground or water bodies. The division maintains regulations for oil pollution control and quality standards for fresh water bodies and waste water management. The Underground Injection Control Program provides classifications for waste storage wells. The Rhode Island Pollution Discharge Elimination System (RIPDES) issues permits for surface water discharge of storm water.

The Division of Air Hazardous Materials provides regulation, monitoring and enforcement relating to improperly stored or discharged toxic waste which has or might cause groundwater contamination. Many of the sites within its purview date back several years, before standards were in effect.

The Division of Water Pollution Control of the Department of Health is responsible for monitoring and maintaining safe drinking water standards for all public water supplies in the state. This division is within the Division of Environmental Policy.

The Department of Transportation (DOT) also has a hand in the control of potential pollution of surface and groundwater supplies. DOT is responsible for the design and construction of state and federal highways, and only recently has the department included runoff mitigation designs for new highways to be constructed. The department is also responsible for de-icing major roads in the state in the winter. DOT has recently started to cover salt storage facilities, and has also conducted experiments with the use of low salt de-icers.

Rhode Island Municipalities

Like the water suppliers, it is at the municipal level where the ultimate responsibility lies for environmental protection and public satisfaction with utility service. Towns and cities regulate land uses within their borders, following standards set by the state. In accordance with the Rhode Island Comprehensive Planning and Land Use Regulation Act of 1988, municipalities must write comprehensive plans and update them at least every five years. These plans must address the issues of environmental protection and growth control, and are submitted to the state Division of Statewide Planning for approval in compliance with the state's master plan. A key feature of the Act is that zoning and subdivision ordinances are required to conform to the comprehensive plan. This is intended to ensure that land development is generally consistent with state standards, especially in environmentally sensitive areas.

Municipal zoning and subdivision ordinances provide important regulatory groundwater and surface water protection opportunities. Developers must conform to site design and construction standards set by the local government. Municipalities may exercise several measures which provide a high degree of control over development. These include site plan review (where a developer negotiates the site designs with staff at the conceptual planning stage), overlay districts (stricter development standards within specific environmentally sensitive areas such as aquifer recharge zones), and site design standards which minimize the impact of runoff.

The Planners

Planning and demand management at the state level is fragmented, but evolving. The Division of Statewide Planning has become arguably the lead agency in the state for comprehensive water management planning. This agency is concerned with coordinating state water resources policy with the Governor's office, state agencies, municipalities, and water authorities. The division also works with the University of Rhode Island Geographic Information System (RIGIS) program, the Narragansett Bay Project, the DEM Land Management Project and other state agencies to maintain a water resources and land use database. Statewide Planning is also responsible for developing state guide plans, which declare goals, objectives, and implementation strategies at the state level.

The Division plays a role in all water resources management planning commissions, including the Water Resources Board, and State Planning Council. Another is the recent Scituate Reservoir Watershed Task Force, which in January 1990 recommended stricter development standards in sensitive areas and increased state authority to manage water supplies.

The most recent addition to the state's planning effort is the Water Resources Coordinating Council (WRCC). This body is an inter-agency task force whose responsibility is to advise the Governor of anticipated future needs and alternatives for water resource management at the state level. Council

members include representatives from the Governor's Policy Office, Health Department, Department of Environmental Management, Water Resources Board, Public Utilities Commission, Narragansett Bay Commission, Providence Water Supply Board, Division of State Wide Planning, and the Rhode Island Water Works Association. In addition, there is an environmental advocate representing the general public.

WRCC has commissioned a major supply and demand forecasting study conducted by the consulting firm Arthur D. Little. This project will provide officials with the most comprehensive baseline information on public water use since the last time such a study was performed in 1967.

One key mandate for WRCC is determining the feasibility of various conservation strategies. WRCC has sponsored demonstration water conservation projects, including residential and institutional retrofits (the installation of efficient water saving fixtures), and the state's first "Xeriscape" conference, which has promoted the use of a landscape design technique pioneered in Arizona which maximizes the use of vegetation that demands little water). In addition, WRCC has coordinated a water use audit of all state buildings.

The Rhode Island Public Utilities Commission (PUC) plays a critical demand management role as the agency which has the authority to set conditions for any rate increases requested by ll public water authorities and waste water treatment agencies whose service areas transcend municipal boundaries. The PUC requires water authorities account for volumes of water suspected of being lost in transmission and encouraged leak detection and

control programs. The Commission has recently required authorities to employ pricing standards which could encourage conservation. The PUC has required the PWSB to link its billing system to that of the Narragansett Bay Commission (NBC) in order to make clearer the relationship between the cost water supply and the cost of waste water treatment. In addition, the PUC has ordered water authorities to prepare emergency response plans, water supply protection studies, and water conservation plans.

The Rhode Island Building Code Commission is responsible for establishing standards for water consuming devices installed in buildings. In 1989, the commission followed the example of Massachusetts by reducing the standard for toilet flush capacity to the "ultra-low" standard of 1.6 gallons.

Rhode Islanders Saving Energy (RISE) is a non-profit organization which provides an important function in the area of residential water conservation. Since the late 1970's, RISE has been a public outreach agency that promotes energy conservation by offering home energy audits and low-interest loans for purchasing and installing such energy saving devices as insulation and water heaters. Funding comes from government grants and support from electric utilities.

RISE employs a field organization which performs energy audits in residential homes. In recent years, the installation of low-flow shower heads and faucet aerators has been added to the audit procedure because of the savings in water and energy required to heat the water.

There are a number of advocacy groups which have played an important role in bringing about reform to policies and practices relating to how water resources are managed in Rhode Island. Save The Bay, the Audubon Society of Rhode Island, the League of Women Voters, the Sierra Club, the Aquidneck Island Coalition, Clean Water Action, The Conservation Law Foundation of New England and the Rhode Island Public Interest Group (RIPIRG) and others have combined efforts under the name of Citizens Campaign for a Sound Water Policy. They have opposed the Big River Reservoir and the Cross Bay Pipeline, criticized PWSB management policies, and participated in the activities of the WRCC. Other groups which have contributed to a critical analysis of water management activities include the Rhode Island Public Expenditures Council (RIPEC), which performed a management study of the PWSB in 1989, and the Coalition for Consumer Justice (CCJ), which advocates pricing policies that promote conservation and protect the interests of the poor and disadvantaged.

As with most states in the region, Rhode Island's government, water supply institutions and advocates for the public have been wrestling with the burgeoning problem of maintaining high quality water supply services in the face of increasing demand and environmental threats to water resources. There have been significant achievements in addressing a number of problems. However, many programs are a product of individual initiative, and there is still enough of a lack of consensus and coordination that the state's ability to effectively resolve its water resources problems remains in doubt.

Chapter 4: Evaluation Criteria

> The closed economy of the future might similarly be called the "spaceman" economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy.
>
> --Kenneth Boulding, "The Economics of the Coming Spaceship Earth", 1966

The water resources management institutional framework reflects the relative priorities of government. Where water supply is plentiful, administrative responsibilities are delineated based on tradition and political priorities. "But when competition for water becomes keener, the actions of the various departments concerned with water management come more and more in conflict with each other, and there is frequently overlapping and loss of efficiency. It then becomes necessary to plan and coordinate water use by setting up frameworks that can ensure an overall approach to water management" (Cunha et al, 1977).

Throughout the nation, water resources management is evolving. The traditional supply management approach is being augmented with increasingly sophisticated demand management techniques. In order to evaluate the effectiveness of a water resource management approach, I have established the following criteria.

A. Integration

Integration is the degree to which management systems work together in a manner to achieve the highest degree of productivity, efficiency and equity in both short and long-range time periods. Successful water management approaches include organizational structures which encourage cooperation in the carrying out of regional goals and objectives.

One such system is the Massachusetts Water Resources Authority (MWRA). This agency was created by the state legislature in 1985 in an effort to consolidate the management of water supply and waste water management for 44 communities in the Boston metropolitan area. An independent public authority, MWRA is Massachusetts' largest water utility, serving almost half the state's population. "MWRA raises its own operating revenues by charging the local communities for the water they use and the sewage they generate. In turn the communities charge their service-area customers for their costs of maintaining their water delivery and sewage systems and for water consumption in homes and businesses" (Cote, 1990).

Because it is an independent agency, MWRA raises its own operating revenues. MWRA "is governed by an 11-member board of directors appointed by the Governor and chaired by the Secretary of Environmental Affairs. The board consists of one member each from the Merrimack River and the Connecticut River watershed areas, one member representing the town of Winthrop, three members from the City of Boston and three members from the MWRA Advisory Board. The Advisory Board includes representatives of the

Authority's service-area communities, the Metropolitan Area Planning Council and the Governor (Cote, 1990).

The MWRA has assumed responsibility for the wholesale distribution of water and sewage disposal services for over 2.5 million people in 60 communities (Kempe, 1989). MWRA manages 130 miles of large aqueducts and 260 miles of large distribution pipelines. The 46 communities supplied by MWRA water manage their own distribution systems.

Previously, the management of water resources in eastern Massachusetts had been segmented. The Metropolitan District Commission (MDC) was responsible for water supply, treatment and delivery to local systems (MDC's present role is to continue to manage the watersheds and reservoirs supplying the MWRA service area). Community water authorities were individually responsible for metering, billing, conservation, and maintaining the efficiency of their transmission lines. Where some local systems aggressively pursued demand management practices such as leak detection and public education, many had done little to promote efficient water use. "This had been largely a result of local funding difficulties, a relatively low cost of water and a lack of awareness of supply problems in general" (Kempe, 1989).

In addition to combining water resources and waste water management, the Authority centralizes a number critical functions. Goals and objectives reflecting regional priorities are now in place, enabling long-range planning strategies to be established. The main objectives of MWRA include "the cleanup of Boston Harbor, improvements to the aging water and sewerage

infrastructure, provision of pure and adequate drinking water and the promotion of water conservation" (Kempe, 1989) for a service area greater than four times the size of that of the PWSB.

The MWRA approach also allows for the development of a common information database, management by watershed districts, the integration of management efforts between local and regional agencies, and provides a clear delineation of authority, where state, regional and local agencies have distinct areas of responsibility. The burden of complying with most environmental protection regulatory requirements is shifted to a regional authority.

Other variations of the MWRA approach exist. In California, revisions in the state Water Code in 1977 encourage public water utilities to adopt conservation programs which mandate the installation of water-saving devices. As a result, water districts such as those in North Marin County and San Jose have instituted what are widely considered state-of-the-art conservation programs (Cote, 1990). In Connecticut, the 1984 Water Supply Plan Act requires all utilities serving more than 1000 people to submit plans for consideration and approval by the Department of Health Services, and the Department of Environmental Protection and the Department of Public Utilities Control for those systems they regulate (Jarema, 1987). In England, the 1973 Water Act consolidated the functions of almost 1500 management units into 10 "Water Authorities" whose areas are based on watershed boundaries. These Authorities are responsible for "water resource conservation, water treatment and distribution, sewerage, sewerage treatment and disposal,

water quality regulation, pollution control, river management including flood alleviation and land drainage, recreation and amenity, fisheries, and navigation" (Parker and Sewell, 1988).

B. Supply Management

Supply Protection: Surface Water

A watershed is an ideal geographic area for the purposes of water resources management. As humans seek to draw from surface and groundwater supplies, the common conditions which effect each source are rooted in an integrated hydrological system. Coordinated regulation of land use and disposal standards within a watershed allows the highest potential of ensuring minimum water resource quality standards may be met.

Watershed protection programs are one of the most effective means of protecting surface water supply. Water systems may delineate critical areas of the watershed, and target specific parcels for protection measures. It is not necessary for land to be purchased outright. A more financially effective strategy is to purchase the development rights or conservation easements. In this way, owners don't have to sell their land and the system doesn't have to exercise its eminent domain power to prevent development. Local municipalities can help protect surface reservoirs by creating watershed protection district zoning ordinances. In this, an overlay area of sensitive areas are designated, and strict land use and density standards are established.

Water systems should have drought emergency planning, where backup water supplies may be tapped when needed. In addition, supply "redundancy" (partitioning of surface water reservoirs so in the event of contamination problems authorities can still draw upon part of the supply source) is a desirable feature.

The achievement of conservation measures at the user's end of the pipeline may pale in comparison with the water lost through leakage in main transmission lines. Transmission and distribution system maintenance and repair is a common problem in older systems in the northeastern United States, where even today there is a day to day reliance on a few lines over 100 years old made of cast iron and wood.

Government financial assistance programs appear to be a mixed blessing. In England, a reduction in federal support has increased administrative and economic efficiency, but "the renewal and replacement of assets have been dire" (Parker and Sewell, 1988). Some states have enacted financial assistance programs to enable community water suppliers to perform the capital improvements necessary to upgrade facilities prone to failures. Washington state pioneered asset protection assistance for water systems, providing 40% grants since 1973. Massachusetts, New Jersey and Pennsylvania have followed suit with grant or loan programs (Humphrey and Walker, 1987).

Supply Protection: Groundwater

The EPA has prepared guidelines for states to enact Wellhead Protection Programs. The focus of these programs is the prevention of contamination of areas which contribute water to public wells. The state initially identifies the critical areas for all public wells in the state. The municipality in which each well is located is responsible for identifying known and potential contamination sources. Management approaches and emergency contingency planning is then developed for the protection of these wells.

Another groundwater protection strategy is a municipal waste water management district ordinance. Areas of critical concern are designated, and land owners within these districts who have ISDS systems are required to keep them running efficiently.

C. Demand Management

In a world placing increasing demands on natural resources and delivery systems, government and water suppliers are accepting conservation as a legitimate strategy for satisfying society's needs. Where technical advances and immense capital investment in engineering solutions have been the modus operandi for developing urban systems in the past, significant population increases and the resulting development in spatially diverse areas have made the traditional approach of increasing supply a more and more expensive solution in keeping up with demand. Environmental externalities in the

development of electricity, oil, nuclear, and water sources have become as much a concern as the increasing costs of their development.

The U.S. Government, in enacting the 1969 National Environmental Policy Act (NEPA), established among its objectives to "achieve a balance between population and resource use" and to "enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources." In 1968, Congress established The National Water Commission, which was charged with "finding alternative means of conserving and making more efficient uses of existing supplies" (Greenberg and Hordon, 1976). Clearly, at the federal level there is a mandate for water conservation. The question is how to effectively and pragmatically achieve such an objective.

Although cities in arid zones have historically been more interested in water conservation, in the late 1980's a wide array of water conservation strategies have been implemented throughout the country. Comprehensive programs have realized notable successes in such cities as Dallas, Los Angeles, Boston, Seattle, and Hyattsville, Maryland (Grisham and Fleming, 1989). These and other urban areas employ one or more of the following methods of demand reduction incentives:

1. modified plumbing codes, requiring 1.6 gallon "ultra low" flush toilets targets the single largest residential water use;
2. retrofitting showerheads, toilets, faucets, and heating/cooling systems with more efficient units;

3. xeriscaping, which maximizes use of vegetation demanding less water through appropriate landscape design;
4. water audits, in which inefficient fixtures are noted, and water consumption is documented in as small an area as possible, as frequently as possible;
5. leak detection, where state-of-the-art equipment can detect water loss in underground distribution systems;
6. universal metering, where every residential, commercial and industrial water customer's consumption is measured (enabling pricing based on actual use);
7. reuse of 'greywater' (once-used water) for use in industry and other processes not requiring "quality" standard water;
8. public education programs to heighten awareness of the need to conserve water and how to do it, and
9. water use restrictions in times of shortages in supply.

According to many authorities, the use of pricing possesses the greatest potential in reducing demand. However, it remains perhaps the most under used of all the water conservation strategies. In the implementation of such a conservation method, authorities should maintain the goal of minimizing any adverse impact of price increases on poor and disadvantaged populations.

Since governments have subsidized capital improvements in resource development and distribution systems, utilities have little incentive to employ traditional market pricing mechanisms which directly relate peak demand with

corresponding higher prices (Greenberg and Hordon, 1976). Artificially low prices and flat and decreasing block rates which actually encourage consumption are still common throughout the country.

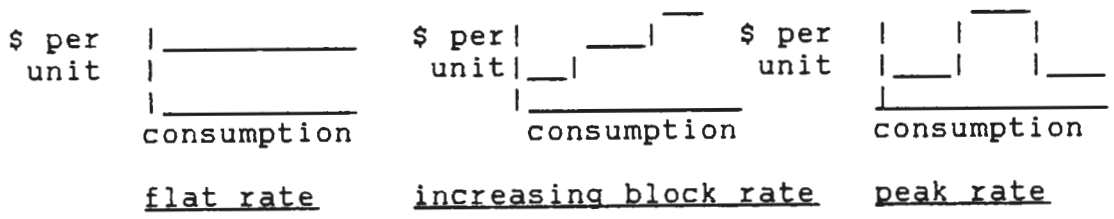
Water systems vary in their size, service areas, sources of supply, and capacities. They all share commonalities, including large fixed costs, and supplies which are negatively correlated with seasonal demand. In 1966, supply acquisition and distribution represented 74.2% of all capital costs of the nation's urban water systems (Mushkin, 1972).

Most water utilities practice pricing policies which not only ignore scarcity rents but also "base price on average, instead of marginal, explicit extraction cost" (Moncur and Pollock, 1988). Average cost pricing is based on the median cost
of supplying product to all consumers. Marginal pricing is based
on the actual cost of service to individual customers or consumer types. The general embracing of average cost pricing is due largely to the regulation and public ownership nature of water suppliers, where the common perception of such enterprises is that they are non-profit in nature (Moncur and Pollock, 1988).

Price levels are a function of demand, costs, subsidies and regulatory constraints. Price rates, however, may be structured "to encourage water conservation, reduce peak demand, attract industry, or help meet other goals" (Goldstein, 1986).

A flat (or uniform) rate is a standard price charged per unit, regardless of quantity consumed. A declining block rate is a structure in which each succeeding block of water consumed is priced at a lower rate than the previous block. Depending on the current structure in place, neither method provides incentives for conservation or equitable distribution of relative expense of water consumption between large and small users. Lippiatt and Weber (1982) reported decreasing block rate schedules accounted for 60% of the water supply systems in the United States, 69% in Belgium, and 34% of residential Canada (where 62% of systems are on fixed rates) (OECD, 1987).

figure 9: Price Rate Structures



Two rate structures providing incentives for conservation are peak rates and increasing block rates. Peak rates increase prices during periods of peak demand (usually the summer months) either for all water consumed, or only that amount over average (off-peak) use. Increasing block rates are provide succeedingly higher prices for increasing increments of consumption. Peak rates have other advantages, including the generation of additional revenues at a time when capital maintenance and improvements customarily take place, and

allows the utility to maintain off-peak rates as low as possible (Goldstein, 1984). Increasing block rates can prove to be a significant burden to large industrial consumers. It is also noted that block and peak rate structures require metering (as do other pricing structures) for each customer, in order to document consumption.

table 2: Pricing Rate Structures in Rhode Island, November 1989
(source: Arthur D. Little, Inc. 11/20/89)

rate structure/	no. of suppliers/	% of total supply
flat rate	4	12.3
flat rate with minimum charge	8	3.9
decreasing block rate	3	41.2
decreasing block rate with minimum charge	7	26.9
increasing block rate with minimum charge	3	4.9
variable block rate	1	3.6
no information	4	7.0

Two rate structures not effected by metering are fixture rates and new user rates. Fixture rates are based on the number of fixtures in a building or dwelling unit. Its drawbacks include little relationship with the amount of water actually consumed, and its lack of conservation incentives. New user rates are

impact fees to new buildings added to the system, reflecting the actual cost of the hook-up.

Spatial Rate structuring has yet to gain popularity as a pricing method. In this pricing scheme, long-term marginal cost increases incurred by the expansion of a utility's service area is reflected in rates based on geographic proximity to the source of supply (Mushkin, 1972).

So what are the constraints to implementing water pricing mechanisms which might encourage conservation? There are actually several incentives to maintain flat and decreasing block rate structures which are based on average costs.

The historic underpricing to consumers is probably the single largest inhibition to progressive pricing. In Providence, previous to March 15, 1988, water rates had been raised only four times in 62 years (Wyss, 1988). This is due in part to the fact that PWSB profits from the sale of Scituate water to other systems helps subsidize rates within the municipality. Water supply officials and the general public have come to regard water supply as a public service. Regulated prices have failed to take into account the full cost of supplying water to the public, and capital shortfalls have had to be covered with public subsides. The use of full-cost pricing represents a version of "sticker shock" to consumers. Indeed, as a result of an initial stab at covering long-range projected costs, the typical residential customer of the Providence Water Supply Board was projected to experience an increase of 49.9%, from $45.25 to

$67.85, over the one year period ending March 15, 1989 (Wyss, 1988). Even with this increase, Providence"s rate is one of the lowest in the state.

Clearly, public recognition and support of progressive pricing measures is critical to the success of their use. Customers often have just a vague concept of water supply technology and financial considerations, and fail to recognize the true correlation between prices and actual costs of their service. In most cases, the rate-setting process is subject to intense political opposition to rate increases. "If no observable problem exists with the water supply system, citizens may consider rate increases unnecessary" (Goldstein, 1984).

The question is then raised of the appropriate management approach and pricing strategy which might provide realistic conservation opportunities for Rhode Island. If water utilities were to become financially self-sustaining, all direct and indirect costs would be recovered through consumer payment for services, even if price levels have to increase to cover the loss of public subsidies and other traditional income sources.

If political hurdles could be overcome, there are several benefits to such 'full cost' pricing. Conservation would be encouraged with the elimination of subsidies. Line items for maintenance would increase, raising the life expectancy of fixed assets. There would be increased incentives for improved administrative and financial management and planning. A change to full-cost pricing would draw public attention to the true value of water.

The rate structure of choice among municipal water systems located in regions in which water is considered a valuable commodity is seasonal

increasing block rates. The city of Tucson, Arizona achieved a 28% reduction in residential demand phasing in such a rate structure from 1975-79, and Santa Fe, New Mexico (which has one of the highest water rates in the country) reduced demand 39.4% between 1974 and 1985 (Grisham and Fleming, 1989).

There are two variations of seasonal rate schedules. The first is a simple winter/summer differential, which is relatively easy to administer. The second is a summer "excess charge" which is applied to summer consumption greater than (a) winter consumption, (b) winter consumption plus a percentage allowance, or (c) a given quantity per consumer" (OECD, 1987). Fairfax County, Virginia realized a 6% demand reduction from 1974 to 1980 by increasing the rate from 70 cents to $2.45 per 1000 gallons for summer use 1.3 times winter use. In Dallas, Texas, by charging a surcharge of 5 cents per cubic meter for all summer consumption over 120 cubic meters per month, the city achieved a peak day demand decrease of 12% on the previous 5 year maximum (OECD, 1987).

A pricing strategy which promotes conservation is to combine water and sewer rates. Both are based on water consumption, and are related by nature, as 'both ends of the pipe'. With this, consumers should become more sensitive to how much water they consume. Additionally, if water customers are billed more frequently (perhaps monthly or quarterly, rather than once a year), they will better appreciate their seasonal consumption patterns.

Seasonal and increasing block rate pricing structures and the assumption of full-cost pricing accounting represent the modern approach to comprehensive

water management. Comprehensive databases and modern management and accounting practices are required to achieve a relatively high standard of sophistication. By ending public subsides and implementing traditional market demand pricing based on marginal rather than average costs, consumers have the opportunity to respond to rates which are based on considerations such as periods of peak demand, the expense of extending a water supply distribution system, and consumption over prescribed levels. This approach is fundamental to the success of any serious municipal conservation effort.

Clearly, there are several water resources management models in existence which effectively consolidate and integrate critical functions in a comprehensive manner. The most important features of most models are the institution of watershed districts, the combining of supply and demand management, the addition of waste water responsibilities to traditional supply-orientation, the maintenance of infrastructure at the regional level, and the promotion of conservation by such means as retrofitting, public outreach, and progressive pricing structures.

figure 9: Water Resources Coordinating Council Hearing, November 10, 1989

Although most Rhode Islanders enjoy the benefit of high quality water services, there are clouds on the horizon. The fact that the Scituate system functions so well is a testament to the planners and engineers of the Providence Water Supply Board and other systems who have designed, built and maintained water systems which have consistently met and exceeded

consumer demand. However, with the defeat of the Big River Reservoir project, encroaching development threatening present water supply sources, and the tendency of water systems to abandon these sources to the state's central system, there is a need for greater coordination between suppliers, regulators, and planners.

Since the first Earth Day in 1970, the state and federal government have progressively encroached on the traditional domain of the local water supply systems. Concerns over environmental impacts of land use development of watersheds has led to increased regulatory controls imposed from above upon local systems.

The State's historic planning approach to its management of water resources has been fragmented and incremental. While the original establishment of the Water Resources Board as the state's central water authority was a progressive and farsighted measure, the Board has limited its purview to only some of its legislative mandates. It has provided financial resources for water resources and distribution, coordination to the activities of water systems, and planning for the development of future surface water supplies. It has resisted water conservation, and lacks the power to facilitate progressive pricing mechanisms and the development of groundwater resources.

Until 1985, when the role of comprehensive planning and water resources protection was instituted, water management policy in the state was driven by the forces of stressing surface water supply development. There has been a prevailing interest in the construction of the Big River Reservoir, and

generations of powerful politicians and technocrats have held that vision. As the pressures of land development and concerns of environmental impacts increase, the need for more centralized and comprehensive planning increases. Instead, the legislature has spread regulatory and planning authority and responsibilities among several state agencies.

Today a system exists in which local systems operate under a plethora of a state and federal command and control regulations. There are significant gaps and overlaps in these rules, and a general lack of coordination of efforts at the state level.

At the same time, other states are beginning to recognize that simply imposing a multitude of environmental protection and conservation measures upon local systems is like lassoing fish in a stream. It takes an inordinate amount of energy to impose the collective will of the larger geopolitical entity upon local systems who have a generally decent track record of service and operate within a maze of incrementally developed devices which often overlap or contain gaps in coverage.

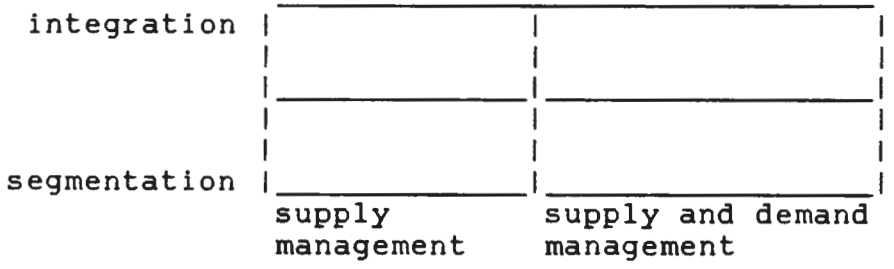
A "comprehensive approach matrix" (figure 8) provides an opportunity to evaluate an approach to water resources management. At one end of the spectrum, water is managed as a public commodity, with the focus on maintaining adequate supply. This approach is called supply management.

At the other end of the spectrum, water is managed as a scarce resource. In addition to a focus on supply management, this approach

emphasizes demand management. In this scheme, methods which promote the conservation of water are employed.

Integration is an additional measure of the potential effectiveness of a system. It is the degree to which the efforts of all agencies and parties relating to the management of water resources are integrated. This spectrum ranges from a segmented organizational structure to an integrated approach.

figure 10: Matrix of Comprehensive Approach



Rhode Island's is approach is less comprehensive than more sophisticated management models, such as the MWRA in neighboring Massachusetts. While

there are many fine individual initiatives such as wellhead protection and municipal comprehensive planning underway, Rhode Island's system is still relatively decentralized. The proposal of the Environmental Quality Study Commission do not clearly address this fundamental problem.

Presently, Rhode Island is still in the lower-right quadrant of the "Matrix of Comprehensive Approach". It remains that the supply, storage, treatment, delivery and protection of such assets does not mirror the physical nature of the land's hydrology. If water is to be considered a critical resource, watershed boundaries, instead if traditional geopolitical boundaries, should dictate the geographical parameters of water resources management. Herein lies a mandate for a regional approach which transcends the traditional municipal or water system delineation.

Rhode Island is currently in a state of transition. The Water Resources Coordinating Council is the lead agent of change. With a mandate to build consensus among key groups for a regional action plan based on current data, WRCC represents a significant opportunity for the many interests involved to transcend traditional parochial perspectives and work for what is in the best interests of the state as a whole.

Chapter 6: Conclusions and Recommendations

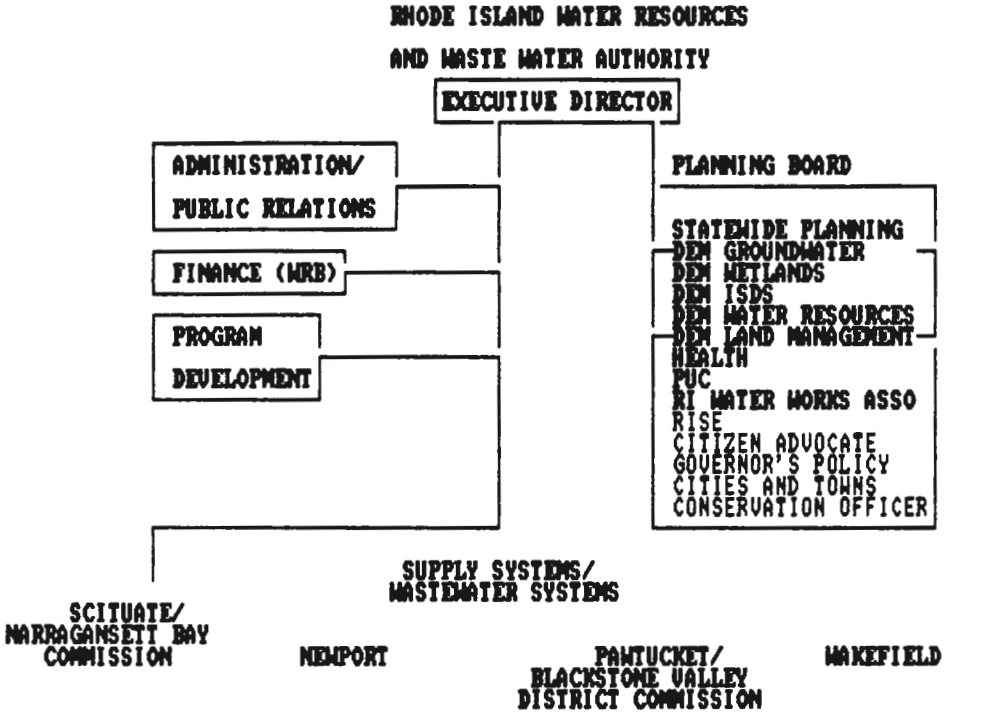
By all indications, the state is moving in the direction of a more centralized and comprehensive water resources management approach. However, there is a question whether Rhode Island is being aggressive enough, given the serious and growing threat of contamination of water supply sources. As public demand increases and spreads out geographically and more and more of the state's population abandons local sources for the primate Scituate system, one has to wonder at what point the government must recognize the realities of Rhode Island's "spaceship" economy, and take appropriate action.

In order to place a premium on the importance of fresh water as a critical resource for the health, safety and welfare of the people of the State of Rhode Island, the leaders of the government should establish a Rhode Island Water Resources and Waste Water Authority (RIWRWWA). This would be a quasi-governmental body which would report directly to the governor. In addition, the new agency would have formal liaisons with key state regulators, suppliers, and planners.

RIWRWWA would be the centralized authority responsible for directing and coordinating all public water resources and waste water management operations in the state. An executive director would be served in his or her administrative capacity by four offices.

Administration/Public Relations would focus on operations and maintenance of surface and groundwater supplies, water treatment, and main

figure 11.



PROPOSED RHODE ISLAND WATER RESOURCES AND WASTE WATER AUTHORITY

transmission lines to water authority distribution systems, coordination of policy and operations of water authorities, and coordination with waste water management systems. This office would plan and administer the distribution of supply to the various water authorities.

Finance would be resemble the present Water Resources Board in its capacity as a central clearinghouse for grants and loans for capital improvements of transmission lines, pumping stations and treatment facilities. In addition, the finance office would administer water supply transactions with the water supply systems, as well as the acquisition of land and conservation easements in wellhead protection districts and watershed areas of critical concern.

The Program Development office would focus on creating comprehensive programs designed to further protect water supply resources, develop a common database on supply, demand, environmental concerns, and financial conditions of all public water resources and waste water management systems in the state. In addition, this office would manage a central residential, industrial, institutional and commercial statewide conservation program, and maintain and accounting of the condition of water transmission lines.

A key feature of the new authority would be the RIWRWWA Planning Board. This body would be comprised of the Chief of the Division of Statewide Planning as Chairman, a member representing DEM Groundwater Division, DEM Wetlands Division, DEM ISDS Division, DEM Water Resources Division, DEM Land Management Program, the State Conservation Officer, a

citizen advocate, and representatives from the Governor's Policy Office, Department of Health, Public Utilities Commission, RI League of Cities and Towns, RISE, and the Rhode Island Water Works Association.

The Planning Board would assume the functions of the Water Resources Coordinating Council. The Board would be responsible for developing policies and long-range planning relating to the statewide interest, including conservation through equitable pricing strategies, and provide direction to Executive Director. The Board would enable the regulatory agencies and water supply institutions to coordinate common policy and planning priorities to be implemented by the Program Development Office, at the direction of the Executive Director.

RIWRWWA would control all sources of public water supply and main transmission lines between water systems. As in the case of the MDC in Massachusetts, it would be desirable to allow the PWSB and others to retain current water supply operations within the new hierarchy. This would centralize water supply management, and ensure consistency in meeting state water quality standards. This would also relieve local water systems of such responsibilities and allow them to focus on managing transmission systems at the local level. This clear administrative delineation would create a sense of parity between water authorities as they would have a similar function, even though their service areas may vary in size and demand. This would also allow a certain uniformity in the relationship between the state and each water authority. Instead of one city system dominating the Rhode Island region, the state would

assert itself into the lead water resources management role, affording the opportunity for planning and management based on a regional perspective.

Another important benefit of this proposal is the ability for RIWRWWA to create a regional uniform pricing standard. Wholesale prices to water utilities would be based on increasing block rate and peak rate structures, and would address the need to balance the present spatial cost inequity experienced by systems such as Bristol County . State guidelines would provide incentives for local systems to adopt similar structure standards, and to establish residential retrofit programs for those in need of offsetting the inevitable rise in rates.

There is precedent for taking such action. In the area of waste water management, the General Assembly has established the Narragansett Bay Commission and Blackstone Valley District Commission. These quasi-governmental state agencies have relieved municipalities of waste water treatment functions, providing service on a regional basis. In the area of solid waste, the state has established the Solid Waste Management Corporation (SWMC), which operates a central landfill facility for all communities who may no longer legally operate municipal dumps within their borders. Operating capital for SWMC comes from a surcharge on "tipping fees" (service charge per truckload).

Given that most of the sources of supply and all transmission lines are presently owned and operated by local water authorities, it would be necessary for the state to compensate those from whom these facilities would be

acquired. In the enabling legislation establishing RIWRWWA, a number of compensation options could be considered. It would appear a fee simple or eminent domain acquisition of wellhead areas, surface supplies, watershed protection districts and main transmission lines would be undesirable due to the immense cost to the state and the ultimate loss of local control of these resources. Instead, it would be desirable for the state to acquire these resources through long-term leasing of property and water withdrawal rights. Part of the compensation could include some quid pro quo agreements relating to wholesale water discounting and/or preferred financial assistance opportunities for authorities, depending on the amount involved in each transaction.

Recognizing the importance of linking water supply and waste water management, under the RIWRWA legislation, quasi-public waste water treatment programs would be absorbed into the new agency. A common database and billing arrangement with corresponding water authorities would be an objective of this move. Municipal waste water management agencies would be required to coordinate their practices with water departments.

There are many advantages to this new scheme. Making water resources more centralized in structure and and more regional in perspective would allow coordinated program development, long-range planning for maintenance and repair of aging systems, centralized pricing rate structure, and reducing of disparity between systems with ample quality water and those experiencing problems (especially in drought conditions). Further, surface and groundwater supply protection measures would fall under the purview of a central authority.

Water authorities would also derive benefits. The larger systems would no longer be saturated with the abundance of federal and state regulatory actions. They also would fall from the purview of the Public Utilities Commission, and would be encouraged to price water according to the rates they would pay RIWRWWA for their supply.

This proposal is politically feasible. There are precedents both within the state and in other areas of the country. With its small size and relatively centralized state government structure, Rhode Island is in better position to enact such a comprehensive measure than almost any other state in the nation. As it has already done in the areas of solid waste management, recycling and municipal comprehensive planning, the Ocean State has the opportunity to move into the national vanguard. RIWRWWA represents an new approach whose time has come.

BIBLIOGRAPHY

Anderson, Frederick, Mandelker, Daniel, and Tarlock, Dan. Environmental Protection: Law and Policy. Boston, 1984.

Arthur D. Little, Inc. Water Supply Analysis for the State of Rhode Island. Cambridge, 1990.

California, State of. The California Water Atlas. Sacramento, 1979.

Concern, Inc. Drinking Water-A Community Guide. Washington, D.C. 1988.

Cote, Melville. "Demand Management of Public Water Supplies: Municipal and Residential Water Conservation Methods and Strategies." Masters degree theses, Tufts University, 1990.

Congress of the United States. Office of Technology Assessment. Use of Models for Water Resources management, Planning, and Policy. Washington, D.C., 1982.

Feather, Diane; Fusco, S.; Hutchinson, M.; Phillips, M.; Schultze, D.; Sherman, K.; Stevens, J.; and Whalen, T. "The Hidden River: a Land Use and Environmental Study for the Runnins River Watershed". Kingston, Rhode Island: the University of Rhode Island Graduate Curriculum in Community Planning and Area Development, 1989.

Goldstien, James. "Full-Cost Water Pricing". American Water Works Journal, February, 1986.

Goldstien, James. Water Rates and Improved Water Utility Management. Massachusetts Audubon Society, March, 1984.

Greenberg, Michael R., and Hordon, Robert M. Water Supply Planning: A Case Study and Systems Analysis. Rutgers-The State University of New Jersey, 1976.

Grisham, A, and Fleming, W.M, "Long-term Options for Municipal Water Conservation. American Water Works Association Journal, March, 1989.

Hite, James, and Ulbrich, Holley. "Subsidizing Water Users or Water Systems?". Land Economics, November, 1988.

Ingham, Wayland. The Providence Water Works, 1869-1969. (unpublished) 1971.

Intergovernmental Policy Analysis Program, University of Rhode Island. Financing the Construction of the Big River Reservoir: an Institutional Analysis of the Revenue Bond Option. Kingston, Rhode Island, 1983.

Laan, Margus. The Search for a New Regional Water Utility Order: the Managerial Politics of Tax Revenue Flows, Open Space, and the Urban-Suburban Conflict in South Central Connecticut. Masters research project, University of Rhode Island, 1982.

Lord, Peter. Unpublished notes. Warwick, Rhode Island, 1989.

Mann, Patrick. "Reform in Costing and Pricing Water". American Water Works Association Journal, March, 1989.

Massachusetts Water Resources Authority. Demand Management Program: Summary Description. Boston, 1989.

Metcalf and Eddy, Inc. Report to the Water Resources Coordinating Board State of Rhode Island on a Development Plan for the Water Supply Resources of Rhode Island. Boston, 1967.

McPhee, John. Encounters With the Archdruid. New York: Farrar, Straus and Giroux, 1971.

Miller, G. Tyler, Jr. Living in the Environment. Belmont, California: Wadsworth Publishing Company, 1982

Moncur, James, and Pollock, Richard. "Scarcity Rents for Water: a Valuation and Pricing Model. Land Economics, February, 1988.

Mushkin, Selma. Public Prices for Public Products. The Urban Institute, 1972.

Organisation for Economic Co-operation and Development. Pricing of Water Services. Paris, 1987.

Reisner, Marc. Cadillac Desert. New York: Viking Penguin, 1986.

Rhode Island Department of Environmental Management. Rhode Island's Non-Point Source Management Plan (draft). Providence, 1988.

Rhode Island Environmental Study Commission. Interim Report. Providence, 1989.

Rhode Island Public Expenditure Council. The Providence Water Supply Board: An Organizational and Management Review. Providence, 1989.

Rhode Island Statewide Planning Program. 208 Water Quality Management Plan for Rhode Island: Draft Plan and Environmental Impact Statement. Providence, 1979.

Rhode Island Statewide Planning Program. The Governor's Conference on Water Policy, Proceedings of Session 1: Defining Policy issues in Water Supply. Providence, 1984.

Rhode Island Statewide Planning Program. Water Supply Policies for Rhode Island. State Guide Plan Element 721. Providence, 1988.

Seattle Water Department. 1985 Conservation Plan. Seattle, 1985.

Schmandt, Jurgen, Smerdon T., and Clarkson, Judith. State Water Policies, A Study of Six States. New York: Praeger Publishers, 1988.

Thomas, John, and Syme, Geoffrey. "Estimating Residential Price Elasticity of Demand for Water: A Contingency Valuation Approach". Water Resources Research, November, 1988.

Wyss, Robert. "Unpaid Bills Lead to Rising Water Confusion" Providence Journal, 12/27/88.

PERIODICAL SOURCES

Jarema, Raymond. "Connecticut's Water Supply Plans." Journal of the New England Water Works Association (June 1987): 118-144.

Kempe, Marcis. "Overview of the MWRA Water Conservation Program." Journal of the New England Water Works Association (June 1989): 74-85.

Loucks, Daniel P., Kindler, Janusz, and Fedra, Kurt. "Interactive Water Resources Modeling and Model Use: An Overview." Water Resources Research (February, 1985): 95-102.

"The Big River Debate." Providence Journal-Bulletin, April 28, 1989, special section.

"State sells off sand, gravel at Big River dirt-cheap." Providence Journal, April 30, 1989, p. A-1.

INTERVIEWS

Barnes, Nancy. Consultant to the Providence Water Supply Board. Providence. April 11, 1990.

Calise, Peter. Acting Director, Rhode Island Water Resources Board. Middletown, Rhode Island. Author's notes, November 29, 1988.

Calise, Peter. Acting Director, Rhode Island Water Resources Board. Providence. Author's notes, February 4, 1990.

Deland, Michael. Director, Environmental Protection Agency Region I. Middletown, Rhode Island. Author's notes, November 29, 1988.

Falcone, William. Assistant Director, Rhode Island Water Resources Board. Providence. Interview, September 21, 1988.

Griffith, Robert. Executive Director, Rhode Island Water Resources Coordinating Council. Providence. Interview, February 5, 1990.

Nunes, Lawrence. Commissioner, Rhode Island Public Utilities Commission. Providence. Interview, April 9, 1990.

Varin, Daniel. Director, Rhode Island Division of Statewide Planning. Providence. Interview, February 3, 1990.

LAWS

Massachusetts ch. 372 of the acts of 1984, as amended (Massachusetts Water Resources Authority enabling act)

RIGL 42-11-10 1985. (Statewide Planning).

RIGL 46-13.1 1985. (Groundwater Protection Act).

RIGL 46-15 1955, as amended 1967, 1971, 1975, 1980, 1986, 1986, 1987 (Water Resources Board).

RIGL 46-15-24 1969, as amended 1975, 1977 (Water Development Fund).

RIGL 46-15-25 1985. (Statewide Planning).

RIGL 46-15.1 1980. (Water Supply Facilities).

RIGL 46-15.2 1987. (Water Facilities Assistance).