NBP-91-59

Narragansett Bay Regionalization Study 145 pp

Metcalf & Eddy

Narragansett Bay Estuary Program

NARRAGANSETT BAY REGIONALIZATION STUDY

PREPARED FOR:
U. S. EPA REGION I
AND THE
NARRAGANSETT BAY PROJECT

PREPARED BY:
METCALF & EDDY

#NBP-91-59

FOREWORD

The United States Congress created the National Estuary Program in 1984, citing its concern for the "health and ecological integrity" of the nation's estuaries and estuarine resources. Narragansett Bay was selected for inclusion in the National Estuary Program in 1984 and designated an "estuary of national significance" in 1988. The Narragansett Bay Project (NBP) was established in 1985. Under the joint sponsorship of the U.S. Environmental Protection Agency and the Rhode Island Department of Environmental Management, the NBP's mandate is to direct a five-year program of research and planning focussed on managing Narragansett Bay and its resources for future generations. The NBP will develop a comprehensive management plan by December, 1991, which will recommend actions to improve and protect the Bay and its natural resources.

The NBP has established the following seven priority issues for Narragansett Bay:

* management of fisheries
* nutrients and potential for eutrophication
* impacts of toxic contaminants
* health and abundance of living resources
* health risk to consumers of contaminated seafood
* land-based impacts on water quality
* recreational uses

The NBP is taking an ecosystem/watershed approach to address these problems and has funded research that will help to improve our understanding of various aspects of these priority problems. The Project is also working to expand and coordinate existing programs among state agencies, governmental institutions, and academic researchers in order to apply research findings to the practical needs of managing the Bay and improving the environmental quality of its watershed.

This report represents the technical results of an investigation performed for the Narragansett Bay Project. The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under Contract # 68-D-90163 with Metcalf & Eddy. It has been subject to the Agency's and the Narragansett Bay Project's peer and administrative review and has been accepted for publication as a technical report by the Management Committee of the Narragansett Bay Project. The results and conclusions contained herein are those of the author(s), and do not necessarily represent the views or recommendations of the NBP. Final recommendations for management actions will be based upon the results of this and other investigations.

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SECTION ONE

INTRODUCTION

1.1 STUDY OBJECTIVES AND OVERVIEW

The Narragansett Bay Project is part of the National Estuaries Program, which was established to investigate, protect and enhance critical estuaries in the United States and is administered by U.S. Environmental Protection Agency (EPA) and the state. Funded by this program, EPA Region I and the Narragansett Bay Project have conducted a joint, five-year investigation of the degraded water quality in Narragansett Bay, Rhode Island. As part of this ongoing investigation, this report provides input for pollution abatement strategies for water quality in Narragansett Bay. This report presents a conceptual study of the feasibility and costs associated with one administrative and four structural regionalization alternatives for sewerage facilities with wastewater discharges to tributaries of upper Narragansett Bay. The common conceptual premise behind the various regionalization alternatives is that a single regional wastewater treatment district could be created by combining the sewerage commissions of Woonsocket, Blackstone Valley District Commission (BVDC), East Providence, Cranston, Warwick, and West Warwick under the Narragansett Bay Water Quality Control Commission (NBC). Both structural and non-structural aspects of regionalization are examined in this study.

Existing information is used to evâluate the feasibility of regionalization, and assess the advantages and disadvantages associated with various regionalization alternatives for the Narragansett Bay. Results of this conceptual evaluation will be used by EPA and the Narragansett Bay Project in preliminary decision-making concerning realistic regionalization alternatives to be pursued further. Water quality issues, such as effluent quality, discharge permit requirements, and positive or negative impacts to receiving waters, are not examined in this report. However, some potential water quality concerns which should be analyzed in conjunction with further consideration of particular options are noted.

1.2 REPORT ORGANIZATION

In addition to an introduction to the regionalization feasibility project, Section One of this report presents a description of the five regionalization alternatives to be examined. Section Two presents implications and the user fee structure associated with the administrative regionalization of the WWTFs. Implications related to each of the four structural regionalization options are presented in Sections Three through Six. The alternatives are compared in Section Seven of this report.

1.3 DESCRIPTION OF SCENARIOS

The one administrative regionalization scenario and four structural regionalization scenarios involving the wastewater districts of upper Narragansett Bay are described below.

1.3.1 Option 1

The administrative regionalization alternative, Option 1, involves consolidation of the administrations of the Blackstone Valley District Commission, Cranston, East Providence, Warwick, West Warwick, and Woonsocket sewerage districts under the authority of an expanded Narragansett Bay Commission. This option examines existing and future administrations, possible advantages and disadvantages of consolidation, and user fee structures.

1.3.2 Option 2 - Discharge at Field's Point WWTF

The first structural regionalization alternative consolidates the seven WWTFs which discharge to the Providence River drainage basin under the administrative authority of the Narragansett Bay Commission. Under Option 2, secondary effluent from the BVDC's Bucklin Point, Cranston, East Providence, Warwick, West Warwick and Woonsocket WWTF would be conveyed overland to a combined discharge point at the NBC's Field's Point WWTF. This alternative includes extension and improvement of the existing discharge structure.

A subalternative, Option 2A is also considered. Under this option, secondary effluent from Woonsocket, East Providence, and BVDC would be discharged through an outfall at East Providence, as opposed to being piped across the Providence River and discharged at Field's Point with the effluent from Cranston, Warwick, West Warwick and NBC.

1.3.3 Option 3 - Discharge at Quonset Point WWTF

The second major structural regionalization option is specific to the East Greenwich - North Kingstown area. It involves the consolidation and overland conveyance of all wastewater discharges which currently discharge to Greenwich Bay to a new deep water outfall originating at the existing Quonset Point WWTF. It is assumed that all wastewater would receive a minimum of secondary treatment. Option 3 involves examination of sewering all presently unsewered areas within the Greenwich Bay drainage basin and the town of North Kingstown, collection and treatment of septage from septage tanks, and pumpout from marina facilities.

1.3.4 Option 4 - Discharge to Block Island Sound

The third regionalization alternative is the consolidation of all WWTFs discharges. Under this scenario, a minimum of secondary treatment would be provided at the plants of origin and combined effluent would be conveyed overland to a marine discharge in Block Island Sound, off Point Judith. WWTFs in South County (Narragansett and Kingston) would also connect to the Rhode Island Sound discharge. Option 4 also assumes that all combined sewerage flow in excess of WWTF capacity would receive a minimum of primary treatment and disinfection, if necessary.

1.3.5 Option 5 - Advanced Wastewater Treatment

Option 5 of this study consists of upgrading the existing WWTFs which discharge to the Narragansett Bay Watershed to advanced secondary treatment and nutrient removal by the year 2000.

SECTION TWO

IMPLICATIONS OF ADMINISTRATIVE REGIONALIZATION

This section examines Option 1, a regionalization scenario for the upper Narragansett Bay area, in which the administrations of seven wastewater treatment facilities discharging to upper Narragansett Bay tributaries would be combined under the Narragansett Bay Commission (Figure 2-1). Possible advantages and disadvantages of this administrative consolidation and the structure of user fees are also presented in this section. The wastewater districts included in this study are:

- Narragansett Bay Commission (NBC)
- Blackstone Valley District Commission (BVDC)
- Cranston
- East Providence
- Warwick
- West Warwick
- Woonsocket

2.1 EXISTING SEWERAGE AUTHORITIES

Administrative information related to the seven existing wastewater districts, addressed under the administration scenario, is presented in the following subsections. The discussion is presented under the headings of Background, Organizational Structure, and Finances. More detailed information is presented for the NBC because the administrative regionalization scenario is based on an expansion of its existing administrative structure.

2.1.1 Narragansett Bay Water Quality Management District Commission

Background. During the 1970s, inconsistent wastewater treatment at the Field's Point WWTF, caused by many years of neglect and a shortage of funds, was contributing heavily to the water quality problems of Narragansett Bay. It was evident that the city of Providence could no longer bear the cost of effective wastewater treatment and in 1980, the Narragansett Bay Water Quality Management District Commission, more commonly referred to as the Narragansett Bay Commission (NBC), was established (P.L. 1980, ch. 342-1) and charged with the acquisition, planning, construction, financing, extension, improvement, operation, and maintenance of the sewerage system. The NBC provides all wastewater services for the cities of Providence, North Providence, Johnston and portions of Cranston and Lincoln.

In 1982, the NBC assumed ownership and management of the Providence sewerage facilities and appurtenances which included the Field's Point sewage treatment plant, interceptors, pump stations and combined sewer overflow facilities. Individual towns retained ownership and responsibility for the lateral sewers. Since the 1987 completion of a $40.5 million rehabilitation and upgrading of the Field's Point WWTF, the NBC has consistently met or surpassed federal and state treatment standards, thus reducing the pollutant loadings to Narragansett Bay.

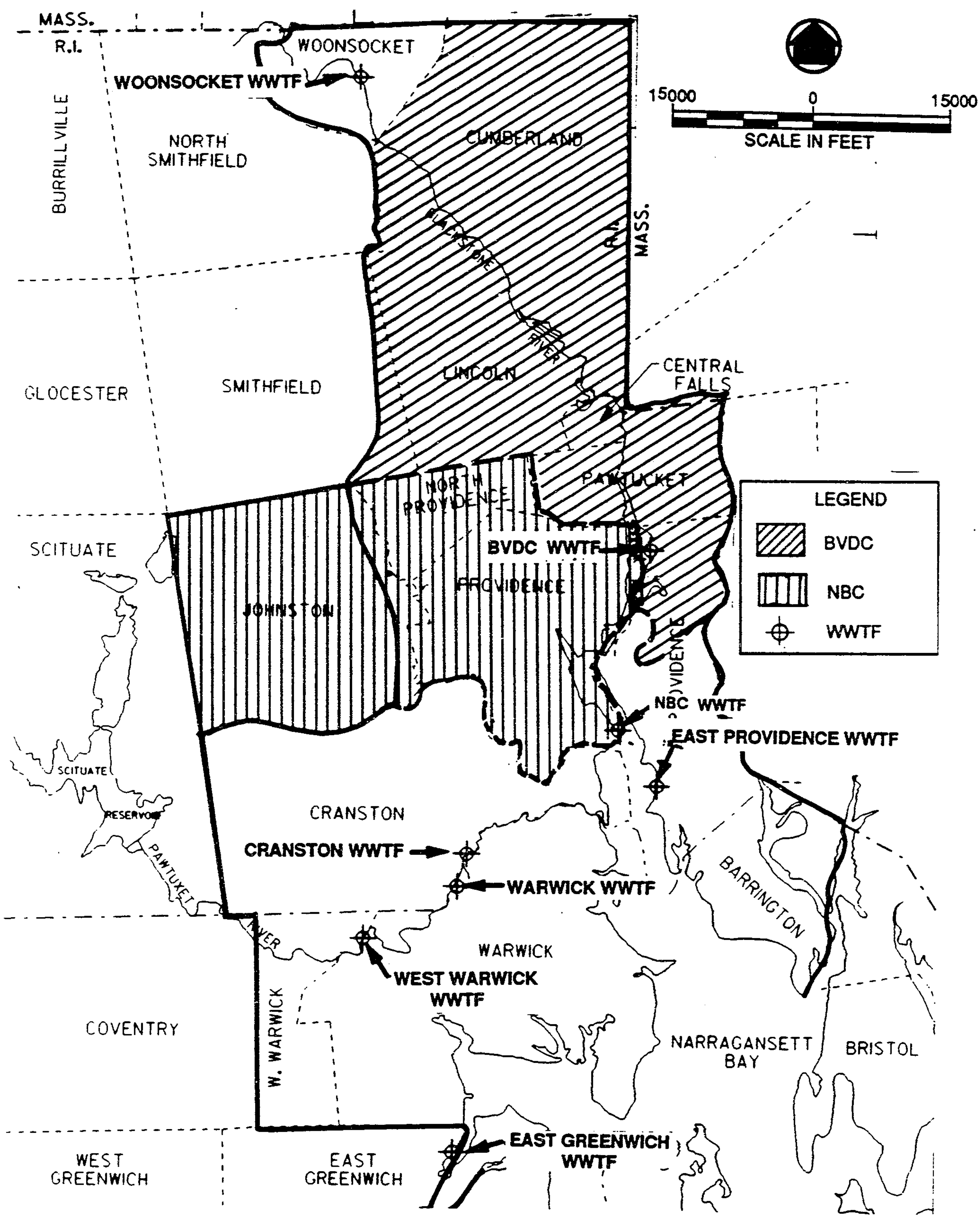


FIGURE 2-1 ADMINISTRATIVE REGIONALIZATION SERVICE AREA

Enabling legislation creating the NBC requires that not more than 50 percent of Rhode Island's state and federal grants be directed to the NBC. It is not mandatory that the NBC receive the full 50 percent allowed. In addition, the legislation allows other communities to voluntarily participate in the Commission by resolution request.

Organizational Structure. The Narragansett Bay Commission is governed by a 17-member Board of Commissioners. Eight members are appointed to the Board by the Governor of Rhode Island. Two members are appointed by the Speaker of the Rhode Island House of Representatives and two are appointed by the Majority Leader of Rhode Island Senate. The city of Providence appoints two members of the Board while the cities of North Providence and Johnston each appoint one member. The length of term for each member is three years and members may be reappointed. The State Budget Officer serves as an ex-officio member of the Commission.

Reporting to the Board of Commissioners is the NBC's Executive Director, who with the assistance of a Deputy Director, directs the four operating units within the Narragansett Bay Commission. The NBC's Office of Planning, Policy and Regulation is responsible for the commission's planning, sewer user fee development, water conservation programs and permits. Responsibilities of the Executive Office include construction and grants, legislative and municipal liaison, employee relations, and public information. The Administration and Finance Division directs the efforts of four departments: Accounting, Customer Service, Management Information Services and Procurement. NBC's Operation Division is divided into five departments: Engineering, Treatment, Maintenance, Interceptor Maintenance and Construction. Of the 165 authorized positions at the NBC, 144 are filled.

Finances. The Narragansett Bay Commission was initially financed when voters statewide approved an $87.7 million bond referendum, thus establishing the Bay Bond Fund for use on NBC capital projects. Sixteen percent of this fund, or $14.059 million, is to be paid back using funds from the NBC constituents. The remaining portion of the fund was provided by the state of Rhode Island. While approximately $59 million of this fund currently remains, all is expected to be spent by Fiscal Year 1994. Amendments made in 1989 to NBC's enabling legislation allow the Commission to issue its own revenue bonds, however these bonds will be fully retired by the NBC district. Narragansett Bay Commission's operating budget is financed by user fees, as approved by the Rhode Island Public Utilities Commission.

Additional information concerning the Narragansett Bay Commission is provided in Table 2-1.

TABLE 2-1. ADMINISTRATIVE CHARACTERISTICS OF EXISTING NARRAGANSETT BAY WASTEWATER TREATMENT FACILITIES

WASTEWATER TREATMENT FACILITY	LOCATION	OWNER/ OPERATOR	RECEIVING WATER LOCATION	COMMUNITIES SERVED	POPULATION SERVED (a)	DESIGN FLOW (MGD)	AVERAGE DAILY FLOW (MGD)	RESIDUALS MANAGEMENT
NARRAGANSETT BAY COMMISSION (FIELD'S POINT)	44 WASHINGTON STREET, PROVIDENCE	NARRAGANSETT BAY COMMISSION	PROVIDENCE RIVER	PROVIDENCE N. PROVIDENCE JOHNSTON CRANSTON (PORTION) LINCOLN (PORTION)	205,500	65	53.5	Present: Incineration at Woonsocket WWTF Short-Term Future: Incineration at Field's Point WWTF Long-Term Future: Proposals under review
BLACKSTONE VALLEY DISTRICT COMMISSION	100 CAMPBELL STREET, E. PROVIDENCE	BLACKSTONE VALLEY DISTRICT COMMISSION	SEEKONK RIVER	CENTRAL FALLS CUMBERLAND E. PROVIDENCE (RUMFORD) LINCOLN (PORTION) PAWTUCKET SMITHFIELD (PORTION)	122,500	31	23.22	Digested sludge landfilled on-site
CRANSTON	140 PENACONETT STREET, CRANSTON	CITY OF CRANSTON	PAWTUCKET RIVER	CRANSTON	71,000	23	12.7	Two incinerators on-site
EAST PROVIDENCE	1 CREST AVENUE, E. PROVIDENCE	CITY OF EAST PROVIDENCE	PROVIDENCE RIVER	E. PROVIDENCE BARRINGTON	54,000	10.4	6.7	Incineration at Woonsocket WWTF
WARWICK	300 SERVICE AVENUE, WARWICK	CITY OF WARWICK	PAWTUCKET RIVER	WARWICK	28,000	5.2	3.26	Composting on-site
WEST WARWICK	PONTIAC ROAD, W. WARWICK	TOWN OF WEST WARWICK	PAWTUCKET RIVER	WEST WARWICK COVENTRY WEST GREENWICH	24,000	5	4.85	Composting on-site
WOONSOCKET	CUMBERLAND HILL ROAD, WOONSOCKET	CITY OF WOONSOCKET	BLACKSTONE RIVER	WOONSOCKET N. SMITHFIELD BLACKSTONE, MA BELLINGHAM, MA (SOUTH)	50,000	16	11.2	Privately operated incinerator used for region (Rhode Island and Massachusetts)

NOTES: (a) SOURCE: RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT, 1988 (BASED ON 1980 CENSUS DATA)

2.1.2 Blackstone Valley District Commission

Background. The Blackstone Valley District Commission (BVDC) was established in 1956 (under Title 46-Chapter 21 G.L.). The Commission was established in response to extensive water pollution caused by an increase in population growth and industrial activity in the Blackstone Valley and exacerbated by shortages and restrictions during World War II. The BVDC treatment facility is located at Bucklin Point, East Providence, and receives wastewater from the communities of Central Falls, Cumberland, East Providence (Rumford), Lincoln, Pawtucket and a portion of Smithfield.

Organizational Structure. The Blackstone Valley District Commission was established in 1947 by an Act of the General Assembly and sponsored by then Governor John O. Pastore.

The BVDC governing board consists of five commissioners: three are appointed by the governor, one appointed by the Rhode Island Department of Health and one appointed by the Rhode Island Department of Environmental Management (RIDEM). Commissioners serve for three-year periods and may be reappointed. Reporting to the governing board is the BVDC's Executive Director who leads the BVDC staff. Departments of the BVDC include administration, project management, pretreatment, wastewater treatment operations and maintenance, accounting and billing, and laboratory. There are 88 BVDC employees.

Finances. Prior to obtaining State of Rhode Island general obligation bonds for capital expenditures, the BVDC must receive approval of the legislature and the state by state-wide referendum. To pay the annual principal and interest on these bonds, BVDC bills municipalities annually in proportion to flow. Operation and maintenance costs are funded under a classification (T1-T12) rate schedule, and commercial and industrial user fees. BVDC is studying waterbased user fees, but has not adopted them pending a second implementation study. Table 2-1 presents additional information about the BVDC's administration.

2.1.3 Other Wastewater Treatment Facilities

The wastewater treatment facilities of Cranston, East Providence, Warwick, West Warwick, and Woonsocket are owned and operated by their respective municipalities. The Cranston WWTF is contracted operated. Cranston, Warwick, and West Warwick are covered by legislation which allows them to provide services and facilities to one another, using a regional approach (208 Basin Plan - Pawtuxet River Basin, 1979). Information regarding the wastewater treatment facilities is presented in Table 2-1.

2.2 COMBINED REGIONAL SEWERAGE AUTHORITY

Background

The U.S. EPA and the Narragansett Bay Project are examining the possibility of combining all of the sewerage districts which discharge into tributaries of upper Narragansett Bay under the umbrella of the Narragansett Bay Commission. Under this scenario, the NBC would assume all responsibility for the operation, maintenance, expansion and improvement of treatment plants, pump stations, CSOs and other related wastewater facilities which currently are owned and operated by the individual sewerage districts. It is also possible that lateral sewers would become the property of the NBC.

With the addition of six WWTF districts, the NBC would be expanded to include 17 Rhode Island communities and two Massachusetts communities, serving an approximate population of 555,000. Total 1990 average daily flow to the WWTFs would be about 115 MGD and total design flow of the WWTFs would be 156 MGD. The WWTFs and their associated systems would continue to be subject to regulations and permitting requirements of the Rhode Island Department of Environmental Management, Rhode Island Public Utilities Commission, and U.S. Environmental Protection Agency.

Enabling legislation would have to be amended to define exact provisions of the legislation, and, therefore, the exact powers and responsibilities of the expanded NBC.

Organizational Structure

The Narragansett Bay Commission Board of Commissioners would likely be expanded or altered to include representatives from the six former WWTF districts. The exact number of representatives from each district would be determined by the state legislature but could be based upon plant capacity or population served in each district. To streamline the NBC governing board, the existing structure of appointments to the board could be altered.

Departments which are common to each of the seven individual facilities would be combined under the expanded Narragansett Bay Commission. These departments would be similar to those departments which currently exist at the NBC. Most Narragansett Bay Commission administrative staff would likely be located in an expanded NBC headquarters. This would ensure a more consistent management of finances and would provide the NBC with a consolidated technical staff. Some employees, such as most operation and maintenance personnel, would continue to be based out of their respective WWTFs. Each facility would likely retain some administrative support and laboratory personnel.

Recent discharge permits issued to WWTFs by RIDEM and U.S. EPA have required analyses of nutrients (phosphorus and nitrogen compounds), metals, volatile organic compounds and bioassays as well as analyses of conventional pollutants such as biochemical oxygen demand (BOD), total suspended solids, suspended solids, chlorine residual and coliform. Some of these analyses require the use of sophisticated and expensive equipment and techniques, and require personnel trained in laboratory procedures, chemistry and biology. These procedures are sometimes beyond the capabilities of WWTF laboratories and are subcontracted to other labs. The laboratory at NBC is currently able to conduct analyses of conventional pollutants, metals, volatile organic analyses, and is expanding with Mass Spectrometry for a wider range of organics analyses. The NBC has employees who are qualified to perform bioassays, however the laboratory does not have adequate space to conduct these tests and they are performed by a contracted lab. A regional lab at the NBC facility could provide cost-effective laboratory analyses to the individual WWTFs, allowing most, if not all, of the required analyses to be performed in-house. Normal wet chemistry laboratory facilities, providing analyses of conventional pollutants could be maintained at the individual WWTFs to assist plant operators in daily process control. With only limited chemical analyses conducted at the WWTF labs, more space could be available in one of the larger WWTF laboratories for performance of bioassays.

Finances

If it acquired the wastewater treatment facilities, the Narragansett Bay Commission would also be required to assume payment of the districts' long-term bonded debts. Capital debt retirement could be funded by obtaining grants and loans and by issuance of bonds. Cost of operation and maintenance and debt service could be funded with an equitable user fee directly to users. With a regional sewer authority, user rates, and the manner used in establishing these rates, would become equitable, though not necessarily uniform, throughout the region (Jankel, 1990). An initial financial settlement could be required between the Narragansett Bay Commission and the communities to rectify any inequities which may exist although in some instances this could result in users paying the debt twice-once then they were served by the municipality which incurred the debt and once by the expanded NBC. Therefore, refinement of existing unpaid debt would be equitable whereas reimbursement for previously retired debt would result in some users paying twice. Although a settlement program could be developed, this would be extremely difficult to implement due to complicated and lengthy negotiations (Jankel, 1990).

2.3 ADMINISTRATIVE IMPLICATIONS OF REGIONALIZATION

Regionalization of the seven sewerage districts under the operation and control of the Narragansett Bay Commission would have both advantages and disadvantages, some actual and others perceived. These are discussed below under the heading of personnel, NBC headquarter facilities, accounting and financial management, relationship with regulatory agencies, facilities operation and maintenance, wastewater collection systems, combined sewer overflow, residuals management, pretreatment, lateral sewers, and regional effects.

2.3.1 Personnel

Advantages. Advantages of an expanded NBC with respect to personnel could include the establishment of uniform job descriptions, qualifications, hiring, labor rates, and benefit packages. A larger organization would be able to obtain better group insurance rate for employees.

Much of the WWTF's engineering, laboratory, administrative, financial and management staffs would be consolidated at a regional office, reducing the number of positions and the budget required to fund these positions. Although it may be true that pay scales at NBC may be generally higher than the municipal positions replaced, the reduction in benefit burden due to the reduction in number of employees would likely result in reduced overall budget requirements. Employees would be assigned to NBC projects and would no longer be required to participate on other municipal projects, creating a more focused staff. A well-trained operations staff, under the control of a single authority, could possibly provide flexibility to address emergency situations at one of the facilities or provide staff to cover deficiencies caused by illness or vacations. Allocation of employee services could be optimized to meet the needs of the region. More specialized personnel, such as those with expertise in the areas of electrical systems, instrumentation systems, mechanics, and process control, whose services were formerly available to only one WWTF, could possibly be available to all WWTFs. The NBC could establish a Process Control Group, consisting of one expert assigned to each WWTF, to solve technical issues at the plants. A consolidated staff could provide in-house services where outside contractors may currently be used.

Disadvantages. A disadvantage to the employees is that organizational restructuring of the NBC could result in the elimination of some employee positions. Municipalities may need to hire replacement staff for employees, such as electricians, whose responsibilities were split between the WWTF and other municipal facilities. Initially, the change in job location for some employees may cause a higher-than-normal employee turn-over rate. Some employees may not enjoy working for a large organization or may experience a natural fear of the unknown and commuting times for some employees will be increased. The NBC would likely be required to buy out the retirement packages of employees of the municipal WWTFs. This could be costly and cause dissention among workers.

Laborers at different WWTFs are members of different labor unions. For example, laborers of the NBC's Field's Point WWTF are members of the Laborer's International Union, while laborers at some of the other plants belong to other unions. Since workers have the power to choose which labor unions they want to belong to, the possibility exists that laborers within the same discipline, such as electricians, could belong to different unions. This could promote infighting among workers and prevent establishment of uniform job classifications, labor rates, and benefits. In addition, some unions may prevent members of other unions from working in their plants, thus restricting the benefits associated with sharing highly skilled personnel throughout the region. This situation could be alleviated if members of the various labor unions view the possibility of larger bargaining power as incentive to joining common unions.

2.3.2 NBC Headquarter Facilities

Advantages. The NBC may have the opportunity to provide centralized facilities such as a regional laboratory, maintenance shops, warehouses, a regional computer, computer aided design (CAD) facilities, a training center and a regional library.

A centralized laboratory facility would provide the region with better quality control of sample analyses. This lab could also improve, or at least gain control of, turn-around-time of chemical analyses. Since there would be no need to purchase duplicates of expensive analytical equipment, the region would have more funds available for higher levels of equipment, such as GC/MS, to allow more analytical work to be performed in-house and thus produce cost savings. The laboratory may also develop the expertise and facilities to provide in-house toxicity testing and bioassays for the region. Personnel at the central laboratory could provide technical guidance to staff at the WWTF labs. The regional lab could hire a QA/QC officer, allowing performance of independent data validation.

At a regional training center, the Commission could provide its own in-house operator training and certification. By increasing the competence level of the staff, better performance may be possible at the plants. Information about new processes and changes in state and federal regulations could be transferred to the staff in a consistent manner. The cost of establishing a training center could possibly be offset somewhat by offering courses to operators outside the region on a fee basis.

The NBC could maintain a library of training, and operation and maintenance manuals for the use of all employees. The library could allocate its budget on expansion rather than on purchasing duplicate copies (up to seven) of documents.

Disadvantages. Access to central facilities may be difficult from the more remote plants, resulting in lost travel time. However, in Rhode Island, it is not uncommon for people to commute to the Providence area from anywhere in the state.

2.3.3 Accounting and Financial Management

Advantages. By combining the seven sewerage districts under an expanded NBC, the WWTFs could establish a uniform system of accounting and billing. As discussed in Section 3.4, both the NBC and BVDC have the potential to encounter difficulty in providing accurate and timely billings because they rely upon water utilities providing multiple systems of water accounting. Implementation of a uniform method of water accounting would provide cost savings since less labor would be required for the interpretation, correction and reduction of data and since short-term borrowing needs would be decreased. Although this cannot be accomplished through regionalization of the wastewater treatment plants, efforts could be made to work with the various water utilities and PUC to facilitate uniform water accounting.

Establishment of equitable rates and billing systems would provide a greater financial resource to the area and permit the direction of funds to the areas of greatest need. Regionalization would allow better financial planning and control of facilities repair. The method of obtaining bonds for capital expenditures would become consistent for all WWTFs. The need for statewide referendums and legislative approval would be eliminated since the NBC is able to issue its own revenue bonds. The potential for better bond ratings may also be increased as is the case in Massachusetts where the Massachusetts Water Resources Authority (MWRA) currently issues its own bonds at a rating superior to that of the state of Massachusetts. Application of grants and financial management would become centralized, providing consistent services to all rate payers.

Cost savings from consolidation may reduce rates or allow the NBC to provide better services. It may prove to be cost-effective to computerize accounts, allowing better tracking of delinquent payments, more rapid processing of billing, assistance with budget planning and annual reports, Rhode Island Public Utilities Commission submissions and justifications.

Disadvantages. Communities would experience a loss of authority over sewer rates with the expansion of the NBC. Towns which currently pay low user fees may protest a rate hike when billing becomes consistent. In communities where operation and maintenance of the system is funded by taxes, switching to a user rate system could result in higher overall user charges if municipalities do not decrease taxes appropriately.

2.3.4 Relationship With Regulatory Agencies

Advantages. With the establishment of a single commission for the upper Narragansett Bay area, the responsibility of operation and control of the facilities would rest with one organization, thus limiting the number of people who would be interacting with the agencies. This could allow agencies and NBC staff to form stronger working relationships for conducting tasks such as the regional planning of systems and facilities as well as the enforcement of discharge permits. The agencies would be interacting with a staff whose time is dedicated to the regional wastewater program and not incumbered by other municipal responsibilities. In addition, a single commission would allow consistent reporting to agencies.

Programs administered by the RIDEM, including the State Revolving Loan Fund (SRF), the Water and Sewer Supply Failure Fund and the Interceptor Bond Fund use relative rankings of water pollution abatement projects as part of the decision-making process for annually awarding assistance. A benefit of WWTF regionalization would be consistent and improved management throughout the treatment system so that information would be available to more readily identify the costs and water quality benefits of proposed projects and that allocation of funds to the projects could be made in a manner to maximize these benefits (Nickolai, 1990).

Disadvantages. No disadvantages with respect to the expanded NBC's relationship with regulating agencies were identified.

2.3.5 Facilities Operation and Maintenance

Advantages. Over time, some uniformity of electrical, instrumentation and mechanical systems could be developed throughout the system, allowing the pooling of spare parts and establishment of a regional preventive maintenance program. The expanded NBC could develop uniform equipment lists and parts storage inventories and buy replacement parts in bulk at better prices, taking advantage of its increased buying power. The purchase of chemicals could be conducted on larger contract basis than is currently available, with additional cost savings to the district. As a quasi-state agency, the NBC conducts its purchasing through the state purchasing department. An expanded NBC may be able to establish its own purchasing department. The NBC could allocate the disposal of waste pumped from septage tanks and marinas to specific WWTFs based on current performances and design capacities of the plants.

Disadvantages. The pooling of spare parts would have limited benefit until such time as uniformity of equipment is actually achieved. In addition, those items unique to a WWTF should be located at the facility, and small common items should be stored at the facility to avoid unnecessary transportation costs (Malone, 1990).

Purchases of bulk materials or chemicals would have to reflect specific requirements of the WWTFs as well as potential cost savings. In addition, some WWTFs may not be available to receive septage, due to individual WWTF's limitations to accommodate this waste. The regional authority may also determine that regional septage facilities are more advantageous than smaller facilities at each WWTF for administration and quality control reasons. In either case, losing septage receiving facilities could result in longer travel distances for septage haulers; the cost of which would be passed on as higher septage disposal prices to some users.

2.3.6 Wastewater Collection Systems

Advantages. Master planning for repair and expansion of the wastewater collection system by a single upper Narragansett Bay sewage district would allow decisions, such as where to construct new sewers, which WWTF should receive wastewater flow from newly sewered areas, and which sewers should be repaired, to be made on a regional basis. Implementation of a preventive maintenance program, involving cleaning and internal inspection of the collection system, pump station monitoring and repair, and assistance with elimination of infiltration and inflow, could be conducted on a regional basis, allowing optimization of available funds.

Disadvantages. A disadvantage of combining the sewerage districts under the Narragansett Bay Commission would be that the Commission would have to assume responsibility for a large amount of infrastructure in varying conditions of repair and age. In addition, the larger service area could make it more difficult to mobilize key personnel to emergency situations, resulting in delayed response time and increased user complaints. If the NBC is given control of infrastructure expansion, a community could lose control of its growth. Representatives of the Narragansett Bay Commission note that the enabling legislation of the BVDC and NBC left responsibility of lateral sewers with the municipalities because local communities use extension of sewers as a growth management tool (Jankel, 1990).

2.3.7 Combined Sewer Overflows

Advantages. There are 63 combined sewer overflows belonging to the Narragansett Bay Commission and 30 CSOs which belong to the BVDC. None of the other sewerage districts being considered for consolidation have combined sewers. With regionalization of the upper Narragansett Bay WWTF districts, funds for combined sewer overflow treatment could be allocated in a manner which optimizes pollution abatement, focusing on improvement of CSOs in areas with the most severe water quality conditions. Alternative actions for cleanup of CSO discharges may include solutions which cross former sewerage district boundaries and would not otherwise have been considered under the existing sewerage district structure.

Disadvantages. Communities without combined sewer overflows may be reluctant to finance CSO projects. CSOs which are of significant concern to some communities (due to beach or shellfish bed closings) may not be given as high priority as other CSOs by the regional district and may not receive priority funding for cleanup design and construction.

2.3.8 Residuals Management

Advantages. Development of a regional plan could be considered an option during long-term planning of NBC's residuals management. A variety of sludge quantities and qualities from the seven WWTFs could provide the NBC with many handling options. By mixing sludge from a larger number of WWTFs, peak concentrations of pollutants in the sludge could be attenuated. On the other hand, the NBC could keep sludges of extreme qualities separate from the other sludges, thus preventing contamination of the marketable sludge and retaining very clean sludge for special uses. Regionalization would allow more efficient use of underutilized sludge processing capacity at some locations.

Disadvantages. Residuals management for the entire region would result in a larger amount of sludge for the district to dispose of or distribute. Communities may be unwilling to host a regional sludge processing facility. A regional residuals management program involving a combination of sludges under one treatment process would be difficult to accomplish given the variations in sludge quality resulting from the current residuals management programs employed at the seven WWTFs, as previously identified in Table 2.1.

2.3.9 Pretreatment

Advantages. A comprehensive pretreatment program for upper Narragansett Bay could be established by the Narragansett Bay Commission. The program would offer regional advantages since it would prioritize industrial dischargers with the highest non-compliance and allow the Commissions to optimize its enforcement actions.

Disadvantages. A disadvantage to the communities is that industrial dischargers, which would have received the enforcement attention of a smaller sewerage district, may not be given as high priority and may not be pursued as actively by the regional district. Since the industrial components of the communities vary, less industrialized communities may be reluctant to finance aspects of pretreatment programs in more highly industrialized communities. This problem could be eliminated if either the industries, or the communities which receive the benefits of the industries, finance the pretreatment programs. Currently, some wastewater treatment facilities such as Narragansett Bay Commission do charge industries fees which contribute to operation of pretreatment programs. These fees are in addition to other charges based on total wastewater flow. For example, the NBC charges industrial pretreatment permit fee based upon the annual number of samples that must be taken from the industry.

2.3.10 Lateral Sewers

Advantages. By transferring ownership and responsibility of the lateral sewers from the municipalities to the expanded NBC, all wastewater facilities would be under the control of the Commission. Repair and expansion of lateral sewers would be eligible for regional funds available to the NBC. Projects of expansion and repair of lateral sewers could be prioritized, ensuring optimum allocation of these funds.

Disadvantages. The NBC would acquire the added responsibility of repairing lateral sewers which fail, thus additional staff may be needed to carry out this responsibility. Control of the lateral sewers under a regional authority would impact the communities' abilities to plan and control development. There could be a loss of political motivation to expedite lateral sewer repairs and users may feel that the NBC is unresponsive to their needs. This disadvantage could be alleviated by ensuring that the communities' respective Departments of Public Works are represented on the NBC's governing board. It should be noted that the Narragansett Bay Commission is not in favor of assuming responsibility for lateral sewers. The NBC feels that responsibility for the lateral sewers would dilute the main mission of the agency (Jankel, 1990).

2.3.11 Potential Regional Effects

Advantages. Benefits to the upper Narragansett Bay region from expansion of the NBC would include centralized planning and decision-making. Environmental impacts of potential modifications in treatment systems or method of disposal could be evaluated regionally. As mentioned in Section 2.3.1, in-house engineering and technician capabilities would be consolidated, to the benefit of the entire region. Greater opportunities for staff specialization would exist.

Disadvantages. Perhaps the greatest disadvantage to regionalization of the sewerage district is the loss of local autonomy. Resistance to communities' incorporation into a larger district may occur. Communities with well-run WWTFs may have to assume part of the burden (and associated costs) of the more poorly-run plants if the initial settlement is not equitable. Cooperation among a large number of towns may be difficult, resulting in delays and disputes. Regional wastewater priorities may not be the same as local priorities. A member community may more likely be required to host an unwanted facility such as sludge or ash disposal. A greatly expanded management board could be perceived as unnecessary bureaucracy. The increased power in lobbying for funds which NBC could acquire from its increased size could be perceived as a threat to other local, smaller sewerage districts. The percentage of grants directed to the NBC would have to be increased from a maximum of 50 percent if other wastewater districts are added.

2.3.12 Summary

Advantages. From the above descriptions, several major advantages emerge as being common to all or most of the above evaluation categories.

One advantage associated with consolidation of the seven WWTF districts is economies of scale. With a larger organization, the Narragansett Bay Commission could consolidate its staff, increased its buying power for and implement a warehouse system of parts and chemicals, and perhaps establish regional facilities such as a library, training center, laboratory, warehouse and maintenance shop. Another advantage would be the establishment of equitable user rates with users paying proportional share of costs, and consistent accounting and billing throughout the region. Regional approaches to issues such as system repair and expansion, waste-load allocation in upper Narragansett Bay, CSO abatement, residuals management, and pretreatment could provide more cost-effective solutions for the upper Narragansett Bay area, and thus provide economic incentives to communities to regionalize. The distribution of additional state funding could become available to all of the WWTF districts if the Bay Bond Fund is replenished. Recent legislative transfer of $16 million in Bay Bond proceeds from NBC to other systems reflects the fact that wastewater treatment is more than a local issue (Nickolai, 1990).

Disadvantages. A disadvantage associated with regionalization is that multiple labor unions in the NBC region could make uniformity among similar positions difficult and would not allow full realization of benefits associated with a consolidated O&M staff, limiting the potential of labor allocation to situations of highest need. Another disadvantage to the existing WWTF districts is that user rates would be higher for some communities than they are now. An equitable settlement of debt, taking into consideration the need to avoid double payment by some communities, would be required at the time of expansion of the NBC. Regionalization would result in a reduction of local authority over decisions related to sewer expansion and sewer rates. In addition, the region's priorities and its selected projects may not coincide with local priorities and their preferred projects.

2.4 USER FEE STRUCTURE

Equity issues in user fees need to be addressed, not only to establish fairness in costs among user classes (residential and nonresidential), but also to satisfy state regulatory requirements. The Rhode Island Department of Environmental Management (RIDEM) requires that a sewer user fee structure allocate costs to users or user classes in direct proportion to those services provided to that user or user class (Narragansett Bay Commission, 5/15/87). This section of the study addresses equity issues in user fees collected by the wastewater facilities under consideration.

The consolidation of administrative activities of seven wastewater treatment facilities under the Narragansett Bay Commission (NBC) would require establishing equity among the different user classes within the same wastewater treatment facility jurisdiction based upon quantity and quality considerations, as well as establishing comparable rates among the seven jurisdictions. The following section summarizes the current user fee structures and charges in the various communities served by the wastewater treatment facilities, identifies the wide range of charges between communities, and notes those user classes which may be paying more or less than their proportional share.

It is important to note that the large differences in user rates among municipalities are the result of a number of factors. These include the age and status of the facilities within the area. For example in some areas the facilities were built with 70% or 75% to 90% federal and state grants, thus the capital costs that must be recovered by user rates are relatively low. Also, for municipalities with older facilities, which were constructed at lower capital costs, the bonds may have been paid off and there may be no bond payments included in the rates. Fees may be higher in some other communities because they have recently implemented required higher level of treatment and are now paying for increased capital and operation and maintenance costs. For example, the Woonsocket facility was built in the early 1970s and bonds could be expected to be retired soon, while modifications to the Cranston facility were completed in the mid-1980's at a capital cost of approximately $20 million. The difference in time and cost of facility construction affects the communities debt service costs, and ultimately the charges to users. Finally, several of the systems are combined and/or have significant inflow and infiltration. The user rates in these communities are by necessity higher than they might be in order to account for this increased flow. Table 2.2 provides a summary of some of the information collected by the Rhode Island DEM in its User Charge Survey.

Table 2.2 shows the amount of grant assistance obtained by the different communities and what their existing (1988 data) annual debt service costs are. The data were reported by the communities, and not independently verified, and thus it is important to note that the numbers are not directly comparable. In addition, the total capital costs of community projects are not shown, and thus it is not possible to determine the percentage of grant assistance to total construction costs. However, the summary provides confirmation of the variability in actual grant assistance among towns. Note for example, that the Woonsocket plant, which was built in the early 1970s received a large amount of grant assistance. The facility is in the latter years of debt repayment, and thus the annual debt service is relatively low compared to the other facilities. Despite the fact that Cranston received a large amount of grant assistance, its annual debt service is high, because it is in the early years of debt repayment for modifications made in the mid-1980s. The NBC received the largest amount of grant assistance and its annual principal and interest payments are lower than the Cranston facility. In addition, the NBC serves a greater number of households than does Cranston enabling the fixed costs to be allocated to a wider base, thus reducing the sewer user charges to individual households.

2.4.1 Current User Fee Structure

The user fees for residential, commercial, and industrial classes vary considerably between the wastewater treatment facilities. Table 2-3 summarizes the different residential rate structures currently used and provides examples of estimated annual charges based on wastewater flow of 200 and 300 gallons per day. The wastewater facilities in Cranston and Woonsocket have established a flat fee for residential use, meaning that a single rate is charged to each household regardless of total wastewater flow. The facility in East Providence collects a portion of its revenues through the town's general tax rate. There is no user charge for those customers using less than

TABLE 2.2. SUMMARY OF FACILITY GRANT ASSISTANCE

Facility	State/ Federal Construction Grants	Annual Cost of Loans (P&I)	# Households Served	Annual Avg. Sewer Service Charge (200 gpd)[1]
BVDC	$16,744,213	$1,487,778	43,855	$85
Cranston	$53,601,770	$3,328,270	27,219	165
E. Providence	$9,859,019	$621,813	16,000	--
NBC	$60,293,296	$1,970,000	60,000	76
Warwick	$12,114,427	$3,000,000	10,400	163
W. Warwick	$7,398,700	$1,607,559	9,000	102
Woonsocket	$21,054,212	$191,250	28,000	65

1 Source of sewer charges is Narragansett Bay Commission "Comparison of Sewer Use Charges" 1/25/90. All other data is from Rhode Island DEM, "Rhode Island User Charge Study", 1988 Data.

220 hundred cubic feet (HCF) per year. Residential and nonresidential customers using more than 220 HCF/year are charged $0.635 for each hundred cubic feet over 220.

The remaining facilities charge rates based upon the volume of water used. The Blackstone Valley District Commission services all or portions of Cumberland, Central Falls, Pawtucket, Lincoln, Smithfield, and East Providence. To recover operation and maintenance costs, the Commission charges a variety of classified flat rates (called T rates) directly to residential customers (except those residing in E. Providence which collects a portion of wastewater charges through the tax rate) based upon different water use allowances. The T-1 rate of $85.00 applies to single family dwellings or other property having similar characteristics with a water use allowance of 10,000 cf/year (74,800 gallons). The T-2 to T-12 rates apply to two-family dwellings, other multi-family dwellings, or other property having similar characteristics, which use up to 58,700 cf (440,000 gallons) per year. A metered rate is applied to all customers using in excess of 58,700 cf per year. The Commission collects debt service cost through a billing to municipalities based upon the percentage of flow each provides to the system. The municipalities, in turn, bill residents and businesses through the general tax rate. Warwick, West Warwick and the Narragansett Bay Commission charge residential customers a flat rate plus an additional unit charge per HCF over a certain amount of water used.

TABLE 2-3. CURRENT RESIDENTIAL ANNUAL USER FEES

Wastewater Treatment Facility	Residential Rate	Annual Charge for Residential HH Using 200 gpd(97.59 HCF)(1,2)	Annual Charge Rate for Residential HH Using 300 gpd (146.39 HCF)(2)
Blackstone Valley District Commission	O&M costs recovered through variety of flat rates based upon water use allowance: from $85/to $501/year. Debt service costs recovered through community tax rates.	$85	$85
Cranston	Flat Fee - $165	$165	$165
E. Providence	No user fee for usage under 220 HCF/yr. Unit charge of $0.635/HCF for usage greater than 220 HCF/year. Additional revenues collected through general tax rate.	-	-
Warwick	Flat Fee $41.15 plus $1.470/HCF for 85% of water consumption	$163	$224
W. Warwick	$ Flat Fee $48 plus $1.10/HCF for 80% of water consumption over 36 HCF	$102	$145
Woonsocket	Flat Fee $65/year	$65	$65
NBC	Flat Fee $76.40 plus $1.05/HCF for water usage over 97.59 HCF/year	$76	$128

Source: Narragansett Bay Commission, "Comparison of Sewer Use Charges" 1/25/90.
1) HCF - Hundred Cubic Feet, 2) Rates are Rounded to Whole Dollars
Note that the sewer use charge does not always cover all costs. For example, BVDC recovers debt service costs through community tax rates, and East Providence also collects some operating revenues through the general tax rate. In Warwick also, the city's general fund pays the interest on the city's wastewater bonds.

The range of estimated annual charges to residential households with average flow of 200 gpd is $65 to $165. The residential customer in Cranston essentially pays 253 percent more in user fee than does a residential user in Woonsocket. The difference in the rate charge is even more significant when the comparison is based upon wastewater flow of 300 gpd. The range is $65 to $224, representing an average cost to households in Warwick approximately 344 percent higher than the average cost to households in Woonsocket.

The rate structure and estimated annual service charges for commercial and industrial customers are shown in Table 2-4. Woonsocket, Warwick, and Cranston assess a unit charge per hundred cubic feet of water used, although Cranston specifies a minimum charge of $227/year. East Providence also assesses a unit charge per hundred cubic feet, although the city only assesses the charge for those properties using more than 220 hundred cubic feet per year. West Warwick assesses a unit charge for every 80 hundred cubic feet of metered water use. Blackstone Valley District Commission has two rate systems to recover operation and maintenance costs - one consisting of a classified system of flat rates based upon the characteristics of a property and corresponding water use allowance, and the other consisting of a unit charge per HCF for metered water use in excess of 59 hundred cubic feet. The Commission recovers debt service costs through a billing to municipalities based upon the percentage of flow each provides to the system. The municipalities then bill property owners through the general tax rate. Narragansett Bay Commission assesses a flat fee based upon the property's meter size plus a unit charge of 0.72 per hundred cubic feet. Meter sizes are expressed in terms of their equivalence to a 5/8 inch meter, the Providence Water Supply Boards standard size. A "capacity factor" is used to convert each meter size into the equivalent of a 5/8 inch meter. A pre-determined unit cost is then assessed against the capacity factor for each meter size. The larger the meter size, the more likely that a property would use more water at a higher rate. Thus these properties are charged higher fees (Mariscal, 1990).

The user fee charges for commercial and industrial users are more difficult to compare among facilities, because of the mixture of flat rates and volumetric charges. In addition, some communities assess industrial permit fees in addition to regular rates. However, in an effort to provide some perspective on the range of rates, examples of charges which would be paid by moderate-sized commercial facilities with wastewater flow of 250,000 gallons per year, and industrial facilities with 500,000 gallons per year are provided on Table 2-3. These examples show a potential range of $217 in Woonsocket to $562 in Warwick for moderate-sized commercial facilities, and a potential range of $434 in Woonsocket to $1124 in Warwick for industrial facilities with an average flow of 500,000 gallons per year.

An important consideration in evaluating these rates and the manner in which they are developed is the extent to which the bills sent to users reflect the actual costs of servicing the particular rate classes. Data on the proportion of actual residential costs per household as compared to the average annual service charge per household are presented in the Rhode Island User Charge Study prepared by the Rhode Island Department of Environmental Management (RIDEM) in July 1989. The survey was completed using procedures given in the

TABLE 2-4. CURRENT NON-RESIDENTIAL USER FEES

Wastewater Treatment Facility	Commercial Rate	Example: Average Annual Fee 250,000 gpy (334 HCF)(1)	Industrial Rate	Example: Average Annual Fee 500,000 gpy (668 HCF)
Blackstone Valley District Commission	O&M costs recovered through variety of flat rates based upon water use allowance: from $85-$501/year; $0.85/HCF for use >59 HCF. Debt service costs recovered through community tax rates.	$234	Variety of flat rates based upon water use allowance: from $85-$501/yr.; $0.85/HCF for use >59 HCF, plus Industrial Permit Fee	$518 plus permit fee.
Cranston	1.52/HCF (min $227)	$508	1.52/HCF (min. $580) plus variable permit fee	$1015 plus variable permit fee
E. Providence	Unit charge of $0.635/HCF for usage greater than 220 HCF/yr.	$72	Unit charge of $0.635/HCF for usage greater than 220 HCF/yr.	$284
Warwick	1.683/HCF	$562	1.683/HCF plus industrial permit fee of $100-1,000	$1124 plus industrial permit fee
W. Warwick	$112/80 HCF	$468	$112/80 HCF	$935
Woonsocket	.65/HCF	$217	.65/HCF	$434
NBC	Flat fee based on meter size plus 0.72/HCF	$240 plus flat fee	Flat fee based on meter size plus 0.34/HCF	$227 plus flat fee

Source: Narragansett Bay Commission - "Comparison of Sewer Use Charges" 1/25/90
1) HCF = Hundred Cubic Feet
2) Rates are Rounded to Whole Dollars

U.S. Environmental Protection Agency's publications Looking at User Charges: A Survey and Report. Municipalities responded to the questionnaire which included a number of questions on average daily residential wastewater flow annual operating costs, annual debt service payments, revenues collected, grant money collected and annual sewer user charges. The municipalities were instructed to provide best available information or their best estimates. Therefore it is possible that methods of accounting among communities were different and would make precise comparisons difficult. However, for the purpose of a preliminary planning study the DEM survey is helpful. The results of the survey, which represent 1988 data, show that residential customers in the Blackstone Valley District Commission, Cranston, Narragansett Bay Commission, and Woonsocket paid more in annual service charges than actual costs per household. The average household in BVDC paid 36% more than the costs attributed to it, a household in NBC paid 71% more, a household in Cranston paid only 2% more, while a household in Woonsocket paid 38% more. Residents of the Blackstone Valley District Commission also paid for debt service costs through the tax bills sent out by each municipality. These results indicate that residential customers were subsidizing, in part, the costs incurred by treatment of other wastewater flow, including stormwater, infiltration/inflow, and/or nonresidential flow. It is expected that residential users would be required to pay some portion of the cost to treat stormwater and infiltration/inflow, however, it is not clear how each of the communities allocates that cost among the different user groups. In the communities of Warwick and West Warwick, however, the opposite was true according to RIDEM survey results. In each of these communities, the average annual service charge per household was less than the total residential cost per household. This would indicate that the nonresidential customers were subsidizing, in part, the residential sector, or that the needed revenues were coming from some other source, such as the communities' general tax funds. In W. Warwick, for example, the survey shows that the average service charge represented 78% of total residential cost per household, while in Warwick the average service charge represented only 58% of the total residential cost per household. Residential customers in Warwick are subsidized, in part, by all properties in the town because the City's General Fund pays the interest on the City's wastewater bonds. The user fee covers the principal payment only (Apogee Research, 1990).

This type of difference also exists in the city of East Providence, which maintains its own wastewater facility as well as being partially serviced by BVDC. The city recovers costs related to debt service and operation and maintenance of the wastewater plant through the general tax rate. Other communities served by the BVDC also recover debt service costs billed to them by BVDC through the general tax rate. This means that the method of cost recovery has its basis in the assessed value of residential and nonresidential property, as opposed to the quantity and quality of wastewater generated by the different rate classes. Therefore, differences result not only between the rate classes but within the rate classes themselves.

2.4.2 Rate Structure Concerns Under Narragansett Bay Commission Consolidation

The differences noted above would be addressed in part by consolidation and responsibility for user fees under the authority of the Narragansett Bay

Commission (NBC). NBC employs a user fee system that requires rates to be based upon a quantity and quality approach, reflecting each user class' contribution of flow, BOD, and TSS to the sewer system. In order to determine the rates, the following procedure must be followed:

- Determination of total costs (revenue requirements) for planning period year
- Estimation of wastewater flow, BOD, TSS contributions from each user class
- Determination of proportion of total costs used to treat wastewater flow (quantity) versus BOD and TSS (quality)
- Allocation of costs to user groups based on their contributions of flow, BOD and TSS
- Calculation of rates for each user class according to different rate structure

Under NBC administrative authority, rates based upon uniform rate structures for each rate class would be billed directly on a semi-annual basis, as they are now, to the residential or nonresidential customer, eliminating any dependence upon municipal general funds and potentially inequitable burden upon tax rates. However, consolidation under the Narragansett Bay Commission would not necessarily resolve all equity issues, nor would it be easily accomplished. Some of the problems in establishing rates now encountered by the various facilities would be transferred to the NBC. For example, the Blackstone Valley District Commission (BVDC) services all or portions of Cumberland, Central Falls, Pawtucket, Lincoln, Smithfield, and East Providence. Water is supplied to BVDC customers by five different water companies, each of which has its own system and schedule for reading meters, and billing. The BVDC is in the process of investigating how to establish a uniform billing system which charges equitable rates in timely fashion. BVDC currently bills its customers once per year for usage in the previous year. If the Commission were to rely on metered water data for direct billing, and did not receive the necessary meter data from the five water companies, the BVDC billing would be delayed causing cash flow shortages (Sams, 1990). Serious cash flow shortages can lead to increased short-term borrowing, resulting in higher debt costs and, possibly, higher interest rates.

If consolidation were to occur, the Narragansett Bay Commission would be dependent upon the water meter readings of the different communities to establish total residential and nonresidential flow, and would thus, at least initially, be subject to the same potential problems of timely billing and collection. The magnitude of the problem would be even larger because more districts would be involved. Therefore, consideration might have to be given by water utilities to establishing a regional water supply billing system to be coordinated with the administration of the regional wastewater district. This type of coordination would facilitate uniform pricing and timely billing. An alternative suggestion to regional water billing is for the NBC to act as a wholesaler and bill each jurisdiction according to each municipality's flow contribution. This would leave the household billing up to the individual jurisdiction (Malone). Although this might alleviate the burden on the NBC it would not help those jurisdictions such as the BVDC which could experience problems due to the number of water suppliers.

The NBC would have to resolve what might appear to some user classes in some communities as an unfair increase in rate charges. It is possible that the residential rate for some communities, such as Woonsocket, would increase substantially over existing rates in order to insure equitable recovery of costs among the user classes. A comparison of total residential costs per household to total annual service charges per household for all seven facilities reveals that service charges represent only 79% of total costs (Rhode Island Department of Environmental Management, 1989). One of the reasons for the revenue shortfall is that recovery of portions of the residential costs in Warwick, East Providence and other communities of BVDC is currently incorporated in the general tax rate. Under a new uniform rate structure, a portion of the revenue shortfall in user fees would be paid directly by charges to "new" residential customers in East Providence and somewhat higher charges to existing residential customers in Warwick and the communities in the BVDC. However, the extent to which this will alleviate the shortfall is unknown. It is assumed that the general tax burden upon residential and nonresidential property owners in these communities would be alleviated due to the transfer of costs from the tax to user fees. However, individual property owners in these communities may experience a net increase or decrease in the amount they actually pay for wastewater treatment services depending upon the value of their property, and the amount of metered water used.

Another consideration in the analysis of equity in regional rates is the advantage/disadvantage of attracting and maintaining industry. Currently, there may be advantages for specific industries to locate within a certain wastewater treatment facility jurisdiction because of rate schedules providing cost breaks for some of those industrial activities (Nickolai, 1990). Regionalized rate design would possibly make for more rational business location decisions for firms within the drainage basin, however, it should be noted that there are a number of factors involved in facility siting, and wastewater costs are just one of those factors.

2.4.3 Conclusions

The available data indicate that there are some rather large differences in the user fees as they are currently administered under the seven wastewater treatment facilities. The differences include potentially unfair burden upon the general tax base in certain communities (taxes are based upon assessed value as opposed to water or wastewater flow) as well as apparent disproportionate allocation of costs among rate classes. Consolidation under NBC would alleviate some of the inequities. To the extent overall administrative costs are reduced, the total amount needed to be collected through user fees would be lessened, resulting in lower fees. A uniform rate structure if not rates themselves, based on quantity and quality of wastewater flow would result in more equity among rate classes across municipal borders. Costs for treating infiltration/inflow and stormwater could also be more equitably distributed among all users based upon analysis of problem areas and agreement as to fairshare of responsibility. Alternatively, an initial agreement could include a settlement for communities which have already expended funds to address CSO and I/I issues, although it would be difficult to develop, and efforts would need to be made to prevent double payment by some users. A regional approach to systematic water meter readings, and pricing would facilitate timely revenue collection, reducing potential reliance upon short-term borrowing. Maintenance of good credit would keep interest rates and payments low, thus contributing to lower user fees. Finally, all rate change requests proposed by the Narragansett Bay Commission must be approved by the Rhode Island Department of Public Utilities (DPUC), thus adding insurance that any uniform regional rate structure proposed by NBC would be reviewed and evaluated for equity considerations.

SECTION THREE
IMPLICATIONS OF REGIONAL DISCHARGE AT FIELD'S POINT

3.1 INTRODUCTION

This section evaluates the feasibility and potential costs of structural regionalization Option #2 - Regional Conveyance and Discharge at Fields Point. This option involves the overland conveyance of effluents from seven wastewater treatment facilities, Narragansett Bay Commission's Fields Point, BVDC's Bucklin Point, Cranston, East Providence, Warwick, West Warwick and Woonsocket, to an outfall into the Providence River off Fields Point in Providence. It has been assumed that all combined sewer flow in excess of WWTF headworks capacity and stormwater control strategies would be managed within the service area of origin. Although it is possible that alternative CSO abatement strategies may be more cost effective, the analysis of such strategies was not within the present scope of work. Consideration of construction scheduling of the various alternatives was also not included.

3.2 METHODS UTILIZED IN FEASIBILITY ANALYSIS

The methods, design data, and basis of costs included in this evaluation of the conveyance and combining of the treated effluent from seven existing wastewater facilities to a single point of discharge at Fields Point are presented in the following subsections. Initial planning estimates were developed for the conveyance costs for each reach for comparison with conceptual costs for advanced wastewater treatment upgrades or other applicable wastewater management scenarios.

3.2.1 Design Flows

The flows used in estimating potential additional infrastructure modifications for this option were obtained from existing information. RIDEM and Narragansett Bay Project files were the major sources and included RIPDES permits, Facility Plans, State-wide Planning Studies, and other similar reports and material.

For purposes of evaluation, existing WWTF design flow and recorded flows were used in estimating treatment process upgrades. Estimates of peak flows to the WWTF headworks were used in sizing of conveyance structures. Under this option all stormwater flows in combined systems in excess of peak flow at headworks are assumed to be handled by providing appropriate CSO abatement upstream of each treatment facility. Peak flows in excess of WWTF headworks capacities have not been included in conveyance system sizing and design.

This does not assume that all flows received at each treatment facility receive secondary treatment. It is assumed that a portion of the flow received at the headworks which cannot receive secondary treatment will be combined with the secondary effluent for subsequent transport to the point of discharge (in this case a Fields Point outfall). There are two facilities where the capacity of the headworks and primary treatment facilities exceed the secondary treatment facilities. They are BVDC's Bucklin Point and NBC's Fields Point. The Bucklin Point facility has a primary treatment capacity reported at 84 mgd, however, the secondary portion of the plant has a peak flow capacity of 46 mgd. Likewise, at Fields Point the primary facilities have a 200 mgd capacity and the secondary facilities a 90 mgd capacity.

3.2.2 Conveyance Route Selection

The selected transmission routes were based on generalized soil and topography data, using USGS mapping and supplemented in some cases with existing utility maps and general roadway layout information. Route locations should be viewed as conceptual in nature. Primary route selection objectives included minimizing excessive deep trenching, potentially difficult permitting (river crossings, wetland areas, and active railway rights-of-way), and minimizing social and infrastructure conflicts (avoiding densely developed urban areas) where immediately obvious and possible.

3.2.3 Construction Costs

The construction costs presented in this study reflect an ENR value of 4700 (March 1990). Prices are based on estimates obtained from prior reports and studies. For the regional discharge options (Option No. 2 and Option No. 4) the construction costs for the conveyance system, including sewer construction, pump station construction, pipe jacking, outfall construction and pump station O&M costs, were estimated using cost curves presented in the Metcalf and Eddy report to the Narragansett Bay Commission titled "Report to the Narragansett Bay Commission on Combined Sewer Overflows in CSO Area A, August, 1986." These cost curves have been modified to reflect an ENR value of 4700 and are enclosed in Appendix A of this report.

The objective of this study is to provide a cost model for use in generalized feasibility comparisons. The costs are not, in most cases, site specific. The construction cost estimates presented are intended to reflect approximate construction costs only and do not include costs such as legal, administrative, land, easements, or other special costs associated with implementation of any specific project. These additional costs would be estimated in a more detailed analysis of selected alternatives.

For the purposes of this study the construction costs for conveyance are intended to represent a reasonable allowance to accommodate transmission of wastewater flows from each treatment plant to Fields Point utilizing a system of gravity sewers, pumping stations, and force mains generally represented by the configuration shown in Figure 3-1. An appropriate allowance for a limited amount of special construction such as jacking, boring, and subaqueous activities has been included in the conveyance cost estimates but not, in most cases, on a site specific basis.

The comparative costs also do not include the incremental costs associated with providing full secondary treatment for those portions of excess flows currently receiving less than secondary treatment (NBC and BVDC).

The estimate for the effluent conveyance and discharge under this option does not include costs for odor control or aeration facilities. Due to the length of the conveyance system, these issues along with the potential costs due to

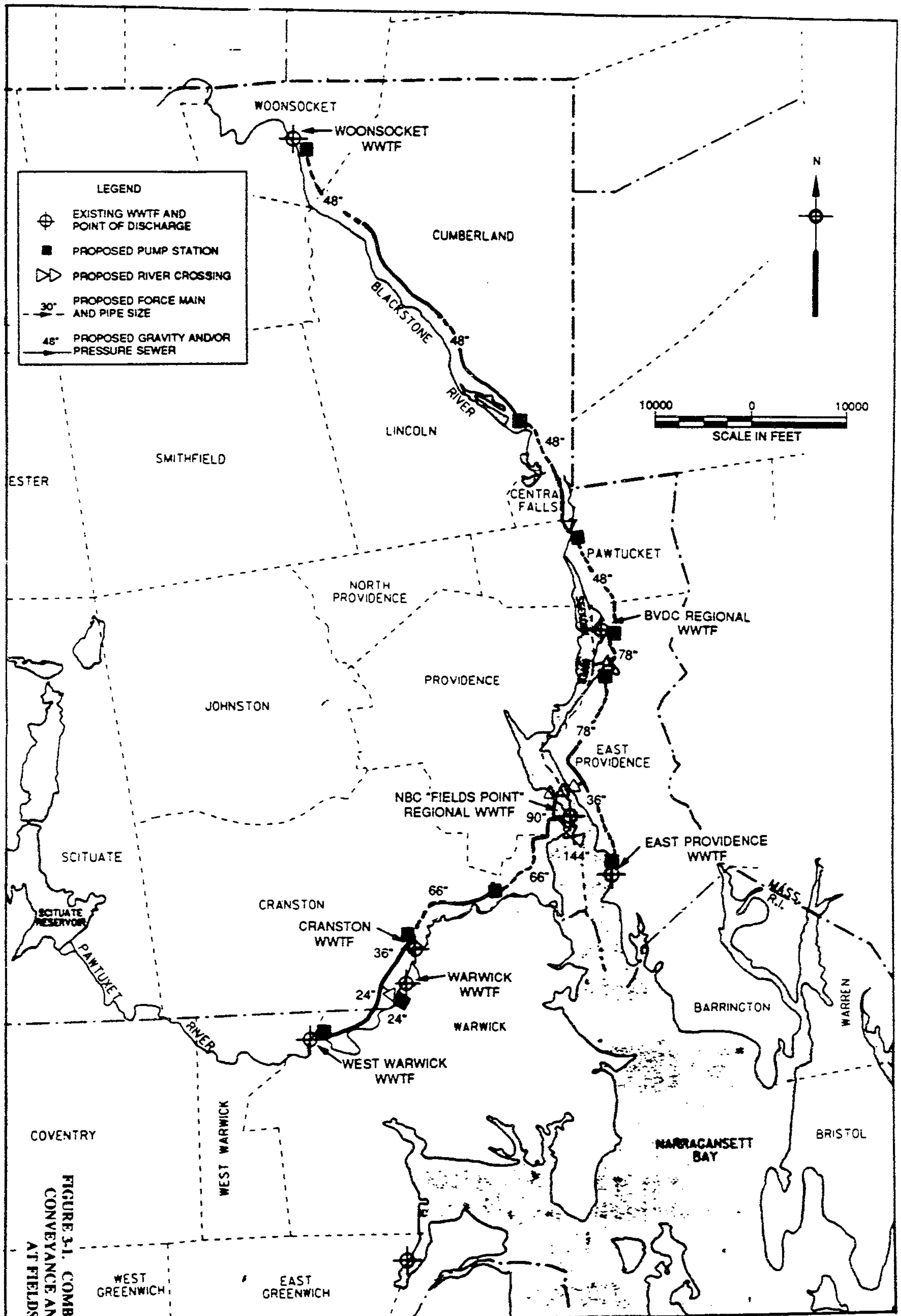


FIGURE 3-1. COMBINED EFFLUENT CONVEYANCE AND DISCHARGE AT FIELDS POINT

corrosive action associated with possible septic action, would need to be considered in any detail design, and potential corrective strategies could be included within the required pump station facilities.

The construction costs include a 35 percent allowance to account for engineering services during design and construction and for ledge removal and general construction contingencies, but do not include extraordinary ledge excavation, additional costs associated with adverse site conditions, or land and easement acquisition costs that would effect total construction/project costs. Although it is recognized that extensive large sewer construction in urban areas is extremely difficult and can rarely be accomplished entirely using cut and cover construction techniques, the planning level of this report did not warrant detailed site evaluations beyond the general material that is available on terrain and soil composition. For the purposes of this study, transmission lines are assumed to be located at customary depths and located such that large scale relocation of existing utilities to accommodate the conceptual layout would not be required.

3.2.4 Operation and Maintenance Costs

The estimated operation and maintenance (O&M) costs for pipelines include an allowance for inspection, cleaning, and repairs to provide for cleaning the entire length of pipeline once in twenty years at a fixed rate of five percent of the total length each year. These costs were based on current market prices for inspection, cleaning and repair services.

Pump station O&M costs were based on annual cost curves generated for pump station peak flow capacities, as presented in Appendix A. This curve is based on operational experience in the wastewater pumping industry. The costs from these curves represent normal O&M costs, such as labor, power, lubricants and spare parts.

Present worth of the estimated annual O&M costs was calculated using an interest rate of 8-7/8 percent established by the U.S. Bureau of Reclamation for Water Resources Planning.

3.2.5 Comparison of Costs

The cost curves developed for use in this study are presented in Appendix B. These curves are based on ENR 4700 (March 1990) and do not reflect additional costs as stated above. Total costs will be expressed in present worth for the purpose of comparison utilizing an interest rate of 8 7/8% for a design period of 20 years. O&M costs were estimated on a uniform annual costs basis prior to determining present worth. For simplicity and consistency of comparison no land costs or salvage values have been considered. The 20 year design period does not reflect the variations of design life between equipment, structures and pipelines, however, the sensitivity of these factors to the present worth analysis are considered minimal at this level of cost estimation.

3.2.6 Pump Stations

Estimated Pumping Station capital and annual operation and maintenance costs are a significant portion of the overall conveyance infrastructure evaluation. Due to the varied terrain of the study area, a number of pump stations will be required to transport and discharge the flow at Fields Point as shown on Figure 3-1. The pump station sites were selected such that force mains and pressure sewers could be utilized wherever possible in order to minimize deep construction which is often more costly than a more conventional system of force mains and gravity lines. The pumping system anticipated would maximize the use of low lift, high capacity pumping facilities in order to minimize pumping costs. The sizing of the pumps have been selected to provide approximately two feet per second velocity in the effluent conduit at average design flows and to discharge peak flows at higher velocities without creating excessive headloss. Multiple Variable Frequency Drive pumps are assumed to be included with at least one additional pump included for redundancy.

3.3 CONVEYANCE ROUTES

An approximate route for conveyance of flows to Fields Point has been established for conceptual purposes as shown in Figure 3-1. It was assumed that the depicted conveyance systems would be contained within existing easements or road layouts. In general, the conveyance routes join existing WWTFs with the intent to place pumping facilities within the WWTF site. Where conveying to a WWTF would result in additional conduit length without apparent benefit, a connection point to the conveyance system was selected for the outlying WWTF. A description of each reach of the conveyance system is presented below.

3.3.1 Woonsocket WWTF to BVDC Regional WWTF

The Woonsocket WWTF is located on the east bank of the Blackstone River approximately 6,500 feet northwest of the Cumberland Town boundary. The conceptual route generally parallels the Blackstone River, Route 122, Route 114, and the east bank of the Seekonk River in a generally southeasterly and southerly direction to the Blackstone Valley District Commission WWTF located at Bucklin Point. The flow would be combined with the BVDC flows at Bucklin Point for transfer to NBC Fields Point. This conveyance route is approximately sixteen miles in length, has a pipe diameter of four feet, and includes three pump stations. The conceptual locations of the pipelines and pump stations are depicted in a general manner on Figure 3.1.

The Woonsocket WWTF has been designed for an average flow of 16.0 million gallons per day (MGD). The WWTF had an average daily flow of 11.2 MGD during the year 1987. A peak wet weather design flow of 40.0 MGD was the basis of sizing the conduits and pump stations for conveying treated Woonsocket effluent to the BVDC WWTF. The conceptual conveyance system design criteria for this reach is listed in Table 3-1.

Approximately 84,000 feet of force main, pressure conduit and three pump stations within this reach have an estimated total capital cost of $36.1 million. This capital cost added to the estimated operations and

CONVEYANCE INFRASTRUCTURE

REACH	FLOW/mgd		PIPELINE		PUMP STATION	
	ADF	PK	DIA. (FT)	LENGTH (FT)	QTY.	SIZE (mgd)
Woonsocket WWTF to BVDC WWTF	16.0	40.0	4.0	84000	3	40.0
BVDC WWTF to Kettle Point	47.0	124.0	6.5	24600	2	124.0
East Providence WWTF to Kettle Point	10.4	26.0	3.0	13800	1	26.0
Kettle Point (subaqueous) to NBC Fields Point WWTF	57.4	150.0	7.5	2000		
West Warwick WWTF to Warwick WWTF	5.0	12.5	2.0	13800	1	12.5
Warwick WWTF to Cranston WWTF	10.2	25.5	3.0	9000	1	13.0
Cranston WWTF to NBC Fields Point WWTF	33.2	83.0	5.5	39800	2	83.0
NBC Fields Point WWTF to Providence River	155.6	433.0	12.0	800		
TOTAL	156	433		187800	10	

TABLE 3-1 CONVEYANCE TO FIELDS POINT OUTFALL

maintenance costs of the conduit and pump stations results in a total present worth cost of $48.0 million as shown in Table 3-2.

3.3.2 BVDC Regional WWTF to Kettle Point

The Blackstone Valley District Commission WWTF is located at Bucklin Point on the east bank of the Seekonk River in the Rumford section of East Providence, approximately 2,500 feet south of the Pawtucket City boundary. The conceptual route generally parallels the Seekonk River, Route 114, and the east bank of the Providence River in a southerly, southwesterly, and southeasterly direction to Kettle Point on the east bank of the Providence River opposite from the Narragansett Bay Commission WWTF located at Fields Point. This conveyance route is approximately 4.7 miles in length, includes two pump stations, and conveys the effluent discharges of both Woonsocket and BVDC WWTFs. The estimated size of the pipe to carry the combined discharge is 6.5 feet in diameter. The conceptual locations of the pipelines and pump stations are depicted in a general manner on Figure 3.1.

The BVDC WWTF has been designed for an average flow of 31.0 MGD. The WWTF had an average daily flow of 23.22 MGD during the year 1987. A peak wet weather design flow of 84 MGD was combined with the 40.0 MGD from the Woonsocket WWTF for a total of one hundred twenty-four (124.0) MGD as the basis of sizing the conduits and pump stations of the combined treated effluent to Kettle Point on the east bank of the Providence River opposite the NBC Fields Point WWTF where it is combined with an additional 26.0 MGD being conveyed from the East Providence WWTF. The conceptual conveyance system design criteria for this reach is listed in Table 3-1.

Approximately 24,600 feet of force main, pressure conduit and two pump stations within the reach have an estimated total capital cost of $30.5 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump stations results in a total present worth cost of $49.2 million as shown in Table 3-2.

3.3.3 East Providence WWTF to Kettle Point

The East Providence WWTF is located on the east bank of the Providence River in the Riverside section of East Providence, approximately 1.6 miles northwest of the Barrington town boundary. The conceptual route generally parallels the east bank of the Providence River in a northwesterly direction to Kettle Point on the east bank of the Providence River opposite from the Narragansett Bay Commission WWTF located at Fields Point. This transmission route is approximately 2.6 miles in length, includes one pump station, and conveys the treated effluent from the East Providence WWTF to Kettle Point in a three foot diameter pipe where it is combined with the effluent discharges from the Woonsocket and BVDC WWTFs.

The East Providence WWTF has been designed for an average flow of 10.4 MGD. The WWTF had an average daily flow of 6.7 MGD during the year 1987. A peak wet weather design flow of 26.0 MGD was the basis of sizing the pipelines and pump station for this reach. The conceptual conveyance system design criteria for this reach are listed in Table 3-1.

CONVEYANCE COST

REACH	CAPITAL/PRESENT WORTH (COSTS = $ x 1,000,000) PIPE	PUMP	TOTAL	ANNUAL O&M PIPE	PUMP	TOTAL	PRESENT WORTH of O&M	TOTAL PRESENT WORTH
Woonsocket WWTF to BVDC WWTF	23.5	12.6	36.1	0.10	1.20	1.30	11.97	48.0
BVDC WWTF to Kettle Point	11.6	18.9	30.5	0.03	2.00	2.03	18.70	49.2
East Providence WWTF to Kettle Point	3.1	3.2	6.3	0.02	0.25	0.27	2.49	8.8
Kettle Point (subaqueous) to NBC Fields Point WWTF	5.9		5.9	0.01		0.01	0.09	6.0
West Warwick WWTF to Warwick WWTF	2.8	2.0	4.8	0.02	0.12	0.14	1.29	6.1
Warwick WWTF to Cranston WWTF	2.9	2.0	4.9	0.01	0.12	0.13	1.20	6.1
Cranston WWTF to NBC Fields Point WWTF	17.5	13.5	31.0	0.04	1.60	1.64	15.11	46.1
NBC Fields Point WWTF to Providence River	3.3		3.3	0.01		0.01	0.09	3.4
TOTAL	70.6	52.3	122.8				50.93	173.8

TABLE 3-2 CONVEYANCE TO FIELDS POINT OUTFALL

Approximately 13,800 feet of force main, pressure conduit and one pump station within this reach have an estimated total capital cost of $6.3 million . This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $8.8 million as shown on Table 3.2.

3.3.4 Kettle Point to NBC Fields Point WWTF

The combined effluent discharges of East Providence, Woonsocket, and BVDC WWTFs is conveyed through a 7.5 foot diameter subaqueous conduit in an inverted siphon arrangement across the Providence River to the NBC Fields Point WWTF. The conceptual location of the conveyance line is shown on Figure 3.1.

The East Providence WWTF peak flow of 26.0 MGD is combined with a peak flow of 124.0 MGD conveyed from the Woonsocket and BVDC WWTFs. The resulting combined peak flow of 150.0 MGD is conveyed through a subaqueous pipeline across the Providence River to the Narragansett Bay Commission Fields Point WWTF and is the basis of sizing the conduit. The conceptual conveyance system design criteria for this reach are listed are Table 3-1.

Approximately 2,000 feet of pressure conduit within this reach has an estimated total capital cost of $5.9 million. This capital cost added to the estimated operations and maintenance costs of the conduit results in a total present worth cost of $6.0 million as shown in Table 3.2.

3.3.5 West Warwick WWTF to Warwick WWTF

The West Warwick WWTF is located on the north bank of the Pawtuxet River at river mile 9.8 and is approximately 2.5 miles south of the Cranston City boundary. The conceptual route generally parallels the Pawtuxet River and Route I-95, in a generally easterly and northeasterly direction to a point on the north bank of the river opposite the Warwick WWTF. This transmission route is approximately 2.6 miles in length and includes one pump station, three railroad crossings, two major highway crossings and conveys the effluent in a two foot diameter pipe. The conceptual locations of the pipelines and pump station are depicted in a general manner on Figure 3.1.

The West Warwick WWTF has been designed for an average flow of 5.0 MGD. The WWTF had an average daily flow of 4.85 MGD during the year 1987. A peak wet weather design flow of 12.5 MGD was the basis of sizing the conduits and pump station for conveying of the treated West Warwick effluent to a point on the north bank of the Pawtuxet River across from the Warwick WWTF. The conceptual conveyance system design criteria for this reach are listed in Table 3-1.

An estimated 13,800 feet of pressure conduit and one pump station within this reach have an estimated total capital cost of $4.8 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $6.1 million as shown in Table 3.2.

3.3.6 Warwick WWTF to Cranston WWTF

The Warwick WWTF is located on the south bank of the Pawtuxet River at river mile 6.0 and is approximately 4,000 feet northwest of the Green Memorial State Airport. The conceptual route crosses the Pawtuxet River to the north bank and connects to the conveyance line originating at the West Warwick WWTF and generally parallels the Pawtuxet River and Route I-95, in a northeasterly direction to the Cranston WWTF. This conveyance route is approximately 1.7 miles in length and includes one pump station, one river crossing, and one major highway crossing. A two foot diameter pipe is used to convey the Warwick effluent across the Pawtuxet River and connects to the West Warwick pipe. A three foot diameter conduit is used to convey the combined effluent discharges of both West Warwick and Warwick WWTFs to the Cranston WWTF. The conceptual locations of the pipelines and pump station are depicted in a general manner on Figure 3.1.

The Warwick WWTF has been designed for an average flow of 5.2 MGD. The WWTF had an average daily flow of 3.26 MGD during the year 1987. A peak wet weather design flow of 13.0 MGD was combined with the 12.5 MGD from the West Warwick WWTF for a total of 25.5 MGD as the basis of sizing the conduits and pump station of the combined treated effluent to the Cranston WWTF. The conceptual conveyance system design criteria for this reach are listed in Table 3-1.

Approximately 9,000 feet of pressure conduit and one pump station within this reach have an estimated total capital cost of $4.9 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $6.1 million as in Table 3.2.

3.3.7 Cranston WWTF to Fields Point

The Cranston WWTF is located on the north bank of the Pawtuxet River at river mile 4.5 and is approximately 7,000 feet northwest of the Green Memorial State Airport. The conceptual route continues to generally parallel the Pawtuxet River for approximately 3.8 miles and turns and runs overland 3.7 miles, in a northeasterly direction to the NBC Fields Point WWTF. This transmission route is approximately 7.5 miles in length, includes two pump stations, six railroad crossings, one major highway crossing, two stream crossings, and conveys the combined effluent discharges of West Warwick, Warwick, and Cranston WWTFs in a 5.5 foot diameter pipe. The conceptual locations of the conduit and pump stations are depicted in a general manner on Figure 3.1.

The Cranston WWTF has been designed for an average flow of 23 MGD. The WWTF had an average daily flow of 12.7 MGD during the year 1987. A peak wet weather design flow of 57.5 MGD was combined with the 25.5 MGD from the West Warwick and Warwick WWTFs for a total of 83.0 MGD as the basis of sizing the conduits and pump stations of the combined treated effluent to the NBC Fields Point WWTF. The conceptual conveyance system design criteria for this reach are listed in Table 3-1.

Approximately 39,800 feet of force main, pressure conduit, gravity sewer, and two pump stations within this reach have an estimated total capital cost of $31.0 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump stations results in a total present worth cost of $46.1 million as shown on Table 3.2.

3.3.8 NBC Fields Point WWTF to Providence River

The NBC WWTF is located at Fields Point in Providence on the west bank of the Providence River approximately three miles southeast of the State Capital Building. The treated effluent from the NBC WWTF is combined with the effluent discharges from the Woonsocket, BVDC, East Providence, West Warwick, Warwick, and Cranston WWTFs at a new junction structure and is then discharged through a new extended outfall originating at the Fields Point WWTF and terminating at channel depth in the Providence River. No effluent diffusers were included in this option due to the shallow channel depth. The conceptual location of the extended outfall is depicted in a general manner on Figure 3.1.

The NBC WWTF has been designed for an average flow of 65.0 MGD. The WWTF had an average daily flow of 53.3 MGD during the year 1987. A peak wet weather design flow of 200.0 MGD was combined with the 83 MGD from the West Warwick, Warwick, and Cranston WWTFs and the 150.0 MGD from the Woonsocket, BVDC, and East Providence WWTFs for a total combined discharge of 433 MGD into the Providence River. This combined total discharge of 433.0 MGD was used as the basis of sizing the outfall of the combined treated effluents from the seven WWTFs. The conceptual conveyance system design criteria for this reach are listed in Table 3-1.

Approximately 800 feet of subaqueous conduit has an estimated total capital cost of $3.3 million. This capital cost added to the estimated operations and maintenance cost of the conduit results in a total present worth cost of $3.4 million as shown in Table 3.2.

3.4. ESTIMATED TOTAL CONVEYANCE COSTS

The cost figures for overland conveyance to a regional outfall at Fields Point by combining the treated effluent discharges from the BVDC, Cranston, East Providence, NBC, Warwick, West Warwick, and Woonsocket WWTFs are shown in Table 3.2.

The overland pipeline system, together with the subaqueous deep water marine outfall, and pump stations have an estimated total capital cost of $122.8 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of approximately $174 million. These cost figures are shown on Table 3.2.

The total capital cost ($122.8 million) could be compared against the anticipated capital cost of upgrading the Cranston, Warwick, and West Warwick plants to AWT. The estimated cost of upgrading all three plants is in the $83-$100 million range (Metcalf & Eddy, 1990; Smith-Barney, 1989).

3.5 FEASIBILITY AND ADVANTAGES OF OPTION 2

The basic intent of the structural regionalization option is to relocate seven major WWTFs discharges in the upper bay to a central outfall location off Fields Point via a new conveyance system. The basic design criteria (i.e., flows and pipe sizes) and estimates of cost were developed as established by EPA criteria without regard to water quality issues that may be associated with implementing Option 2.

This option is considered technically feasible, however, the reasoning behind the perceived benefit of this option should be examined, since several non-costs factors may significantly reduce the feasibility of this structural regionalization.

At the preliminary level of cost evaluations performed for this study the total present worth of a new conveyance system, considering construction costs and annual O&M for 20 years, is approximately $174 million. This figure is between 40 to 60 percent less than the estimated costs for upgrading the existing WWTFs to advanced wastewater treatment standards developed in Section 6 of this report. Accordingly, Option 2 may offer significant cost savings as compared to Option 5 described in Section 6.

Obviously, with a sewer construction project of this size and complexity (35 miles of 4.0 feet to 7.5 feet diameter pipe, 10 pump stations and outfall), the magnitude of special construction conditions other than obvious river crossings and jackings cannot be specifically identified given the preliminary level of engineering applied during this study. Accordingly, a 35 percent cost factor was included in the estimated construction costs as an allowance for engineering and contingency for special conditions. However, since planning level estimates were made without site specific detailed information there is no reliable basis for assigning contingency factors and the resultant transport costs should be viewed accordingly.

Some concern has been expressed about the feasibility, desirability, cost effectiveness, and environmental benefits of this option. Therefore, the following modifications to structural regionalization should be considered in evaluating the feasibility of this option.

1. Instead of constructing a 16 mile long conveyance system from the Woonsocket WWTF to the BVDC WWTF, consider upgrading the Woonsocket plant to AWT as necessary for receiving water quality concerns. The total present worth (construction and O&M) for upgrading Woonsocket to AWT based on alternatives developed in Section 6 is likely to be 15 percent lower than the costs for conveying Woonsocket effluent to BVDC. The cost savings for the AWT upgrade at Woonsocket could be even greater if it is determined that the plant need only nitrify their effluent rather than remove nitrogen (denitrify), as assumed in Section 6.

2. Leave the Warwick, West Warwick and Cranston WWTFs discharges in their current locations in the Pawtuxet River and upgrade each plant to address local water quality concerns. The 1983 "Pawtuxet River,

Rhode Island, Use Attainability Study" identifies these three treatment facilities as major contributors of flow to the river, especially during low flow periods. Relocating the discharges from the river to the bay would likely compound water quality problems in the Pawtuxet River by reducing flow. Upgrading the treatment at these plants was considered one method to improve the quality of the Pawtuxet River identified in the use attainability study. In addition, the need for nitrogen removal as opposed to nitrification levels of treatment should be evaluated for relative water quality impacts. As noted above, the capital cost of upgrading these three wastewater facilities is between 68 and 82 percent of the capital cost of the combined conveyance system.

3. Rather than combining the east shore discharges of BVDC and East Providence, then conveying them subaqueously to the west shore at NBC, then discharging into the bay; it may be more cost-effective to extend the East Providence outfall from its current location to deep water and construct a new outfall from the east shore for BVDC effluent. Alternatively, Woonsocket and East Providence could be combined and discharged through one outfall from the east shore to deep water. The advantage to this modification would be to avoid a river crossing for the purpose of conveying flow to Fields Point for common discharge into the bay. This modification to Option 2 is presented below as Option 2A.

3.5.1 Option 2A - Regional Conveyance and Discharge at Fields' Point and East Providence WWTFs

This section evaluates the feasibility and potential cost of a modified structural regionalization Option #2A - Regional Conveyance and Discharge at Fields Point and East Providence WWTFs. As depicted in Figure 3-2, this option involves the overland conveyance of effluents from four wastewater treatment facilities, NBC Field's Point, Cranston, Warwick, and West Warwick to an outfall into the Providence River off Fields Point in Providence, and an overland conveyance and combined effluent discharge from BVDC's Bucklin Point, Woonsocket, and East Providence WWTFs to an outfall into the Providence River off the East Providence wastewater treatment facility.

The conveyance routes and estimated costs for Option 2A are the same as that which was described in Option 2 with the following exceptions:

BVDC WWTF to East Providence. From BVDC Bucklin Point WWTF the conceptual route generally parallels the Seekonk River, Route 114, and the east bank of the Providence River in a southerly, southwesterly, and southeasterly direction to the East Providence WWTF located on the east bank of the Providence River. This transmission route is approximately 7.3 miles in length, includes three pump stations, and conveys the effluent discharges of both Woonsocket and BVDC WWTFs. The estimated size of the pipe to carry the combined discharge is 6.5 feet in diameter. The conceptual locations of the transmission lines and pump stations are depicted in a general manner on Figure 3-2 and design criteria are summarized in Table 3-3.

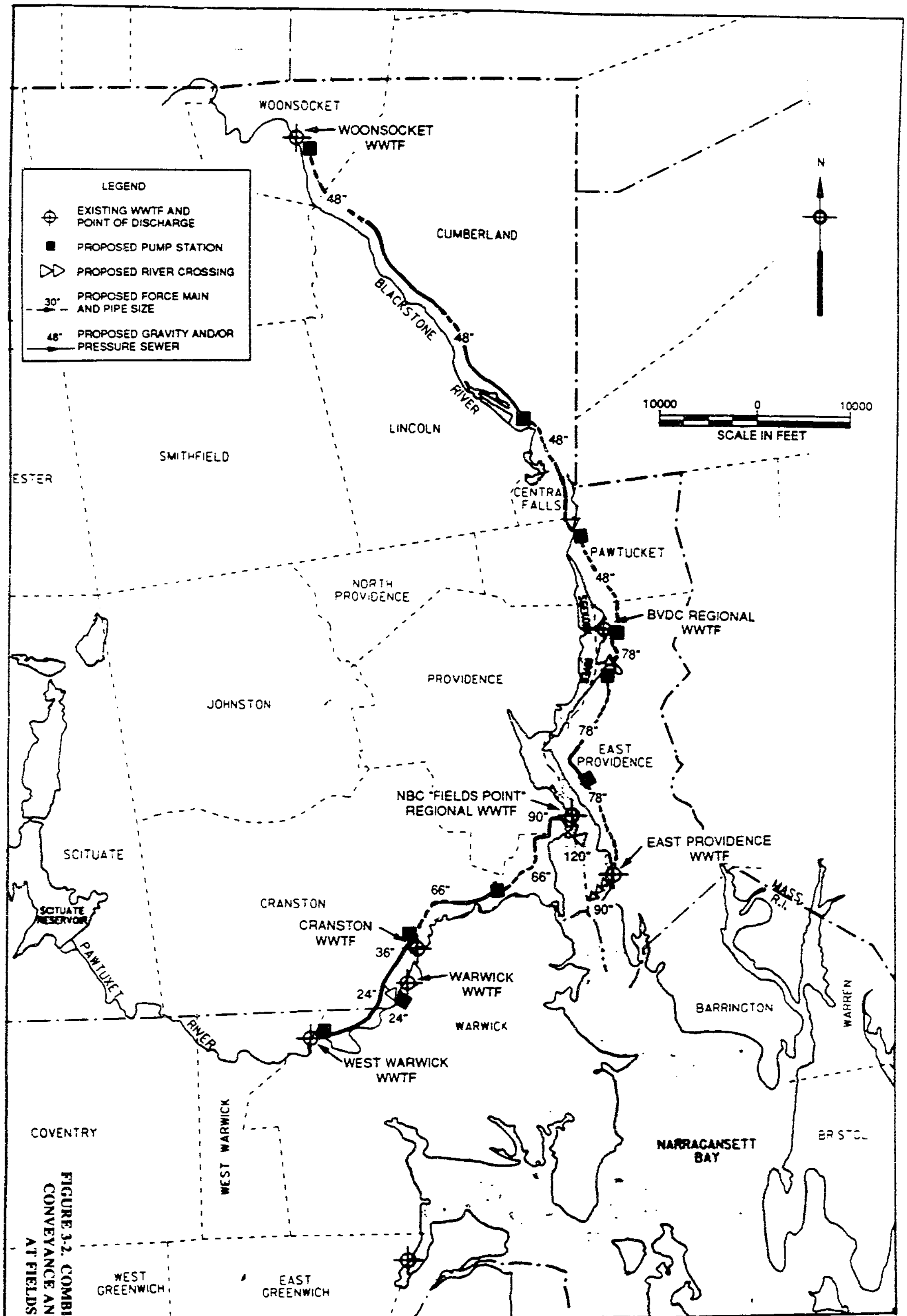


FIGURE 3-2. COMBINED EFFLUENT CONVEYANCE AND DISCHARGE AT FIELDS POINT

METCALF & EDDY

REACH	FLOW/mgd		PIPELINE		PUMP STATION	
	ADF	PK	DIA. (FT)	LENGTH (FT)	QTY.	SIZE (mgd)
Woonsocket WWTF to BVDC WWTF	16.0	40.0	4.0	84000	3	40.0
BVDC WWTF to East Providence WWTF	47.0	124.0	6.5	38400	3	124.0
East Providence WWTF to Providence River	57.4	150.0	7.5	1000		
West Warwick WWTF to Warwick WWTF	5.0	12.5	2.0	13800	1	12.5
Warwick WWTF to Cranston WWTF	10.2	25.5	3.0	9000	1	13.0
Cranston WWTF to NBC Fields Point WWTF	33.2	83.0	5.5	39800	2	83.0
NBC Fields Point WWTF to Providence River	98.2	283.0	10.0	800		
TOTAL	156	433		186800	10	

TABLE 3-3. OPTION 2A, EAST SHORE AND WEST SHORE DISCHARGE, CONVEYANCE INFRASTRUCTURE

A peak wet weather design flow of 84.0 mgd from the BVDC WWTF was combined with the 40.0 mgd for the Woonsocket WWTF for a total of 124.0 mgd as the basis of sizing the transmission conduits and pump stations of the combined treated effluent to the east bank of the Providence River. There, it is combined with an additional 26.0 mgd from the East Providence WWTF.

Approximately 38,400 feet of force main and pressure conduit, and three pump stations have an estimated total capital cost of $46.2 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump stations results in a total present worth cost of $74.2 million.

East Providence WWTF to Providence River (East Shore Discharge). The combined effluent discharges of East Providence, Woonsocket, and BVDC WWTFs (150 mgd) is conveyed through a 7.5 foot diameter outfall into the Providence River off the East Providence WWTF. No effluent diffusers were included in this option due to the shallow channel depth. The conceptual location of the transmission line is generally as shown on Figure 3-2 and design criteria are summarized in Table 3.3.

Approximately 1,000 feet of outfall conduit have an estimated total capital cost of $3.0 million which includes a 35 percent allowance for engineering services during design and construction, and general construction contingencies. This capital cost added to the estimated operations and maintenance costs of the conduit results in a total present worth cost of $3.1 million as shown in Table 3.4.

NBC Fields Point WWTF to Providence River (West Shore Discharge). The treated effluent for the NBC WWTF is combined with the effluent discharged from the West Warwick, Warwick, and Cranston WWTFs, and is then discharged through a new conduit terminating at the existing NBC discharge point or through a new extended outfall originating at the Fields Point WWTF and terminating at channel depth in the Providence River. The conceptual location of the extended outfall is depicted in a general manner on Figure 3-2 and design criteria are summarized in Table 3.3.

A peak wet weather design flow of 200.0 mgd from Fields Point was combined with the 83.0 mgd for the West Warwick, Warwick and Cranston WWTFs for a total combined discharge of 283.0 million gallons per day into the Providence River. This combined total discharge of 283.0 mgd was used as the basis of sizing the outfall of the combined treated effluents from the four WWTFs.

Approximately 800 feet of subaqueous conduit have an estimated total capital cost of $3.0 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump stations results in a total present worth cost of $3.1 million as shown on Table 3.4.

Estimated Total Conveyance Costs

The capital cost for the remaining reaches including Woonsocket to BVDC, West Warwick to Warwick, Warwick to Cranston and Cranston to Fields Point were previously estimated in Option 2 and are brought forward from Table 3.2 to Table 3-4.

REACH	CAPITAL/PRESENT WORTH (COSTS = $ x 1,000,000)			ANNUAL O&M			PRESENT WORTH of O&M	TOTAL PRESENT WORTH
	PIPE	PUMP	TOTAL	PIPE	PUMP	TOTAL		
Woonsocket WWTF to BVDC WWTF	23.5	12.6	36.1	0.10	1.20	1.30	11.97	48.0
BVDC WWTF East Providence WWTF	17.6	28.6	46.2	0.05	3.00	3.05	28.09	74.2
East Providence WWTF to Providence River	3.0		3.0	0.01		0.01	0.09	3.0
West Warwick WWTF to Warwick WWTF	2.8	2.0	4.8	0.02	0.12	0.14	1.29	6.1
Warwick WWTF to Cranston WWTF	2.9	2.0	4.9	0.01	0.12	0.13	1.20	6.1
Cranston WWTF to NBC Fields Point WWTF	17.5	13.5	31.0	0.04	1.60	1.64	15.11	46.1
NBC Fields Point WWTF to Providence River	3.0		3.0	0.01		0.01	0.09	3.1
TOTAL	70.2	58.7	128.8				57.84	186.7

TABLE 3-4. OPTION 2A, EAST SHORE AND WEST SHORE DISCHARGE, ESTIMATED COST

The total estimated capital cost for separate east shore and west shore regional conveyance systems under Options 2A is $129 million as shown in Table 3.4. This capital cost added to the estimated operations and maintenance costs of the conduit and pump stations results in a total present worth cost of $187 million.

SECTION FOUR
CONSOLIDATION OF GREENWICH BAY DISCHARGES

4.1 INTRODUCTION

This section examines Option 3, in which all wastewater discharges are removed from the Greenwich Bay drainage basin. The study area for Option 3 is shown in Figure 4-1. Central to this option is the relocation of the East Greenwich WWTF discharge to the Quonset Point WWTF in North Kingstown via overland conveyance as shown in Figure 4-2. Also included in this option is the provision of sewerage to all presently unsewered areas within the Greenwich Bay drainage basin, along with the provision of treatment facilities capable of handling septage from septic tanks as well as from marina pumpout facilities. As with Options 2 and 4 all wastewater is to receive a minimum of secondary treatment.

Included within this section are estimates of the costs to convey wastewater overland from the East Greenwich WWTF to the Quonset Point WWTF, the costs of extending or constructing a new Quonset Point WWTF outfall to a deep water location in the middle of Narragansett Bay, and the costs of providing additional storage and pumping facilities at Quonset Point to accommodate the additional flows. Estimates are also provided for the costs of providing sewer service to all presently unsewered areas within the Greenwich Bay drainage basin which includes portions of Warwick, West Warwick and East Greenwich and for providing sewerage to portions of the town of North Kingstown in which the Quonset Point WWTF is located. Provision for stormwater collection and treatment facilities in the Greenwich Bay drainage basin area are not included in this option.

4.2 PROVISION OF SEWER SERVICE TO UNSEWERED AREAS IN THE GREENWICH BAY DRAINAGE BASIN AND IN NORTH KINGSTOWN

The service area considered in this option consists of those portions of Warwick, West Warwick, and East Greenwich within the Greenwich Bay drainage basin and the town of North Kingstown and is shown in Figure 4-1. For those areas within the Greenwich Bay drainage basin, sewer service is assumed to be provided to all areas within the basin. For North Kingstown, sewer service is assumed for only those areas previously designated for sewer service in facilities plans or area wide management plans.

In general, the addition of sewers to a previously unsewered area involves installation of lateral sewers (usually 8- to 12-inch diameter) with smaller diameter spurs for building connections and larger diameter interceptor sewers.

For the purposes of this study, it is assumed that to provide sewer service, 8-inch internal sewer will be installed and placed in streets at an average depth of 8 feet deep. The approximate lengths of sewers needed has been estimated based upon the general conditions prevalent in each municipality. Using these assumptions, it is estimated that the construction costs for new sewers will be $85/linear foot of sewer. The operations and maintenance costs for new sewers is based upon providing cleaning of the pipe and is estimated

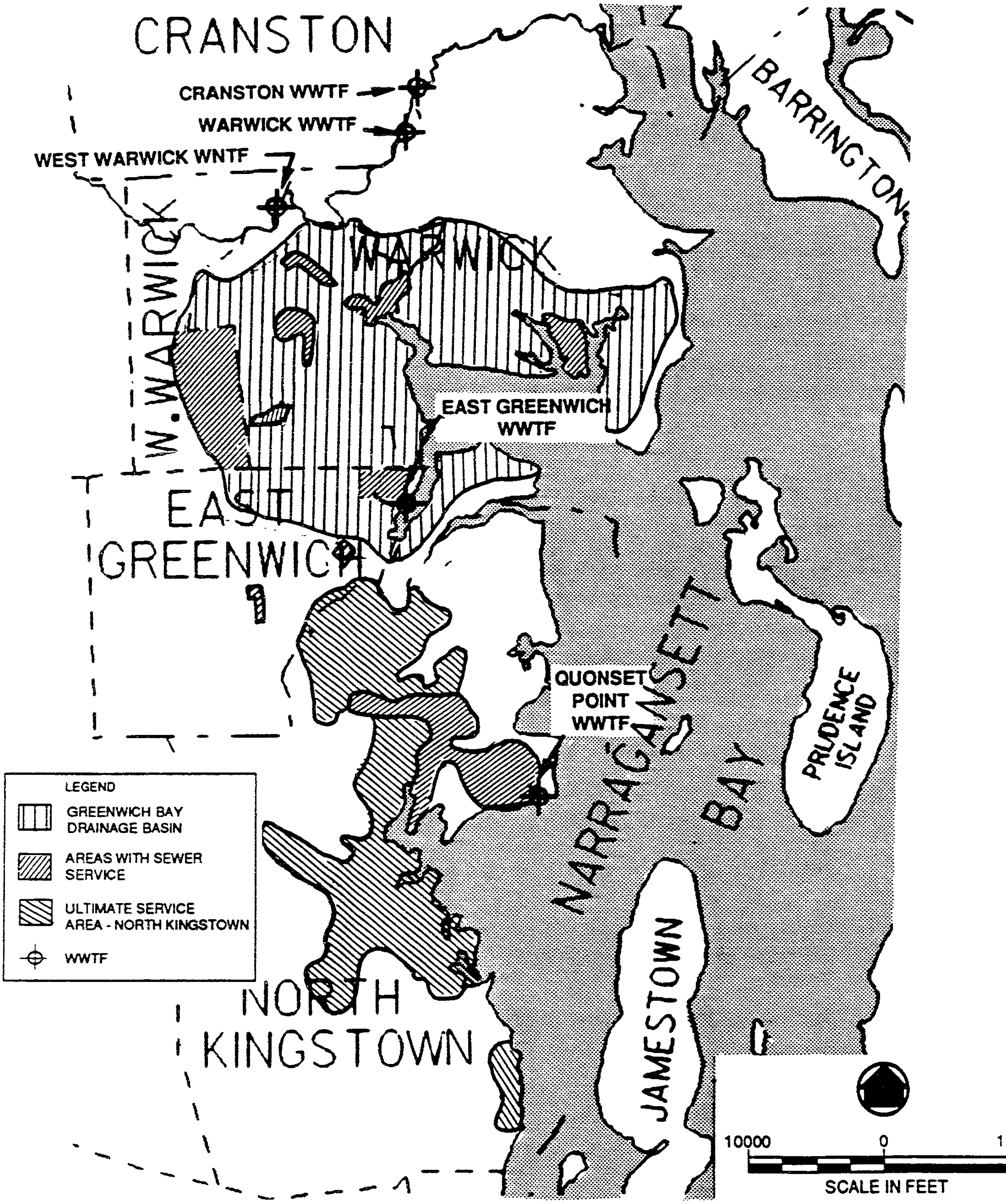


FIGURE 4-1 SEWER SERVICE AREAS

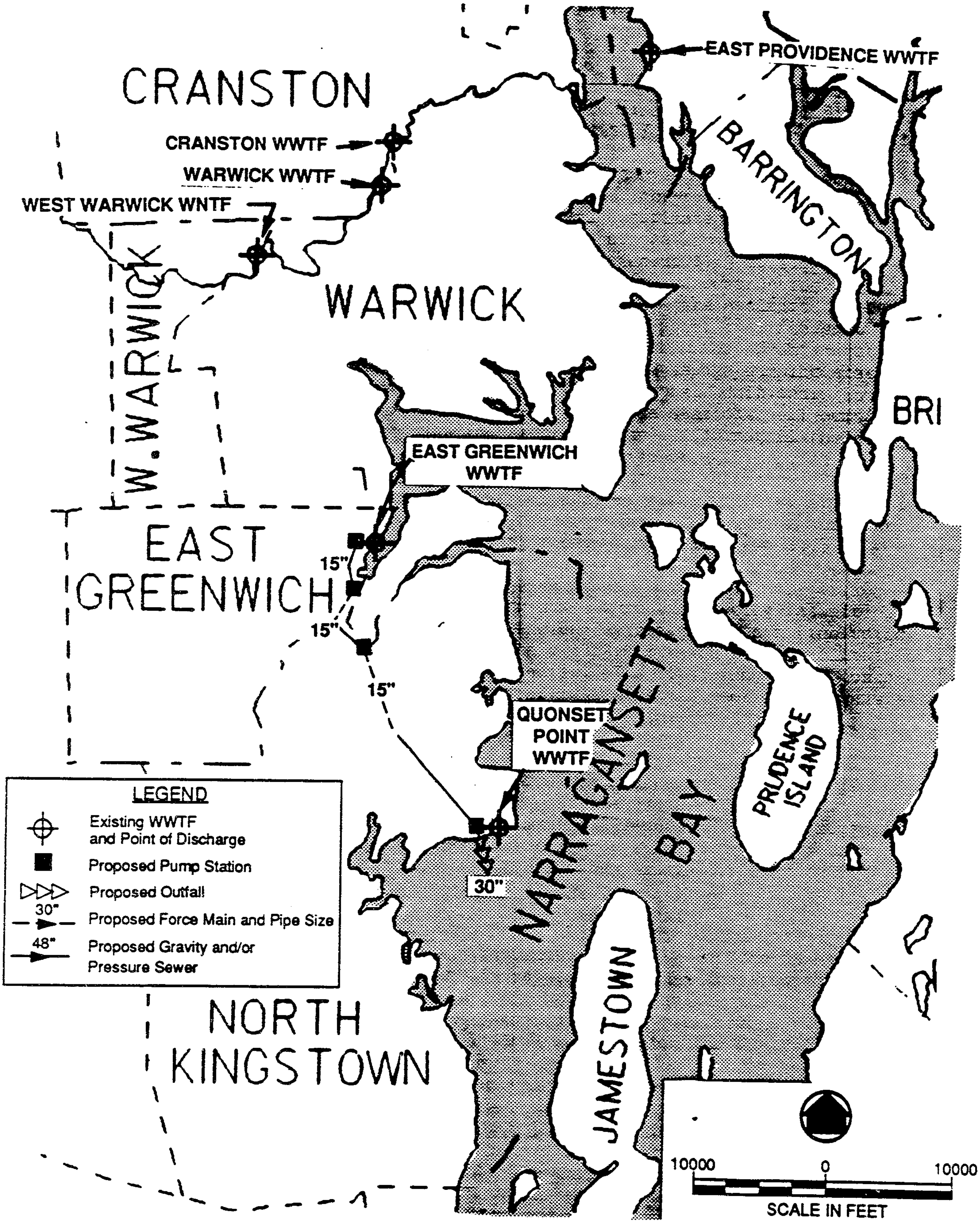


FIGURE 4-2 COMBINED EFFLUENT CONVEYANCE & DISCHARGE AT QUONSET POINT

to have a present worth of $5 per linear foot of pipe. Construction and operations and maintenance costs for pump stations have been estimated i similar fashion as in Options 2 and 4.

The additional flows expected from providing sewers to presently unsewer areas within the Greenwich Bay drainage basin and in North Kingstown wer estimated using projected populations for the municipality or subsection municipalities presently sewered in order to estimate population density Using these estimated population densities, the population of the unsewe areas of those municipalities within the Greenwich Bay drainage basin an North Kingstown was estimated. Using per capita flow estimates for each municipality from previously published documents, the sewage flows were estimated. Where applicable, allowances were provided for industrial an other flows based on the ratio of existing industrial flow to existing residential flow. Infiltration was estimated using an assumed allowance 500 gpd/in-mi for new pipe. This value will rise as the pipe ages, alth not significantly over the 20-year design period considered in this stud Peak flows were estimated by using existing peaking factors for each municipality. For Warwick, West Warwick, and East Greenwich these values represent estimated flows from the Greenwich Bay drainage basin only; it assumed that no additional sewerage will be provided in these municipali outside of the Greenwich Bay drainage basin.

4.2.1 East Greenwich

Existing Sewerage. At present, only a small portion of the area of East Greenwich has sewer connections. The major portion of this sewered area the northeast section of the town. The construction of the Hunt River interceptor was to provide for sewer service for up to 70 percent of the town's area, but at present only a section of the town known as the Lillibridge plat near the downtown section and businesses along Route 2 including the High School are served by this interceptor sewer. The sec of town within the Greenwich Bay drainage basin is also within the north section of town and includes the downtown section already sewered. Prov sewerage to the presently unsewered section of town within the Greenwich drainage basin can be accommodated through the use of the Hunt River interceptor. Flow by gravity from the newly sewered areas to the treatm facility should be possible without the installation of any new pumping facilities.

Additional Sewerage. In order to provide sewer service to all parts of Greenwich within the Greenwich Bay drainage basin, approximately 112,000 of new sewers would be required. This figure is based upon the lengths streets without sewers in East Greenwich in the Greenwich Bay drainage b and includes an allowance for spurs off of the laterals to the edge of t streets for building connections. Using the aforementioned assumptions installation of new sewer pipe, it is estimated that the capital costs f providing sewer service to the presently unsewered areas of East Greenwi within the Greenwich Bay drainage basin will cost $12.9 million with an allowance of 35 percent extra for engineering services during design a construction and for general construction contingencies. The annual c cleaning and maintenance of the new sewers are estimated to be $0.06

per year. It is estimated that no pump stations will be needed. The combined total present worth of providing new sewers for the section of East Greenwich within the Greenwich Bay drainage basin is estimated at $13.5 million.

The flow contribution from these newly sewered areas was estimated by dividing the section of town within the Greenwich Bay drainage basin into areas based on their respective census tract locations. The first area lies within Census Tract CT209.01 which includes the downtown section of East Greenwich and is the most densely populated section of the town. The second area lies within Census Tract CT209.02 which is more sparsely populated. The unsewered population of each area was estimated by dividing the projected population of the census tract for the year 2000 (population of CT209.01 = 4350, population of CT209.02 = 7950. Figures projected to 1990 from 1980 census figures as cited in the Advanced Secondary Treatment Review Document, September 1981) by the area of the census tract (area of CT209.01 = 0.98 sq. mi., area of CT209.02 = 15.71 sq. mi.) to obtain a population density for that tract. Then the calculated density was multiplied by the area without sewers in each census tract (unsewered area in CT209.01 = 0.77 sq. mi., and unsewered area in CT209.02 1.29 sq. mi.) to obtain the unsewered population in each tract.

Based upon information from an I/I study for East Greenwich the estimated residential flow is approximately 100 gallons per capita per day (gpcd). Using this value and the estimated unsewered populations within the Greenwich Bay drainage basin in each census tract, it is estimated that an additional 0.14 mgd of domestic sewage flow will be expected at the East Greenwich WWTF. In addition, based on the ratio of existing domestic to industrial flows, it is estimated that industrial flow contributions of up to 0.11 mgd may be possible. An infiltration allowance of 0.08 mgd was taken for the new sewers. Thus, the average daily flow expected from providing sewerage to the portions of East Greenwich within the Greenwich Bay drainage basin is estimated to be 0.33 mgd. This estimated flow coupled with the existing 1989 average flow of 0.81 mgd is anticipated to increase the total plant flow to 1.14 mgd at the East Greenwich WWTF.

4.2.2 Warwick

Existing Sewerage. At present, sewerage has been provided for those portions of Warwick within the Greenwich Bay drainage basin at which septic tank problems have been experienced. Thus, the tendency is that there are no uniformly sewered sections of town within the Greenwich Bay drainage basin. There are six separate areas with sewers within the Greenwich Bay drainage basin. Of the 15.76 square miles of Warwick within the Greenwich Bay drainage basin, approximately 1.3 square miles (about 8 percent) of this area has sewer service. Providing sewers to the unsewered areas of Warwick within the Greenwich Bay drainage basin will likely entail construction of new pump stations and interceptors as the Warwick WWTF is located in the Pawtuxet River drainage basin. However, this circumstance is advantageous as conveyance of the additional flows to the Warwick WWTF will remove the flow from the Greenwich Bay drainage basin as intended.

An exception occurs in the Potowomut Neck section of Warwick. This portion of Warwick does not share a land border with the remainder of Warwick. In order to accommodate flows from this section of Warwick at the Warwick WWTF, an interceptor through East Greenwich along with a series of pump stations would have to be built. However, through a regionalization agreement, flows from Potowomut Neck could be sent to either the East Greenwich or Quonset Point WWTF. As the intention of this option is to convey flows from East Greenwich to Quonset Point, it is more reasonable to assume that flow from the Potowomut Neck section of Warwick will be conveyed to and treated at Quonset Point rather than incurring additional treatment and transport costs at East Greenwich.

Additional Sewerage. In order to estimate the amount of sewers required in the portion of Warwick within the Greenwich Bay drainage basin (except Potowomut Neck), the total unsewered area was determined and this area was divided into areas of sparse development and dense development. Of the unsewered area (14.47 square miles), approximately 1.54 square miles is assumed to be unsewerable due to wetlands and topography. Of the remaining 12.93 square miles of sewerable area, 5.69 square miles is sparsely inhabited and the remaining 7.24 square miles is densely populated. It was assumed that lot sizes are approximately 20,000 square feet in the densely populated areas of Warwick and that these areas would require 172 linear feet per acre of sewer. In the sparsely populated areas of Warwick, it was assumed that one half of the sewerable area was taken up by 20,000 square foot lots (with the same sewerage requirements) and that one half of the sewerable area is taken up by one acre lots which are assumed to require 110 linear feet of sewer per acre. These assumptions are based upon full development of the sewerable areas.

Using the aforementioned assumptions for installation of new sewer pipe, approximately 1,310,000 feet of additional sewers will be needed. To install this length of pipe, it is estimated that the capital costs would be $150.3 million which includes an allowance of 35 percent for engineering services during design and construction and for general construction contingencies. The annual costs for cleaning and maintenance of the new sewers are estimated to be about $0.71 million per year.

In order to convey the additional flows to the Warwick WWTF it is estimated that 8 sewage pumping stations will be needed in the following locations: Buttonwoods/Brush Neck, Chepiwanoxet, Cowesett, Dark Entry Brook/Maskerchugg River, South Warwick Neck, Arnold Neck, and in the vicinity of the Lippitt School. Although some of the additional flows may be able to be handled by existing pump stations, most of the new pump stations will be located at or near sea level and will be evenly distributed throughout the basin. These pump stations are preliminarily sized for the same capacity which is assumed to be one eighth of the additional flow (0.6 mgd ADF, and 1.5 mgd peak) and pump against approximately the same dynamic heads (80 feet). To install the new pump stations, the estimated construction costs are about $9.10 million with an allowance of 35 percent for engineering and construction contingencies. Annual operations and maintenance costs for the new pump stations are estimated to be about $0.16 million for labor, energy, and maintenance of the stations.

The combined total present worth of providing new sewers and pump stations in the section of Warwick within the Greenwich Bay drainage basin (excluding Potowomut Neck) is estimated to be approximately $167.4 million.

In the Potowomut Neck section of Warwick, it has been estimated previously from the Quonset Facilities Plan by C. E. Maguire, Inc. that 17,000 feet of additional sewer pipe will be needed to convey and estimated 0.3 mgd on average and 0.75 mgd at peak. It is estimated that the capital costs for installing this new pipe in Potowomut Neck will be about $1.9 million including an allowance of 35 percent for engineering and construction contingencies. The annual O&M costs for the new sewers are estimated to be about $0.01 million per year. In order to convey the additional flows to the Warwick city line, where these sewers may be connected to the North Kingstown or East Greenwich sewer system, it is estimated that 2 sewage pumping stations will be needed, each with the capacity to convey the total additional flow from Potowomut Neck. It is assumed that each of these stations will pump against approximately the same dynamic heads (50 feet). To install the new pump stations, the estimated construction costs are about $2.2 million including an allowance of 35 percent for construction contingencies. Annual operations and maintenance costs for the new pump stations are estimated to be about $0.03 million. The combined total present worth of providing new sewers and pump stations on Potowomut Neck is estimated at approximately $4.5 million.

The total construction costs for providing new sewers and pumping facilities in the sections of Warwick within the Greenwich Bay drainage basin (including Potowomut Neck) is estimated at approximately $163.5 million with an allowance of 35 percent for engineering and contingencies. The total annual O&M costs for providing the new sewers and pumping facilities in the sections of Warwick within the Greenwich Bay drainage basin (including Potowomut Neck) is estimated to be approximately $0.91 million.

The combined total present worth for all additional sewerage facilities in the sections of Warwick within the Greenwich Bay drainage basin (including Potowomut Neck) is estimated to be approximately $171.9 million. Although it is unlikely that sewage flows from Potowomut Neck will be conveyed to the Warwick WWTF, the costs for providing these sewers must be borne by the city of Warwick.

The flow contribution from these newly sewered areas (excluding Potowomut Neck) was developed by estimating the population densities in the densely and in the sparsely inhabited areas based on population projections from the Wastewater Facilities Plan (dated May, 1978 by C. E. Maguire, Inc.). Assuming 7.5 persons per acre in the dense areas and .8 persons per acre in the sparse areas, the estimated population in unsewered areas within the Greenwich Bay drainage basin is 37,665 persons. From the above mentioned facilities plan, the per capita flow in Warwick was estimated to be 90 gpcd. Combining the estimated population with the per capita flows, results in an estimated additional domestic to the Warwick WWTF of 3.39 mgd. To allow for industrial contributions, a flow of 0.98 mgd was assumed based upon the existing ratio of industrial to domestic flows. An infiltration allowance of 0.99 mgd was taken for the new sewers. Thus, the total flow expected from providing sewerage to the portions of Warwick within the Greenwich Bay drainage basin except Potowomut Neck is estimated to be 5.36 mgd. This estimated flow coupled with the existing 1989 average flow of 3.62 mgd will represent a total plant flow of 8.98 mgd at the Warwick WWTF.

4.2.3 West Warwick

Existing Sewerage. The town of West Warwick presently has sewer service to over 95 percent of the community. It was assumed for the purposes of this study, that the portion of West Warwick which is within the Greenwich Bay drainage basin is essentially completely sewered. There may be some residences within the town that have sewer service available but are not connected. The costs of connecting the few unconnected households in West Warwick was considered negligible.

4.2.4 North Kingstown

Existing Sewerage. At present, there is no sewer service available for the town of North Kingstown. The existing sewers in the town serve only the areas within the military installations at Quonset Point and Davisville. Although the military has ceased most operations within these complexes, the Rhode Island Port Authority and Economic Development Corporation is overseeing the redevelopment of these areas for industrial uses. The majority of the flows to the existing Quonset Point WWTF located in North Kingstown are from industries within the redevelopment areas.

Additional Sewerage. The 1977 report, Quonset Facilities Plan for Wastewater collection and Treatment in the Town of North Kingstown, Rhode Island by C. E. Maguire, Inc. presented a plan for providing sewerage for the town. This plan was reiterated in the 1978 report Preliminary Evaluation of Publicly Owned Wastewater Treatment and Collection Systems by the Area wide Water Quality Management Project. The plan presents a phased approach for the construction of sewers within North Kingstown. However, for the purposes of this study, it was assumed that sewers will be constructed within the ultimate service area presented within the report. In order to determine the amount of sewers needed, it is assumed that of the ultimate service area (9.12 sq. mi.) 80 percent (7.30 sq. miles) will be sewerable and will require 150 linear feet of sewers per acre (based on approximately one half acre lots). Using these assumptions and also assuming installation of 8 inch diameter pipe eight feet deep, it is estimated that 701,000 feet of sewers will be needed for North Kingstown's ultimate service area. It is estimated that the capital costs for providing sewers for the town of North Kingstown will cost about $80.4 million including an allowance of 35 percent for engineering and contingencies. The annual costs for cleaning and maintenance of the new sewers are estimated to be about $0.38 million per year.

In order to convey the additional flows to the Quonset Point WWTF it is estimated that nine sewage pumping stations will be needed. Six of these pump stations will serve the outlying areas of North Kingstown and will convey flows to the remaining three centrally located pump stations. The six outlying stations are likely to be located at: Hamilton, Saunderstown, Allenton, Lafayette, Stony Lane, and Poplar Point. The three central stations will likely be placed in previously designated locations at Mill Creek, Cocomcossuc Brook and in Wickford Village. If a regional agreement is reached with the City of Warwick, then the Mill Creek pump station will likely have to be able to convey flows from the Potowomut Neck section of Warwick. It is assumed that the outlying pump stations will have a peak pumping capacity of 1.0 mgd and will pump against a head of 100 feet, and that the central pump stations will have a peak pumping capacity of 2.5 mgd and will pump against a head of 50 feet. To install the new pump stations, the estimated construction costs are about $9.7 million including an allowance of 35 percent for engineering construction contingencies. Annual operations and maintenance costs for the new pump stations are estimated to be about $0.15 million.

The total construction costs for providing new sewers and pumping facilities for North Kingstown is estimated to be approximately $90.1 million including an allowance of 35 percent for engineering and contingencies. The total annual O&M costs for providing the new sewers and pumping facilities for North Kingstown is estimated to be approximately $0.53 million. The combined total present worth for all additional sewerage facilities is estimated to be approximately $95.0 million.

The flow contribution from these newly sewered areas was estimated by taking the projected 1990 population of North Kingstown from the 1970 report Wastewater Collection and Disposal Facilities for the Town of North Kingstown, Rhode Island and assuming that 80 percent of the town's population will reside within the ultimate sewer service area. The population density is assumed to be uniform throughout this area. Thus, with a projected 1990 population of 29,100, sewer service would be provided to a 1990 population of 23,280. From the above mentioned facilities plan, the per capita flow in North Kingstown was estimated to be 81 gpcd. Combining the estimated population with the per capita flows results in an estimated additional domestic to the Quonset Point WWTF of 1.89 mgd. To allow for industrial contributions, a flow of 0.79 mgd was assumed based upon the existing ratio of industrial to domestic flows. An infiltration allowance of 0.53 mgd was taken for the new sewers. Thus, the total flow estimated from the ultimate sewer service area in North Kingstown is 3.21 mgd. This estimated flow added to the existing 1989 average flow of 1.0 mgd will generate an average daily plant flow of 4.21 mgd at the Quonset Point WWTF. If the flows (0.3 mgd) from Potowomut Neck are included at Quonset Point, the total plant flow would be 4.51 mgd.

4.2.5 Summary

A summary of the added infrastructure required to provide sewerage to the Greenwich Bay Drainage basin and to sections of North Kingstown is given in Table 4-1. A summary of the estimated costs to provide sewerage to the Greenwich Bay Drainage basin and to sections of North Kingstown is given in Table 4-2.

TABLE 4-1. SEWERAGE OF GREENWICH BAY DRAINAGE BASIN INFASTRUCTURE

MUNICIPALITY	ADD'L FLOW		ADD'L SEWER PIPE		PUMP STATIONS			
						CAPACITY		TDH
	ADF (MGD)	PEAK (MGD)	DIA. (IN.)	LENGTH (FT.)	QTY.	ADF (MGD)	PEAK (MGD)	FEET
EAST GREENWICH	0.33	1.03	8	112,000	0			
WARWICK								
EXCEPT POTOWOMUT NECK	5.36	13.40	8	1,310,000	8	0.6	1.5	80
POTOWOMUT NECK	0.30	0.75	8	17,000	2	0.3	0.75	50
SUBTOTAL			8	1,327,000	10			
WEST WARWICK	0.00	0.00	8	0	0			
NORTH KINGSTOWN	3.21	8.03	8	701,000	6	0.4	1	100
					3	1	2.5	50
TOTAL	9.20	23.21		2,140,000	19			

4.3 COLLECTION AND TREATMENT OF SEPTAGE AND MARINA PUMPOUT WASTE

4.3.1 Existing Septage Collection and Treatment

Of the communities in the Greenwich Bay drainage basin and North Kingstown, at present only Warwick receives septage at its WWTF. East Greenwich has the capability of receiving septage but does not because of operational difficulties. The plants under construction at Quonset Point and at West Warwick will also have the capability of receiving septage. The Cranston WWTF accepts septage from all communities. It is likely that the majority of the septage from these communities goes to the Cranston WWTF if it does not go to the Warwick WWTF. The following is the septage receiving capabilities and actual volumes received.

Plant	Volume Received (gal)	Receiving Capability (gal/day)	
East Greenwich (Under Const.)	0	8,000	
Warwick	15,500	20,000	(1989)
West Warwick (Under Const.)	0	50,000	
North Kingstown (Under Const.)	0	17,000	
Cranston	28,000	32,000	(1987)

At present, there are no marina pumpout facilities either in Greenwich Bay nor within any of the coastal harbors in North Kingstown.

4.3.2 Additional Septage Volumes

The provision of sewers to all unsewered areas within the Greenwich Bay drainage basin and in North Kingstown will substantially reduce the amounts of septage generated and consequently the septage volumes received (or potentially received) will be reduced. Potential septage volumes are estimated based on the assumption that there will normally be one pumpout of 1000 gallons every three years per household unit and that there is an average of 3.5 persons per household unit. It is also assumed that septage can be received at a plant on an average of 140 days per year. These assumptions are similar to those made in the facilities plan for East Greenwich.

In Warwick, the provision of sewerage to the Greenwich Bay drainage basin will eliminate an estimated 2,200,000 gallons per year of septage or 15,000 gpd. This reduction will lower the potential volume received at the Warwick WWTF to 15,000 gpd which is below the operator defined limit of 20,000 gpd. At the West Warwick WWTF there should be little change in the potential septage will likely be placed in previously designated locations at Mill Creek, Cocomcossuc Brook and in Wickford Village. If a regional agreement is reached with the City of Warwick, then the Mill Creek pump station will likely have to be able to convey flows from the Potowomut Neck section of Warwick. It is assumed that the outlying pump stations will have a peak pumping capacity of 1.0 mgd and will pump against a head of 100 feet, and that the central pump stations will have a peak pumping capacity of 2.5 mgd and will pump against a head of 50 feet. To install the new pump stations, the estimated construction costs are about $9.7 million including an allowance of 35 percent for engineering construction contingencies. Annual operations and maintenance costs for the new pump stations are estimated to be about $0.15 million.

The total construction costs for providing new sewers and pumping facilities for North Kingstown is estimated to be approximately $90.1 million including an allowance of 35 percent for engineering and contingencies. The total annual O&M costs for providing the new sewers and pumping facilities for North Kingstown is estimated to be approximately $0.53 million. The combined total present worth for all additional sewerage facilities is estimated to be approximately $95.0 million.

The flow contribution from these newly sewered areas was estimated by taking the projected 1990 population of North Kingstown from the 1970 report Wastewater Collection and Disposal Facilities for the Town of North Kingstown, Rhode Island and assuming that 80 percent of the town's population will reside within the ultimate sewer service area. The population density is assumed to be uniform throughout this area. Thus, with a projected 1990 population of 29,100, sewer service would be provided to a 1990 population of 23,280. From the above mentioned facilities plan, the per capita flow in North Kingstown was estimated to be 81 gpcd. Combining the estimated population with the per capita flows results in an estimated additional domestic to the Quonset Point WWTF of 1.89 mgd. To allow for industrial contributions, a flow of 0.79 mgd was assumed based upon the existing ratio of industrial to domestic flows. An infiltration allowance of 0.53 mgd was taken for the new sewers. Thus, the total flow estimated from the ultimate sewer service area in North Kingstown is 3.21 mgd. This estimated flow added to the existing 1989 average flow of 1.0 mgd will generate an average daily plant flow of 4.21 mgd at the Quonset Point WWTF. If the flows (0.3 mgd) from Potowomut Neck are included at Quonset Point, the total plant flow would be 4.51 mgd.

4.2.5 Summary

A summary of the added infrastructure required to provide sewerage to the Greenwich Bay Drainage basin and to sections of North Kingstown is given in Table 4-1. A summary of the estimated costs to provide sewerage to the Greenwich Bay Drainage basin and to sections of North Kingstown is given in Table 4-2.

volumes received as no additional sewers are likely to be needed in the section of West Warwick within the Greenwich Bay drainage basin.

In East Greenwich, there must be an operational or equipment change so that the existing septage receiving facilities may be put in use. The addition of sewerage to the Greenwich Bay drainage basin will eliminate 160,000 gallons per year or 1200 gpd of septage. Assuming the remainder of the town that is currently unsewered has a population of 8200 people, then it is estimated that 780,000 gallons per year or 6000 gpd of septage will need to be accommodated at the East Greenwich WWTF.

In North Kingstown, the new Quonset Point WWTF will be capable of handling up to 17,000 gallons per day of septage. Assuming that the present septage generated by the town is 2,800,000 gallons per year or 20,000 gpd, the addition of sewerage to the town will reduce the potential septage volumes by 2,200,000 gallons per year (16,000 gpd) to 600,000 gallons per year (9000 gpd). Thus, the new plant should be capable of accommodating the town's septage and possibly some from surrounding communities. The septage load to the Cranston WWTF will likely be substantially reduced as well.

4.3.3 Marina Pumpouts

Because of the extremely high usage of recreational boating within Narragansett Bay and especially Greenwich Bay, it has been proposed that all boats with marine sanitation devices also have holding tanks to prevent discharge of their wastes into the waters of Greenwich Bay. At present, however, there are few facilities available to accommodate the pumping out of boat holding tank wastes in Narragansett Bay and none within Greenwich Bay. From the Harbor Management Plans for East Greenwich and Warwick, the following number of slips and moorings are in use:

	Slips	Moorings
East Greenwich	233	110
Warwick	2573	734
Total	2806	844

From the Harbor Management Plans, it was stated that no new slips or moorings will be installed and that, at present, waiting lists exist to acquire dockage so that all slips and moorings will be in use.

In order to accommodate boat holding tank wastes, it is assumed that all major areas of boat moorage have marina pumpout facilities. It is not within the scope of this report to determine whether each commercial marina should have its own pumpout facility or that one central pumpout facility be located in each cove or bay. The estimated volumes of pumpouts from marine holding tanks are based upon the following assumptions:

- At peak boat usage (May through September) periods 50 percent of the boats are in use

- 10 percent of boats in slips are liveaboards, 1 percent of boats in moorings are liveaboards

- Liveaboard boats require 4 pumpouts per week, transient boats require 1 pumpout per week

These assumptions are based upon the Harbor Management Plans for East Greenwich and Warwick, and on the EPA's Coastal Marinas Assessment Handbook. It is assumed that the characteristics of boat holding tank wastes are similar to those of recreational vehicles. Using figures quoted in the report "Recreational Vehicle Disposal Stations at Highway Rest Areas", the assumed characteristics of the pumped out wastes are:

Volume:	16.5 gal/pumpout
TSS :	3120. mg/l
BOD :	3110. mg/l
Formaldehyde:	170. mg/l

Based upon this information, the following peak loadings can be expected to be generated from marina pumpouts:

	East Greenwich	Warwick	Total
Volume (gpd)	981	9666	10650
BOD (lb/day)	25	251	276
TSS (lb/day)	26	252	278
Formaldehyde (lb/day)	1.4	13.7	15.1

4.3.4 Additional Facilities Needed to Treat Septage and Marina Pumpouts

With the exception of the presence of formaldehyde or other preservatives or disinfectants, marina pumpout wastes have strength similar to septage. It is recommended that marina pumpout wastes be received at WWTF's in a similar manner to septage. Because of the presence of formaldehyde or other preservatives or disinfectants, the rate at which the combined septage/marina pumpout is added to the waste stream at the treatment plant should be lower than for septage alone. It may be necessary to dilute this combined waste with plant water before addition to the waste stream.

Based on the estimated values above, the total combined septage and marina pumpout wastes to be received at the WWTF's under study are estimated as follows:

	Septage (gpd)	Marina Pumpout (gpd)	Total Combined (gpd)	Existing (or Future) Capacity (gpd)
East Greenwich	6000	1000	7000	8000
Warwick	15,000	10,000	25,000	20,000
West Warwick	1000	0	1000	50,000
North Kingstown	4000	5000*	9000	17,000

* Assumed value due to lack of information and based on size of harbor areas in relation to those in Greenwich Bay.

From the Quonset Facilities Plan for Wastewater Collection and Treatment in the Town of North Kingstown, Rhode Island, the septage receiving station at the WWTF will be designed to accommodate marina pumpout wastes from the harbors along the North Kingstown coast, although information for expected loadings at Quonset Point are not available.

From the above table, the only plant likely to have difficulties accommodating the anticipated volumes of septage and marina pumpout wastes will be Warwick. It may be necessary to send a portion of these wastes to either Cranston or West Warwick.

4.4 EAST GREENWICH WWTF

4.4.1 Existing Conditions

The East Greenwich WWTF is located on the west bank of Greenwich Cove, approximately 2,000 feet south of the Warwick City Boundary (as shown in Figure 4-2). The present treatment facility is designed to provide advanced secondary treatment using rotating biological contactors and effluent filters. The plant has a design capacity of 1.24 mgd and a peak capacity of 3.9 mgd. Based on effluent data from 1989, the following parameters were reported:

Flow	0.807 mgd
BOD	14.0 mg/l
TSS	14.5 mg/l
Total N	11.6 mg/l

These values are close to meeting the stated standards for advanced secondary treatment with nutrient removal stated in Section 6 of this report (BOD = 10 mg/l, TSS = 10 mg/l, and Total N = 8-10 mg/l). These standards were met on 6 occasions for BOD and on 5 occasions for Total N in 1989. It must be determined whether total compliance may be achieved through operational changes or whether further upgrades of the level of treatment provided are necessary. Additional capital outlays may not be required to provide advanced wastewater treatment.

It is the intention to relocate this discharge to Quonset Point via overland conveyance. In order to convey the effluent to Quonset Point, a minimum of secondary effluent levels must be achieved, which the East Greenwich WWTF readily attains.

If flows from presently sewered areas remain roughly the same as the present, the addition of flows from newly sewered areas within the Greenwich Bay drainage basin would bring the plant's flows to 1.14 mgd, which is within its design flow capacity of 1.24 mgd. If the estimated flow of 0.30 mgd from Potowomut Neck were sent to East Greenwich WWTF, then the average daily flow would be 1.44 mgd (0.81 mgd current flow + 0.33 mgd additional flow from East Greenwich + 0.30 mgd from Potowomut Neck). This flow would exceed the East Greenwich WWTF design capacity of 1.24 mgd by 0.20 mgd. This may reduce the effluent quality, however, with the rotating biological contractors, it is expected that secondary treatment could be maintained. The reduced effluent quality may be satisfactory considering the proposed new outfall off Quonset Point into the bay.

4.4.4 Needed Conveyance to Transport East Greenwich Effluent to Quonset Point

The conceptual route of the conveyance system between the East Greenwich WWTF and the Quonset Point WWTF is shown in Figure 4-2. The route originates at the East Greenwich WWTF and follows Crompton Avenue along the coastline of Greenwich Cove. At the end of Crompton Avenue, the route crosses the Maskerchugg River adjacent to the Conrail railroad tracks. The conveyance system then follows Potowomut Road to Austin Road on which the upstream end of Potowomut Pond (on the Hunt River) is crossed. The route then turns to parallel Boston Post Road (U.S. Route 1). The route along Route 1 crosses Sandhill Brook, the Pine River, and a tributary of Mill Creek before turning onto Roger Williams Way at the entrance to the Quonset Point Reservation. Along Roger Williams Way, the interceptor crosses Mill Creek before reaching the Quonset Point WWTF location near the airfield. This pipeline is 15 inches in diameter, approximately 7.1 miles in length, and includes three pump stations, one of which would be located at or near the East Greenwich WWTF. The treated effluent from the East Greenwich WWTF is combined with the effluent discharged from the Quonset Point WWTF for discharge into Narragansett Bay.

In order to provide the piping for the East Greenwich-Quonset Point effluent conveyance system, it is estimated that construction costs will be about \$3.0 million and that annual O&M costs will be about \$0.04 million. The needed pumping facilities are estimated to have construction costs of about \$5.7 million and annual O&M costs of about \$0.11 million. The present worth of all O&M costs for a 20-year planning period is estimated to be about \$1.4 million and the combined total present worth of capital and O&M costs is estimated to be approximately \$10.1 million to convey flow from East Greenwich to Quonset Point. These estimated costs are presented in Table 4-3.

4.5 QUONSET POINT WWTF

4.5.1 Existing Conditions

The Quonset Point WWTF (existing and under construction and shown in Figure 4-2) is located at the end of Roger Williams Way in the Quonset Point Naval

CONVEYANCE INFRASTRUCTURE

REACH	FLOW/mgd		PIPELINE		PUMP STATION	
	ADF	PK	DIA. (INCH)	LENGTH (FT)	QTY.	SIZE (mgd)
East Greenwich WWTF to Quonset Point WWTF	1.44	4.32	15.0	37400	3	4.32
Quonset Point WWTF to Narragansett Bay	5.4	13.6	30.0	800	1	13.6
TOTAL	5.4	13.6		38200	4	

CONVEYANCE COST

REACH	(COSTS = $ x 1,000,000) CAPITAL/PRESENT WORTH			O&M/ANNUAL			PRESEN WORTH of O&M	TOTAL PRESENT WORTH
	PIPE	PUMP	TOTAL	PIPE	PUMP	TOTAL		
East Greenwich WWTF to Quonset Point WWTF	3.0	5.7	8.7	0.04	0.11	0.15	1.4	10.1
Quonset Point WWTF to Narragansett Bay	2.7	2.3	5.0	0.01	0.10	0.11	1.0	6.0
TOTAL	5.7	7.9	13.7				2.4	16.1

TABLE 4-3 CONVEYANCE OF EAST GREENWICH WWTF EFFLUENT TO QUONSET POINT

Reservation near the runways of the former Naval Air Station. At the present time, the Quonset Point WWTF is a primary treatment facility with a design capacity of 2.35 mgd. Current average daily flow is approximately 1.0 mgd. As mentioned previously, the plant serves the Quonset redevelopment area which is managed by the Rhode Island Port Authority and Economic Development Corporation. There still exists some of the military facilities in this area which are also served by the Quonset Point WWTF.

Construction has recently begun to replace this primary treatment facility with a secondary treatment facility. This facility is designed to provide secondary treatment through the use of rotating biological contactors. The plant will have an average design capacity when construction is completed of 2.6 mgd with the capability of future expansions to accommodate average flows up to 3.9 mgd. The site on which the Quonset Point WWTF is located is somewhat restricted as it lies between a former aircraft carrier pier and the runways and taxiway for the old naval air station.

4.5.2 Needed Expansions to Accommodate Flows from Newly Sewered Areas

If the town of North Kingstown provides sewerage to its ultimate service area as described above, flows to the Quonset Point WWTF will exceed the plant's design capacity of 2.6 mgd by 1.36 mgd (1.0 mgd current flow and 2.86 mgd future North Kingston flow). If this were to occur, then the planned future expansion of the WWTF to a design capacity of 3.9 mgd would likely have to take place.

4.5.3 Needed Facilities to Accommodate Transported Flows from East Greenwich and Potowomut Neck

Taking the existing and future flows from East Greenwich, North Kingstown, and the Potowomut Neck section of Warwick after provision of the additional sewers as detailed above, a combined average daily flow of 5.4 mgd and peak flow of 13.6 mgd must be conveyed through a modified or new outfall structure at Quonset Point to Narragansett Bay. These flows were used as the basis of sizing the pump station, marine outfall, diffuser, and risers for the discharge of the combined treated effluent. The present outfall at Quonset Point is built into the Navy Pier with several diffusers along the pier. As the ship channel leading to the pier is between 30 to 35 feet deep all the way up to the pier, there is likely to be sufficient depth to accommodate extension or replacement of the present outfall. However, it is uncertain as to whether there will be sufficient mixing and/or dilution available at a location close to shore.

Two potential outfall locations were reviewed, both of which entail a 30 inch diameter outfall pipe. The first would locate the outfall and diffusers approximately 800 feet from shore within the shipping channel to the Quonset Pier at the same depth of about 30 to 35 feet but at a location where mixing potential is likely to be improved. The construction costs for this outfall option are estimated to be about $2.7 million and the annual O&M costs are estimated to be about $0.01 million per year.

The second outfall option would be to locate the outfall such that discharge would be into the East Passage of Narragansett Bay in which there would be significantly greater depths and mixing potential available. The outfall for this option would be approximately 26,000 feet long and would be located off the east coast of Jamestown (Conanicut Island) at an approximate depth of 66 feet. Because of the prohibitively expensive, construction costs for this outfall option, it was not considered further. The conceptual location of the outfall for the selected option and pump station are depicted in a general manner on Figure 4-2.

The construction costs for a pump station to convey the combined effluents from Quonset Point are estimated to be about $2.3 million. Its annual O&M costs are estimated to be about $0.1 million.

The total construction cost is estimated to be approximately $5.0 million for the selected outfall option and the effluent pump station. Total annual O&M costs are estimated to be about $0.11 million for the selected outfall option and the effluent pump station. The combined present worth of the effluent pump station and the 800 foot outfall is estimated to be $6.0 million. These cost figures are shown in Table 4-3.

4.6 ESTIMATED TOTAL COSTS FOR OPTION 3

The estimated cost for providing sewerage to the Greenwich Bay drainage basin and to the ultimate service area of North Kingstown along with conveying flows from East Greenwich to Quonset Point and discharging them to Narragansett Bay are presented in Tables 4-2 and 4-3.

The total construction costs of this option, not including WWTF expansions or upgrades is estimated to be approximately $280 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $297 million dollars for the option. These cost figures are shown on Table 4-4.

4.7 FEASIBILITY AND ADVANTAGES OF OPTION 3

4.7.1 Provision of Sewers for the Greenwich Bay Drainage Basin and North Kingstown

Despite the potential advantages to water quality from the removal of wastewater discharges, there are a number of secondary concerns and issues regarding the feasibility of providing sewers to all areas within the Greenwich Bay drainage basin that merit discussion in regards to the feasibility of this option. The assumption that only the areas within the Greenwich Bay drainage basin in the municipalities concerned will receive sewerage is simplistic as other areas of the municipalities may require or are planned to receive sewerage in the future. There may also be areas within the Greenwich Bay drainage basin for which the priority of providing sewers is

TABLE 4-4. TOTAL ESTIMATED COSTS FOR OPTION THREE

	(COSTS x $1,000,000)			
	CONSTRUCTION COSTS	ANNUAL O&M COSTS	PRESENT WORTH OF ANN. COSTS	TOTAL PW OF CAP. AND O&M COSTS
PROVISION OF SEWERS TO THE GREENWICH BAY DRAINAGE BASIN AND TO SECTIONS OF NORTH KINGSTOWN	$266.50	$1.50	$13.90	$280.40
CONVEYANCE OF EFFLUENT FROM EAST GREENWICH WWTF TO QUONSET POINT WWTF	$8.70	$0.15	$1.40	$10.10
CONVEYANCE OF COMBINED EFFLUENT FROM EAST GREENWICH, NORTH KINGSTOWN, AND POTOWOMUT NECK THROUGH PUMP STATION AND OUTFALL AT QUONSET POINT	$5.00	$0.11	$1.00	$6.00
TOTAL	$280.20	$1.76	$16.30	$296.50

minimal or not cost-effective. For example, in some sparsely populated areas distant from Greenwich Bay, the costs of providing sewer service would be outweighed by the fact that substantial levels of treatment may be affected by on-lot systems, especially those with well-drained soils, so that any beneficial effects on Greenwich Bay from providing sewers would be minimal or non-existent. Furthermore, it was assumed that existing pipelines would be capable of conveying the additional flows from the newly sewered areas. Although the design hydraulic capacity of the existing sewers may be sufficient, these existing pipes may require rehabilitation or replacements that are not accounted for in this study.

It is acknowledged that there are a number of problem areas in which there is a definite need for sewers, but there could be significant cost savings by determining which areas have the highest priority for sewers rather than installing sewers in a blanket manner throughout the Greenwich Bay drainage basin. As the greatest problems with water quality appear to be occurring in Greenwich Cove, perhaps it may prove necessary to sewer only those areas in the Greenwich Bay drainage basin with identified problems with on-lot sewage systems draining directly to Greenwich Cove, rather than sewering the entire basin.

The provision of sewers to all unsewered areas of the Greenwich Bay drainage basin will likely be the most feasible within East Greenwich. The Hunt River Interceptor was designed to accommodate flows from 40 percent of the area and 70 percent of the population of the town. The area served by this interceptor includes nearly all of the section of town within the Greenwich Bay drainage basin. The presence of this interceptor eliminates the need for additional interceptors in East Greenwich so that only lateral sewers and building connections would be needed.

The additional flows to the East Greenwich WWTF would bring the plant's flow slightly over its intended design capacity. The plant currently provides advanced secondary treatment. The addition of flows in excess of its design capacity may cause a reduction in effluent quality, however, it is expected that a minimum of secondary effluent levels would still be achieved. It must be further investigated as to whether this plant could accommodate any additional flows from Warwick (including the Potowomut Neck section) while still achieving secondary effluent levels.

The city of Warwick has the largest area within the Greenwich Bay drainage basin. Of this area, only about eight percent has sewer service so that the requirements for sewerage in Warwick are the greatest of any of the municipalities concerned. Many of the unsewered areas within Warwick in the Greenwich Bay drainage basin are sparsely populated and are in the upper reaches of the drainage basin. Information taken from previous facilities plans suggests that there have been relatively few septic system problems within these areas so that the future to serve the entire area may not be realized. Only a portion of the densely populated areas Have had reported septic system problems. These areas with problems have a definite need for sewers, especially those directly along the coast of Greenwich Bay.

Because the Warwick WWTF is located in the Pawtuxet River basin conveyance of sewage from the Greenwich Bay drainage basin to the WWTF requires pumping a considerable distance. Furthermore, the estimated additional flows to the Warwick WWTF would hydraulically overload the Warwick WWTF. In order to accommodate the increase in flows, the Warwick WWTF would require expansion if all flows generated within Warwick are to be treated at the Warwick plant.

An alternative to conveying all of Warwick's additional sewage flows to the Warwick WWTF would be to convey flows to another municipality's WWTF that may be more closely located to the source. For example, some of the southwest sections of Warwick are more closely located to the West Warwick or the East Greenwich WWTF than they are to the Warwick WWTF. Through a regional agreement, one or both of these WWTFs could treat a portion of Warwick's sewage flow. It appears that the West Warwick WWTF will have excess capacity upon its completion so that some flows from the sections of Warwick adjacent to West Warwick could be accommodated at the West Warwick WWTF. Although transfer of flows to the East Greenwich WWTF would entail increasing the capacity of the interceptor sewer to the Quonset Point WWTF, it may be more cost-effective to do so. Another option would be to send flows in excess of that which the Warwick WWTF may treat to the Cranston WWTF, where there is a significant amount of excess secondary treatment capacity available.

The treatment of flows from the Potowomut Neck section of Warwick will require an agreement with either East Greenwich or North Kingstown to treat the flows at their WWTFs or an agreement with the town of East Greenwich to convey these flows through East Greenwich to connect with Warwick sewers. Neither East Greenwich nor North Kingstown will have excess capacity when they receive the additional flows from newly sewered areas within their own towns. It must be determined whether it is more feasible to direct flows to the Quonset Point plant or to the East Greenwich plant. The East Greenwich plant is significantly closer to Potowomut Neck, however, the additional flow would exceed the plant design capacity if the remaining portion of East Greenwich in the drainage basin is also sewered. The design capacity at East Greenwich would be exceeded by 16 percent (1.44 mgd vs. 1.24 mgd) which may be accommodated without expansion or with minimal expansion requirements. Conveying Potowomut flows to Quonset Point would reduce the needed capacity of the East Greenwich WWTF and effluent conveyance system but would increase the loading on the Quonset Point plant. The Quonset Point WWTF would already be over capacity with the added flows from the newly sewered areas of North Kingstown, so that a plant expansion at Quonset Point would be necessary to accommodate flows from Potowomut Neck.

The additional flow from providing sewers for the ultimate service area in the town of North Kingstown will cause the Quonset Point plant's design capacity to be exceeded. The town must investigate whether a reduction in the ultimate service area would allow flows to be reduced at Quonset Point to levels that can be accommodated by the present design. The extent of which the former military facilities are developed will have a major influence on the total flow to Quonset Point. It may be that the addition of any sewage flow from North Kingstown would cause the plant's design capacity to be exceeded. In such case, the Quonset Point plant would have to be expanded and it would not be unreasonable to plan for expansion of the plant to include the ultimate service area of the entire town and to include flows from the Potowomut Neck section of Warwick as well. As there have been a large number of recorded on-lot disposal system problems throughout the town of North Kingstown, the provision of sewers for the majority of the town should be seriously considered. The population distribution and the geography of the North Kingstown would probably preclude the provision of sewers in selected areas where on-lot problems exist as may be the case in Warwick. One possibility that could result in the reduction of flow to Quonset Point while still providing sewerage is the conveyance of flows from the Saunderstown area in the southern portion of North Kingstown to the South Kingstown WWTF through a regional agreement.

Several potential problems with the installation of sewerage in previously developed areas may arise. Much of the densely developed areas, especially in East Greenwich and North Kingstown are of historical importance and sewer construction in these areas would require special precautions. There is also the potential for added disruption and costs associated with rock excavation and the need to avoid wetland areas that should be considered during design of the new sewers.

A phased approach towards construction of sewers in the Greenwich Bay drainage basin may be advantageous for two primary reasons. First, there are a number of areas where there already exist problems with on-lot disposal systems and these areas should receive priority. Second, a phased approach may allow payment of the costs of the new sewers to be distributed over time.

4.7.2 Septage Volumes

In general, the provision of sewer service to such large areas as the Greenwich Bay drainage basin and North Kingstown will significantly reduce the volumes of septage generated that must be treated at one of several treatment plants in the region. At the present time, only Warwick and Cranston accept septage from homes within the Greenwich Bay drainage basin and North Kingstown. With the completion of the West Warwick and Quonset Point WWTFs, the septage receiving capability for these areas will be increased. East Greenwich should consider improving its septage handling facility or replace it, to avoid the costs of sending its septage to another community. However, it appears there will be ample capacity in other communities if East Greenwich chooses not to receive septage.

4.7.3 Marina Pumpouts

The installation of pumpout facilities for marine holding tanks would, in essence, increase the organic loadings to the plants accepting marina pumpout wastes. The characteristics of septage and marina pumpout wastes are similar and it is likely that these two wastes would be handled at the same receiving facility. However, the presence of disinfectants and preservatives such as formaldehyde in marina pumpouts could cause operational problems not normally encountered with septage unless the marina wastes are stored in a separate holding tank and blended appropriately with the influent sewage flows. Greater operational care with slower feed rates or greater dilution of the combined wastes is a likely requirement.

If improvements to the quality of the waters of Greenwich Bay are to be realized, then significant reductions in the discharges of marine sanitation devices into these waters must be achieved. At present, there are no pumpout facilities in Greenwich Bay or along the North Kingstown coast and most boats simply discharge their holding tanks directly into the harbors. An enforceable compliance program must be instituted with which boat owners are encouraged to comply. To ensure compliance, pumpout facilities should be readily accessible and the costs for using the pumpout facilities should not be prohibitive or else boat owners will not comply and water quality objectives will not be realized.

4.7.4 Conveyance of East Greenwich WWTF Effluent to Quonset Point and Effluent Outfall in Narragansett Bay

It is apparent that the removal of the East Greenwich WWTF discharge from Greenwich Cove may be an important step towards improving the water quality in Greenwich Cove and in Greenwich Bay.

The conveyance of flows from East Greenwich to Quonset Point is technically feasible with a couple of potential problems. There are a number of environmentally sensitive areas which must be traversed by an effluent conveyance pipeline between the two plants and the flow would require pumping (from depths below sea level) at least twice.

Before implementation of the effluent conveyance system between East Greenwich and Quonset Point, it should be determined, as an alternative approach, whether a properly operating WWTF at East Greenwich producing advanced secondary quality effluent with nutrient removal would be, in fact, more beneficial to the quality of the waters of Greenwich Cove and Greenwich Bay. High quality effluent discharge would prevent further deterioration of water quality and would aid in the flushing out of the waters of Greenwich Cove. However, operational reliability of the plant must be be viewed as a premium requirement since one upset of the plant could have serious detriment to the quality of the receiving waters.

It is likely that an effluent pumping station and outfall discharge facility would have to be located remotely from the Quonset Point WWTF as the area contiguous to this WWTF site is restricted by an airfield. The site is likely to be further congested if the needed expansions are carried out.

The present location of the outfall is not likely to be effective in achieving local water quality objectives as it is near shore and would not realize the benefits of offshore currents available for mixing and dilution. Placement of a new outfall at an appropriate distance off shore at a depth of 30 to 35 feet would likely be required to disperse the effluent from the combined East Greenwich-Quonset Point discharge. The possibility of locating the outfall on the east side of Jamestown in the East Passage does not appear to be feasible due to the great length of pipe required to reach that location.

SECTION FIVE

IMPLICATIONS OF REGIONAL DISCHARGE AT POINT JUDITH

5.1 INTRODUCTION

This section evaluates the feasibility and potential costs of structural regionalization Option #4 - Discharge at Point Judith. This option involves the overland conveyance of effluents from eleven wastewater treatment facilities, Narragansett Bay Commission's Fields Point, BVDC's Bucklin Point, Cranston, East Greenwich, East Providence, Narragansett, Quonset Point, South Kingstown, Warwick, West Warwick and Woonsocket, to a new deep water marine outfall into Block Island Sound off Point Judith. It has been assumed that all combined sewer flow in excess of WWTF headworks capacity and stormwater control strategies would be managed within the service area of origin. Although it is possible that alternative CSO abatement strategies may be more cost effective, the analysis of such strategies was not within the present scope of work. Consideration of construction schedules of the various alternatives were also not included in the scope of work.

5.2 METHODS UTILIZED IN FEASIBILITY ANALYSIS

The methods, design data, and basis of costs included in this evaluation of the conveyance and combining of the treated effluent from eleven existing wastewater facilities to a single point of discharge at Point Judith is presented in the following subsections. Initial planning estimates were developed for the conveyance costs for each reach for comparison with conceptual costs for advanced wastewater treatment upgrades or other applicable wastewater management scenarios.

5.2.1 Design Flows

The flows used in estimating potential additional infrastructure modifications for this option were obtained from existing information. RIDEM and Narragansett Bay Project files were the major sources and included RIPDES permits, Facility Plans, State-wide Planning Studies, and other similar reports and material.

For purposes of evaluation, existing WWTF design flow and recorded flows were used in estimating treatment process upgrades. Estimates of peak flows to the WWTF headworks were used in sizing of conveyance structures. Under this option all stormwater flows in combined systems in excess of peak flow at headworks are assumed to be handled by providing appropriate CSO abatement upstream of each treatment facility. Peak flows in excess of WWTF headworks capacities have not been included in conveyance system sizing and design.

This does not assume that all flows received at each treatment facility receive secondary treatment. It is assumed that a portion of the flow received at the headworks which cannot receive secondary treatment will be combined with the secondary effluent for subsequent transport to the point of discharge (in this case a Point Judith outfall). There are two facilities where the capacity of the headworks and primary treatment facilities exceed the secondary treatment facilities. They are BVDC's Bucklin Point and NBC's Fields Point. The Bucklin Point facility has a primary treatment capacity reported at 84 MGD, however, the secondary portion of the plant has a peak flow capacity of 46 MGD. Likewise, at Fields Point the primary facilities have a 200 MGD capacity and the secondary facilities a 90 MGD capacity. The flows exceeding secondary capacity at both of these plants receive disinfection as a final treatment process prior to discharge.

5.2.2 Conveyance Route Selection

The selected transmission routes were based on generalized soil and topography data, using USGS mapping and supplemented in some cases with existing utility maps and general roadway layout information. Route locations should be viewed as conceptual in nature. Primary route selection objectives included minimizing excessive deep trenching, potentially difficult permitting (river crossings, wetland areas, and active railway rights-of-way), and minimizing social and infrastructure conflicts (avoiding densely developed urban areas) where immediately obvious and possible.

5.2.3 Construction Costs

The construction costs presented in this study reflect an ENR value of 4700 (March 1990). For the regional discharge options (Option No. 2 and Option No. 4) the construction costs for the conveyance system, including sewer construction, pump station construction, pipe jacking, outfall construction and pump station O&M costs, were estimated using cost curves presented in the Metcalf & Eddy report to the NBC titled "Report to the Narragansett Bay Commission on Combined Sewer Overflows in CSO Area A." These cost curves have been modified to reflect an ENR value of 4700 and are presented in Appendix A of this report.

The objective of this study is to provide a cost model for use in generalized feasibility comparisons. The costs are not, in most cases, site specific. The construction cost estimates presented are intended to reflect approximate construction costs only and do not include costs such as legal, administrative, land, easements, or other special costs associated with implementation of any specific project.

For the purposes of this study the construction costs for conveyance are intended to represent a reasonable allowance to accommodate transmission of wastewater flows from each treatment plant to Point Judith utilizing a system of gravity sewers, pumping stations, and force mains generally represented by the configuration shown in Figure 5-1. An appropriate allowance for a limited amount of special construction such as jacking, boring, and subaqueous activities has been included in the conveyance cost estimates but not, in most cases, on a site specific basis.

The comparative costs also do not include the incremental costs associated with providing full secondary treatment for those portions of excess flows currently receiving less than secondary treatment (NBC and BVDC).

The estimate for the effluent conveyance and discharge under this option does not include costs for odor control or aeration facilities. Due to the length of the conveyance system, these issues along with the potential costs due to corrosive action associated with possible septic action, would need to be considered in any detail design and potential corrective strategies could be included within the required pump station facilities.

The construction costs include a 35 percent allowance to account for engineering services during design and construction and for ledge removal and general construction contingencies but do not include extraordinary ledge excavation, additional costs associated with adverse site conditions, or land and easement acquisition costs that would effect total construction/project costs. Although it is recognized that extensive large sewer construction in urban areas is extremely difficult and can rarely be accomplished entirely using cut and cover construction techniques, the planning level of this report did not warrant detailed site evaluations beyond the general material that is available on terrain and soil composition. For the purposes of this study, transmission lines are assumed to be located at customary depths and located such that large scale relocation of existing utilities to accommodate the conceptual layout would not be required.

5.2.4 Operation and Maintenance Costs

The estimated operation and maintenance (O&M) costs for pipelines include an allowance for inspection, cleaning, and repairs to provide for cleaning the entire length of pipeline once in twenty years at a fixed rate of five percent of the total length each year. These costs were based on current market prices for inspection, cleaning and repair services.

Pump station O&M costs were based on annual cost curves generated for pump station peak flow capacities, as presented in Appendix A. This curve is based on operational experience in the wastewater pumping industry. The costs from these curves represent normal O&M costs, such as labor, power, lubricants and spare parts.

5.2.5 Comparison of Costs

The cost curves developed for use in this study are presented in Appendix B. These curves are based on ENR 4700 (March 1990) and do not reflect additional costs as stated above. Total costs will be expressed in present worth for the purpose of comparison utilizing an interest rate of 8 7/8 percent for a planning period of 20 years which is the discount rate established by the U.S. Bureau of Reclamation. O&M costs were estimated on a uniform manual cost basis prior to determining present worth. For simplicity and consistency of comparison, no land costs or salvage values have been considered. The 20 year planning period does not reflect the variations of design life between equipment, structures and pipelines, however, the sensitivity of these factors to the present worth analysis are considered minimal at this level of cost estimation.

5.2.6 Pump Stations

Estimated Pumping Station capital and annual operation and maintenance costs are a significant portion of the overall conveyance infrastructure evaluation. Due to the varied terrain of the study area, a number of pump stations will be required to transport the flow to Point Judith as shown on Figure 5-1. The pump station sites were selected such that force mains and pressure sewers could be utilized wherever possible in order to minimize deep construction which is often more costly than a more conventional system of force mains and gravity lines. The pumping system anticipated would maximize the use of low lift, high capacity pumping facilities in order to minimize pumping costs. The sizing of the pumps have been selected to provide approximately two feet per second velocity in the effluent conduit at average design flows and to discharge peak flows at higher velocities without creating excessive headloss. Multiple Variable Frequency Drive pumps are assumed to be included with at least one additional pump included for redundancy.

5.3 CONVEYANCE ROUTES

An approximate route for conveyance of flows to Point Judith has been established for conceptual purposes as shown in Figure 5-1. It was assumed that the depicted conveyance systems would be contained within existing easements or road layouts. In general, the conveyance routes join existing WWTFs with the intent to place pumping facilities within the WWTF site. Where conveying to a WWTF would result in additional conduit length without apparent benefit, a connection point to the conveyance system was selected for the outlying WWTF. A description of each reach of the conveyance system is presented below.

5.3.1 Woonsocket WWTF to BVDC Regional WWTF

The Woonsocket WWTF is located on the east bank of the Blackstone River approximately 6,500 feet northwest of the Cumberland Town boundary. The conceptual route generally parallels the Blackstone River, Route 122, Route 114, and the east bank of the Seekonk River in a generally southeasterly and southerly direction to the Blackstone Valley District Commission WWTF located at Bucklin Point. The flow would be combined with the BVDC flows at Bucklin Point for transfer to NBC Fields Point. This reach is approximately sixteen miles in length, has a pipe diameter of four feet, and includes three pump stations. The conceptual locations of the pipelines and pump stations are depicted in a general manner on Figure 5.1.

The Woonsocket WWTF has been designed for an average flow of 16.0 MGD. The WWTF had an average daily flow of 11.2 MGD during the year 1987. A peak wet weather design flow of 40.0 MGD was the basis of sizing the conduits and pump stations for conveying treated Woonsocket effluent to the BVDC WWTF. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 84,000 feet of force main, pressure conduit and three pump stations within this reach have an estimated total capital cost of $36.1 million. This capital cost added to the estimated operations and

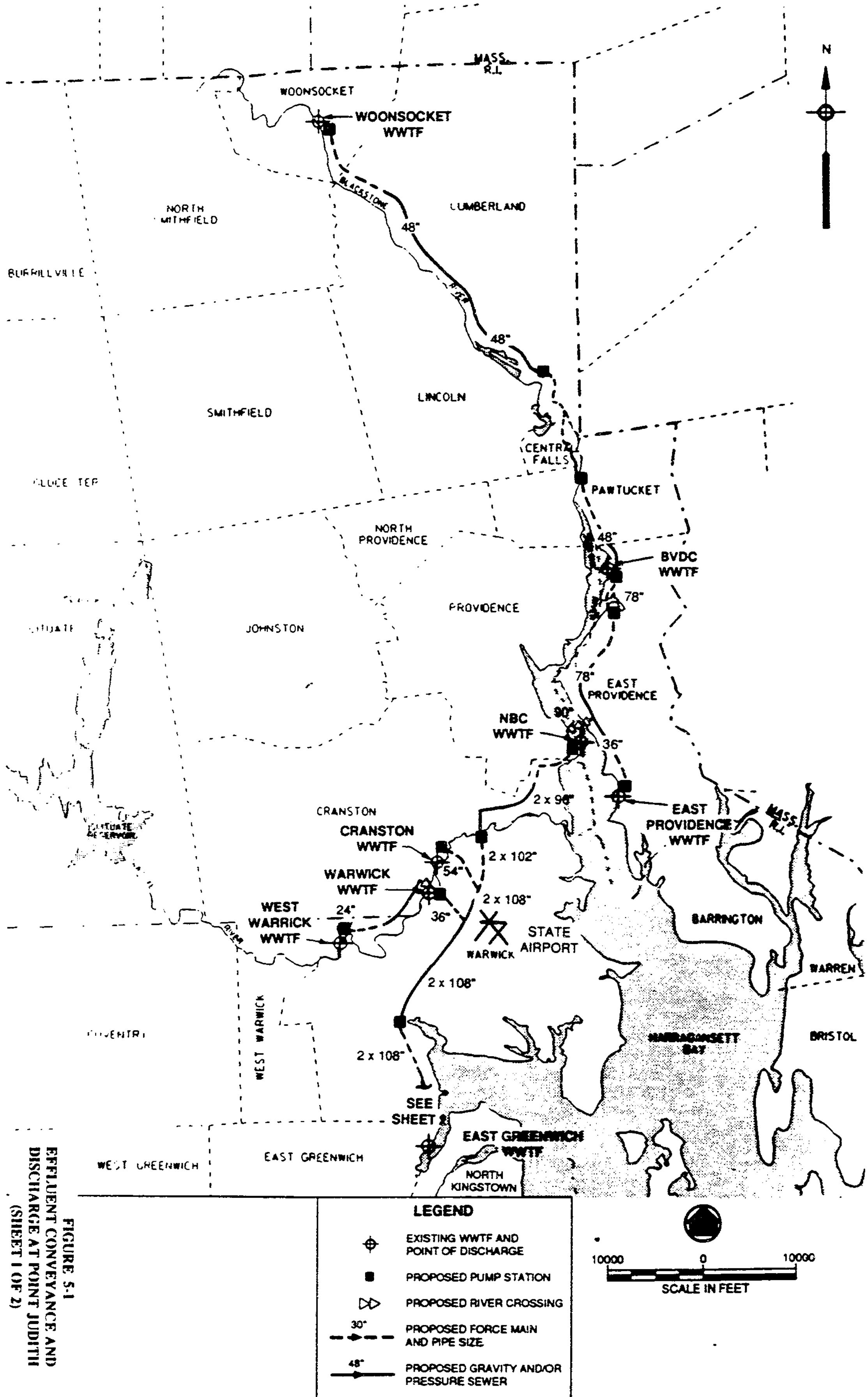
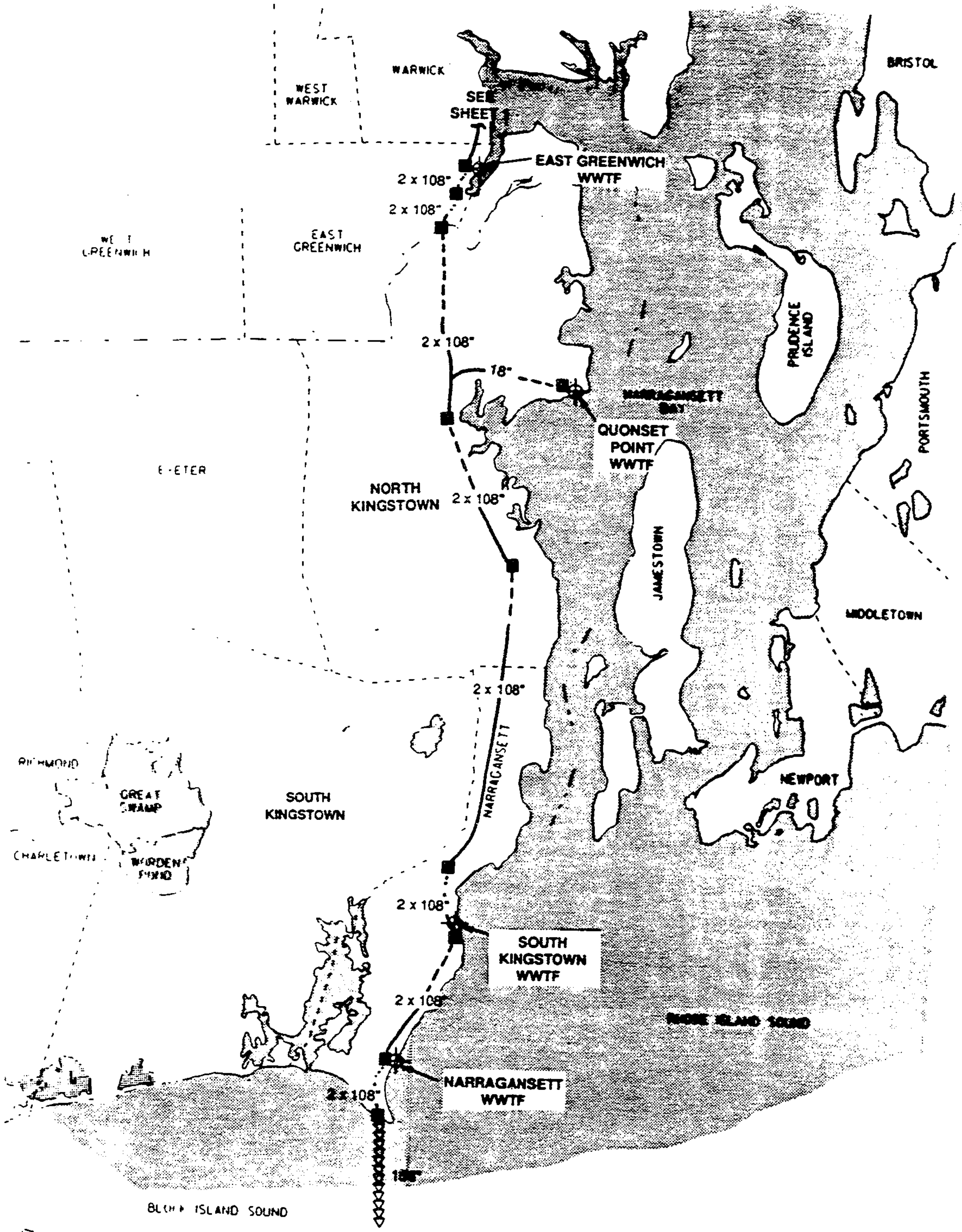


FIGURE 5-1
EFFLUENT CONVEYANCE AND DISCHARGE AT POINT JUDITH
(SHEET 1 OF 2)

METCALF & EDDY



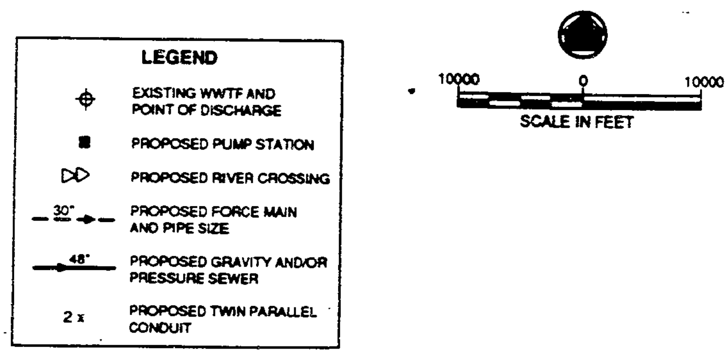


FIGURE 5-1
EFFLUENT CONVEYANCE AND DISCHARGE AT POINT JUDITH
(SHEET 2 OF 2)

METCALF & EDDY

CONVEYANCE INFRASTRUCTURE

REACH	FLOW/mgd		PIPELINE		PUMP STATION	
	ADF	PK	DIA. (FT)	LENGTH (FT)	QTY.	SIZE (mgd)
Woonsocket WWTF to BVDC Bucklin Point WWTF	16.0	40.0	4.0	84000	3	40.0
BVDC Bucklin Point WWTF to Kettle Point	47.0	124.0	6.5	24800	2	124.0
East Providence WWTF to Kettle Point	10.4	26.0	3.0	13800	1	26.0
Kettle Point (subaqueous) to NBC Fields Point WWTF	57.4	150.0	7.5	2000		
NBC Fields Point WWTF to Sand Pond	122.4	350.0	2x 8.0	26600	2	350.0
Cranston WWTF to Sand Pond	23.0	57.5	4.5	7000	1	58.0
Sand Pond to State Airport	145.4	407.5	2x 8.5	7400		
West Warwick WWTF to Warwick WWTF	5.0	12.5	2.0	14800	1	12.5
Warwick WWTF to State Airport	10.2	25.5	3.0	7200	1	25.5
Green Memorial State Airport to East Greenwich WWTF	155.6	433.0	2x 9.0	16200	1	433.0
East Greenwich WWTF to Camp Avenue	156.8	436.9	2x 9.0	26000	3	437.0
Quonset Point WWTF to Route 1	2.6	6.5	1.5	15400	1	6.5
Camp Avenue to South Pier Road	159.4	443.4	2x 9.0	72000	3	443.0
South Kingstown WWTF to Ocean Road	4.1	9.9	2.0	4000		
South Pier Road to Narragansett WWTF	163.5	453.3	2x 9.0	16000	1	453.0
Narragasett WWTF to Point Judith	164.9	455.8	2x 9.0	9200	1	456.0
Point Judith to Block Island Sound	164.9	455.8	13.0	21000	1	456.0
TOTAL	165	456		367200	22	

TABLE 5-1 CONVEYANCE TO POINT JUDITH DEEP WATER MARINE OUTFALL

maintenance costs of the conduit and pump stations results in a total present worth cost of $48.0 million as shown in Table 5.2.

5.3.2 BVDC Regional WWTF to Kettle Point

The Blackstone Valley District Commission WWTF is located at Bucklin Point on the east bank of the Seekonk River in the Rumford section of East Providence, approximately 2,500 feet south of the Pawtucket City boundary. The conceptual route generally parallels the Seekonk River, Route 114, and the east bank of the Providence River in a southerly, southwesterly, and southeasterly directions to Kettle Point on the east bank of the Providence River opposite from the Narragansett Bay Commission WWTF located at Fields Point. This reach is approximately 4.7 miles in length, includes two pump stations, and conveys the effluent discharges of both Woonsocket and BVDC WWTFs. The estimated size of the pipe to carry the combined discharge is 6.5 feet in diameter. The conceptual locations of the pipelines and pump stations are depicted in a general manner on Figure 5.1.

The BVDC WWTF has been designed for an average flow of 31.0 MGD. The WWTF had an average daily flow of 23.22 MGD during the year 1987. A peak wet weather design flow of 84.0 MGD was combined with the 40.0 MGD from the Woonsocket WWTF for a total of 124.0 MGD as the basis of sizing the conduits and pump stations of the combined treated effluent to Kettle Point on the east bank of the Providence River opposite the NBC Fields Point WWTF where it is combined with an additional 26.0 MGD being conveyed from the East Providence WWTF. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 24,600 feet of force main, pressure conduit and two pump stations within this reach have an estimated total capital cost of $30.5 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump stations results in a total present worth cost of as $49.2 million as shown in detail in Table 5.2.

5.3.3 East Providence WWTF to Kettle Point

The East Providence WWTF is located on the east bank of the Providence River in the Riverside section of East Providence, approximately 1.6 miles northwest of the Barrington town boundary. The conceptual route generally parallels the east bank of the Providence River in a northwesterly direction to Kettle Point on the east bank of the Providence River opposite from the Narragansett Bay Commission WWTF located at Fields Point. This reach is approximately 2.6 miles in length, includes one pump station, and conveys the treated effluent from the East Providence WWTF to Kettle Point in a three foot diameter pipe where it is combined with the effluent discharges from the Woonsocket and BVDC WWTFs.

The East Providence WWTF has been designed for an average flow of ten and four 10.4 MGD. The WWTF had an average daily flow of 6.7 MGD during the year 1987. A peak wet weather design flow of 26.0 MGD was the basis of sizing the pipelines and pump station for this reach. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

CONVEYANCE COST

REACH	(COSTS = $ x 1,000,000) CAPITAL/PRESENT WORTH			ANNUAL O&M			PRESENT WORTH of O&M	TOTAL PRESENT WORTH
	PIPE	PUMP	TOTAL	PIPE	PUMP	TOTAL		
Woonsocket WWTF to BVDC Bucklin Point WWTF	23.5	12.6	36.1	0.10	1.20	1.30	11.97	48.0
BVDC Bucklin Point WWTF to Kettle Point	11.6	18.9	30.5	0.03	2.00	2.03	18.70	49.2
East Providence WWTF to Kettle Point	3.1	3.2	6.3	0.02	0.25	0.27	2.49	8.8
Kettle Point (subaqueous) to NBC Fields Point WWTF	5.9		5.9	0.01		0.01	0.09	6.0
NBC Fields Point WWTF to Sand Pond	36.8	48.6	85.4	0.06	7.00	7.06	65.03	150.5
Cranston WWTF to Sand Pond	3.9	6.8	10.7	0.01	0.60	0.61	5.62	16.3
Sand Pond to State Airport	10.1		10.1	0.02		0.02	0.18	10.3
West Warwick WWTF to Warwick WWTF	3.8	2.0	5.8	0.02	0.12	0.14	1.29	7.1
Warwick WWTF to State Airport	1.7	3.2	5.0	0.01	0.25	0.26	2.39	7.4
Green Memorial State Airport to East Greenwich WWTF	23.8	36.5	60.2	0.03	4.30	4.33	39.88	100.1
East Greenwich WWTF to Camp Avenue	42.5	109.4	151.9	0.06	13.10	13.16	121.21	273.1
Quonset Point WWTF to Route 1	1.2	2.0	3.3	0.02	0.06	0.08	0.74	4.0
Camp Avenue to South Pier Road	110.6	109.4	219.9	0.16	13.20	13.36	123.05	343.0
South Kingstown WWTF to Ocean Road	0.7		0.7	0.01		0.01	0.09	0.8
South Pier Road to Narragansett WWTF	22.3	36.5	58.7	0.03	4.50	4.53	41.72	100.5
Narragasett WWTF to Point Judith	12.8	36.5	49.3	0.02	4.50	4.52	41.63	90.9
Point Judith to Block Island Sound	139.7	36.5	176.2	0.02	4.50	4.52	41.63	217.8
TOTAL	454.2	461.9	916.0				517.73	1433.7

TABLE 5-2 CONVEYANCE TO POINT JUDITH DEEP WATER MARINE OUTFALL

Approximately 13,800 feet of force main, pressure conduit and one pump station within this reach have an estimated total capital cost of $6.3 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $8.8 million as shown on Table 5.2.

5.3.4 Kettle Point to NBC Fields Point WWTF

The combined effluent discharges of East Providence, Woonsocket, and BVDC WWTFs is conveyed through a 7.5 foot diameter subaqueous conduit in an inverted siphon arrangement across the Providence River to the NBC Fields Point WWTF. The conceptual location of the conveyance line is shown on Figure 5.1.

The East Providence WWTF peak flow of 26.0 MGD was combined with a peak flow of 124.0 MGD conveyed from the Woonsocket and BVDC WWTFs. The resulting combined peak flow of 150.0 MGD is conveyed through a subaqueous pipeline across the Providence River to the Narragansett Bay Commission Fields Point WWTF and is the basis of sizing the conduit. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 2,000 feet of pressure conduit within this reach has an estimated total capital cost of $5.9 million. This capital cost added to the estimated operations and maintenance costs of the conduit results in a total present worth cost of $6.0 million as shown in Table 5.2.

5.3.5 NBC Fields Point WWTF to Sand Pond

The NBC WWTF is located at Fields Point in Providence on the west bank of the Providence River approximately three miles southeast of the State Capital Building. The treated effluent from the NBC WWTF is combined with the effluent discharges from the Woonsocket, BVDC, and East Providence WWTFs and is then pumped and conveyed in a southerly and southwesterly direction to a location north of the Green Memorial State Airport near Sand Pond where it is combined with the effluent flow from the Cranston WWTF. The conceptual route generally parallels the Pawtuxet River and Route 1. This reach is approximately 5 miles in length and includes two pump stations. A twin 8 foot diameter pipe system was used for cost estimating purposes. The conceptual locations of the pipelines and pump stations are depicted in a general manner on Figure 5.1.

The NBC WWTF has been designed for an average flow of 65.0 MGD. The WWTF had an average daily flow of 53.3 MGD during the year 1987. A peak wet weather design flow of 200.0 MGD was combined with the 150.0 MGD from the Woonsocket, BVDC, and East Providence WWTFs for a total combined peak discharge of 350.0 MGD. This combined total discharge of three hundred fifty (350.0) MGD was used as the basis of sizing the transmission lines and pump stations. The conceptual conveyance system design criteria for this reach is listed in Table 5.1.

Approximately 53,200 feet (2 pipes at 26,200 feet) of force main, pressure conduit, gravity sewer, and two pump stations within this reach have an estimated total capital cost of $85.4 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump stations results in a total present worth cost of $150.5 million as shown in Table 5.2.

5.3.6 Cranston WWTF to Sand Pond

The Cranston WWTF is located on the north bank of the Pawtuxet River at river mile 4.5 and is approximately 7,000 feet northwest of the Green Memorial State Airport. This reach is intended to convey effluent from the Cranston WWTF only to a point of connection in the conveyance system. The conceptual route crosses the Pawtuxet River to the south bank and generally parallels Route 1 in a southerly direction to a point just northerly of the Airport near Sand Pond where it connects to the main conveyance system. This reach is approximately 1.3 miles in length, includes one pump station, and conveys the effluent discharge of Cranston WWTF in a 4.5 foot diameter pipe. The conceptual locations of the pipelines and pump station are depicted in a general manner on Figure 5.1.

The Cranston WWTF has been designed for an average flow of 23.0 MGD. The WWTF had an average daily flow of 12.7 MGD during the year 1987. A peak wet weather design flow of 57.5 MGD was the basis of sizing the transmission conduits and pump stations for the treated effluent. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 7,000 feet of force main, pressure conduit, gravity sewer, and one pump station within this reach have an estimated total capital cost of $10.7 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $16.3 million as shown in Table 5.2.

5.3.7 Sand Pond to Green Memorial State Airport

The treated effluent from the Cranston WWTF is combined with the effluent discharges from the NBC, Woonsocket, BVDC, and East Providence WWTFs and is then conveyed in a southwesterly direction to a point west of the Green Memorial State Airport in Hillsgrove where it is combined with the effluent flow from the West Warwick and Warwick WWTFs. The conceptual route generally parallels Route 1. This reach is approximately 1.4 miles in length. A twin 8.5 foot diameter pipe system was used for cost estimating purposes. The conceptual locations of the pipelines are depicted in a general manner on Figure 5.1.

The Cranston WWTF peak flow of 57.5 MGD was combined with the 350.0 MGD from the Woonsocket, NBC, BVDC, and East Providence WWTFs for a total combined peak discharge of 407.5 MGD. This combined flow of 407.5 MGD was used as the basis of sizing the pipelines. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 14,800 feet (2 pipes at 7,400 feet) of force main, pressure conduit, and gravity sewer within this reach, have an estimated total capital cost of $10.1 million. This capital cost added to the estimated operations and maintenance costs of the conduit results in a total present worth cost of $10.3 million as shown in Table 5.2.

5.3.8 West Warwick WWTF to Warwick WWTF

The West Warwick WWTF is located on the north bank of the Pawtuxet River at river mile 9.8 and is approximately 2.5 miles south of the Cranston City boundary. The conceptual route generally parallels the Pawtuxet River and Route I-95, in a generally easterly and northeasterly direction to a point on the north bank of the river opposite the Warwick WWTF and crosses the Pawtuxet River to the south bank and the Warwick WWTF. This reach is approximately 2.8 miles in length, includes one pump station, and conveys the effluent in a two foot diameter pipe. The conceptual locations of the pipelines and pump station are depicted in a general manner on Figure 5.1.

The West Warwick WWTF has been designed for an average flow of 5.0 MGD. The WWTF had an average daily flow of 4.85 MGD during the year 1987. A peak wet weather design flow of 12.5 MGD was the basis of sizing the conduits and pump station for conveying the treated West Warwick effluent to the Warwick WWTF. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

An estimated 14,800 feet of pressure conduit and one pump station within this reach have an estimated total capital cost of $5.8 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $7.1 million as shown in Table 5.2.

5.3.9 Warwick WWTF to Airport

The Warwick WWTF is located on the south bank of the Pawtuxet River at river mile 6.0 and is approximately 4,000 feet northwest of the Green Memorial State Airport. The conceptual route crosses Route I-95 and connects to the conveyance system at a point to the west of the airport in Hillsgrove. This reach is approximately 1.4 miles in length and includes one pump station. A three foot diameter conduit is used to convey the combined effluent discharges of both West Warwick and Warwick WWTFs. The conceptual locations of the pipelines and pump station are depicted in a general manner on Figure 5.1.

The Warwick WWTF has been designed for an average flow of 5.2 MGD. The WWTF had an average daily flow of 3.26 MGD during the year 1987. A peak wet weather design flow of 13.0 MGD was combined with the 12.5 MGD from the West Warwick WWTF for a total of 25.5 MGD as the basis of sizing the conduits and pump station for the combined treated effluent. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 7,200 feet of pressure conduit and one pump station within this reach have an estimated total capital cost of $5.0 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $7.4 million as shown on Table 5.2.

5.3.10 State Airport to East Greenwich WWTF

The treated effluent from the West Warwick and Warwick WWTFs is combined with the effluent discharges from the Cranston, NBC, Woonsocket, BVDC, and East Providence WWTFs and is then conveyed in a southerly direction to the East Greenwich WWTF. The conceptual route generally parallels Route 1. This reach is approximately 3.1 miles in length and requires one pump station. A twin 9 foot diameter pipe system was used for cost estimating purposes. The conceptual locations of the pipelines and pump station are depicted in a general manner on Figure 5.1.

The peak flow of 25.5 MGD from the West Warwick and Warwick WWTFs was combined with the peak flow of 407.5 MGD from the five upstream WWTFs for a total of 433 MGD as the basis of sizing the conduits and pump stations of the combined treated effluent. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 32,400 feet (2 pipes at 16,200 feet) of force main, pressure conduit, gravity sewer, and one pump station within this reach have an estimated total capital cost of $60.2 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $100.1 million as shown in Table 5.2.

5.3.11 East Greenwich WWTF to Camp Avenue

The East Greenwich WWTF is located on the west bank of Greenwich Cove, approximately 2,000 feet south of the Warwick City Boundary. The conceptual route of this reach extends from the WWTF, then parallels Route 1 to a Quonset Point WWTF, north of Wickford Harbor near Camp Avenue. This reach is approximately 4.9 miles in length and includes three pump stations. The treated effluent from the East Greenwich WWTF is combined with the effluent discharges from the BVDC, Cranston, East Providence, NBC, Warwick, West Warwick, and Woonsocket WWTFs and is then conveyed in a twin 9 foot diameter pipe system. The conceptual locations of the pipelines and pump station are depicted in a general manner on Figure 5.1.

The East Greenwich WWTF has been designed for an average flow of 1.24 MGD. The WWTF had an average daily flow of 0.739 MGD during 1987. A peak wet weather design flow of 3.9 MGD was combined with the 433.0 MGD peak flow from the seven upstream WWTFs for a total of 437 MGD as the basis for sizing the conduits and pump stations of the combined treated effluent. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

An estimated 52,000 feet (2 pipes at 26,000 feet) of force main, pressure conduit, gravity sewer, and three pump stations within this reach have an estimated total capital cost of $151.9 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump stations results in a total present worth cost of $273.1 million as shown in Table 5.2.

The additional sewerage proposed for the Greenwich Bay area under Option 3 in Section 4 of this report would generate approximately an additional 7.0 mgd and 17.7 mgd of average daily flow and peak flow, respectively, within this reach from East Greenwich and Warwick. This additional flow would not significantly affect the regional conveyance system size or cost. However, as presented in Section 4 the additional construction cost for sewerage in this area is estimated at $176 million. The estimated present worth of O&M costs for new facilities of approximately $9.0 million result in a total present worth of $185 million for new lateral sewers in this reach.

5.3.12 Quonset Point WWTF to Route One

The Quonset Point WWTF is located on the west shore of Narragansett Bay just north of Wickford Harbor. This reach is intended to convey effluent from the Quonset Point WWTF only to a point of connection in the conveyance system. The conceptual route follows a generally westerly direction to a point near Route 1 at the intersection of Camp Avenue where it connects to the main conveyance system. This reach is approximately 2.9 miles in length, includes one pump station, and conveys the effluent discharge of Quonset Point WWTF in a 1.5 foot diameter pipe. The conceptual locations of the pipelines and pump station within this reach are depicted in a general manner on Figure 5.1.

The Rhode Island Port Authority's Quonset Point WWTF has been designed for an average flow of 2.6 MGD. The WWTF had an average daily flow of 0.844 MGD during the year 1987. A peak wet weather design flow of 6.5 MGD was the basis of sizing the conduits and pump station for conveying treated Quonset Point effluent to the combined effluent conveyance system. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

15,400 feet of force main, pressure conduit, gravity sewer, and one pump station within this reach have an estimated total capital cost of $3.3 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $4.0 million as shown in Table 5.2.

5.3.13 Camp Avenue to South Pier Road

The treated effluent from the Quonset Point WWTF is combined with the effluent discharges from the BVDC, Cranston, East Greenwich, East Providence, NBC, Warwick, West Warwick, and Woonsocket WWTFs and is then conveyed in a twin 9 foot diameter pipe system in a southerly direction. The conceptual route generally parallels Route 1 to Wickford Center, Route 1A to Route 138, the east bank of the Pettaquamscutt River (the west side of Boston Neck), and Route 1A to a point near the Ocean Road intersection with South Pier Road. This reach is approximately 13.6 miles in length and requires three pump stations. The conceptual locations of the pipelines and pump stations are depicted in a general manner on Figure 5.1.

The Quonset Point WWTF peak wet weather design flow of 6.5 MGD was combined with the peak flow of 437 MGD from the eight upstream WWTFs for a total of 443.4 MGD as the basis of sizing the conduits and pump stations of the combined treated effluent within this reach. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 144,000 feet (2 pipes at 72,000 feet) of force main, pressure conduit, gravity sewer, and three pump stations within this reach have an estimated total capital cost of $219.9 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump stations results in a total present worth cost of $343.0 million as shown in Table 5.2.

The additional sewerage proposed for the North Kingstown area under Option 3 in Section 4 of this report would generate an additional 2.86 mgd and 7.15 mgd of average daily flow and peak flow, respectively, within this reach from North Kingstown. This additional flow would not significantly affect the regional conveyance system size or cost. However, as presented in Section 4 the additional construction cost for sewerage in this area is estimated at $90 million. The estimated present worth of O&M costs for new facilities of $5 million results in a total present worth of $95 million for new lateral sewers in this reach.

5.3.14 South Kingstown WWTF to Ocean Road

The South Kingstown WWTF is located in the Town of Narragansett on Westmoreland Street and is approximately 23,000 feet northeast of Point Judith. The conceptual route generally parallels South Pier Road in an easterly direction to a point near its intersection with Ocean Road where it connects to the main conveyance system. This reach is approximately 0.7 miles in length and conveys the effluent discharge of South Kingstown WWTF in a 2.0 foot diameter pipe. The conceptual locations of the pipelines are depicted in a general manner on Figure 5.1.

The South Kingstown WWTF located near Narragansett Pier, has been designed for an average flow of 4.13 MGD. The WWTF had an average daily flow of 2.6 MGD during the year 1987. A peak wet weather design flow of 9.92 MGD was the basis of sizing the conduits for conveying treated South Kingstown effluent to the combined effluent conveyance system. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

An estimated 4,000 feet of pressure conduit and gravity sewer within this reach have an estimated total capital cost of $0.7 million. This capital cost added to the estimated operations and maintenance costs of the conduit results in a total Present worth cost of $0.8 million as shown on Table 5.2.

5.3.15 South Pier Road to Narragansett WWTF

The treated effluent from the South Kingstown WWTF is combined with the effluent discharges from the BVDC, Cranston, East Greenwich, East Providence, NBC, Quonset Point, Warwick, West Warwick, and Woonsocket WWTFs and is then conveyed in a twin 9 foot diameter pipe system in a southerly direction. The conceptual route generally parallels Ocean Road and the west bank of Narragansett Bay to the Narragansett WWTF located in Scarborough Hills. This reach is approximately 3.0 miles in length and requires one pump station. The conceptual locations of the pipelines and pump stations are depicted in a general manner on Figure 5.1.

The South Kingstown WWTF peak wet weather design flow of 9.92 MGD was combined with the peak flow of 443.4 MGD from the nine upstream WWTFs for a total of 453.3 MGD as the basis of sizing the conduits and pump stations for the combined treated effluent within this reach. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 32,000 feet (2 pipes at 16,000 feet) of force main, pressure conduit, gravity sewer, and one pump station within this reach have an estimated total capital cost of $58.7 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $100.5 million as shown in Table 5.2.

5.3.16 Narragansett/Scarborough Hills WWTF to Point Judith

The Narragansett WWTF is located on the west shore of Narragansett Bay approximately 9,000 feet north of Point Judith. The conceptual route follows a generally southerly direction generally parallel to Ocean Road to Point Judith. The treated effluent from the Narragansett WWTF is combined with the effluent discharges from the BVDC, Cranston, East Greenwich, East Providence, NBC, Quonset Point, South Kingstown, Warwick, West Warwick, and Woonsocket WWTFs and is then conveyed in a twin 9 foot diameter pipe system. This reach is approximately 1.7 miles in length and requires one pump station. The conceptual locations of the pipelines and pump stations are depicted in a general manner on Figure 5.1.

The Narragansett WWTF has been designed for an average flow of 1.4 MGD. The WWTF had an average daily flow of 0.985 MGD during the year 1987. A peak wet weather design flow of 2.45 MGD combined with the peak flow of 453.3 MGD from the ten upstream WWTFs for a total of 455.8 MGD as the basis of sizing the conduits and pump stations for the combined treated effluent. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 18,400 feet (2 pipes at 9,200 feet) of force main, pressure conduit, gravity sewer, and one pump station within this reach have an estimated total capital cost of $49.3 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $90.9 million as shown in Table 5.2.

5.3.17 Point Judith Outfall

The treated effluent from the eleven WWTFs of BVDC, Cranston, East Greenwich, East Providence, Narragansett, NBC, Quonset Point, South Kingstown, Warwick, West Warwick, and Woonsocket WWTFs is then discharged through a 13 foot diameter subaqueous pipe or tunnel in a southerly direction to an approximate depth of 100 feet in Block Island Sound. The deep water marine outfall is approximately 3.4 miles in length and requires one pump station. It was estimated that this outfall equipped with an appropriate diffuser and discharging the treated effluents from the eleven upstream WWTFs at a depth of 90 to 100 feet in ocean waters may provide adequate dilution. The conceptual location of the outfall and pump station are depicted in a general manner on Figure 5.1.

The combined design average flow of 164.7 MGD and peak wet weather design flow of 455.8 MGD from the eleven WWTFs of BVDC, Cranston, East Greenwich, East Providence, Narragansett, NBC, Quonset Point, South Kingstown, Warwick, West Warwick, and Woonsocket WWTFs were the basis of sizing the pump station, marine outfall, and diffuser. The conceptual conveyance system design criteria for this reach are listed in Table 5.1.

Approximately 21,000 feet of outfall diffuser, risers, and one pump station have an estimated total capital cost of $176.2 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $217.8 million as shown in Table 5.1.

5.4. ESTIMATED TOTAL CONVEYANCE COSTS

The estimated cost for overland conveyance to a point of discharge at Point Judith by combining the treated effluent discharges from the BVDC, Cranston, East Greenwich, East Providence, Narragansett, NBC, Quonset Point, South Kingstown, Warwick, West Warwick, and Woonsocket WWTFs are presented in Table 5.2.

The overland pipeline system, together with the subaqueous deep water marine outfall, and pump stations have an estimated total capital cost of $916 million. This capital cost added to the estimated operations and maintenance costs of the conduit and pump station results in a total present worth cost of $1,434 million as shown in Table 5.2.

5.5 FEASIBILITY AND ADVANTAGE OF OPTION 4

The intent of the Point Judith outfall option is similar to that of Option 2 (Fields Point outfall), except the combined effluent flows are conveyed overland to Point Judith in Narragansett to a new outfall extending into Block Island Sound. In addition to the seven WWTFs included in Option 2, effluent from four additional plants (East Greenwich, Narragansett, Quonset Point and South Kingstown) were picked up in the conveyance system between Fields Point and Point Judith.

Option 4 is considered technically feasible and the comments and considerations regarding the conveyance of effluent from Woonsocket to Fields Point as discussed in Option 2, also apply to the conveyance system from Fields Point to Point Judith.

The peak flows conveyed increase from 350 MGD at Fields Point to 456 MGD at Point Judith with the addition of WWTF discharges along this route. The construction costs for conveying this flow was based upon building twin pipelines assuming this would minimize special pipe fabrication and installation requirements for larger pipes of equivalent area. This twin construction method was selected as a representative cost alternative, and does not imply that variations from this method are not cost-effective. In fact, there may be situations in the conveyance system design where one larger pipeline or tunneling may be more cost-effective than two smaller pipelines. However, the cost of a cut and cover construction technique for a twin pipeline is considered average in the range of other possible construction alternatives.

The estimated construction cost of nearly $916 million for the entire conveyance system clearly makes Option 4 the most expensive option under study. Because of this cost imbalance, before this option is examined further it should be demonstrated that the benefits obtained from a regional discharge into Block Island Sound far exceed the benefits of either the regional discharge at Fields Point or the upgrade of the WWTFs to AWT alternatives. The results of this study do not indicate that the benefits of Option 4 clearly exceed those of Options 2 or 5. However, water quality impacts should be factored in. It should be noted that if this option were implemented, there would be an avoided cost of upgrading the Cranston, Warwick, and West Warwick facilities to AWT, representing a cost savings of approximately $83 million.

The Point Judith outfall and diffusers length utilized in this study conceptually account for the water depth necessary to disperse the peak discharge flow. However, the outfall location doesn't include water quality considerations, such as oxygen demand, of a discharge of this magnitude into the sound. This should be determined by modelling and ocean current studies of the area.

One potential alternative to a conveyance system of pressure and force main from Fields Point to Point Judith is a deep tunnel. Current bid costs from actual tunnel projects and designs suggest a unit cost for large tunnel work in the neighborhood of $4,000 to $5,000 per linear foot. This results in a tunnel cost 20 to 50 percent greater than the costs for overland conveyance at normal depths developed in this study. However, some of the risk factors and non-cost factors working against highly disruptive surface construction methods may be reduced by the subsurface construction methods for tunneling. Accordingly, tunneling between this reach of the conveyance system and portions of other reaches, should not be ruled out until an appropriate cost effectiveness analysis, which was beyond the scope of this study, has been performed.

SECTION SIX

IMPLEMENTATION OF ADVANCED WASTEWATER TREATMENT IN TREATMENT PLANTS DISCHARGING TO NARRAGANSETT BAY

6.1 INTRODUCTION

An alternative approach towards improving the quality of the Narragansett Bay is to increase the level of treatment at the existing wastewater treatment facilities in the watershed. The existing treatment plants are currently designed to meet secondary treatment levels mandated by the Clean Water Act. In this section, the feasibility of providing advanced wastewater treatment (AWT) at selected Rhode Island wastewater treatment plants that discharge to Narragansett Bay will be studied and the potential costs of implementing such treatment levels will be estimated. For the purposes of this study, the wastewater treatment facilities considered include: Bucklin Point (Blackstone Valley District Commission), Cranston, East Providence, Field's Point (Narragansett Bay Commission), Warwick, West Warwick, and Woonsocket.

Additionally, consideration will be given to the feasibility of conveying the effluent from the seven wastewater treatment facilities (WWTF) to a new regional AWT facility located at Fields Point, near the existing Narragansett Bay Commission treatment facility.

It should be noted that three of the communities under consideration have just signed contracts with engineering firms for facilities plans to upgrade facilities to AWT (Malone, 1990). Therefore, any further analysis of this option should be coordinated with the three facility plan efforts through the Rhode Island Wastewater Management Section Coordinator.

6.2 DEFINITION OF ADVANCED WASTEWATER TREATMENT AND APPLICABILITY TO NARRAGANSETT BAY STUDY

Advanced wastewater treatment encompasses a wide variety of different treatment processes. For the purposes of this study, advanced wastewater treatment will include those processes that result in greater removals of conventional wastewater pollutants [biochemical oxygen demand (BOD_5) and total suspended solids (TSS)] than required by the definition of secondary treatment (BOD = 30 mg/l and TSS = 30 mg/l) and those processes which affect removals of nitrogen that may be responsible for accelerating the eutrophication process in Narragansett Bay. We have been told to consider nitrogen as the limiting nutrient in the Bay. Therefore, advanced wastewater treatment including nutrient removal is limited to the removal of nitrogen only.

The effluent discharge parameters, used in this study, for advanced wastewater treatment include BOD_5 concentrations equal to or less than 10 mg/l (monthly average basis), total suspended solids concentrations equal to or less than 10 mg/l and total nitrogen concentrations of 8 to 10 mg/l.

The assumed effluent discharge parameters were applied to all the treatment facilities investigated without consideration of receiving water quality. Local water quality based discharge parameters may result in more or less restrictive effluent limitations than used for this study. However, developing site specific discharge parameters is beyond the intent of this study and is the topic of ongoing and future Narragansett Bay studies.

6.3 METHOD OF PROVIDING ADVANCED WASTEWATER TREATMENT AND DEVELOPING COSTS

6.3.1 Process Selection

There are several method currently in use for the removal of nitrogen from wastewater. Nitrogen removal can be achieved by either biological or physical-chemical means. Biological nitrogen removal involves a nitrification process and a denitrification process either in separate stage systems or combined stage systems. Some examples of separate stage systems include suspended growth, downflow filter, fluidized bed, and rotating biological contactor (RBC) systems. Typical combined stage systems include alternating reactor, multi-compartment (Bardenpho and A_2/O) and oxidation ditch systems. Physical-chemical nitrogen removal processes developed for wastewater treatment include ammonia stripping, breakpoint chlorination and selective ion exchange.

It is not the purpose of this study to perform a facility plan evaluation of all the above nitrogen removal methods for application at each existing treatment facility. The bases for process selection include the following factors:

a. Maximize usage of existing facilities under a "retrofit" approach.

b. The available land area for new facilities is generally limited.

c. All existing WWTF's have activated sludge processes.

d. Use common effluent discharge parameters; BOD_5 = 10 mg/l, TSS = 10 mg/l and Total Nitrogen = 8-10 mg/l.

Using these criteria and experience in the wastewater treatment industry, two biological nitrogen removal systems were selected as most feasible for universal application at the seven WWTF's under investigation. The two feasible alternatives are single stage nitrification with downflow denitrifying filters and combined stage nitrification/denitrification with dual media filters. A brief description of the conventional secondary treatment process typical for the existing facilities and the two advanced wastewater treatment alternatives follows.

6.2.1 Conventional Secondary Treatment Process

The conventional secondary treatment process is typical for the existing WWTFs under study. A basic process flow diagram for conventional secondary treatment is illustrated in Figure 6-1A. The aeration tanks are generally sized to provide a hydraulic detention time of 4 to 8 hours based on design

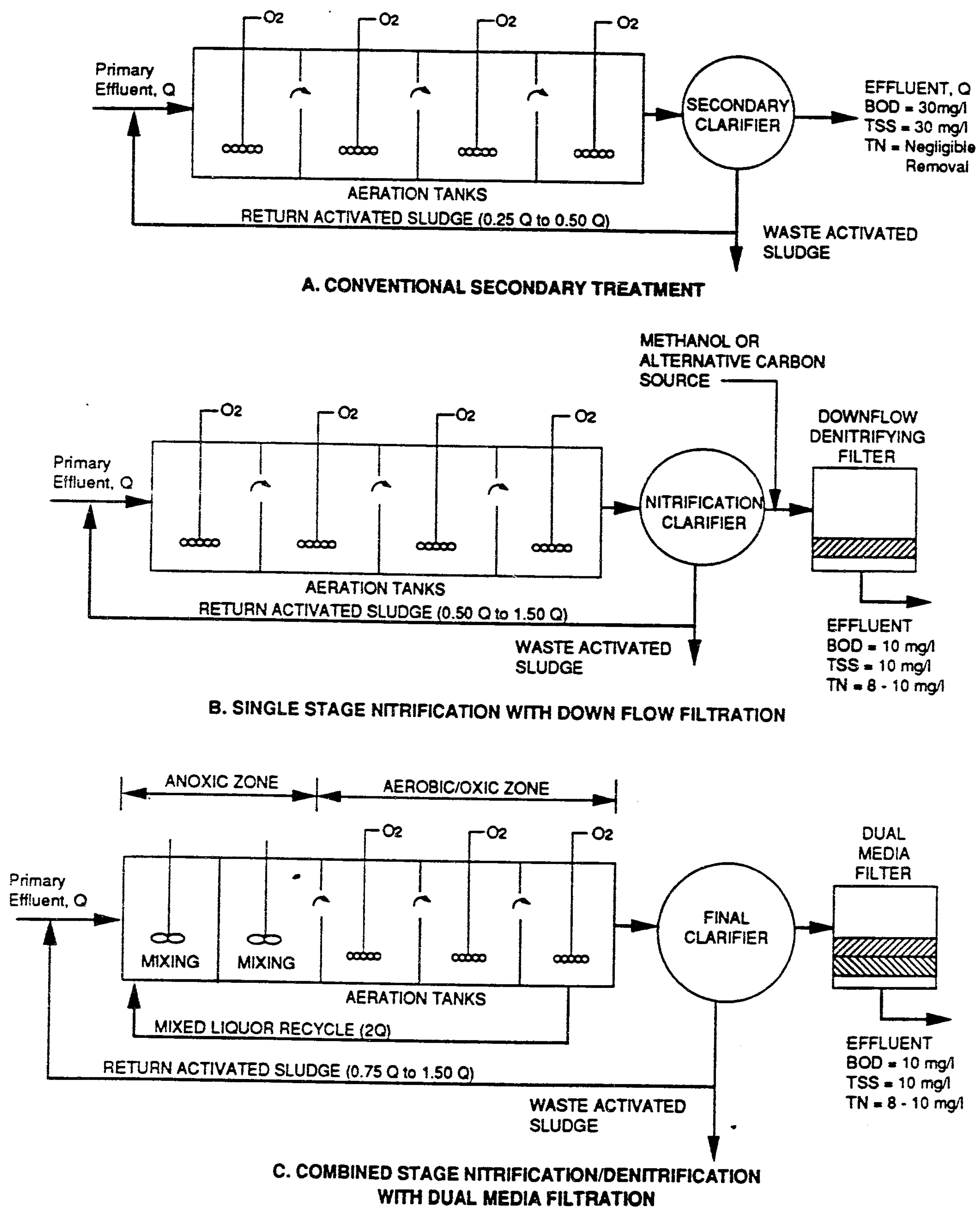


FIGURE 6-1. BASIC PROCESS FLOW DIAGRAMS

average daily flow. The activated sludge process is characterized by a return sludge ratio of 25 to 50 percent of design average flow, a food to mixed liquor volatile solids (MLVSS) ratio of 0.2 to 0.4 and a sludge age of 5 to 15 days. The conventional secondary treatment process can achieve up to 90 percent BOD removal efficiency.

6.2.2 Single Stage Nitrification with Downflow Filters

As an advanced wastewater treatment alternative for the existing WWTF's, single stage nitrification involves utilizing spare aeration capacity or constructing additional tankage where spare capacity does not exist and increasing settling tank and return sludge pumping capacity if necessary to achieve an aeration tank hydraulic detention time of 6 to 10 hours and a return sludge return of 50 to 150 percent of design average flow. The single stage nitrification process is further characterized by a F/MLVSS ratio of 0.15 to 0.25 and a sludge age of 8 to 12 days. For the purpose of this study it was assumed that year-round nitrification/denitrification is required with cold weather operation at a wastewater temperature of 10°C (50°F).

A basic process flow diagram for single stage nitrification with downflow filters is presented in Figure 6-1B. The nitrified effluent is then passed through a downflow filter, also known as a denitrifying filter. Preceding the denitrifying filter a supplemental carbon source, such as methanol, must be added to provide the carbon required for biological denitrification to occur in the filter. The downflow filter requires a deep filter media bed (minimum depth of six feet) in order to denitrify. A hydraulic loading rate of approximately 1.0 gpm/square foot is generally used for cold weather conditions. This filtration system typically requires influent pumping, backwash pumping, and a chemical feed system for methanol or other carbon source.

6.2.3 Combined Stage Nitrification/Denitrification With Dual Media Filters

This advanced wastewater treatment alternative includes a reactor separated into an anoxic zone and a aerobic/oxic zone. This activated sludge system is designed to achieve nitrification and denitrification on a year-round basis at wastewater temperatures as low as 50°F.

A basic process flow design for combined stage nitrification/denitrification with dual media filtration is illustrated in Figure 6-1C.

The anoxic zone is the site of biological denitrification, wherein the majority of nitrates and nitrites contained in wastewater are reduced to nitrogen gas which is released from the flow stream into the atmosphere. The anoxic zone is typically designed to achieved a 2 to 3 hour hydraulic detention time, based on average daily flow. A significant internal recycle of nitrified mixed liquor from the aerobic/oxic zone (approximately 200 percent of average daily flow) is required.

The aerobic/oxic zone is responsible for nitrifying the total kjeldahl nitrogen (TKN) which passes through the anoxic zone and for removing carbonaceous BOD. The aerobic/oxic zone is designed for a 6 to 9 hour hydraulic detention time and a return activated sludge rate of 75 to 150 percent of average daily flow. The system was sized for MLVSS of 2000 to 2500 mg/l, a food to MLVSS ratio of 0.15 to 0.20 and a sludge age of 8 to 12 days.

Following the combined stage nitrification/denitrification system, dual media filters (typically sand and anthracite coal) provide a physical filtration process to achieve the effluent discharge limits for BOD and TSS. The dual media filters were sized according to a hydraulic loading rate design criteria of 3 to 4 gpm/square foot at average daily flow.

6.3.2 Methods of Estimating Costs for Advanced Wastewater Treatment

For each plant, the necessary modifications and additions to provide advanced wastewater treatment were determined for both alternatives. Space requirements and land availability at each wastewater facility site were not included in the analysis. Based upon necessary treatment plant modifications costs were developed for each of the seven plants in the following manner.

The major construction cost components are shown below:

<u>Component</u>

Concrete Tankage (Aeration)
Concrete Tankage (Anoxic Zone)
Mechanical Aerators
Air Blowers
Air Diffusers
Anoxic Mixed Liquor Recycle Pumps
Primary and Secondary Clarifiers
Intermediate Pump Stations
Dual Media Gravity Filters
Downflow Denitrification Filters
Methanol Storage and Feed System
Backwash Retention Tanks

The costs to construct or modify each of the plant's process units were developed using standard cost estimating procedures which include conceptual design, quantity takeoffs, equipment quotations and unit cost information. In some instances, planning level cost curves previously developed by Metcalf and Eddy were used for items such as clarifiers and new aeration tanks. Where possible, information derived from recent construction cost data was incorporated. As with the conveyance alternatives addressed in other sections of this report, an ENR Construction Cost Index of 4700 is used as the datum for the construction costs associated with the two advanced wastewater treatment alternatives.

Once the estimated construction costs for the above items were determined, an allowance was made for miscellaneous non-component items which cannot be accurately determined until final design. Non-component items would include electrical wiring, instrumentation and control, site preparation, yard piping. Also included in this allowance is an adjustment for the fact that work will be performed on an existing site, and that retrofitting of existing process units must occur while maintaining plant operation. It was assumed that these non-component costs will account for approximately 30% of the construction costs of the components listed above, which is similar to the allowance made for the above non-component items in the Assessment of Cost and Effectiveness of Biological Nutrient Removal Technologies in the Chesapeake Bay Drainage Basin. The grand total also included a 35 percent allowance for engineering services during design and construction, and for general construction contingencies.

Annual operation and maintenance (O&M) costs were estimated for the additional basic operation and maintenance items at a treatment plant that would be needed to provide advanced wastewater treatment, namely, labor, power, maintenance, and chemicals. Labor requirements were estimated using the procedures outlined in the EPA manual Estimating Staffing for Municipal Wastewater Treatment Facilities (March, 1973). Personnel requirements were based on one employee working 1500 hours per year assuming a 5-day work week, and an average 29 days for holidays, vacations and sick leave, and 6 ½ hours per day of productive work. Salary requirements were estimated using the WPCF Special Report, 1980 Salaries of Wastewater Personnel, which were updated using the EPA OM&R Labor Index for a typical 5 MGD wastewater treatment plant for the first quarter, 1980 of 2.45 and for the third quarter, 1989 of 3.60. These labor rates were considered similar to those in March of 1990, which is the base for present worth costs in this report.

Power requirements were estimated using unit horsepower sizing for equipment, pumping power requirements, and energy usage curves from EPA's Innovative and Alternative Technology Assessment Manual (EPA 430/9-78-009). Power requirement were then converted to yearly usage and costs determined assuming electricity to cost $0.085/KWh which is an average of the industrial rates in the Narragansett Bay area.

Chemical costs were restricted to the costs of supplying methanol for the downflow denitrifying filters. A cost of $0.70/gallon was used based on information from local suppliers which assumes delivery via 6500 gallon tank truck. It was assumed that lime, which would be needed to maintain alkalinity in the single stage nitrification tanks, would not be required due to the high pH and alkalinity of the potable water supplies in the study area. Denitrification in the anoxic zones should supply sufficient alkalinity for that process option.

The additional operation and maintenance costs for a 20 year planning period were then analyzed using the discount rate for water resources planning established by the U.S. Bureau of Reclamation of 8-7/8 percent to develop a present worth of these additional operations and maintenance costs. These present worth costs were then combined with the estimated construction costs to obtain a total present worth cost of providing advanced wastewater treatment at each facility.

The estimated costs do not include additional project costs for engineering services during planning, design and construction contract administration or for resident representation during construction.

6.4 DESCRIPTION OF PLANTS STUDIED

6.4.1 Introduction

In this section, a description of the existing conditions at each of the plants under consideration will be given. Included in these descriptions will be the flows and loads that are presently being observed at these plants under average conditions and the flows and loads that are to be expected under design conditions. As no influent information was available, total nitrogen concentrations to each plant were assumed to be at 30 mg/l except at Field's Point, where because of its low influent BOD load, a total nitrogen concentration of 20 mg/l was assumed. A description of the types of process units in place at each plant will be given with mention made of the potential for modifications to provide advanced wastewater treatment at those plants.

Using the methods described above, the requirements for each plant to achieve advanced wastewater treatment were developed for both possible upgrade alternatives. Descriptions of the necessary modifications to each unit process and the additional process units for both alternatives are presented.

Following the descriptions of the modifications and additions to the plants are descriptions of the capital and annual costs that have been estimated for these upgrades. For comparison purposes, the present worth of the capital and O&M costs are also presented.

A summary of the estimated costs of providing advanced wastewater treatment at all of the studied facilities is presented following a description of each plant.

6.4.2 Bucklin Point WWTF (Blackstone Valley District Commission)

Existing Conditions

- Service Area-East Providence, Central Falls, Cumberland, Lincoln, Pawtucket, and Smithfield

- Flow

Present Day Average-	23.2 MGD
Design Average	31.0 MGD
Design Peak	46.0 MGD (Secondary)
	84.0 MGD (Primary)

- Influent Loads

BOD Concentration	228 mg/l (Existing)
	250 mg/l (Design)
Suspended Solids	173 mg/l (Existing)
	200 mg/l (Design)
Total Nitrogen	30 mg/l (Assumed)

- Process Type Conventional Activated Sludge

- Existing Process Units

Primary Clarifiers	
Number	2
Dimensions	230 feet long 68 feet wide 10.5 feet deep
Aeration Tanks	
Number	4
Stages/Tank	5
Dimensions	64 feet long (320 feet long overall) 64 feet wide 18.5 feet deep
Aeration System	20-75 HP Mechanical Surface Aerators
Secondary Clarifiers	
Number	6
Dimensions	4-111 foot diam. (Exist) 10 feet deep 2-110 foot diameter (New) 12 feet deep
Return Sludge System	4 pumps (1 standby) 0-75% Q

Modifications for Advanced Wastewater Treatment

From the review of the expected performance of these process units, it was determined that both the primary and secondary clarifiers will provide adequate clarification under either of the advanced wastewater treatment alternatives. The configuration of the activated sludge tanks as well as the availability of land adjacent to these tanks indicates that they would be amenable to the modifications required for either advanced wastewater treatment scheme. There also appears to be sufficient site area available for the installation of filtration units and their appurtenances. There is an effluent pump station at the plant which could be used to convey flows to the filters. However, a new effluent pump station would likely have to be constructed to convey filter effluent to the Seekonk River unless the filters could be set high enough to discharge by gravity into the river, at peak flow and river stage.

Modifications Indicated for Single Stage Nitrification and Denitrifying Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Aeration Tanks	
Number	1
Stages/Tank	5
Dimensions	64 feet long (320 feet long overall) 64 feet wide 18.5 feet deep
Aeration System	

Replace existing 20-75 HP mechanical surface aerators with 20-100 hp mechanical surface aerators. Install 5 New 100 HP mechanical surface aerators in new tank.

Secondary Clarifiers	None
Return Sludge System	1 new pump 50-100% Q Total Capacity
Intermediate Pump Station	
	4-15 MGD, 60 HP Pumps 15 feet TDH
Downflow Denitrifying Filters	
Number	18
Surface Area/Filter	45 feet by 30 feet
Media Depth	6 feet
Backwash Storage	3,240,000 gal. capacity
Methanol Storage and Feed System	
	56,000 gal. capacity

Modifications Indicated for Combined Stage Nitrification-Denitrification and Dual Media Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Anoxic Zones	
Number	6 (4 converted cells from existing aeration tanks) (2 Constructed with new aeration tanks)
Mixers	24-10 HP Turbine Mixers
Mixed Liquor Recycle	
	12-5.2 MGD, 40 HP pumps (200% Q)
Aeration Tanks	
Number	2
Stages/Tank	4 (Existing aeration tanks converted to 4 stage)
Dimensions	64 feet long (256 feet long overall) 64 feet wide 18.5 feet deep

Aeration System

Replace existing 20-75 HP mechanical surface aerators with 16-100 hp mechanical surface aerators. Install 8 New 100 HP mechanical surface aerators in two new tanks.

Secondary Clarifiers	None
Return Sludge System	1 new pump 50-100% Q Total Capacity

Intermediate Pump Station	
	4-15 mgd, 60 HP Pumps
	15 feet TDH
Dual Media Filters	
Number	5
Surface Area/Filter	45 feet by 30 feet
Media Depth	3 feet
Backwash Storage	1,620,000 gal. capacity

Costs to Provide Advanced Wastewater Treatment

Single Stage Nitrification and Denitrifying Filters

In order to retrofit the Bucklin Point WWTF to provide the desired levels of treatment using single stage nitrification and denitrifying filters, it is estimated that the construction costs will be $24,438,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $42,888,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $42.847.000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of capital and O&M costs is estimated to be $85,735,000 as shown in Table 6-3.

Combined Stage Nitrification-Denitrification and Dual Media Filters

In order to retrofit the Bucklin Point WWTF to provide the desired levels of treatment using combined stage nitrification-denitrification with dual media filters, it is estimated that the construction costs will be $17,597,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $30,883,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment are estimated to be $32,937,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of capital and O&M costs is estimated to be $63,820,000 as shown in Table 6-3.

Feasibility of Providing Advanced Wastewater Treatment

There is apparently sufficient site area available to implement either advanced wastewater treatment alternative at Bucklin Point WWTF. However, there exists a hydraulic restriction between the primary clarifiers and the aeration tanks that must be alleviated if additional aeration tankage is to be added. As mentioned above, there is an effluent pump station at this plant which could possibly be used to convey flows to the new filters. Whether this is feasible depends upon the chosen location of the filters and the pumping head required. It is more likely that the existing station can be used with the dual media filters because of the smaller pumping heads required for these filters in comparison with the denitrifying filters. One other factor is that the existing effluent pump station is designed to convey up to 84 mgd while

PLANT	PRIM. CLAR.	SSN AERATION	ANOXIC TANK	SEC. CLAR.	DUAL FILT.	DENIT. FILT.	INTER. PUMP	TOTAL COMPONENT COSTS	MISC. NON-COMPONENT COSTS	ENGINEER. AND CON-TINGENCY	TOTAL EST. CAPITAL COSTS
BUCKLIN POINT (BVDC)	$0	$3,222,000	$0	$200,000	$0	$19,816,000	$1,200,000	$24,438,000	$7,331,000	$11,119,000	$42,888,000
CRANSTON	$0	$2,605,000	$0	$0	$0	$15,238,000	$1,200,000	$19,043,000	$5,713,000	$8,665,000	$33,421,000
EAST PROVIDENCE	$0	$1,104,000	$0	$1,000,000	$0	$9,352,000	$500,000	$11,956,000	$3,587,000	$5,440,000	$20,983,000
FIELD'S POINT (NBC)	$0	$4,407,000	$0	$0	$0	$34,438,000	$2,100,000	$40,945,000	$12,284,000	$18,630,000	$71,859,000
WARWICK	$0	$0	$0	$180,000	$0	$6,006,000	$500,000	$6,686,000	$2,006,000	$3,042,000	$11,734,000
WEST WARWICK	$0	$870,000	$0	$0	$0	$5,672,000	$600,000	$7,142,000	$2,143,000	$3,250,000	$12,535,000
WOONSOCKET	$500,000	$1,662,000		$1,300,000	$0	$16,938,000	$1,100,000	$21,500,000	$6,450,000	$9,783,000	$37,733,000
	INCLUDES CLARIFIER AND EQUIPMENT	INCLUDES TANKS AND AERATION EQUIP.	INCLUDES TANKS, MIXERS, AND RECYCLE PUMPS	INCLUDES CLARIFER AND EQUIPMENT, AND RETURN SLUDGE PUMPS	INCLUDES FILTERS, BACKWASH PUMPS AND EQUIPMENT, AND BACKWASH STORAGE TANKS	INCLUDES FILTERS, BACKWASH PUMPS AND EQUIP., BACKWASH STORAGE, AND METHANOL FEED EQUIP. AND STORAGE	INCLUDES PUMPS AND BLDGS.		EST. AT 30% OF COMPONENT COSTS	35% OF COMPONENT AND NON-COMPONENT COSTS (18% ENGINEERING AND 17% CONTINGENCY)	

TABLE 6-1 ESTIMATED CONSTRUCTION COSTS TO IMPLEMENT SINGLE STAGE NITRIFICATION WITH DOWNFLOW DENITRIFYING FILTERS

TABLE 6-1
(CONT.)

PLANT	PRIM. CLAR.	SSN AERATION	ANOXIC TANK	SEC. CLAR.	DUAL MEDIA FILT.	DENIT. FILT.	INTER. PUMP	TOTAL COMPONENT COSTS	MISC. NON-COMPONENT COSTS	ENGINEER. AND CON-TINGENCY	TOTAL EST. CAPITAL COSTS
BUCKLIN POINT (BVDC)	$0	$4,567,000	$2,764,000	$200,000	$8,866,000	$0	$1,200,000	$17,597,000	$5,279,000	$8,007,000	$30,883,000
CRANSTON	$0	$2,605,000	$4,094,000	$0	$7,920,000	$0	$1,200,000	$15,819,000	$4,746,000	$7,198,000	$27,763,000
EAST PROVIDENCE	$0	$1,104,000	$2,141,000	$1,000,000	$4,440,000	$0	$500,000	$9,185,000	$2,756,000	$4,179,000	$16,120,000
FIELD'S POINT (NBC)	$0	$4,407,000	$7,704,000	$0	$15,272,000	$0	$2,100,000	$29,483,000	$8,845,000	$13,415,000	$51,743,000
WARWICK	$0	$0	$853,000	$180,000	$3,040,000	$0	$500,000	$4,573,000	$1,372,000	$2,081,000	$8,026,000
WEST WARWICK	$0	$870,000	$1,375,000	$0	$2,790,000	$0	$600,000	$5,635,000	$1,691,000	$2,564,000	$9,890,000
WOONSOCKET	$500,000	$1,662,000	$1,603,000	$1,300,000	$8,936,000	$0	$1,100,000	$15,101,000	$4,530,000	$6,871,000	$26,502,000
	INCLUDES CLARIFIER AND EQUIPMENT	INCLUDES TANKS AND AERATION EQUIP.	INCLUDES TANKS, MIXERS, AND RECYCLE PUMPS	INCLUDES CLARIFER AND EQUIPMENT, AND RETURN SLUDGE PUMPS	INCLUDES FILTERS, BACKWASH PUMPS AND EQUIPMENT, AND BACKWASH STORAGE TANKS	INCLUDES FILTERS, BACKWASH PUMPS AND EQUIP., BACKWASH STORAGE, AND METHANOL FEED EQUIP. AND STORAGE	INCLUDES PUMPS AND BLDGS.		EST. AT 30% OF COMPONENT COSTS	35% OF COMPONENT AND NON-COMPONENT COSTS (18% ENGINEERING AND 17% CONTINGENCY)	

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TABLE 6-1 (CONT.) ESTIMATED CONSTRUCTION COSTS TO IMPLEMENT COMBINED STAGE NITRIFICATION-DENITRIFICATION WITH DUAL MEDIA FILTERS

PLANT	MAINTENANCE	LABOR	POWER	CHEMICAL	TOTAL	PRESENT WORTH
BUCKLIN POINT (BVDC)	$1,487,000	$225,000	$2,463,000	$477,000	$4,652,000	$42,847,000
CRANSTON	$1,159,000	$180,000	$1,359,000	$349,000	$3,047,000	$28,064,000
EAST PROVIDENCE	$727,000	$148,000	$471,000	$170,000	$1,516,000	$13,963,000
FIELD'S POINT (NBC)	$2,491,000	$364,000	$1,984,000	$1,022,000	$5,861,000	$53,982,000
WARWICK	$407,000	$61,000	$106,000	$85,000	$659,000	$6,070,000
WEST WARWICK	$435,000	$103,000	$290,000	$119,000	$947,000	$8,722,000
WOONSOCKET	$1,308,000	$180,000	$532,000	$613,000	$2,633,000	$24,251,000
	ESTIMATED AT 4% OF CONST. COSTS (COMPONENT AND NON-COMPONENT AND 17% CONTINGENCY)	INCLUDES MANHOURS FOR OPERATIONS AND MAINTENANCE	POWER COSTS AT $0.085/KWh	METHANOL COSTS		n=20 YR. i=8 7/8%

TABLE 6-2 ESTIMATED ADDITIONAL ANNUAL O&M COSTS FOR PROVIDING SINGLE STAGE NITRIFICATION AND DOWNFLOW DENITRIFYING FILTERS

TABLE 6-2
(CONT.)

PLANT	MAINTENANCE	LABOR	POWER	CHEMICAL	TOTAL	PRESENT WORTH
BUCKLIN POINT (BVDC)	$1,071,000	$164,000	$2,341,000	$0	$3,576,000	$32,937,000
CRANSTON	$962,000	$164,000	$1,911,000	$0	$3,037,000	$27,972,000
EAST PROVIDENCE	$559,000	$126,000	$462,000	$0	$1,147,000	$10,564,000
FIELD'S POINT (NBC)	$1,794,000	$309,000	$1,662,000	$0	$3,765,000	$34,677,000
WARWICK	$278,000	$45,000	$86,000	$0	$409,000	$3,767,000
WEST WARWICK	$343,000	$77,000	$293,000	$0	$713,000	$6,567,000
WOONSOCKET	$919,000	$164,000	$466,000	$0	$1,549,000	$14,267,000
	ESTIMATED AT 4% OF CONST. COSTS (COMPONENT AND NON-COMPONENT AND 17% CONTINGENCY)	INCLUDES MANHOURS FOR OPERATIONS AND MAINTENANCE	POWER COSTS AT $0.085/KWh	METHANOL COSTS		n=20 YR. i=8 7/8%

TABLE 6-2 (CONT.) ESTIMATED ADDITIONAL ANNUAL O&M COSTS FOR PROVIDING COMBINED STAGE NITRIFICATION-DENITRIFICATION AND DUAL MEDIA FILTERS

PLANT	ESTIMATED CAPITAL COSTS	ESTIMATED ADDITIONAL ANNUAL O&M COSTS	PRESENT WORTH OF ANNUAL COSTS	TOTAL ESTIMATED PRESENT WORTH COSTS
BUCKLIN POINT (BVDC)	$42,888,000	$4,652,000	$42,847,000	$85,735,000
CRANSTON	$33,421,000	$3,047,000	$28,064,000	$61,485,000
EAST PROVIDENCE	$20,983,000	$1,516,000	$13,963,000	$34,946,000
FIELD'S POINT (NBC)	$71,859,000	$5,861,000	$53,982,000	$125,841,000
WARWICK	$11,734,000	$659,000	$6,070,000	$17,804,000
WEST WARWICK	$12,535,000	$947,000	$8,722,000	$21,257,000
WOONSOCKET	$37,733,000	$2,633,000	$24,251,000	$61,984,000
TOTALS	$231,153,000	$19,315,000	$177,899,000	$409,052,000

TABLE 6-3 SUMMARY OF ESTIMATED COSTS TO PROVIDE SINGLE STAGE NITRIFICATION WITH DOWNFLOW DENITRIFYING FILTERS

TABLE 6-3
(CONT.)

PLANT	ESTIMATED CAPITAL COSTS	ESTIMATED ADDITIONAL ANNUAL O&M COSTS	PRESENT WORTH OF ANNUAL COSTS	TOTAL ESTIMATED PRESENT WORTH COSTS
BUCKLIN POINT (BVDC)	$30,883,000	$3,576,000	$32,937,000	$63,820,000
CRANSTON	$27,763,000	$3,037,000	$27,972,000	$55,735,000
EAST PROVIDENCE	$16,120,000	$1,147,000	$10,564,000	$26,684,000
FIELD'S POINT (NBC)	$51,743,000	$3,765,000	$34,677,000	$86,420,000
WARWICK	$8,026,000	$409,000	$3,767,000	$11,793,000
WEST WARWICK	$9,890,000	$713,000	$6,567,000	$16,457,000
WOONSOCKET	$26,502,000	$1,549,000	$14,267,000	$40,769,000
TOTALS	$170,927,000	$14,196,000	$130,751,000	$301,678,000

TABLE 6-3 (CONT.) SUMMARY OF ESTIMATED COSTS TO PROVIDE COMBINED STAGE NITRIFICATION-DENITRIFICATION WITH DUAL MEDIA FILTERS advanced wastewater treatment will only treat 46 mgd. Because of this fact, use of the existing station may be more feasible, although a new effluent pump station would also have to be able to convey a full 84 mgd to the Seekonk River. An alternative to construction of a new 84 mgd effluent pump station would be to set the filters high enough so that effluent can flow by gravity to the river so that a new effluent pump station would only have to convey effluent only receiving primary treatment during peak wet weather flows.

6.4.3 Cranston WWTF

Existing Conditions

- Service Area Cranston
- Flow

Present Day Average	12.2 MGD
Design Average	23.0 MGD
Design Peak	44.0 MGD

- Influent Loads

BOD Concentration	169 mg/l (Existing)
	209 mg/l (Design)
Suspended Solids	158 mg/l (Existing)
	182 mg/l (Design)
Total Nitrogen	30 mg/l (Assumed)

- Process Type Conventional Activated Sludge
- Existing Process Units

Primary Clarifiers	
Number	3
Dimensions	130 foot diameter
	12 feet deep
Aeration Tanks	
Number	4
Stages/Tank	1
Dimensions	62 feet wide
	124 feet long
	25 feet deep
Aeration System	Submerged Turbine Aeration
	2-5400 cfm blowers
	1-3550 cfm blower
	12-75 HP Aerators
Secondary Clarifiers	
Number	4
Dimensions	140 foot diameter
	14 feet deep
Return Sludge System	5 pumps
	50-75% Q

Modifications for Advanced Wastewater Treatment

The Cranston WWTF is a relatively new facility which was designed to accommodate flows and loads from a major industrial contributor who has since ceased operations in Cranston. Thus at present, this plant is underloaded. Furthermore, when the new plant was constructed, the plant that was replaced was abandoned but not destroyed and it still remains at the site. An option considered during the design of the new plant was to route final effluent from the new plant through the old plant where nitrification would be affected. For the purpose of this study, use of the old plant was not considered. This option should be further explored if advanced wastewater treatment is to be implemented at Cranston as it could represent significant cost savings by using existing tankage. However, denitrification facilities would still have to be constructed to achieve the desired levels of treatment.

Modifications Indicated for Single Stage Nitrification and Denitrifying Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Aeration Tanks	
Number	2
Stages/Tank	1
Dimensions	62 feet wide 124 feet long 25 feet deep
Aeration System	2-5400 cfm blowers 1-3550 cfm blower 6 New 75 HP mechanical aerators and turbine spargers
Secondary Clarifiers	None
Return Sludge System	No new pumps needed
Intermediate Pump Station	4-15 MGD, 60 HP pumps 15 foot TDH
Downflow Denitrifying Filters	
Number	16
Surface Area/Filter	50 feet by 20 feet
Media Depth	6 feet
Backwash Storage	1,600,000 gal. capacity
Methanol Storage and Feed System	41,000 gal. capacity

Modifications Indicated for Combined Stage Nitrification-Denitrification and Dual Media Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Anoxic Zones	
Number	6
Mixers	24
Mixed Liquor Recycle	

	6-7.7 MGD, 40 HP pumps 200% Q
Aeration Tanks	
Number	2
Stages/Tank	1
Dimensions	62 feet wide 124 feet long 25 feet deep
Aeration System	2-5400 cfm blowers 1-3550 cfm blower 6 New 75 HP mechanical aerators and turbine spargers
Secondary Clarifiers	None
Return Sludge System	No new pumps needed
Intermediate Pump Station	
	4-15 MGD, 60 HP pumps 10 foot TDH
Dual Media Filters	
Number	6
Surface Area/Filter	50 feet by 20 feet
Media Depth	3 feet
Backwash Storage	1,200,000 gal. capacity

Costs to Provide Advanced Wastewater Treatment

Single Stage Nitrification and Denitrifying Filters

In order to retrofit the Cranston WWTF to provide the desired levels of treatment using single stage nitrification and denitrifying filters, it is estimated that the construction costs will be $19,042,500 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $33,421,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $28,064,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of capital and O&M costs is estimated to be $61,485,000 as shown in Table 6-3.

Combined Stage Nitrification-Denitrification and Dual Media Filters

In order to retrofit the Cranston WWTF to provide the desired levels of treatment using combined stage nitrification-denitrification with dual media filters, it is estimated that the construction costs will be $15,819,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $27,763,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $27,972,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of all costs is estimated to be $55,735,000 as shown in Table 6-3.

Feasibility of Providing Advanced Wastewater Treatment

With the abandoned old treatment plant remaining on site, there should be adequate space to accommodate either of the above treatment options. The actual effectiveness of the submerged turbine aeration system for oxygen transfer must be verified as it is understood that there have been problems with it not providing the expected amounts of oxygen. The requirements used for the aeration system in this study attempt to account for this situation as the assumed oxygen transfer capability in our analyses is much less than has been reported previously.

6.4.4 East Providence WWTF

Existing Conditions

- Service Area East Providence, Barrington
- Flow

Present Day Average	4.5 MGD
Design Average	10.4 MGD
Design Peak	21.2 MGD
	(26.0 MGD for AWT)

- Influent Loads

BOD Concentration	159 mg/l (Existing)
	160 mg/l (Design)
Suspended Solids	127 mg/l (Existing)
	130 mg/l (Design)
Total Nitrogen	30 mg/l (Assumed)

- Process Type Conventional Activated Sludge
- Existing Process Units

Primary Clarifiers	
Number	4
Dimensions	110 feet long
	28 feet wide
	7.9 feet deep
Aeration Tanks	
Number	4
Stages/Tank	3
Dimensions	98.5 feet diameter
	11 feet deep
Aeration System	12-20 HP Mechanical Surface Aerators
Secondary Clarifiers	
Number	2
Dimensions	110 foot diameter
	12 feet deep
Return Sludge System	3 pumps
	75% Q Assumed

Modifications for Advanced Wastewater Treatment

The East Providence plant was upgraded in 1974, and four of the six trickling filters were converted to activated sludge aeration tanks. The remaining two still exist and it may be possible to convert these to aeration tanks as well. However, the configuration of the four tanks in operation is not optimal, so that it may be better to construct new tanks. There is a significant hydraulic restriction between the primary clarifiers and the aeration tanks which should be alleviated prior to the implementation of any advanced wastewater treatment option.

Modifications Indicated for Single Stage Nitrification and Denitrifying Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Aeration Tanks	
Number	2
Stages/Tank	3
Dimensions	120 feet long 30 feet wide 15 feet deep

Aeration System
Replace existing 12-20 HP mechanical surface aerators with 12-40 HP mechanical surface aerators. Install 6 new 40 HP mechanical surface aerators in new tanks.

Secondary Clarifiers	
Number	1
Dimensions	110 foot diameter 12 feet deep
Return Sludge System	3-20 HP pumps at 1.33 MGD each up to 100% Q
Intermediate Pump Station	3-13 MGD, 60 HP Pumps 15 feet TDH
Downflow Denitrifying Filters	
Number	14
Surface Area/Filter	30 feet by 20 feet
Media Depth	6 feet
Backwash Storage	1,450,000 gal. capacity
Methanol Storage and Feed System	20,000 gal. capacity

Modifications Indicated for Combined Stage Nitrification-Denitrification and Dual Media Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Anoxic Zones	
Number	6
Mixers	24-5 HP Turbine Mixers

Mixed Liquor Recycle	
	12-1.7 MGD, 10 HP Pumps
	200% Q
Aeration Tanks	
Number	2
Stages/Tank	3
Dimensions	120 feet long
	30 feet wide
	15 feet deep

Aeration System

Replace existing 12-20 HP mechanical surface aerators with 12-40 HP mechanical surface aerators. Install 6 new 40 HP mechanical surface aerators in new tanks.

Secondary Clarifiers	
Number	1
Dimensions	110 foot diameter
	12 feet deep
Return Sludge System	3-20 HP pumps at 1.33 MGD each
	up to 100% Q
Intermediate Pump Station	
	4-13 MGD, 60 HP Pumps
	15 feet TDH
Dual Media Filters	
Number	5
Surface Area/Filter	30 feet by 20 feet
Media Depth	3 feet
Backwash Storage	490,000 gal. capacity

Costs to Provide Advanced Wastewater Treatment

Single Stage Nitrification and Denitrifying Filters

In order to retrofit the East Providence WWTF to provide the desired levels of treatment using single stage nitrification and denitrifying filters, it is estimated that the construction costs will be $11,956,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $20,983,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $13,963,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of capital and O&M costs is estimated to be $34,946,000 as shown in Table 6-3.

Combined Stage Nitrification-Denitrification and Dual Media Filters

In order to retrofit the East Providence WWTF to provide the desired levels of treatment using combined stage nitrification-denitrification with dual media filters, it is estimated that the construction costs will be $9,185,000 for component alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $16,120,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $10,564,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of all costs is estimated to be $26,684,000 as shown in Table 6-3.

Feasibility of Providing Advanced Wastewater Treatment

Information of site availability is not clear. Based on 1989 effluent data, the plant is underloaded and is producing nitrified effluent with BOD and suspended solids levels below 10 mg/l even though its design year is 1995. The feasibility of utilizing the abandoned trickling filters should be investigated as their use could represent some costs savings.

6.4.5 Field's Point WWTF (Narragansett Bay Commission)

Existing Conditions

- Service Area-Providence, North Providence, Johnston, portions of Cranston and Lincoln

- Flow

Present Day Average	54.4 MGD
Design Average	65.0 MGD
Design Peak	91.0 MGD (Secondary)
	200.0 MGD (Primary)

- Influent Loads

BOD Concentration	112 mg/l (Existing)
	126 mg/l (Design)
Suspended Solids	166 mg/l (Existing)
	155 mg/l (Design)
Total Nitrogen	20 mg/l (Assumed)

- Process Type Conventional Activated Sludge

- Existing Process Units

Primary Clarifiers	
Number	4
Dimensions	96 foot diameter
	13 feet deep
Number	4
Dimensions	120 foot diameter
	12 feet deep
Aeration Tanks	
Number	10
Stages/Tank	1
Dimensions	72 feet wide
	109.5 feet long
	17 feet deep
Aeration System	Fine bubble diffused air
	2-6050 cfm blowers

	2-4525 cfm blowers
	1-3000 cfm blowers
Secondary Clarifiers	
Number	6
Dimensions	125 foot diameter
	14 feet deep
Number	2 (Not in use)
Dimensions	115 foot diameter
	9 feet deep
Number	5 (Not in use)
Dimensions	103 feet wide
	103 feet long
	11 feet deep
Return Sludge System	6 pumps at 10.8 MGD each
	50-75% Q

Modifications for Advanced Wastewater Treatment

The site at Field's Point is very restricted. In order to incorporate many of the required processes for upgrading the plant, some of the existing (but abandoned) secondary clarifiers would have to be either replaced or put back into use.

Modifications Indicated for Single Stage Nitrification and Denitrifying Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Aeration Tanks	
Number	5
Stages/Tank	1
Dimensions	72 feet wide
	109.5 feet long
	17 feet deep
Aeration System	Add new
	2-6050 cfm blowers
	2-4525 cfm blowers
	1-3000 cfm blowers

Secondary Clarifiers
Convert 3 of the 5 square clarifiers to 100 foot diameter circular (as has been done with primary clarifiers)

Use 1 one of two abandoned 115 foot diameter clarifiers

Return Sludge System	Use all return sludge pumps
Intermediate Pump Station	
	4-30 MGD, 200 HP
	15 foot TDH
Downflow Denitrifying Filters	
Number	36
Surface Area/Filter	40 feet by 30 feet

Media Depth	6 feet
Backwash Storage	4,800,000 gal. capacity
Methanol Storage and Feed System	120,000 gal. capacity

Modifications Indicated for Combined Stage Nitrification-Denitrification and Dual Media Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Anoxic Zones	
Number	15
Mixers	60
Mixed Liquor Recycle	15-8.67 MGD, 10 HP Pumps 200% Q
Aeration Tanks	
Number	5
Stages/Tank	1
Dimensions	72 feet wide 109.5 feet long 17 feet deep
Aeration System	Add new 2-6050 cfm blowers 2-4525 cfm blowers 1-3000 cfm blowers

Secondary Clarifiers
Convert 2 of the 5 square clarifiers to 100 foot diameter circular (as has been done with primary clarifiers). Use both abandoned 115 foot diameter clarifiers

Return Sludge System	Use all return sludge pumps
Intermediate Pump Station	4-30 MGD, 200 HP Pumps 15 foot TDH
Dual Media Filters	
Number	10
Surface Area/Filter	40 feet by 30 feet
Media Depth	3 feet
Backwash Storage	1,450,000 gal. capacity

Costs to Provide Advanced Wastewater Treatment

Single Stage Nitrification and Denitrifying Filters

In order to retrofit the Field's Point WWTF to provide the desired levels of treatment using single stage nitrification and denitrifying filters, it is estimated that the construction costs will be $40,945,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $71,859,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $53,982,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of capital and O&M costs is estimated to be $125,841,000 as shown in Table 6-3.

Combined Stage Nitrification-Denitrification and Dual Media Filters

In order to retrofit the Field's Point WWTF to provide the desired levels of treatment using combined stage nitrification-denitrification with dual media filters, it is estimated that the construction costs will be $29,483,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $51,743,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $34,677,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of capital and O&M costs is estimated to be $86,420,000 as shown in Table 6-3.

Feasibility of Providing Advanced Wastewater Treatment

The existing abandoned secondary clarifiers at Field's Point must undergo modification or demolition in order to provide space for advanced wastewater treatment. The square clarifiers should be converted to circular tanks in a similar manner as were the primary clarifiers. Depending upon the advanced wastewater treatment process option chosen, two or three of these clarifiers could have to be modified. Because of the restricted site area the clarifiers not converted must be demolished to accommodate either filters or additional aeration tanks. The capacity of the existing intermediate pump station conveying flow to the aeration tanks must be confirmed to ensure that the new battery of aeration tanks may be served as well. Furthermore, if the anoxic zones must be placed preceding the existing pump station, then the capacity of that pump station would have to be much higher. If the newly acquired parcel of land directly across the street is available, the filtration process may be constructed within that area.

6.4.6 Warwick WWTF

Existing Conditions

- Service Area Warwick
- Flow

Present Day Average	3.62 MGD
Design Average	5.2 MGD
Design Peak	13 MGD

- Influent Loads

BOD Concentration	208 mg/l (Existing)
	225 mg/l (Design)
Suspended Solids	196 mg/l (Existing)

	200 mg/l (Design)
Total Nitrogen	30 mg/l (Assumed)

- Process Type   Conventional Activated Sludge

- Existing Process Units

Primary Clarifiers	
Number	2
Dimensions	108 feet long 30 feet wide 7 feet deep
Aeration Tanks	
Number	6
Stages/Tank	1
Dimensions	22 feet wide 180 feet long 12.5 feet deep
Aeration System	Fine bubble diffused air 3-5000 cfm blowers (1 standby)
Secondary Clarifiers	
Number	3
Dimensions	70 foot diameter 9 feet deep
Return Sludge System	4 pumps (2 standby) at 1.5 MGD each 60% Q

Modifications for Advanced Wastewater Treatment

Under present loading conditions and process configuration, there does not seem to be a need for modifications to the aeration tanks to provide nitrification. However, previous facilities planning figures from 1982 indicate significantly higher loadings than are being experienced. If these loadings are ever experienced then expansion of the aeration tanks may be necessary in order to provide the levels of treatment desired. For the purpose of this study, no additional aeration tanks were considered necessary.

Modifications Indicated for Single Stage Nitrification and Denitrifying Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Aeration Tanks	
Number	None
Stages/Tank	
Dimensions	
Aeration System	
Secondary Clarifiers	None
Return Sludge System	2 new pumps at 1.5 MGD each 100% Q
Intermediate Pump Station	
	3-6.5 MGD, 40 HP pumps 15 foot TDH

Downflow Denitrifying Filters	
Number	8
Surface Area/Filter	30 feet by 20 feet
Media Depth	6 feet
Backwash Storage	965,000 gal. capacity
Methanol Storage and Feed System	20,000 gal. capacity

Modifications Indicated for Combined Stage Nitrification-Denitrification and Dual Media Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Anoxic Zones	
Number	6
Mixers	24-1 HP Turbine Mixers
Mixed Liquor Recycle	3-3.5 MGD, 20 HP Pumps (200% Q)
Aeration Tanks	
Number	None
Stages/Tank	
Dimensions	
Aeration System	None
Secondary Clarifiers	None
Return Sludge System	2 new pumps at 1.5 MGD each 100% Q
Intermediate Pump Station	3-6.5 MGD, 40 HP pumps 10 foot TDH
Dual Media Filters	
Number	3
Surface Area/Filter	30 feet by 20 feet
Media Depth	3
Backwash Storage	490,000 gal. capacity

Costs to Provide Advanced Wastewater Treatment

Single Stage Nitrification and Denitrifying Filters

In order to retrofit the Warwick WWTF to provide the desired levels of treatment using single stage nitrification and denitrifying filters, it is estimated that the construction costs will be $6,686,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $11,734,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $6,070,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of all costs is estimated to be $17,804,000 as shown in Table 6-3.

Combined Stage Nitrification-Denitrification and Dual Media Filters

In order to retrofit the Warwick WWTF to provide the desired levels of treatment using combined stage nitrification-denitrification with dual media filters, it is estimated that the construction costs will be $4,573,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $8,026,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $3,767,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of all costs is estimated to be $11,793,000 as shown in Table 6-3.

Feasibility of Providing Advanced Wastewater Treatment

It may be possible to reconfigure the aeration tanks so that flow passes through a number of stages rather than one long tank. Furthermore, the configuration of these tanks may be such that they could be modified to place the anoxic zones at the front end of the tanks through the addition of separating walls and the replacement of the aeration equipment in the zones with mixers. In such a case additional aeration tankage may be required. This possibility should be confirmed if combined stage nitrification-denitrification implemented, if chosen.

6.4.7 West Warwick WWTF

Existing Conditions

- Service Area West Warwick

- Flow

Present Day Average	4.85 MGD
Design Average	5.0 MGD (Existing)
	7.9 MGD (Under Const.)
Design Peak	18.1 MGD

- Influent Loads

BOD Concentration	154 mg/l (Existing)
	225.6 mg/l (Design)
Suspended Solids	121 mg/l (Existing)
	221.5 mg/l (Design)
Total Nitrogen	30 mg/l (Assumed)

- Process Type Conventional Activated Sludge

- Existing Process Units

Primary Clarifiers

Number	6 (Existing)
Dimensions	50 feet long
	16 feet wide
	9.5 feet deep

Number	2 (Under Const.)
Dimensions	75 foot diameter 13 feet deep
Aeration Tanks	
Number	2 (Existing, South)
Stages/Tank	1
Dimensions	28 feet wide 140 feet long 10 feet deep
Number	2 (Existing, North)
Stages/Tank	3
Dimensions	28 feet wide 28 feet long (84 feet long overall) 14.5 feet deep
Number	2 (Under Const.)
Stages/Tank	3
Dimensions	55 feet wide 55 feet long (165 feet long overall) 18.5 feet deep
Aeration System	Fine bubble diffused air 3-3000 cfm blowers
Secondary Clarifiers	
Number	6 (Existing)
Dimensions	70 feet long 20 feet wide 9.5 feet deep
Number	2 (Under Construction)
Dimensions	100 foot diameter 14 feet deep
Return Sludge System	3 pumps at 4.0 MGD each (Assumed) 50% Q

Modifications for Advanced Wastewater Treatment

The West Warwick WWTF is presently undergoing construction to expand the design flow capacity from 5.0 mgd capacity to 7.9 mgd capacity. When construction is complete, the south side train will have been demolished and the north side train will be abandoned, so that there is room to accommodate the necessary changes to provide advanced wastewater treatment. If advanced wastewater treatment is implemented, the new train will remain and little or no rehabilitative work should be needed.

Modifications Indicated for Single Stage Nitrification and Denitrifying Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Aeration Tanks	
Number	No new tanks
Stages/Tank	1 new stage per tank

Dimensions	55 feet wide 55 feet long (220 feet long overall) 18.5 feet deep
Aeration System	2-4000 cfm blowers
Secondary Clarifiers	None
Return Sludge System	No new pumps 100% Q
Intermediate Pump Station	3-9 MGD, 60 HP Pumps 15 foot TDH
Downflow Denitrifying Filters	
Number	10
Surface Area/Filter	30 feet by 20 feet
Media Depth	6
Backwash Storage	1,450,000 gal. capacity
Methanol Storage and Feed System	120,000 gal. capacity

Modifications Indicated for Combined Stage Nitrification-Denitrification and Dual Media Filters

- Modified or Additional Process Units

Primary Clarifiers	None
Anoxic Zones	
Number	2
Mixers	8-7.5 HP
Mixed Liquor Recycle	15-10 HP pumps at 1.07 MGD each 200% Q
Aeration Tanks	
Number	No new tanks
Stages/Tank	1 new stage per tank
Dimensions	55 feet wide 55 feet long (220 feet long overall) 18.5 feet deep
Aeration System	2-4000 cfm blowers
Secondary Clarifiers	None
Return Sludge System	No new pumps 100% Q
Intermediate Pump Station	3-9 MGD, 60 HP pumps 10 feet TDH
Dual Media Filters	
Number	4
Surface Area/Filter	30 feet by 20 feet
Media Depth	3
Backwash Storage	490,000 gal. capacity

Costs to Provide Advanced Wastewater Treatment

Single Stage Nitrification and Denitrifying Filters

In order to retrofit the West Warwick WWTF to provide the desired levels of treatment using single stage nitrification and denitrifying filters, it is estimated that the construction costs will be $7,142,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $12,535,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $8,722,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of all costs is estimated to be $21,257,000 as shown in Table 6-3.

Combined Stage Nitrification-Denitrification and Dual Media Filters

In order to retrofit the West Warwick WWTF to provide the desired levels of treatment using combined stage nitrification-denitrification with dual media filters, it is estimated that the construction costs will be $5,635,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $9,890,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $6,567,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of all costs is estimated to be $16,457,000 as shown in Table 6-3.

Feasibility of Providing Advanced Wastewater Treatment

With the new construction at this plant, there is space available but the present configuration of the new train may be difficult to install additional aeration tankage or anoxic zones. It may be possible to place the new tanks to the south of the existing (under construction) tanks. In order to operate the aeration tanks in single stage nitrification mode, the tanks must be operated in the plug flow mode (the tanks have this operational flexibility). There appears to be sufficient area for construction of the filters.

6.4.8 Woonsocket WWTF

Existing Conditions

- Service Area   Woonsocket

- Flow

Present Day Average	8.92 MGD
Design Average	16 MGD
Design Peak	32 MGD
	40 MGD (for AWT)

- Influent Loads

BOD Concentration	137 mg/l (Existing)
	150 mg/l (Design)
Suspended Solids	112 mg/l (Existing)
	150 mg/l (Design)
Total Nitrogen	30 mg/l (Assumed)

- Existing Process Units

Primary Clarifiers	
Number	2
Dimensions	90 foot diameter
	11 feet deep
Aeration Tanks	
Number	4
Stages/Tank	4
Dimensions	46 feet wide
	46 feet long
	184 feet long overall
	15 feet deep
Aeration System	16-40 HP Mechanical Surface Aerators
Secondary Clarifiers	
Number	3
Dimensions	110 feet diameter
	12 feet deep
Return Sludge System	Number of pumps unknown
	50-75% Q

Modifications for Advanced Wastewater Treatment

From the review of the existing processes at this plant, there is a need for additional primary and secondary clarification in order to provide the lower surface loading rates required for advanced wastewater treatment. The configuration of the site must be further investigated to determine the location of the filter process and intermediate pumping facilities, especially with the needed addition of several process units.

Modifications Indicated for Single Stage Nitrification and Denitrifying Filters

- Modified or Additional Process Units

Primary Clarifiers	
Number	1
Dimensions	90 foot diameter
	11 feet deep
Aeration Tanks	
Number	2
Stages/Tank	4
Dimensions	46 feet wide
	46 feet long
	184 feet long overall
	15 feet deep
Aeration System	8-40 HP Mechanical Surface Aerators

Secondary Clarifiers	
Number	1
Dimensions	110 foot diameter 12 feet deep
Return Sludge System	100% Q
Intermediate Pump Station	3-20 MGD, 100 HP pumps 15 feet TDH
Downflow Denitrifying Filters	
Number	15
Surface Area/Filter	40 feet by 20 feet
Media Depth	6 feet
Backwash Storage	1,920,000 gal. capacity
Methanol Storage and Feed System	120,000 gal. capacity

Modifications Indicated for Combined Stage Nitrification-Denitrification and Dual Media Filters

- Modified or Additional Process Units

Primary Clarifiers	
Number	1
Dimensions	90 foot diameter 11 feet deep
Anoxic Zones	
Number	6
Mixers	24-5 HP Turbine Mixers
Mixed Liquor Recycle	6-30 HP pumps at 5.33 MGD each 200% Q
Aeration Tanks	
Number	2
Stages/Tank	4
Dimensions	46 feet wide 46 feet long 184 feet long overall 15 feet deep
Aeration System	8-40 HP Mechanical Surface Aerators
Secondary Clarifiers	
Number	1
Dimensions	110 foot diameter 12 feet deep
Return Sludge System	100% Q
Intermediate Pump Station	3-20 MGD, 100 HP pumps 15 feet TDH
Dual Media Filters	
Number	6
Surface Area/Filter	40 feet by 20 feet
Media Depth	3 feet
Backwash Storage	965,000 gal. capacity

Costs to Provide Advanced Wastewater Treatment

Single Stage Nitrification and Denitrifying Filters

In order to retrofit the Woonsocket WWTF to provide the desired levels of treatment using single stage nitrification and denitrifying filters, it is estimated that the construction costs will be $21,500,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $37,733,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $24,251,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of all costs is estimated to be $61,984,000 as shown in Table 6-3.

Combined Stage Nitrification-Denitrification and Dual Media Filters

In order to retrofit the Woonsocket WWTF to provide the desired levels of treatment using combined stage nitrification-denitrification with dual media filters, it is estimated that the construction costs will be $15,101,000 for component items alone. A listing of the costs of the necessary components is given in Table 6-1. The estimated grand total of capital costs with all allowances is $26,502,000. The present worth of the additional annual operating and maintenance costs for providing this level of treatment is estimated to be $14,267,000. A listing of the additional O&M costs for providing advanced wastewater treatment using this option is given in Table 6-2. The present worth of all costs is estimated to be $40,769,000 as shown in Table 6-3.

Feasibility of Providing Advanced Wastewater Treatment

The configuration of the aeration tanks at Woonsocket is such that the first stage of these tanks could be converted to anoxic zones if the option of combined stage nitrification-denitrification is chosen. If so, two additional aeration tanks would have to be built. To provide single stage nitrification, only one new tank would have to be built.

6.4.9 Overall Costs of Providing Advance Wastewater Treatment

The estimated costs for the construction of the additional or modified component of each plant to provide advanced wastewater treatment are presented in Table 6-1. This table also includes allowances for non-component costs and for contingencies. The estimated additional annual costs for operation and maintenance of the new or modified facilities are presented in Table 6-2. A grand summary of the construction costs and the annual additional operations and maintenance costs is presented on a present worth basis for a 20 year design period in Table 6-3. It is important to note that approximately $83 million of this total represents the cost to upgrade Cranston, Warwick, and West Warwick facilities to AWT.

6.5 REGIONAL ADVANCED WASTEWATER TREATMENT AT FIELD'S POINT

A separate investigation was performed into the feasibility of conveying the effluent from the seven existing secondary treatment facilities to a new regional AWT facility at Field's Point. The conveyance aspect of this alternative was previously developed in Section 2.

To evaluate the facilities necessary for a regional AWT facility the design flow and loads were assumed to be the sum of existing plants design capacities and typical secondary effluent discharge parameters, respectively. Therefore, the design flow capacity for the regional AWT plant would be 155.6 mgd. A peak flow of 433 mgd was estimated for this facility using the peak flows developed in Section 3 of this report. The influent pollutant loads would be typical for secondary effluent at 30 mg/l, 30 mg/l, and 20 mg/l for BOD, TSS and total nitrogen, respectively.

A facility of this size and influent characteristics would require a separate stage nitrification system followed by a denitrification system. For illustration purposes the denitrifying system selected is a downflow filter.

The basic area requirements for a regional AWT facility include the following:

Aeration tank surface area	=	127,000	square feet (at 20 feet deep)
Clarifier surface area	=	433,000	square feet
Down flow filter surface area	=	110,000	square feet
Total Process Area Required	=	670,000	square feet (15 acres)

The above process areas do not include an allowance for intermediate pump stations to lift the influent into the new facility and to lift flow into the denitrifying filters. In addition, the area estimate does not include an allowance for sludge handling facilities. A complete regional AWT facility could require 20 acres of land or more.

A potentially feasible alternative to a regional AWT facility capable of removing nitrogen from secondary effluent is to construct a regional denitrification facility capable of removing nitrogen from nitrified effluent. This would require the existing WWTF's to construct facilities to nitrify their effluent. The denitrifying process area required, as discussed above, is approximately 2.5 acres. The complete area required to implement this alternative is in the range of 4 to 5 acres to accommodate the regional denitrification process and modifications to the existing Field's Point WWTF necessary to achieve a nitrified effluent. This alternative may be more feasible than the complete nitrification/denitrification AWT facility considering the Narragansett Bay Commission's recent purchase of approximately 7 acres of land adjacent to the existing WWTF. However, this land has been reserved for alternative needs by the NBC as discussed in their Capital Improvement Program report.

The gross area requirements of aeration tanks, clarifiers and denitrifying filters for a regional AWT facility were used to estimate an order of magnitude of construction cost. Similar miscellaneous costs and contingency factors, as previously used for cost analysis at existing WWTF upgrades, were added to the component costs to develop estimated construction costs under both regional AWT scenarios.

The estimated capital cost, including construction cost plus a 35 percent allowance for engineering and contingencies, for a regional separate stage nitrification system and a denitrification system capable of removing nitrogen from secondary effluent is approximately $235 million. This estimate does not include an allowance for the purchase of additional land for a 20 acre facility. It should be noted that even if the cost for an acre of land is $100,000, the total cost for the 20 acres would be $2 million, and would represent only one percent of the total capital cost.

The capital cost for the second regional AWT scenario wherein the regional facility is designed to remove nitrogen from a nitrified effluent is approximately $150 million. This cost does not include the additional costs for upgrading the seven existing WWTF's to achieve a nitrified effluent. Using the single stage nitrification components of estimated costs for upgrading the plants to single stage nitrification and denitrification using downflow filters developed earlier in this section; the total estimated capital cost to upgrade the seven existing WWTF's to single stage nitrification is approximately $30 million. Therefore, the combined construction costs for treatment facility upgrade and a new denitrification facility is approximately $180 million.

The conveyance construction costs developed under Section 2 for transport from the existing treatment plants to a new outfall at Fields Point was estimated at $123 million. This cost must be added to the treatment facility costs developed above, to determine the total construction cost for either Regional AWT scenario. Therefore, the total construction cost for a regional separate stage nitrification and denitrification facility is approximately $358 million similarly, the total estimated construction cost for a regional denitrification facility and upgrading existing treatment plants to achieve nitrification is $303 million.

It is apparent from this analysis that a regional denitrification facility at Field's Point is more feasible than a regional nitrification/denitrification facility considering the cost savings, the process area requirements and the ability to upgrade existing treatment plants.

It is also noteworthy that, from a construction cost basis alone, the two regional AWT scenarios are from 1.3 to 2.0 times the construction cost for upgrading all seven WWTFs to achieve nitrogen removal. This range depends upon the regional facility and existing facility upgrade scenario selected.

6.6 FEASIBILITY AND ADVANTAGES OF OPTION 5

The intent of Option 5 is to upgrade the existing WWTFs discharging into the upper bay area to advanced treatment as an alternative pollution abatement strategy to the regional conveyance options. One set of advanced wastewater treatment discharge parameters was used as a basis to evaluate process needs at all seven plants reviewed in this study. The common effluent parameters included BOD_5, TSS and total nitrogen limits of 10 mg/l, 10 mg/l, and

8-10 mg/l, respectively. A second alternative under Option 5 was evaluated involving the construction of a regional AWT facility at Fields Point in conjunction with the regional conveyance system under Option 2.

Upgrading the existing WWTFs is a technically feasible option. Previous comments in this section for each plant suggest that additions and modifications can be made to the existing facilities to meet the effluent criteria established for this study. Two process alternatives were selected for implementation on the basis of being generally applicable to the seven WWTFs, including single stage nitrification with downflow denitrifying filters and combined stage nitrification-denitrification with dual media filters. On a total present worth basis for all seven plants, considering construction costs and annual O&M costs for 20 years, the second process alternative (combined stage nitrification-denitrification with dual media filters) is approximately 30 percent less costly then the single stage nitrification with downflow filters alternative. A similar percentage of cost savings between process alternatives is experienced on a plant-by-plant basis.

The regional AWT facility at Fields Point alternative, capable of removing nitrogen from the combined effluent of the existing seven secondary treatment facilities, appears to be less feasible than upgrading each plant. There are two major factors leading toward this conclusion. First, the construction cost for the regional conveyance system and the new treatment facility is estimated at $358 million. This is nearly twice the construction cost for upgrading the existing WWTFs. Although O&M costs were not evaluated, it is highly unlikely that sufficient O&M cost savings for a regional plant could be realized to offset the construction cost differences. The second factor reducing the feasibility of this option is the land requirements for the regional AWT facility. It was estimated that nearly 20 acres of land are necessary for a 155 mgd facility. This amount of additional land is not readily available at the Fields Point site. This study is not intended to identify or search for alternative plant sites.

A modification to this alternative potentially increases the feasibility of a regional AWT facility at Fields Point. This involves upgrading the existing WWTFs tributary to Field's Point to a treatment level capable of producing a nitrified effluent, then transporting the nitrified effluent to a new regional denitrification facility at Fields Point. This modification eliminates the need for aeration tankage at the regional facility, thereby reducing the area requirements. This modification would result in an estimated construction cost of $303 million which represents approximately a 15 percent cost savings over the regional nitrification-denitrification facility. This alternative cost estimate allows for construction of nitrification facilities at the seven existing plants, the conveyance system and the regional denitrification facility. Even more significant than the potential 15 percent cost savings is the reduction in process area required for the regional facility. By eliminating the need for aeration tankage the area required at Fields Point is reduced from 20 acres to approximately 5 acres. A plant expansion of size at Field's Point would be much less difficult to implement than the 20 acre expansion alternative.

Several concerns and limitations regarding the feasibility and implementation of this option are as follows:

1. Water quality based criteria for establishing discharge limitations have not been evaluated for the seven WWTFs. Additional engineering evaluations should be conducted to determine what levels of treatment at each facility are required to be consistent with water quality objectives. It is possible that significant cost savings could be realized if it is determined that nitrogen removal requirements associated with water quality objectives differ substantially from the requirements assumed in this study.

2. No consideration of phosphorus loadings was given to the point source discharges in the bay. The AWT facilities were developed with nitrogen removal as the primary objective. Phosphorus removal would result in additional process requirements at additional construction and O&M costs.

3. The implementation of this option for the seven WWTFs in the upper bay may appear to be an inequitable placement of burden for the improvement of Narragansett Bay without similar requirements for the remaining publically-owned treatment works along other portions of the bay. The benefits derived by the service areas, subject to this study, may not be as significant as benefits derived by other communities directly on the bay or in other areas of the bay.

SECTION SEVEN
COMPARISON OF OPTIONS

7.1 GENERAL

In response to the EPA work assignment (No. 5), five pollution abatement strategies were studied for the Narragansett Bay. One of the alternatives involved only the administrative regionalization of selected WWTFs in the Providence River drainage basin. The other four alternatives involved structural modification to wastewater conveyance and/or treatment systems, as follows:

- Regional discharge at Fields Point (Option 2)
- Consolidation of Greenwich Bay discharges (Option 3)
- Regional discharge at Point Judith (Option 4)
- Advanced wastewater treatment at existing WWTFs (Option 5)

With the exception of the regional discharges (Options 2 and 4), each option was developed independently. The regional discharge at Point Judith option is an extension of the conveyance system developed for the regional discharge at Fields Point. However, instead of an outfall at Fields Point, the conveyance system was extended south to a new outfall off Point Judith.

A modification of Option 2 was also analyzed. Option 2A called for the effluent from Woonsocket, BVDC and East Providence to be discharged through an outfall at East Providence, as opposed to being conveyed to Fields Point.

Option 3, the consolidation of Greenwich Bay discharge, was a separate analysis for an isolated area of the Bay and does not directly compare with the larger regional options for the upper bay. The feasibility and advantages of Option 3 for the Greenwich Bay area are discussed in Section 4 of this report.

Options 2, 2A, 4 and 5 present alternative pollution abatement strategies for seven WWTFs that are in, or are tributary to the upper bay area. Therefore, these four options can be compared on the basis of feasibility and costs. A rigid cost-effectiveness analysis of the alternatives is not appropriate given the conceptual nature and the contractural scope of this study.

7.2 COMPARISON OF OPTIONS 2, 2A, 4 AND 5

The most significant comparison of options can be made with respect to cost, however, as described in previous chapters, it is necessary to be cognizant of the limitations of this study. Estimates of costs are preliminary and involved numerous assumptions. The costs developed in this study represent a reasonable order of magnitude for implementing a particular option. These costs are not intended to represent total project cost.

In this section a general comparison of options is made on the basis of costs and some other non-cost factors such as socioeconomics and the environment. In addition, other feasible options and considerations potentially worth further investigation are identified.

As shown in Table 7.1, the pollution abatement option with the lowest present worth is the regional discharge at Fields Point (Option 2). Note that Option 2A is slightly more costly. This is due to higher conveyance costs from BVDC to East Providence. Further analysis of this option should consider whether these additional costs are offset by scheduling and permitting factors. The total present worth of upgrading all seven WWTFs to advanced treatment levels with nitrogen removal is approximately double the present worth of Option 2. Similarly, the regional discharge at Point Judith (Option 4) has nearly 10 times the present worth of Option 2. There would be avoided costs of upgrading the Cranston, Warwick and West Warwick facilities to AWT under Options 2 and 4. This cost savings is estimated to be approximately $83 million.

However, as previously discussed in Sections 3 and 5 the feasibility of Options 2 and 4, although technically feasible, carry a degree of risk which cannot be determined at this level of planning. The risk is primarily in the areas of unforeseen construction issues and environmental permitting situations. The WWTFs upgrade option is considered to carry less of this risk associated with the conveyance system.

A basic non-cost consideration for implementing any of the three options is water quality. At this level of study the only option that clearly improves the quality of the bay is Option 5, upgrading the existing WWTFs. Improving the effluent quality will obviously reduce the pollutant loads from the treatment plants. However, it is yet to be determined that combining discharges from seven (Option 2) or eleven (Option 4) secondary treatment facilities and releasing it into deeper Bay or Sound waters will have a net benefit on the Bay. There is reasonable concern that a large outfall at Fields Point or Block Island Sound will simply relocate and/or concentrate water quality problems. Therefore, these water quality issues must be addressed before recommending a regional discharge over upgrading existing WWTFs.

7.3 MODIFICATIONS TO OPTION 2, 2A, 4 AND 5

Direct implementation of any one of these four options may not be the most cost-effective or appropriate course of action for improving water quality in Narragansett Bay. As previously presented in Sections 3, 5 and 6 of this report, the primary concerns regarding the feasibility of these options are highlighted as follows:

1. The combined discharge from a regional conveyance system will be low in dissolved oxygen and impose a significant oxygen demand in a localized area (Option 2 and Option 4).

2. The land required for a regional AWT facility to remove nitrogen from a combined secondary effluent is approximately 20 acres. Acquiring an additional 20 acres at the Fields Point (Option 5) site does not appear feasible at this time.

TABLE 7-1. SUMMARY OF COSTS (AND AVOIDED COSTS) OF OPTIONS

Option	Description of Option	Estimated Cost of Option (In millions) Capital	O&M	Total Annual	Present Worth	Measures Avoided	Avoided Costs
2	Regional Discharge at Fields Point	$122.8	50.9		173.8	No AWT at Cranston, Warwick or W. Warwick	$83 (M&E)
2A	Regional Discharge at Fields Point and E. Providence	$128.8	57.8		186.7		
3	Consolidation of Greenwich Bay Discharges	$280.2	16.3		296.5		
4	Regional Discharge at Point Judith	$916	517.7		1433.7	No AWT at Cranston, Warwick or W. Warwick	$83 (M&E)
5	Advanced WWT at existing WWTFs						$83 (M&E)
	• SSN & Denitrifying Filters	$231.2	19.3	177.9	409.1	Cranston, Warwick and West Warwick AWT already planned	$83 (M&E)
	• Conb. Stage & Dual Media Filters	170.9	14.2	130.8	301.7		
	Regional AWT at Fields Point						
	• Nit./Denit. Facility	$358					
	• Denit. Fac. & WWTF Upgrade	$303					

3. There are a number of potential water quality concerns which cannot be addressed in this report due to the limitations of scope. However, these potential concerns, including the adequacy of the Narragansett Bay channel for a regional outfall and the impact of flow changes in the Pawtucxet River upon water quality need to be addressed. These issues could be addressed through more detailed analysis of a hybrid option.

One possible hybrid option is presented below for general concept only. It has not been developed to the level of Options 2, 4 and 5.

A combination of Option 2 and Option 5 may result in a hybrid option significantly more feasible than either option alone. Rather than constructing long pipelines and pump stations for conveying effluent from Woonsocket, Warwick, West Warwick and Cranston to Fields Point, it may be more beneficial to leave their outfalls in place. These four facilities could be upgraded to advanced wastewater treatment in response to local receiving water needs. Secondly, instead of conveying the east shore effluents from BVDC and East Providence across the river then back out to the Bay at Fields Point, construct an outfall from the east shore directly into the bay. Then, if necessary, consider extending the existing Fields Point plant outfall to deeper water. It would then remain to be determined whether or not discharging the secondary effluent from BVDC, Fields Points and East Providence, into deeper water, would meet overall water quality goals set for the Bay.

The benefits of this hybrid option over Option 2 and Option 5 are as follows:

1. The total present worth of constructing the conveyance system from Woonsocket to BVDC is $48 million, whereas, the similar cost for AWT upgrade to provide nitrification-denitrification with dual media filters at Woonsocket is $40.8 million. This represents a potential cost savings of almost 15 percent.

2. Upgrading the West Warwick, Warwick and Cranston WWTF to AWT while leaving the outfalls in place should contribute to improving the Pawtuxet River quality.

Deep tunneling was proposed as an alternative construction method to the dual pipe system described for conveying effluent from Fields Point to Point Judith in Option 4. Although the tunneling costs generally would run 20 to 50 percent more than conventional pipeline construction, the non-cost benefits such as having fewer pump stations and less disturbances during construction should be evaluated in a thorough cost-effectiveness analysis before a tunnel alternative is eliminated from further consideration.

The intent of this report was to provide an order of magnitude of cost and to review the technical feasibility of four pollution abatement strategies for Narragansett Bay with specific emphasis on the upper bay area. In addition, an assessment of administrative feasibility was made for the formulation of a combined regional sewerage authority in the service area for seven existing WWTFs. In accordance with the requirements of this study, no specific

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recommendations regarding implementation of options and future courses of action are offered. The information presented in this report is part of an ongoing effort involving the U.S. Environmental Protection Agency and the Narragansett Bay project.

APPENDIX A

COST CURVES

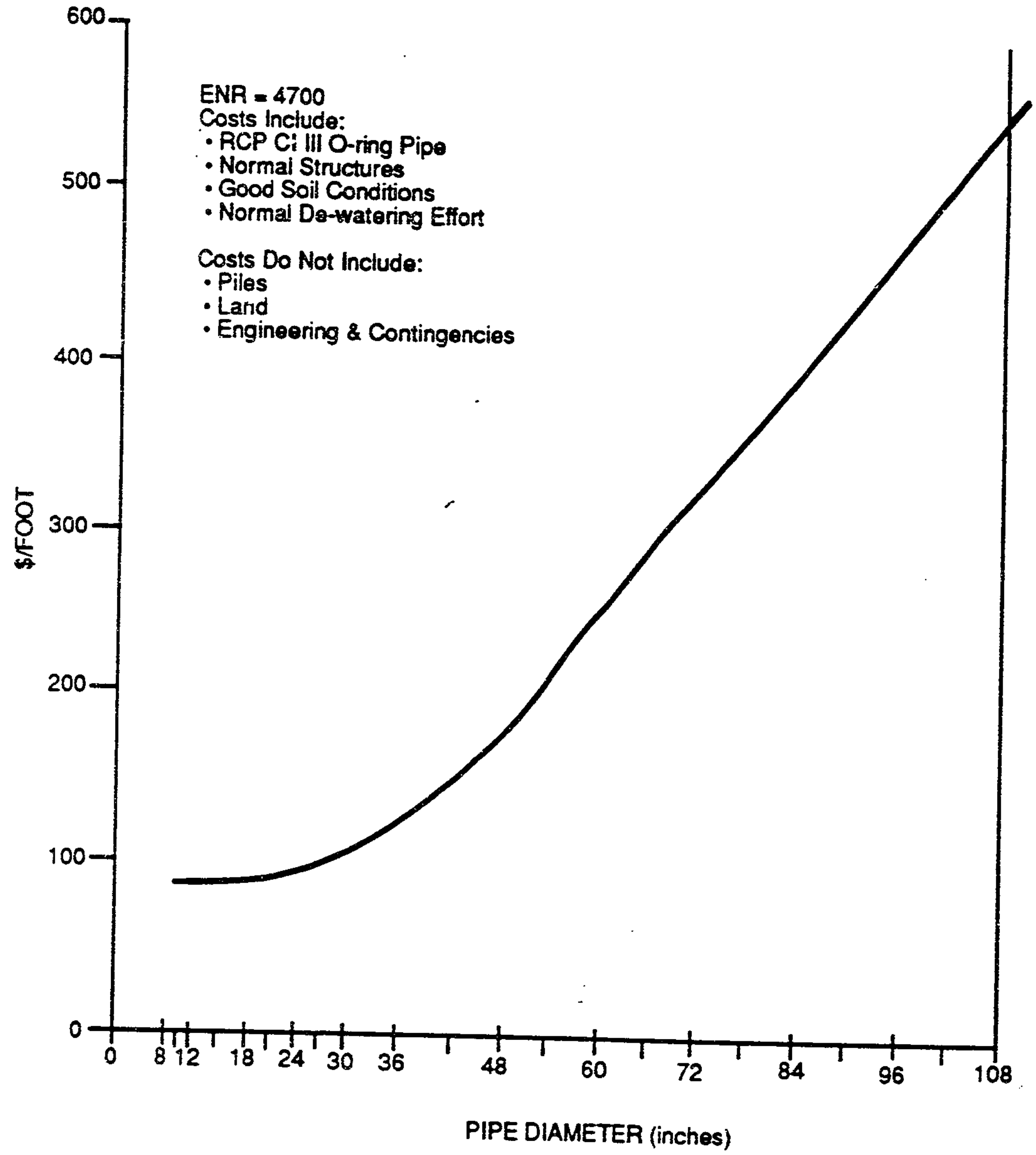

FIGURE A-1. BASE SEWER CONSTRUCTION COST

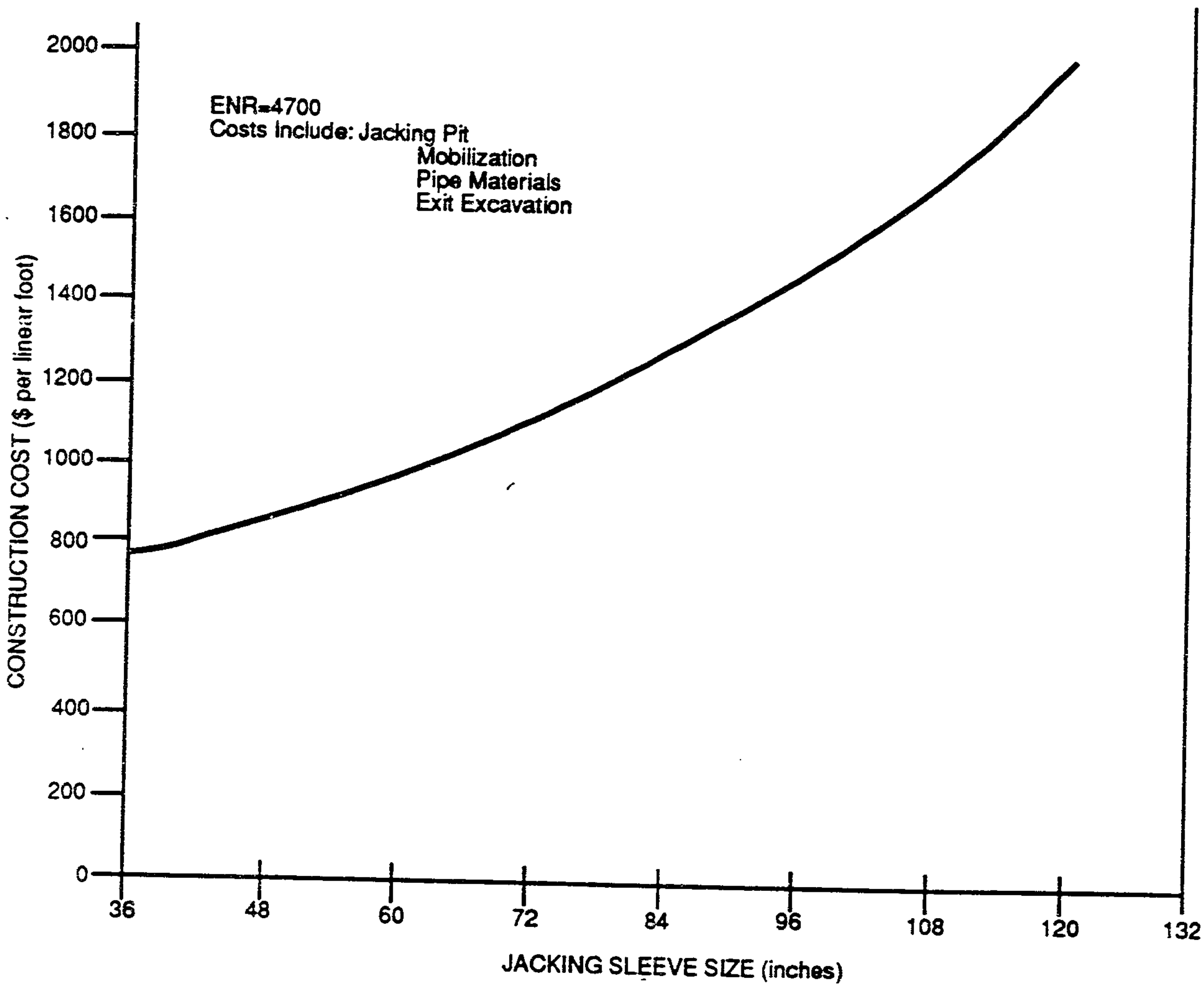

FIGURE A-2. PIPE JACKING COSTS

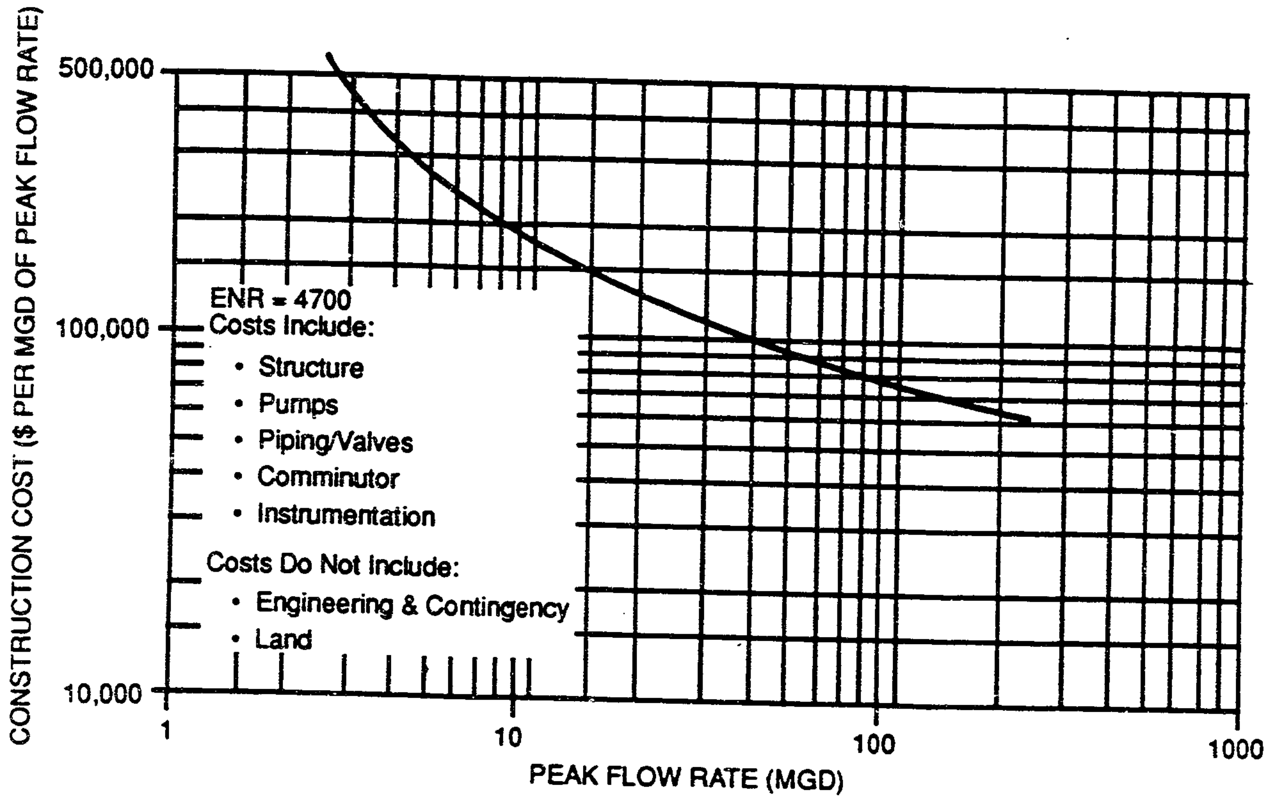

FIGURE A-3. SEWAGE PUMPING STATION - CAPITAL COST

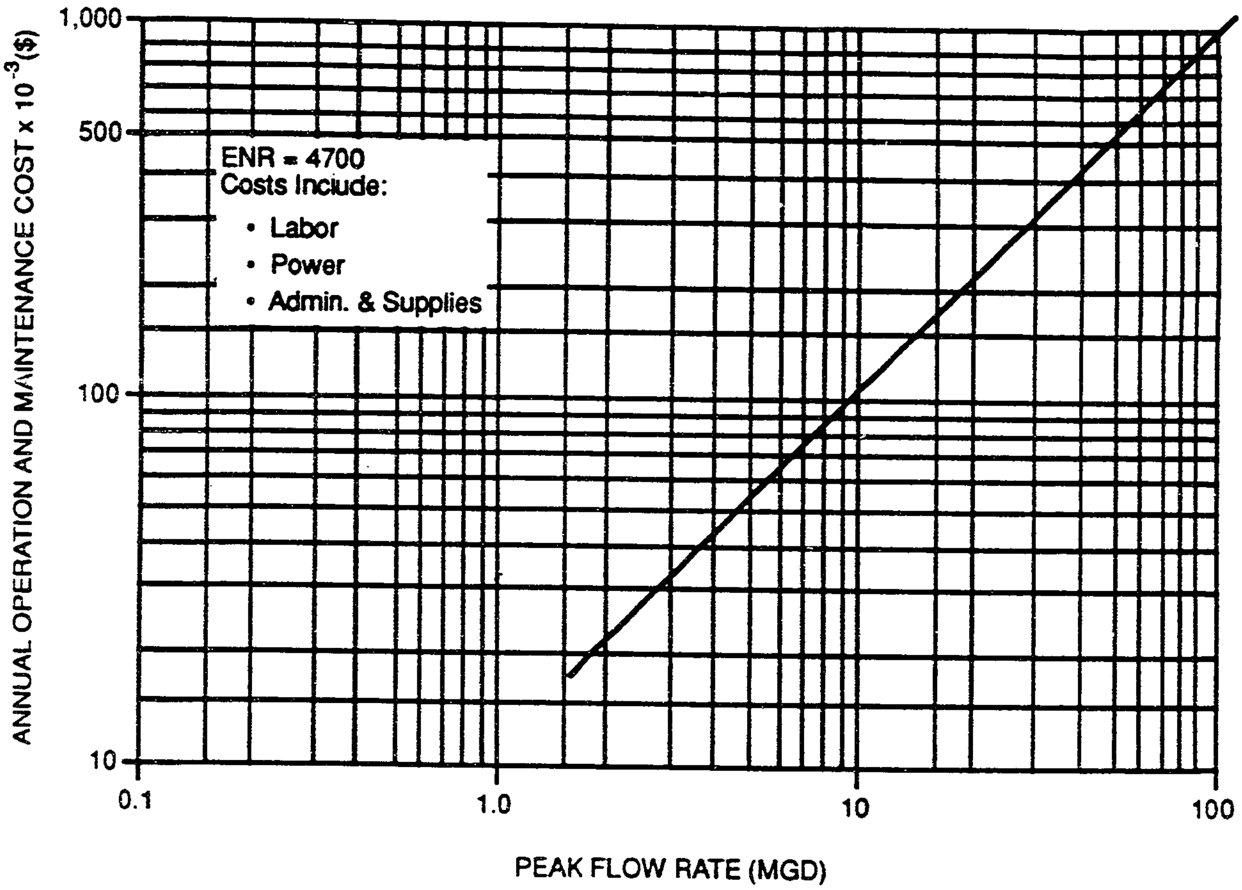

FIGURE A-4. SEWAGE PUMPING STATION - ANNUAL OPERATION AND MAINTENANCE COST

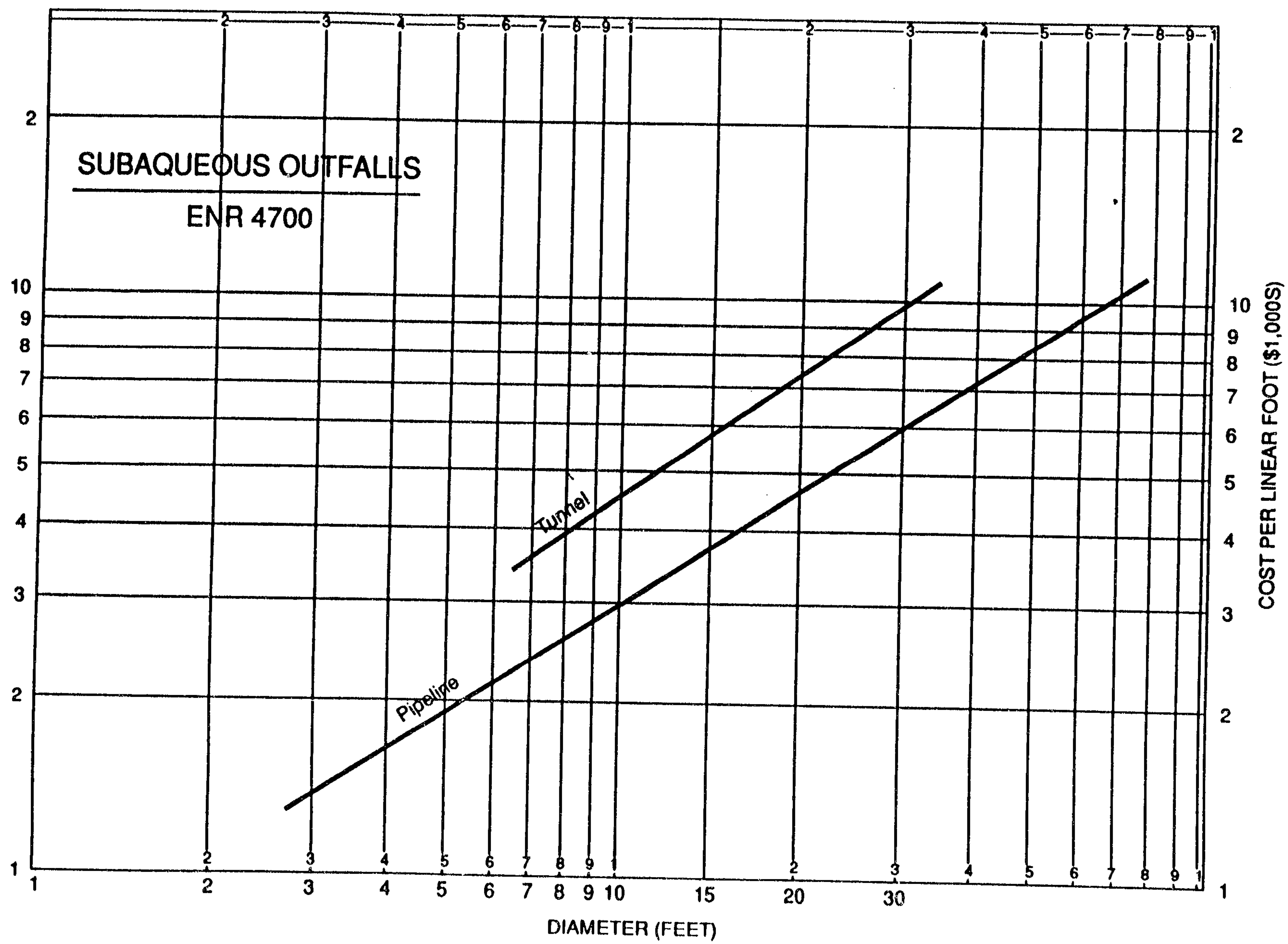
SUBAQUEOUS OUTFALLS
ENR 4700
Tunnel
Pipeline
DIAMETER (FEET)
COST PER LINEAR FOOT ($1,000S)

FIGURE A-5.

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