Volume 3 of 3
Supporting Documentation Report

Wastewater Conveyance Feasibility Investigation, Cranston, RI

May 1995

US Army Corps
of Engineers
New England Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	May 1995	Feasibility Study

4. TITLE AND SUBTITLE

Volume 3 of 3
Wastewater Conveyance Feasibility Investigation, Cranston, RI
Supporting Documentation Report

5. FUNDING NUMBERS

6. AUTHOR(S)

Department of the Army
Corps of Engineers, New England Division

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Department of the Army
Corps of Engineers, New England Division
Waltham, Massachusetts 02254-9149

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Department of the Army
Corps of Engineers, New England Division
Waltham, Massachusetts 02254-9149

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release
Distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The Water Resources Development Act of 1990, Public Law 101-640 authorized the Corps of Engineers (Corps), in consultation with the Environmental Protection Agency (EPA), to conduct a wastewater conveyance feasibility study for transporting contaminants from the Central Landfill site and other sources of pollution in Rhode Island to a wastewater treatment facility in Cranston, Rhode Island, through the use of a regional connector system.

The study strategy was to develop and assess options to address future wastewater conveyance needs. Sites are located in Cranston and Johnston, Rhode Island. Several options were identified based on analysis of the city's existing sewer system, review of the city's wastewater flow projections, and coordination with the city. The study options include a combination of improvements to the existing system and construction of new sewers and pumping stations.

14. SUBJECT TERMS

Wastewater Conveyance, Sewer Interceptor

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

Wastewater Conveyance Feasibility Investigation
Cranston, Rhode Island

INDEX OF VOLUMES

VOLUME 1

MAIN REPORT AND ENVIRONMENTAL ASSESSMENT

VOLUME 2

APPENDIX A	Task 12b - Proposed Project, Hydraulic Analysis
APPENDIX B	Task 12d - Proposed Project, Pumping Station Mechanical Design
APPENDIX C	Task 12a - Proposed Project, Geotechnical Evaluation
APPENDIX D	Task 12c - Proposed Project, Pumping Stations and Sewers, Civil Engineering Design
APPENDIX E	Task 13b - Proposed Project, Real Estate Costs

VOLUME 3

APPENDIX F	Task 3 - Identification of Wastewater Flows
APPENDIX G	Task 4 - Review of Information on Cranston's Wastewater Treatment Facility Capacity
APPENDIX H	Task 5 - Identification of Existing Sewer System Capacity
APPENDIX I	Task 7 and 9 - Report on Feasibility Level Design and Cost Estimates for Wastewater Conveyance Options
APPENDIX J	Task 10b - Socio/Economic Assessment
APPENDIX K	Task 10c - Water Quality and Hydrology Assessment
APPENDIX L	Task 10d - Archaeological/Historic Assessment
APPENDIX M	Task 10e - Ecological Assessment

Wastewater Conveyance Feasibility Investigation
Cranston, Rhode Island

VOLUME 3
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APPENDIX F

Task 3 - Identification of Wastewater Flows

Section 117, Cranston Rhode Island
Wastewater Conveyance System Feasibility Investigation

Feasibility Report Appendix
Task 3 - Identification of Wastewater Flows

Revised Draft

Department of the Army
Corps of Engineers, New England Division
Waltham, Massachusetts

January 1994
(additional text modifications on May 31, 1994)

TABLE OF CONTENTS

	Page
INTRODUCTION	F-1
POPULATION PROJECTIONS	F-1
INDUSTRIAL AND COMMERCIAL LAND USE	F-4
STATE INSTITUTIONAL LAND USE	F-6
LANDFILLS	F-7
JOHNSTON INDUSTRIAL AREA	F-9
WASTEWATER FLOW FACTORS	F-10
PROJECTED AVERAGE DAY WASTEWATER FLOW	F-13
PROJECTED FLOWS TO WASTEWATER COLLECTION SYSTEM	F-15
EVALUATION OF WATER CONSERVATION	F-16
REFERENCES	F-18

ATTACHMENT 1 - WASTEWATER FLOW CALCULATIONS

ATTACHMENT 2 - WEST CRANSTON TRUNK SEWERS

LIST OF TABLES

		Page
Table 1	Projected Total Population by Pump District	F-3
Table 2	Industrial and Commercial Zoning by Pump District	F-5
Table 3	Population Forecasts for Howard Center	F-6
Table 4	Projected Average Day Wastewater Flow by Service Area	F-13
Table 5	Projected Average Day Wastewater Flow by Category	F-14
Table 6	Potential Household Water Savings with Water Efficient Fixtures	F-16

LIST OF FIGURES

		Follows Page
Figure 1	Study Sites and Pump Station Districts	F-1

INTRODUCTION

The wastewater conveyance system feasibility study focuses on specific areas in Cranston and Johnston. The study sites are industrial and residential land in west Cranston; the Howard Center in east Cranston; Central, Vinagro, and Capuano Landfills; and industrial Land in southern Johnston (Figure 1).

This report provides a brief review of the the projection of wastewater flows utilized in the feasibility study. The population projections and the majority of the wastewater flow projections for the study were provided by the City of Cranston's engineering consultant, Tutela Engineering Associates, Inc. in a letter report to the Corps (February 25, 1993). These projections were developed for the city's Draft Wastewater Facility Plan. However, three sites considered in the feasibility study (the Vinagro and Capuano landfills, and the Johnston industrial land) are not considered in the city's Facility Plan and estimates for future flows for these sites were developed by the Corps. A summary of the wastewater flows to be used in the feasibility study was provided to the city in a draft memorandum dated March 23, 1993. This report is an expansion of that memorandum and will eventually be incorporated into the final feasibility report.

This report also provides information on water conservation measures.

POPULATION PROJECTIONS

According to the 1990 U.S. Census there were 76,060 people in the city of Cranston. Tutela Engineering Associates, Inc. (Draft Facility Plan, April 1992) projects a population of 83,020 people by 2015 and a population of 91,370 people by the year 2045.

In order to project population growth, two areas were considered, west and east Cranston, as separated by I-295. Populations in the two areas were projected to 2015 and 2045 (build-out condition). Populations in 2015 was estimated by straight line interpolation. West Cranston includes the majority of the expected residential growth and east Cranston includes the majority of the existing population.

The city recognizes that the most important issue in the next two decades concerning future land use patterns will be the management of growth in west Cranston in a manner that will balance the objectives relating to housing, economic development, natural resources, open space, public services, and facilities. The objectives of the city in west Cranston relative to residential development is to promote actions that protect natural resources and serve a variety of housing needs (City of Cranston, Comprehensive Plan, 1992).

In order to achieve a balance between open space and continued growth in west Cranston, the City Comprehensive Plan suggests that at total build-out west Cranston contain about 5,840 residential units. The plan also recommends 500 acres of open space (exclusive of wetlands) in west Cranston be preserved through implementation of the following strategies.

The first strategy is direct preservation of 124 acres of open space through acquisition, easement, or similar method. Residential development that would have occurred on this land is transferred to the development of a 120-acre Village Center at the intersection of Pippin Orchard Road and Scituate Avenue. The Comprehensive Plan suggests 180 residential units and associated community facilities (school, library, post office, bank, and convenience shopping) be located at the Village Center.

Also the Comprehensive Plan proposes protecting another 370 acres of developable land by promoting clustering of new residential developments in west Cranston. Under this plan the same number of units would be built on a tract of land, however the individual units would have smaller lots and 25 percent of the tract would be preserved as "common open space".

Based on the Comprehensive Plan goals, Tutela Engineering Associates, Inc. estimated that at total build-out (2045), west Cranston will contain a population of about 17,500 (assuming 5,840 dwelling units and 3 persons dwelling unit). Linear growth was assumed from 1990 to 2045 and the population for 2015 was interpolated to be 11,640 people. Currently, the population in west Cranston is about 6,800 (Tutela Engineering Associates, Inc., Letter Report, February 25, 1993).

East Cranston is not expected to undergo the same development pressure as west Cranston. In east Cranston the main concern is maintenance of existing housing units and preservation of housing resources for a wide range of income and housing needs (City of Cranston, Comprehensive Plan, 1992). Population in east Cranston is assumed to increase to a build-out condition by the year 2045 of 73,870 people assuming an increase of 6.5% from the 1990 estimated population of 69,304 people, an additional 4,566 people (Tutela Engineering Associates, Inc., Letter Report, February 25, 1993).

The Wastewater Facility Plan and the Feasibility Study require population projections by wastewater pump station district to determine future collection system needs. The methodology described above was applied to individual pump station districts by Tutela Engineering Associates, Inc. to determine future contributing populations. Projection of total population by wastewater pump station district is included in Table 1.

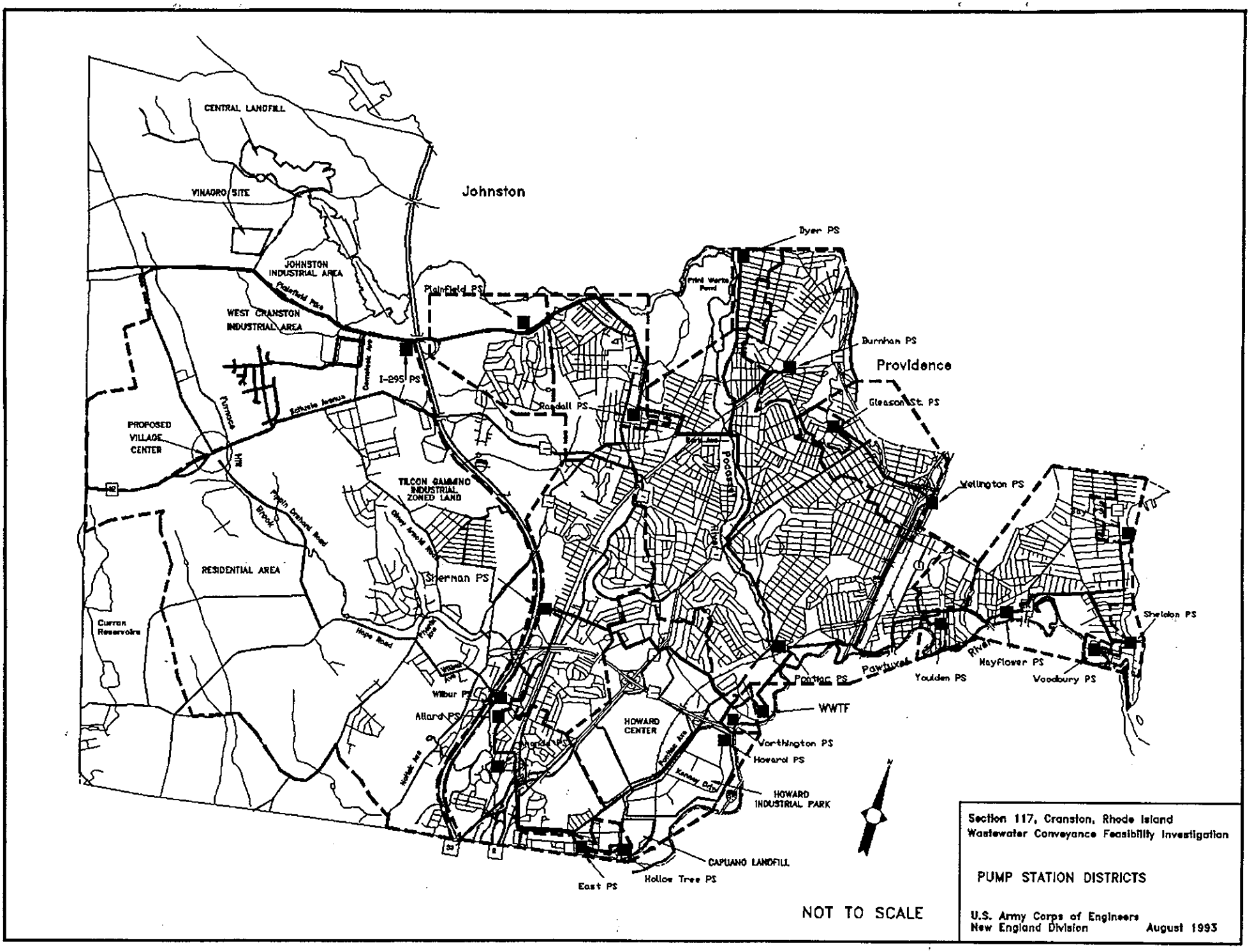

CENTRAL LANDFILL
VINAGRO SITE
Johnston
JOHNSTON INDUSTRIAL AREA
Plainfield Pike
WEST CRANSTON INDUSTRIAL AREA
Plainfield PS
I-295 PS
Cemetery Ave
Furnace Hill
Eclipse Avenue
PROPOSED VILLAGE CENTER
TILCON GAMMINO INDUSTRIAL ZONED LAND
Pippin Orchard Road
Brook
Olney Arnold Road
RESIDENTIAL AREA
Sherman PS
Curran Reservoirs
Hope Road
Wilbur Ave
Wilbur PS
Allard PS
Hollak Ave
HOWARD CENTER
Pontiac Ave
Kenney Drive
HOWARD INDUSTRIAL PARK
CAPUANO LANDFILL
East PS
Hollow Tree PS
Dyer PS
Print Works Pond
Burnham PS
Providence
Randall PS
Gleason St. PS
Pocasset River
Wellington PS
Sheldon PS
Pontiac PS
Pawtuxet River
Youlden PS
Mayflower PS
Woodbury PS
WWTF
Worthington PS
Howard PS
NOT TO SCALE
Section 117, Cranston, Rhode Island
Wastewater Conveyance Feasibility Investigation
PUMP STATION DISTRICTS
U.S. Army Corps of Engineers
New England Division
August 1993

FIGURE 1

Table 1. Projected Total Population by Pump District

	Population (1)(2)		
	1990	2015	2045
West Cranston			
Wilbur District	0	5,405	11,890
I-295 District	570	1,775	3,220
Unsewered	6,186	4,460	2,390
Subtotal	6,756	11,640	17,500
East Cranston			
Woodbury District	266	274	284
Seaview District	45	46	48
Sheldon District	1,019	1,051	1,090
Bay District	970	1,001	1,037
Mayflower District	7,626	7,867	8,155
Youlden District	996	1,027	1,065
Gleason District	457	472	489
Wellington District	3,551	3,663	3,797
Dyer District	670	691	717
Burnham District	4,501	4,643	4,813
Plainfield District	1,575	1,625	1,684
Randall District	3,063	3,160	3,276
Hollow Tree District	92	95	99
East District	615	635	658
Amanda District	106	110	114
Allard District	2,134	2,201	2,282
Sherman District	4,484	4,625	4,795
Worthington District	0	0	0
Howard District	3,500	3,500	3,500
Siphon District	1,244	1,283	1,330
Pontiac District	32,390	33,411	34,637
Subtotal	69,304	71,380	73,870
City Total	76,060	83,020	91,370

(1) Pump district population is population tributary by gravity to pump station.

(2) Source: Tutela Engineering Associates, Inc., Letter Report, February 25, 1993.

INDUSTRIAL AND COMMERCIAL LAND USE

Tutela Engineering Associates, Inc. reports that the city of Cranston has zoned about 1,800 acres total for industrial use and about 529 acres total for commercial use.

About a third of the area for industrial development is located in west Cranston in two areas, one area is along Plainfield Pike and Comstock Parkway and the other area is along Natick Avenue (Tilcon Gammino). In east Cranston the Howard Industrial Park contains about ten percent of the total industrial land.

The city's goal is to ensure that sufficient land is zoned and provided with adequate infrastructure to provide for the city's future industrial development needs. The city's Comprehensive Plan states the city's desire to protect the capacity and integrity of roads, sewers, and water systems servicing the Howard and northwest Cranston industrial parks.

Most of the city's commercial land is currently located in east Cranston. However, the city has plans to develop a Village Center in northwest Cranston. The city's goal is to ensure new and expanded commercial development along major roadways exhibit a high standard of design and are compatible with the existing roadway functions and adjacent residential neighborhoods.

A tabulation of current commercial and industrial zoning by pump district is provided in Table 2. For purposes of projecting wastewater flows from these areas for the Facility Plan, Tutela Engineering Associates, Inc. assumed about two-thirds development by 2015 and full development of these lands by 2045, except at Howard Industrial Park where it was assumed all of the industrial land would be fully utilized by 2015.

Table 2. Industrial and Commercial Zoning by Pump District

	Industrial (1) (acres)	Commercial (1) (acres)
West Cranston		
Wilbur Pump District	139.5	0.0
I-295 District	469.8	0.0
Subtotal	609.3	0.0
East Cranston		
Woodbury District	0.0	0.0
Seaview District	0.0	0.0
Sheldon District	0.0	17.6
Bay District	13.1	2.9
Mayflower District	100.7	34.6
Youlden District	7.4	0.0
Gleason District	20.4	0.0
Wellington District	38.2	16.1
Dyer District	13.5	10.8
Burnham District	180.6	4.0
Plainfield District	0.0	56.4
Randall District	70.8	22.0
Hollow Tree District	3.7	0.0
East District	0.0	0.4
Amanda District	0.0	0.0
Allard District	15.8	54.9
Sherman District	0.0	13.3
Worthington District	72.6	0.0
Howard District	190.5	0.0
Siphon District	19.8	61.4
Pontiac District	446.4	234.6
Subtotal	1,193.5	529.0
City Total:	1,802.8	529.0

(1) Source: Tutela Engineering Associates, Inc., Letter Report, February 25, 1993.

STATE INSTITUTIONAL LAND USE

The "Howard Center" is on about 450 acres of institutional land in east Cranston near Route 37, Route 2, and Pontiac Avenue. The center consists of about 94 buildings some of which are prisons and hospitals, accommodating adult and juvenile criminal offenders, geriatric/chronically ill, substance abusers, homeless, mentally ill, multiple handicapped, and the criminally insane.

The State of Rhode Island, Office of Strategic Planning is currently drafting a strategic master plan for use of the buildings and lands at the facility. Preliminary information on projected clients and employees for different development scenarios is contained in Table 3.

Scenario I considers utilizing present buildings to program capacity. Scenario II considers utilizing present buildings to program capacity plus the addition of a courthouse and a substance abuse facility. Scenario III considers utilization of vacant buildings as general office space. Scenario IV considers double bunking in medium security. No decisions have been made regarding any of the potential expansions, additions or utilizations of vacant space. None of the scenarios are mutually exclusive.

Table 3. Population Forecasts for Howard Center

		Scenarios (1)			
	Current (1)	I	II	III	IV
Employees					
first shift	2,947	2,977	3,190		
second shift	656	666	670		
third shift	352	357	360		
Total	3,955	4,000	4,220	add 1,300 employees	
Volunteers	55	55	55		
Visitors	747	772	1,777		
Clients	3,765	4,280	4,315		add 400 clients

(1) Information from memorandum State of Rhode Island, Department of Administration, Division of Planning, Office of Strategic Planning, August, 14, 1992.

As noted in Cranston's Comprehensive Plan "the continued expansion of the facilities at the Howard Center have become an issue of concern to the city, especially as existing buffers - between institutional uses in the complex and residential and commercial uses outside it have diminished". The city's goal is to ensure that reuse, reorganization and/or disposition of State facilities do not result in either physical expansion of the complex or more intensive use for correctional purposes, and are consistent with community development needs and objectives. A city policy related to this goal is to establish a cap on the total prison population based on current building capacity.

LANDFILLS

Central Landfill. The landfill consists of a 154 acre parcel within a 610-acre parcel called the "Central Landfill" operated by the Rhode Island Solid Waste Management Corporation (RISWMC).

This landfill is located north of Cranston in Johnston on Green Hill Avenue. The site was first used as a landfill in the 1960's, and it accepted liquid wastes in the 1970's. The site consists of two areas, the operational area and the landfill area. The operational area contains the materials recycling facility (MRF), the commercial recycling area (e.g. refrigerators, stoves, tires, waste oil, auto batteries), the scale house, the methane recovery facility, a tree chipping area and composting facility. The landfill area is being utilized in sections. One section consists of recent solid waste disposal and past solid waste disposal. This section includes the former liquid hazardous waste disposal site, approximately one-third acre. A new section is constructed outside the border of the other section and will be used for future solid waste disposal.

In anticipation of wastewater disposal needs at the site, RISWMC entered into a contract in 1988 with the City of Cranston to dispose of 400,000 gallons per day (gpd) of leachate and other wastewater flows from the landfill into Cranston's sewer system. The RISWMC has built a connection to the city sewer in Plainfield Pike. Plans are underway to collect and pretreat leachate from the landfill and discharge the effluent. The city has recently, August 27, 1992, issued RISWMC an industrial wastewater discharge permit to allow 100,800 gpd of discharge.

In addition, groundwater contamination at the site as a result of landfill refuse, and chemical sludges and liquids in the former hazardous waste disposal area is addressed in a Remedial Investigation and Feasibility Study (RI/FS) conducted by EPA under the"Superfund Program". The remedial design phase is expected to begin in 1995. The proposed plan includes extracting contaminated groundwater from the "hot spot" and pretreating it before it is discharged to either on-site surface water or to the Cranston sewer system.

The landfill permit with the Town of Johnson expires in 1994, however RISWMC is negotiating with the town for a 20-year extension.

Vinagro Landfill. This is about a 40-acre site also located on Green Hill Avenue in Johnston. The site includes a closed landfill, a hog farm, a recycling facility, and demolition debris facility. On-site groundwater monitoring wells have been found to contain volatile organic compounds. The Rhode Island Department of Environmental Management has ordered some corrective actions at the site, including covering the landfill, however, treatment of groundwater below the site has not been required. Debris was disposed of at this site during the 1980's, but it was not a licensed landfill at the time.

This site is also under investigation by the EPA's Superfund program, site assessment group. The EPA completed the Screening Site Inspection Report in October 1989 and determined the site should go to the next step in the evaluation process.

Future groundwater remedial actions at the site are not known at this time. If actions were to include consideration of pumping, pretreating contaminated groundwater, and discharging the effluent to the Cranston collection system, wastewater effluent studies and a city industrial discharge permit would be required. Also the Vinagro Landfill, although adjacent to the Central Landfill, is not included in Cranston's designated service area and is not considered in the city's on-going Facility Plan. A tie-in of this area would require an amendment to the Facility Plan and a major modification to the city's approved pretreatment program. (Letter from RI DEM, dated February 16, 1993.)

Capuano Landfill. The Capuano Landfill otherwise known as the Cranston Sanitary Landfill is about a 47-acre closed landfill located on Pontiac Avenue near the Pawtuxet River in Cranston. The landfill began operation in 1943 for disposal of domestic waste and eventually began accepting industrial wastes till operation ceased in the 1980s. Reportedly hazardous wastes were disposed of at the landfill during the 1970's. Volatile organic compounds and inorganic elements have been detected in groundwater samples from monitoring wells located on-site. The Rhode Island Department of Environmental Management has ordered some corrective actions at the site, including capping the landfill, however, treatment of groundwater below the site has not been required.

This site is also under investigation by the EPA's Superfund, site assessment group. The EPA completed the Screening Site Inspection Report in October 1982 and determined the site should go on to the next step in the evaluation process.

Future groundwater remedial actions at the site are not known at this time. If they were to include consideration of pumping and pretreating contaminated groundwater and discharging the effluent to the Cranston sewerage system, wastewater effluent studies and a city industrial discharge permit would be required.

JOHNSTON INDUSTRIAL AREA

This area is about a 100-acre site in Johnston located along Plainfield Pike at the Cranston city line and west of Route I-295. The Town of Johnston "Comprehensive Community Plan", Draft, 1991 identifies this area as future industrial zoned land. Further, the plan identifies that municipal water is presently available to the site, however municipal sewer service is not available.

The plan notes that arrangements would be necessary to tie into the Cranston collection system. However, the town has not formally approached the city to request such a sewer tie-in. Similar to the Vinagro Landfill, this site is not included in Cranston's designated service area and is not being considered in the city's on-going Facility Plan. A tie-in of this area would require an amendment to the Facility Plan and a major modification to the city's approved pretreatment program.

The city of Cranston would like to encourage development in this area of Johnston compatible with the light industrial development occurring along Plainfield Pike in Cranston. However, the city is concerned that the town of Johnston is allowing strip commercial development to occur in this area. The Cranston Comprehensive Plan, states: "that the city should work with the town to ensure that development on the northerly side of the Plainfield Pike enhances and reinforces the image and the function of the Pike to the benefit of both communities. In this regard, Cranston should utilize its available water and sewer capacity to further its planning objectives, and should not provide infrastructure assistance for land uses which detract from these objectives." The feasibility study assumes the communities will work together to develop compatible industrial use of the land in this area.

WASTEWATER FLOW FACTORS

In order to calculate future wastewater flow from various areas of the city, Tutela Engineering Associates, Inc. (Letter Report February, 25, 1993) selected the following wastewater flow factors.

Residential

The residential wastewater flow projections are made based on a wastewater flow factor of 100 gallons per capita per day (gpcd). The residential flow generation rate of 100 gpcd is based upon actual water consumption rates in the city. Outlined below is the base data used to select the residential generation rate (Letter from Tutela Engineering Associates, January 29, 1993).

	1988	1990
Residential Water Use (gallons)	218,442,500	228,805,302
Estimated Service Population	4,290	5,182
Water Use (gpcd)	140	121
Percent Wastewater	0.85	0.85
Wastewater Generated (gpcd)	119	103

Selected Residential Wastewater Flow Factor = 100 gpcd

Industrial

The industrial wastewater flow projections for land in northwest Cranston are based on a wastewater flow factor of 1,300 gpd/acre. This area is located along Plainfield Pike and Comstock Parkway and primarily supports light industries. Outlined below is the data used to select the industrial generation rate (Tutela Engineering Associates, Inc., Letter Report, February 25, 1993).

Current Northwest Cranston Wastewater Flow

Estimated Industrial Flow (gpd)	311,650
Estimated Industrial Development (acres)	234.9

Selected Northwest Cranston Wastewater Flow Factor = 1,300 gpd/acre

The wastewater flow factor of 1,300 gpd was also used by the Corps to project the flows for the industrial area in Johnston adjacent to the northwest Cranston area. It is assumed that this area would support development similar to that occurring in northwest Cranston.

The industrial wastewater flow projections for industrial land in other parts of Cranston are based on a selected wastewater flow factor of 5,770 gpd/acre. (Tutela Engineering Associates, Inc., Letter Report, February 25, 1993)

Commercial

The commercial wastewater flow projections are based on a selected wastewater flow factor of 3,780 gpd/acre. (Tutela Engineering Associates, Inc., Letter Report, February 25, 1993)

Infiltration

Estimates of projected infiltration are based on a factor of 40 gallons per capita per day except for calculation of flows in northwest where a factor of 250 gpd/inch-mile of sewer was selected. The selection of 40 gpcd is based on EPA guidelines for allowable infiltration. The selection of 250 gpd/inch-mile for northwest Cranston is based on a recommendation by the Rhode Island Department of Environmental Management to Tutela Engineering. (Tutela Engineering Associates, Inc., Letter Report, February 25, 1993)

Institutional

The wastewater flow projections for the Howard Center are based on an actual average annual wastewater flow of 1.0 mgd as estimated by the city for sewer billing purposes (Tutela Engineering Associates, Inc., Draft Facility Plan, April, 1992). This wastewater flow rate appears to be consistent with the recorded water use for the center of 1.35 mgd from August 1991 thorough July 1992. (Water consumption records provided by Paul Bowen, Facilities and Maintenance.) Some of the water supplied to the center is used by the central power plant for steam generation. Tutela Engineering Associates, Inc. selected an institutional wastewater flow rate of 1.1 mgd for 2015 and assumed the flow from the Center would not increase beyond this amount.

Landfills

Existing information obtained from state and federal agencies on landfill sites in the study area (Central, Vinagro, and Capuano Landfills) was reviewed to determine if these studies provided an estimate of future discharges to the Cranston collection system.

Studies of Central Landfill have shown definite groundwater contamination and EPA plans some form of remediation. In July 1992, GZA Inc. prepared a draft feasibility report for Central Landfill which discusses groundwater treatment and pumping solutions which could treat flows and discharge them to surface water or to the Cranston collection system. The GZA feasibility report uses 216,000 gpd for estimating long term operation and material costs. In addition to possible groundwater pumping Central Landfill may also generate flows from its leachate collection system, gas recovery system, and proposed resource recovery facility. The Rhode Island Solid Waste Management Corporation and the city have entered into an agreement to accept a wastewater discharge of 400,000 gpd from Central Landfill into the Cranston sewer system. Total landfill needs are not expected to exceed the 400,000 gpd limit.

Current remediation actions at Vinagro and Capuano landfills do not include groundwater pumping and treatment, so reviewed reports did not contain information on this possibility. In estimating groundwater pumping flows for these landfills, it was assumed that the required pumping would be that necessary to keep the plume from moving off site. This would be equal to groundwater movement under the site. Assuming minimum streamflow is related to groundwater movement, an estimate of 0.001 cubic feet per second per acre of groundwater flows was used. This was derived from USGS Geological Survey Professional Paper "Drainage Density and Streamflow" which measured the average minimum monthly streamflow in 15 small eastern drainage areas. Estimated flows for Vinagro are 35,000 gpd, and 60,000 gpd for Capuano.

PROJECTED AVERAGE DAY WASTEWATER FLOW

Wastewater flow projections for study sites are grouped into three service areas:

Service Area 1 includes residential and industrial lands in northwest Cranston, the proposed Village Center at the intersection of Pipin Orchard Road and Scituate Avenue, proposed industrial land in Johnston, and Vinagro and Central Landfills.

Service Area 2 includes residential and industrial lands in west Cranston south of Scituate Avenue.

Service Area 3 includes the Howard Center, Howard Industrial Park, and Capuano Landfill.

Average day wastewater flow estimates are based on population projections, land use, and wastewater flow factors discussed in the preceding sections of the report. Projected flow by service area is reported in Table 4 and reported by category in Table 5.

Table 4. Projected Average Day Wastewater Flow by Service Area

	2015 gpd	2045 gpd
SERVICE AREA 1		
Northwest Cranston Residential	177,500	322,000
Northwest Cranston Industrial	415,175	610,740
Village Center Commercial	23,000	34,050
Central Landfill	400,000	400,000
Vinagro Landfill	35,000	35,000
Johnston Industrial	87,000	130,000
Infiltration	30,820	46,000
Subtotal	1,168,495	1,577,790
SERVICE AREA 2		
South of Situate Ave. Residential	540,500	1,189,000
South of Scituate Ave. Industrial	547,342	804,915
Infiltration	216,200	475,600
Subtotal	1,304,042	2,469,515
SERVICE AREA 3		
Howard Center	1,100,000	1,100,000
Howard Industrial	1,084,760	1,084,760
Capuano Landfill	60,000	60,000
Infiltration	72,000	72,000
Subtotal	2,316,760	2,316,760
Total	4,789,297	6,364,065

Table 5. Projected Average Day Wastewater Flow by Category

	2015 gpd	2045 gpd
Residential		
Northwest Cranston Residential	177,500	322,000
South of Scituate Ave. Residential	540,500	1,189,000
Subtotal	718,000	1,511,000
Industrial and Commercial		
Northwest Cranston Industrial	415,175	610,740
South of Scituate Ave. Industrial	547,342	804,915
Johnston Industrial	87,000	130,000
Howard Industrial	1,084,760	1,084,760
Village Center Commercial	23,000	34,050
Subtotal	2,157,277	2,664,465
Institutional		
Howard Center	1,100,000	1,100,000
Landfill		
Central Landfill	400,000	400,000
Vinagro Landfill	35,000	35,000
Capuano Landfill	60,000	60,000
Subtotal	495,000	495,000
Infiltration		
Service Area 1	30,820	46,000
Service Area 2	216,200	475,600
Service Area 3	72,000	72,000
Subtotal	319,020	593,600
Total	4,789,297	6,364,065

PROJECTED FLOWS TO WASTEWATER COLLECTION SYSTEM

The design or assessment of sewers and pump stations requires an estimate of the quantity of wastewater to be conveyed by various components of the collection system. The components of interest are:

Area 1 - Scituate pump station and force main/variable grade sewer
I-295 pump station
14-inch force main/variable grade sewer from I-295 pump station to Cranston Street
Cranston Street, Park Ave, and Pocasset Interceptor gravity sewers
Pontiac pump station and force main

Area 2 - Trunk sewers in west Cranston
Wilbur pump station and force main/gravity sewers or force main/variable grade sewer
Sockanosset interceptor gravity sewers
Wastewater treatment facility influent pumps

Area 3 - Sharpe Drive, Ross-Simons Drive, and Kenny Drive gravity sewers
Howard pump station and force main
Wastewater treatment facility influent pumps

Tutela Engineering Associates, Inc. provided calculations of projected average day and peak hourly flows for sewers and pump stations dated February 25, 1993. As wastewater enters the system at various points, average day flows were calculated for each point using the criteria described in the previous sections. Next a peak hourly flow was determined in accordance with the size of the average day flow and selected peak factor. Peak factors are selected based on information contained in the "ASCE-Manuals and Reports on Engineering Practice-NO. 60" and knowledge of the Cranston collection system. Infiltration and landfill flows are not peaked. Calculated flows for pump stations and sewer lines in this study are included as Attachment 1 and 2.

EVALUATION OF WATER CONSERVATION

The components of a residential water conservation program are aimed at reducing indoor water use (toilet, shower, and faucet water use); reducing outdoor water use (landscape watering, car washing); eliminating leaks; and accurately metering water use. Conservation practices aimed at indoor water use may also result in a reduction in wastewater flow. The following describes water efficient fixtures and reviews existing water conservation policies in Cranston.

Water Saving Fixtures - Water-efficient plumbing fixtures include low-volume toilets, low-flow shower heads, and low-flow faucets. Conventional toilets in pre-1990 homes use 3.5-7.0 gallons per flush (gpf). The maximum flow rate of common showerheads in pre-1990 homes averages about 3.0 to 8.0 gallons per minute (gpm). The average conventional kitchen faucets have a maximum flow capacity of 3.0 to 7.0 gpm (Vickers 1990).

Water use savings can be realized by replacing plumbing fixtures with lower-volume toilets that use 1.6 gpf, and showerheads and faucets that use 2.5 gpm. For illustrative purposes Table 6 shows a range of potential per capita water use savings by fixture assuming a per capita fixture use rate.

Table 6. Potential Household Water Savings With Water Efficient Fixtures.

	Water Use of Standard Fixture	Water Use of Water Efficient Fixture	Potential Savings (1)
Toilet	3.5-7.0 gpf	1.6 gpf	7.6 - 21.6 gpcd
Shower Head	3.0-8.0 gpm	2.5 gpm	2.5 - 27.5 gpcd
Faucet	3.0-7.0 gpm	2.5 gpm	2.0 - 18.0 gpcd

(1) Assumes four flushes per day, a 5.0 minute shower, and about 4.0 minutes per day of faucet use.

For example a home which currently has 3.5 gpf toilet(s) may save 7.6 gpcd if the toilet(s) was replaced with a water efficient fixture utilizing only 1.6 gpf. Likewise, replacing shower heads and faucets using 3.0 gpm with water efficient fixtures utilizing only 2.5 gpm may save an additional 4.5 gpcd. Total savings under this replacement scenario would be about 12 gpcd. In a home with standard fixtures that utilize more water, replacement of fixtures would result in higher savings.

The actual per capita water use savings from retrofitting an existing home or requiring water efficient plumbing fixtures in a new home may vary considerably depending on the actual individual use and prior fixture capacity.

Conservation Policies - Existing water conservation policies in Cranston are implemented through the agencies supplying water to city homes and through the Rhode Island state plumbing code.

The Providence Water Supply Board supplies the city east of I-295, and the city of Cranston Water Department supplies the portion west of I-295. The Kent County Water Authority also supplies a small part in the southwest portion of the city. The three companies install and maintain their respective distribution systems and bill their customers directly. The Providence Water Supply Board retails water directly to east Cranston and wholesales water to both the city and the Kent County Water Authority.

The Providence Water Supply Board (PWSB) has started a program to distribute free residential water conservation retrofit kits that include:

1 low flow showerhead, 2.5 gpm
2 faucet aerators, 2.5 gpm
1 toilet displacement bag, 1.25 gal
leak detection dye tablets

The homeowner is responsible for installing the water-efficient fixtures. The toilet bag is to be used in the back of the toilet to reduce flush volume and the dye tablets are to be used to detect toilet leaks. The PWSB estimates that about 900 customers in Cranston have accepted these retrofit kits (Letter from Providence Water Supply Board, July 30, 1993).

The City of Cranston Water Department has conducted water conservation programs that include mailings of water conservation literature and leak detection dye tablets. The Water Department has also replaced meters and conducted a leak detection program in efforts to quantify and reduce the demand for water. The Water Department is currently beginning to prepare a Water Supply Management Plan to meet the rules and regulations established in "The Rhode Island Department of Environmental Management Rules and Regulations for Water Supply Management Planning, August, 1992". These rules require that about 10 percent of homes be targeted annually by water suppliers for distribution and installation of water savings devices.

In addition to the water supply agency's efforts to retrofit existing homes with water-efficient fixtures, the 1990 Rhode Island state plumbing code requires the use of 1.6 gpf toilets, 2.5 gpm faucets, and 2.5 gpm shower heads. As a result new homes built in Cranston after 1990 should be fitted with water efficient fixtures.

The implementation of the outlined policies in west Cranston has the potential to result in a decrease in per capita water use in new and retrofitted households. However, declining household size, larger landscaped areas, and other water using appliances may increase per capita water use. The only reliable way to estimate the impact of the outlined water conservation policies on future per capita water use and wastewater flow in Cranston is to monitor future water use trends. Given the extent of the existing policies, no additional domestic water conservation programs are suggested for west Cranston. However, it is recommended that the city continue to pursue opportunities to reduce water use through implementation of existing policies and programs.

REFERENCES

American Society of Civil Engineers, "Manuals and Reports on Engineering Practice No. 60", 1982.

City of Cranston, Comprehensive Plan, February 1992.

State of Rhode Island, Department of Environmental Management, "Rules and Regulations For Water Supply Management Planning", August, 1992.

State of Rhode Island, Department of Environmental Management, Division of Water Resources, letter of February 16, 1993

State of Rhode Island, Department of Administration, Division of Planning, Office of Strategic Planning, Memorandum, Population Forecasts for Howard, August 14, 1992

Town of Johnston, Draft Comprehensive Community Plan, December 1991.

Tutela Engineering Associates,Inc., Letter of January 29, 1993.

Tutela Engineering Associates, Inc., Letter report on calculations developed to determine projected flows at selected components of the Cranston collection system, February 25, 1993.

Tutela Engineering Associates, Inc., Draft Wastewater Facility Plan, April 1992.

Providence Water Supply Board, Letter from Peter Lepage, July 30, 1993.

Vickers, Amy, "Water-Use Efficiency Standards for Plumbing Fixtures: Benefits of National Legislation", Journal of American Water Works, May 1990.

ATTACHMENT 1

WASTEWATER FLOW CALCULATIONS

The assessment of feasibility study options requires an estimate of the quantity of wastewater to be conveyed by various components of the collection system. For the most part flow projections were provided by the city in their consultant's Tutela Engineering Associates letter report of February 25, 1993 to the Corps.

Various options were considered initially for conveying flows from service areas to the Cranston Wastewater Treatment Facility (WWTF). In consultation with the city, the following options were selected for feasibility analysis. Option 1A, 1B, and 1C address conveyance of flows from Service Area 1. Options 2A, 2B, 2C, and 2D address conveyance of flows from Service Area 2. Option 3A addresses conveyance flows from Service Area 3. Components of these options are discussed in general in the following paragraphs. Detailed discussion is included in the Task 7 and 9 report "Feasibility Level Design and Cost Estimates for Wastewater Conveyance Options".

Projected pump station flows and sewer flows for these options are presented in the following tables and approximate node locations for wastewater inflow calculations for the Sockanosset Interceptor and the Howard pumping station collection system are shown on figures A-1 and A-2.

Option 1A. This option provides for conveyance of projected wastewater flows from Service Area 1 to the WWTF through modifications and expansion of the existing sewerage system.

Under this option wastewater flows from Service Area 1 would be pumped from the I-295 pumping station (designed and scheduled for construction by the city in 1994) into the existing 14-inch force main\variable grade sewer which discharges to the gravity sewer in Cranston Street. Wastewater would flow by gravity through sewers in Cranston Street, Park Avenue, and the Pocasset Interceptor to the Pontiac pumping station. Flows at the Pontiac pumping station would be pumped to the WWTF.

In addition, a new pumping station is required to collect flows from Service Area 1 in the area of Pipin Orchard Road and the Village Center. The city's facility plan proposes a new pumping station, from the pumping station to the I-295 pumping station (Wastewater Facility Plan Amendment, February 1993, Tutela Engineering Associates. Inc.).

New lateral sewers would also be required in Service Area 1 to collect future wastewater flows from currently unsewered areas. However, the design and cost of these are not included in this feasibility study.

Option 1B. This option is similar to Option 1A. However, projected wastewater flows for the Vinagro Landfill and the Johnston industrial area are not included.

Option 1C. This option is the proposed "Scituate Pumping Station", and new force main\variable grade sewer.

Option 2A. This option provides a connector system to convey projected wastewater flows from Service Area 2 to the WWTF. Wastewater would be pumped from a proposed pumping station located near I-295 and Wilbur Avenue through the proposed "Garden Hills" force main/variable grade sewer to the WWTF.

Option 2B. This option is considered as an alternative to Option 2A. The proposed Garden Hills force main/variable grade sewer of Option 2A is replaced with a proposed "Garden Hills" force main/gravity sewer.

Option 2C. This option is considered as an alternative to Option 2A and 2B. The proposed "Turner" force main replaces the Garden Hills force main/variable grade sewer. The Turner force main would discharge to the existing Sockanosset Interceptor on Belvedere Drive. Wastewater would flow by gravity through the interceptor to the "siphon" in Webb Street and into the influent screw pumps at the WWTF.

Option 2D. This option considers the location and cost of trunk sewers in Service Area 2 (west Cranston area). Flows from this area would flow to the proposed Wilbur pumping station. Trunk sewers considered include; the proposed Tilcon gravity sewer, the proposed Comstock gravity sewer, and the proposed Natick/Phenix trunk sewer. Also, a pumping station and force main are proposed near the intersection of Phenix Avenue and Burlingame Road. However, the pumping station and force main are not required until after 2015.

Lateral sewer lines would also be required to collect existing and future wastewater flows from Service Area 2. However, design and cost of these are not included in this feasibility study.

Option 3A. This option provides for conveyance of projected wastewater flows from Service Area 3 to the WWTF through modifications to the existing sewerage system. Wastewater flows would be conveyed by gravity through the existing main sewers in Kenny Drive, Ross-Simmons Drive, and Sharpe Drive to the Howard pumping station. Flows would be pumped through the Howard force main to the "siphon" in Webb Street into the influent screw pumps at the WWTF.

Information for Pump Station Feasibility Analysis in mgd August 1993

	Projected Flow 2015 ADF (mgd)	Peak Flow (mgd)	Projected Flow 2045 ADF (mgd)	Peak Flow (mgd)
Service Area 1				
Option A - with Johnston industrial area and Vinagro Landfill wastewater flows				
Scituate Pump Station	0.094	0.416	0.161	0.726
I-295 P.S.	1.168	3.018	1.578	4.347
Pontiac Pump Station	13.790	30.303	16.781	37.564
Service Area 1				
Option B - without Johnston industrial area and Vinagro Landfill wastewater flows				
Scituate Pump Station	0.094	0.416	0.161	0.726
I-295 P.S.	1.046	2.721	1.413	3.922
Pontiac Pump Station	13.668	30.051	16.616	37.204
Service Area 1				
Option C				
Scituate Pump Station	0.094	0.416	0.161	0.726
Service Area 2				
Option A				
West Cranston Trunk Sewer(s)				
Wilbur pump station	1.304	4.074	2.470	7.408
Service Area 2				
Option B				
West Cranston Trunk Sewer(s)				
Wilbur pump station	1.304	4.074	2.470	7.408
WWTF influent pumps	5.656	15.039	7.254	17.893
Service Area 2				
Option C				
West Cranston Trunk Sewer(s)				
Wilbur pump station	1.304	4.074	2.470	7.408
WWTF influent pumps	5.656	15.039	7.254	17.893
Service Area 3				
Howard Pump Station	2.316	6.686	2.316	6.686
WWTF influent pumps without Wilbur P.S.	4.352	12.054	4.785	13.100

Notes:
ADF - average daily flow
Peak - maximum hourly flow

Information for Pump Station feasibility Analysis in gpm August 1993

	Projected Flow 2015 ADF (gpm)	Peak Flow (gpm)	Projected Flow 2045 ADF (gpm)	Peak Flow (gpm)
Service Area 1				
Option A - with Johnston industrial area and Vinagro Landfill wastewater flows				
Scituate Pump Station	66	289	112	504
I-295 P.S.	811	2,095	1,096	3,018
Pontiac Pump Station	9,576	21,044	11,653	26,086
Service Area 1				
Option B - without Johnston industrial area and Vinagro Landfill wastewater flows				
Scituate Pump Station	66	289	112	504
I-295 P.S.	726	1,890	981	2,724
Pontiac Pump Station	9,492	20,869	11,539	25,836
Service Area 1				
Option C				
Scituate Pump Station	66	289	112	504
Service Area 2				
Option A				
West Cranston Trunk Sewer(s)				
Wilbur pump station	906	2,829	1,715	5,144
Service Area 2				
Option B				
West Cranston Trunk Sewer(s)				
Wilbur pump station	906	2,829	1,715	5,144
WWTF influent pumps	3,928	10,444	5,038	12,425
Service Area 2				
Option C				
West Cranston Trunk Sewer(s)				
Wilbur pump station	906	2,829	1,715	5,144
WWTF influent pumps	3,928	10,444	5,038	12,425
Service Area 3				
Howard Pump Station	1,608	4,643	1,608	4,643
WWTF influent pumps without Wilbur P.S.	3,022	8,370	3,323	9,097

Projected Flow to Scituate Pump Station August 1993

	2015	2045
Residential Flow		
Residential Land (acres)	644	644
Zoning	A-80 and Village Center	A-80 and Village Center
Projected Population	622	1,120
Wastewater Flow Factor	100	100
ADF Domestic Wastewater, gpd	62,200	111,960
Peak Factor	5.44	5.44
Peak Flow, gpd	338,368	609,062
Commercial Flow in Village Center		
ADF, Commercial, gpd	23,000	34,050
Peak Factor	3	3
Peak Flow, gpd	69,000	102,150
Infiltration, gpd	8,521	15,333
Total ADF, gpd	93,721	161,343
Total Peak Flow, gpd	415,889	726,545

Projected Flow to I-295 Pump Station August 1993

	2015	2045
Residential Flow		
Residential Land	1,075	1,075
Zoning	varies	varies
Projected Population	1,775	3,220
Wastewater Flow Factor, gpcd	100	100
ADF Domestic Wastewater, gpd	177,500	322,000
Peak Factor	5.5	4.8
Total Peak Flow, gpd	976,250	1,542,030
Cranston Industrial and Commercial Flow		
Industrial Land (acres)	469.8	469.8
Industrial Dev (%)	68	100
Wastewater Flow Factor gpd/acre	1,300	1,300
ADF Industrial, gpd	415,175	610,740
Village Center, gpd	23,000	34,050
Total, gpd	438,175	644,790
Peak Factor	3	3
Total Peak Flow, gpd	1,314,525	1,934,370
Johnston Industrial Flow		
Industrial Land (acres)	100	100
Wastewater Flow Factor gpd/acre	1,300	1,300
Industrial Dev (%)	67	100
ADF Industrial, gpd	87,000	130,000
Peak Factor	3	3
Total Peak Flow gpd	261,000	390,000
Landfill Flow		
Central Landfill, gpd	400,000	400,000
Vinagro Landfill, gpd	35,000	35,000
Infiltration, gpd	30,820	46,000
Total ADF with Johnston and Vinagro sites, gpd	1,168,495	1,577,790
Total Peak Flow with Johnston and Vinagro sites, gpd	3,017,595	4,347,400
Total ADF without Johnston and Vinagro sites, gpd	1,046,495	1,412,790
Total Peak Flow without Johnston and Vinagro sites, gpd	2,721,595	3,922,400

Projected Flow to Pontiac Pump Station August 1993

East Cranston	2015	2045
Residential Flow		
Residential Land (acres)	NA	NA
Zoning	varies	varies
Projected Population	57,850	61,092
Wastewater Flow Factor	100	100
ADF Domestic Wastewater, gpd	5,785,000	6,109,200
Industrial Flow		
Industrial Land (acres)	891.1	891.1
Industrial Dev (%)	68	100
Wastewater Flow Factor, gpd/acre	5,770	5,770
ADF Industrial, gpd	3,496,320	5,141,647
Commercial Flow		
Commercial Land (acres)	399	399
Commercial Dev (%)	68	100
Wastewater Flow Factor, gpd/acre	3,780	3,780
ADF Commercial, gpd	1,025,590	1,508,220
Infiltration, gpd	2,314,000	2,443,680

Northwest Cranston, I-295 Pump Station		
Residential Flow		
Residential Land (acres)	1,075	1,075
Zoning	varies	varies
Projected Population	1,775	3,220
Wastewater Flow Factor	100	100
ADF Domestic Wastewater, gpd	177,500	322,000
Industrial Flow		
Industrial Land (acres)	469.8	469.8
Industrial Dev (%)	68	100
Wastewater Flow Factor, gpd/acre	1,300	1,300
ADF Industrial, gpd	415,175	610,740
Commercial Flow		
Village Center, gpd	23,000	34,050
Johnston Industrial Flow		
ADF Industrial, gpd	87,000	130,000
Landfill Flow		
Central Landfill, gpd	400,000	400,000
Vinagro Landfill, gpd	35,000	35,000
Infiltration, gpd	30,820	46,000

Total ADF with Johnston and Vinagro, gpd	13,789,405	16,780,537
Peak Factor	2.5	2.5
Total Peak Flow with Johnston and Vinagro, gpd	30,303,781	37,564,323
Total ADF without Johnston and Vinagro, gpd	13,667,405	16,615,537
Peak Factor	2.5	2.5
Total Peak Flow without Johnston and Vinagro, gpd	30,051,281	37,204,323

Projected Flow to Wilbur Pump Station August 1993

	2015	2045
Residential Flow		
Residential Land (acres)	4,460	4,460
Zoning	varies	varies
Projected Population	5,405	11,890
Wastewater Flow Factor	100	100
ADF Domestic Wastewater, gpd	540,500	1,189,000
Peak Factor	4.10	3.80
Peak Flow, gpd	2,216,050	4,518,200
Industrial Flow		
Industrial Land (acres)	139.5	139.5
Industrial Dev (%)	68	100
Wastewater Flow Factor, gpd/acre	5,770	5,770
ADF Industrial, gpd	547,342	804,915
Peak Factor	3	3
Peak Flow, gpd	1,642,027	2,414,745
Infiltration, gpd	216,200	475,600
Total ADF, gpd	1,304,042	2,469,515
Total Peak Flow, gpd	4,074,277	7,408,545

Projected Flow to Howard Pump Station August 1993

	2015	2045
Institutional Flow, gpd	1,100,000	1,100,000
Industrial Flow		
Industrial Land (acres)	188	188
Industrial Dev (%)	100	100
Wastewater Flow Factor, gpd/acre	5,770	5,770
ADF Industrial, gpd	1,084,760	1,084,760
Landfill Flow		
Capuano Landfill, gpd	60,000	60,000
Infiltration, gpd	72,000	72,000
Total ADF to Howard Pump Station, gpd	2,316,760	2,316,760
Peak Factor	3	3
Total Peak Flow to Howard Pump Station, gpd	6,686,280	6,686,280

Projected flow to WWTF Influent Pumps With Wilbur Pump Station August 1993

Residential flow	2015 Population	WWFF gpcd	Total gpd	2045 Population	WWFF gpcd	Total gpd
Howard pump station	0	100	0	0	100	0
Worthington pump station	0	100	0	0	100	0
Wilbur Pump Station	5,405	100	540,500	11,890	100	1189000
Sherman pump station	7,525	100	752,500	7,948	100	794800
Sockanossett Int.	1,260	100	126,000	1,330	100	133000
Total ADF			1,419,000			2,116,800

Industrial Land	2015 acres	Dev (%)	WWFF gpd/acre	Total gpd	2045 acres	Dev (%)	WWFF gpd/acre	Total gpd
Howard pump station	190.5	100	5,770	1,099,185	190.5	100	5,770	1,099,185
Worthington pump station	72.6	68	5,770	284,853	72.6	100	5,770	418,902
Wilbur pump station	139.5	68	5,770	547,342	139.5	100	5,770	804,915
Sherman Pump Station	19.5	68	5,770	76,510	19.5	100	5,770	112,515
Sockanosset Interceptor	19.8	68	5,770	77,687	19.8	100	5,770	114,246
Total ADF	441.9			2,085,578	441.9			2,549,763

Commercial Land	2015 acres	Dev (%)	WWFF gpd/acre	Total gpd	2045 acres	Dev (%)	WWFF gpd/acre	Total gpd
Howard pump station	0.0	NA	3,780	0	0.0	NA	3,780	0
Worthington pump station	0.0	NA	3,780	0	0.0	NA	3,780	0
Wilbur pump station	0.0	NA	3,780	0	0.0	NA	3,780	0
Sherman Pump Station	68.6	68	3,780	176,329	68.6	100	3,780	259,308
Sockanosset Interceptor	61.4	68	3,780	157,823	61.4	100	3,780	232,092
Total ADF				334,152				491,400

Institutional Land Use	2015	Total gpd	2045	Total gpd
Howard pump station		1,100,000		1,100,000
Worthington pump station		0		0
Wilbur Pump Station		0		0
Sherman Pump Station		0		0
Sockanosset Interceptor		0		0
Total ADF		1,100,000		1,100,000

Infiltration, gpd	2015	Total gpd	2045	Total gpd
Total		657,024		936,144

Capuano Landfill Flow	2015	Total gpd	2045	Total gpd
Landfill Flow		60,000		60,000

Total ADF to siphon (gpd)	5,655,754	7,254,107
Peak Factor	2.9	2.7
Total Peak Flow to Siphon (gpd)	15,039,341	17,892,644

Projected flow to WWTF Influent Pumps Without Wilbur Pump Station August 1993

Residential flow	2015 population	WWFF gpcd	Total gpd	2045 population	WWFF gpcd	Total gpd
Howard pump station	0	100	0	0	100	0
Worthington pump station	0	100	0	0	100	0
Sherman Pump Station	7,525	100	752,500	7,948	100	794800
Sockanossett Int.	1,260	100	126,000	1,330	100	133000
Total ADF			878,500			927,800

Industrial Land	2015 acres	Dev (%)	WWFF gpd/acre	Total gpd	2045 acres	Dev (%)	WWFF gpd/acre	Total gpd
Howard pump station	190.5	100	5,770	1,099,185	190.5	100	5,770	1,099,185
Worthington pump station	72.6	68	5,770	284,853	72.6	100	5,770	418,902
Sherman Pump Station	19.5	68	5,770	76,510	19.5	100	5,770	112,515
Sockanosset Interceptor	19.8	68	5,770	77,687	19.8	100	5,770	114,246
Total ADF				1,538,236				1,744,848

Commercial Land	2015 acres	Dev (%)	WWFF gpd/acre	Total gpd	2045 acres	Dev (%)	WWFF gpd/acre	Total gpd
Howard pump station	0.0	NA	3,780	0	0.0	NA	3,780	0
Worthington pump station	0.0	NA	3,780	0	0.0	NA	3,780	0
Sherman Pump Station	68.6	68	3,780	176,329	68.6	100	3,780	259,308
Sockanosset Interceptor	61.4	68	3,780	157,823	61.4	100	3,780	232,092
Total ADF				334,152				491,400

Institutional Land Use	2015	Total gpd	2045	Total gpd
Howard pump station		1,100,000		1,100,000
Worthington pump station		0		0
Sherman Pump Station		0		0
Sockanosset Interceptor		0		0
Total ADF		1,100,000		1,100,000

Infiltration, gpd	2015	WWFF	Total	2045	WWFF	Total
Total			440,824			460,544

Capuano Landfill Flow	2015	Total gpd	2045	Total gpd
Landfill Flow		60,000		60,000

Total ADF to siphon (gpd)		4,351,712	4,784,592
Peak Factor		3.00	2.95
Total Peak Flow to Siphon (gpd)		12,053,488	13,099,486

Service Area 1, Option A, 2015 and 2045 Projected Peak Wastewater Flow to Cranston St, Park Ave, Pocasset Interceptor

Segment ID	2015 Central Landfill NW Cranston, and part E. Cranston (1) (gpm)	2015 Vinagro Landfill (gpm)	2015 Johnston Industrial Area (gpm)	2015 Total (gpm)	2045 Central Landfill NW Cranston, and part E. Cranston (1) (gpm)	2045 Vinagro Landfill (gpm)	2045 Johnston Industrial Area (gpm)	2045 Total (gpm)
I-295 P. S.	1,890	20	180	2,090	2,724	20	270	3,014
VGS	1,890	20	180	2,090	2,724	20	270	3,014
Cranston Street								
108	4,650	20	180	4,850	5,800	20	270	6,090
109	4,650	20	180	4,850	5,800	20	270	6,090
110	4,650	20	180	4,850	5,800	20	270	6,090
111	4,650	20	180	4,850	5,800	20	270	6,090
112	4,650	20	180	4,850	5,800	20	270	6,090
Park Ave.								
113	5,430	20	180	5,630	6,440	20	270	6,730
114	5,430	20	180	5,630	6,440	20	270	6,730
115	5,430	20	180	5,630	6,440	20	270	6,730
116	5,450	20	180	5,650	6,550	20	270	6,840
117	5,450	20	180	5,650	6,550	20	270	6,840
118	5,450	20	180	5,650	6,550	20	270	6,840
119	5,450	20	180	5,650	6,550	20	270	6,840
120	5,450	20	180	5,650	6,550	20	270	6,840
121	5,450	20	180	5,650	6,550	20	270	6,840
122	5,450	20	180	5,650	6,550	20	270	6,840
123	5,570	20	180	5,770	6,560	20	270	6,850
124	5,570	20	180	5,770	6,560	20	270	6,850
125	5,570	20	180	5,770	6,560	20	270	6,850
Pocasset Int., Deborah Way Cross Country								
126	9,022	20	180	9,222	10,930	20	270	11,220
127	9,022	20	180	9,222	10,930	20	270	11,220
128	9,022	20	180	9,222	10,930	20	270	11,220
129	9,022	20	180	9,222	10,930	20	270	11,220
130	9,022	20	180	9,222	10,930	20	270	11,220
131	9,200	20	180	9,400	11,060	20	270	11,350
132	9,200	20	180	9,400	11,060	20	270	11,350
133	9,200	20	180	9,400	11,060	20	270	11,350
134	9,800	20	180	10,000	11,740	20	270	12,030
135	9,800	20	180	10,000	11,740	20	270	12,030
136	9,800	20	180	10,000	11,740	20	270	12,030
137	9,800	20	180	10,000	11,740	20	270	12,030
138	9,800	20	180	10,000	11,740	20	270	12,030
139	9,800	20	180	10,000	11,740	20	270	12,030
140	9,800	20	180	10,000	11,740	20	270	12,030
141	9,800	20	180	10,000	11,740	20	270	12,030
142	10,330	20	180	10,530	12,340	20	270	12,630
143	10,930	20	180	11,130	13,010	20	270	13,300
144	10,930	20	180	11,130	13,010	20	270	13,300
145	10,930	20	180	11,130	13,010	20	270	13,300
146	10,930	20	180	11,130	13,010	20	270	13,300
Knollwood Rd								
147	10,930	20	180	11,130	13,010	20	270	13,300
148	10,930	20	180	11,130	13,010	20	270	13,300
Reservoir Ave								
149	11,424	20	180	11,624	13,520	20	270	13,810
150	11,424	20	180	11,624	13,520	20	270	13,810
151	11,424	20	180	11,624	13,520	20	270	13,810
Delway Rd								
152	11,424	20	180	11,624	13,520	20	270	13,810
153	11,424	20	180	11,624	13,520	20	270	13,810
154	11,424	20	180	11,624	13,520	20	270	13,810
155	11,424	20	180	11,624	13,520	20	270	13,810
Intervale Rd Cross Country								
156	11,620	20	180	11,820	13,730	20	270	14,020
157	11,620	20	180	11,820	13,730	20	270	14,020
158	12,240	20	180	12,440	14,470	20	270	14,760
159	12,240	20	180	12,440	14,470	20	270	14,760
160	12,240	20	180	12,440	14,470	20	270	14,760
161	12,240	20	180	12,440	14,470	20	270	14,760
162	13,340	20	180	13,540	15,710	20	270	16,000
163	13,340	20	180	13,540	15,710	20	270	16,000
164	13,340	20	180	13,540	15,710	20	270	16,000
165	13,340	20	180	13,540	15,710	20	270	16,000
166	13,340	20	180	13,540	15,710	20	270	16,000
167	13,340	20	180	13,540	15,710	20	270	16,000
168	13,610	20	180	13,810	15,799	20	270	16,089
169	13,610	20	180	13,810	15,799	20	270	16,089
170	13,610	20	180	13,810	15,799	20	270	16,089
Pontiac Ave								
171	13,670	20	180	13,870	15,818	20	270	16,108
172	13,750	20	180	13,950	16,130	20	270	16,420
Flows enter Pontiac pump station								

(1) Flow projections provided by Tutela Engineering Associates, February 25, 1993.

Service Area 1, Option B, 2015 and 2045 Projected Peak Wastewater Flow to Cranston St, Park Ave, Pocasset Interceptor

Segment ID	2015 Central Landfill, NW Cranston, and part E. Cranston (1) (gpm)	2015 Vinagro Landfill (gpm)	2015 Johnston Industrial Area (gpm)	2015 Total (gpm)	2045 Central Landfill, NW Cranston, and part E. Cranston (1) (gpm)	2045 Vinagro Landfill (gpm)	2045 Johnston Industrial Area (gpm)	2045 Total (gpm)
I-295 P. S.	1,890	0	0	1,890	2,724	0	0	2,724
VGS	1,890	0	0	1,890	2,724	0	0	2,724
Cranston Street								
108	4,650	0	0	4,650	5,800	0	0	5,800
109	4,650	0	0	4,650	5,800	0	0	5,800
110	4,650	0	0	4,650	5,800	0	0	5,800
111	4,650	0	0	4,650	5,800	0	0	5,800
112	4,650	0	0	4,650	5,800	0	0	5,800
Park Ave.								
113	5,430	0	0	5,430	6,440	0	0	6,440
114	5,430	0	0	5,430	6,440	0	0	6,440
115	5,430	0	0	5,430	6,440	0	0	6,440
116	5,450	0	0	5,450	6,440	0	0	6,550
117	5,450	0	0	5,450	6,440	0	0	6,550
118	5,450	0	0	5,450	6,440	0	0	6,550
119	5,450	0	0	5,450	6,440	0	0	6,550
120	5,450	0	0	5,450	6,440	0	0	6,550
121	5,450	0	0	5,450	6,440	0	0	6,550
122	5,450	0	0	5,450	6,440	0	0	6,550
123	5,570	0	0	5,570	6,560	0	0	6,560
124	5,570	0	0	5,570	6,560	0	0	6,560
125	5,570	0	0	5,570	6,560	0	0	6,560
Pocasset Int., Deborah Way Cross Country								
126	9,022	0	0	9,022	10,930	0	0	10,930
127	9,022	0	0	9,022	10,930	0	0	10,930
128	9,022	0	0	9,022	10,930	0	0	10,930
129	9,022	0	0	9,022	10,930	0	0	10,930
130	9,022	0	0	9,022	10,930	0	0	10,930
131	9,200	0	0	9,200	11,060	0	0	11,060
132	9,200	0	0	9,200	11,060	0	0	11,060
133	9,200	0	0	9,200	11,060	0	0	11,060
134	9,800	0	0	9,800	11,740	0	0	11,740
135	9,800	0	0	9,800	11,740	0	0	11,740
136	9,800	0	0	9,800	11,740	0	0	11,740
137	9,800	0	0	9,800	11,740	0	0	11,740
138	9,800	0	0	9,800	11,740	0	0	11,740
139	9,800	0	0	9,800	11,740	0	0	11,740
140	9,800	0	0	9,800	11,740	0	0	11,740
141	9,800	0	0	9,800	11,740	0	0	11,740
142	10,330	0	0	10,330	12,340	0	0	12,340
143	10,930	0	0	10,930	13,010	0	0	13,010
144	10,930	0	0	10,930	13,010	0	0	13,010
145	10,930	0	0	10,930	13,010	0	0	13,010
146	10,930	0	0	10,930	13,010	0	0	13,010
Knollwood Road								
147	10,930	0	0	10,930	13,010	0	0	13,010
148	10,930	0	0	10,930	13,010	0	0	13,010
Reservoir Avenue								
149	11,424	0	0	11,424	13,520	0	0	13,520
150	11,424	0	0	11,424	13,520	0	0	13,520
151	11,424	0	0	11,424	13,520	0	0	13,520
Delway Road								
152	11,424	0	0	11,424	13,520	0	0	13,520
153	11,424	0	0	11,424	13,520	0	0	13,520
154	11,424	0	0	11,424	13,520	0	0	13,520
155	11,424	0	0	11,424	13,520	0	0	13,520
Intervale Road Cross Country								
156	11,620	0	0	11,620	13,730	0	0	13,730
157	11,620	0	0	11,620	13,730	0	0	13,730
158	12,240	0	0	12,240	14,470	0	0	14,470
159	12,240	0	0	12,240	14,470	0	0	14,470
160	12,240	0	0	12,240	14,470	0	0	14,470
161	12,240	0	0	12,240	14,470	0	0	14,470
162	13,340	0	0	13,340	15,710	0	0	15,710
163	13,340	0	0	13,340	15,710	0	0	15,710
164	13,340	0	0	13,340	15,710	0	0	15,710
165	13,340	0	0	13,340	15,710	0	0	15,710
166	13,340	0	0	13,340	15,710	0	0	15,710
167	13,340	0	0	13,340	15,710	0	0	15,710
168	13,610	0	0	13,610	15,799	0	0	15,799
169	13,610	0	0	13,610	15,799	0	0	15,799
170	13,610	0	0	13,610	15,799	0	0	15,799
Pontiac Ave								
171	13,670	0	0	13,670	15,818	0	0	15,818
172	13,750	0	0	13,750	16,130	0	0	16,130
Flows enter Pontiac pump station								

(1) Flow projection provided by Tutela Engineering Associates, Inc. February 25, 1993

Service Area 2, Option C, 2015 Projected Wastewater Flow to Sockanosett Interceptor August 1993

Population and Land Use Sewer Segment ID	Node	S. East Cranston 2015 Pop.	West Cranston 2015 Pop.	Total 2015 Pop.	S. East Cranston Comm. (acres)	West Cranston Comm. (acres)	Total Comm. (acres)	S. East Cranston Ind. (acres)	West Cranston Ind. (acres)	Total Ind. (acres)
Belvedere, 249	A	7,734	5,405	13,139	68.6	0	68.6	19.5	139.5	159.0
Hoffman, 269	B	7,752	5,405	13,157	68.6	0	68.6	19.5	139.5	159.0
Jennings, 278	C	7,874	5,405	13,279	74.9	0	74.9	19.5	139.5	159.0
Kennedy, 343	D	7,877	5,405	13,282	74.9	0	74.9	19.5	139.5	159.0
Cross Country, 273	E	7,950	5,405	13,355	74.9	0	74.9	19.5	139.5	159.0
Cross Country, 193	F	8,222	5,405	13,627	74.9	0	74.9	19.5	139.5	159.0
Cross Country, 125	G	8,225	5,405	13,630	74.9	0	74.9	19.5	139.5	159.0
Cross Country, 99	H	8,684	5,405	14,089	102.5	0	102.5	19.5	139.5	159.0
Cross Country, 166	I	8,785	5,405	14,190	102.5	0	102.5	19.5	139.5	159.0
Cross Country,213	J	8,785	5,405	14,190	130.0	0	130.0	28.8	139.5	168.3
Pettaconsett Ave, 295	K	8,785	5,405	14,190	130.0	0	130.0	39.3	139.5	178.8

2015 ADF, mgd (1)		Residential	Commercial	Industrial	Infiltration	Total
Belvedere, 249	A	1.314	0.176	0.624	0.526	2.64
Hoffman, 269	B	1.316	0.176	0.624	0.526	2.64
Jennings, 278	C	1.328	0.193	0.624	0.531	2.68
Kennedy, 343	D	1.328	0.193	0.624	0.531	2.68
Cross Country, 273	E	1.336	0.193	0.624	0.534	2.69
Cross Country, 193	F	1.363	0.193	0.624	0.545	2.72
Cross Country, 125	G	1.363	0.193	0.624	0.545	2.72
Cross Country, 99	H	1.409	0.263	0.624	0.564	2.86
Cross Country, 166	I	1.419	0.263	0.624	0.568	2.87
Cross Country,213	J	1.419	0.334	0.660	0.568	2.98
Pettaconsett Ave, 295	K	1.419	0.334	0.702	0.568	3.02

2015 Peak Flow, mgd (1)		Residential	Commercial	Industrial	Infiltration	Total
Belvedere, 249	A	4.730	0.529	1.872	0.526	7.656
Hoffman, 269	B	4.737	0.529	1.872	0.526	7.663
Jennings, 278	C	4.780	0.578	1.872	0.531	7.761
Kennedy, 343	D	4.782	0.578	1.872	0.531	7.762
Cross Country, 273	E	4.808	0.578	1.872	0.534	7.791
Cross Country, 193	F	4.906	0.578	1.872	0.545	7.900
Cross Country, 125	G	4.907	0.578	1.872	0.545	7.901
Cross Country, 99	H	4.931	0.790	1.872	0.564	8.157
Cross Country, 166	I	4.967	0.790	1.872	0.568	8.196
Cross Country,213	J	4.967	1.002	1.981	0.568	8.518
Pettaconsett Ave, 295	K	4.967	1.002	2.105	0.568	8.641

2015 Peak Flow, gpm (1)		Residential	Commercial	Industrial	Infiltration	Total
Belvedere, 249	A	3,285	367	1,300	365	5,317
Hoffman, 269	B	3,289	367	1,300	365	5,322
Jennings, 278	C	3,320	401	1,300	369	5,389
Kennedy, 343	D	3,321	401	1,300	369	5,390
Cross Country, 273	E	3,339	401	1,300	371	5,411
Cross Country, 193	F	3,407	401	1,300	379	5,486
Cross Country, 125	G	3,408	401	1,300	379	5,487
Cross Country, 99	H	3,424	549	1,300	391	5,664
Cross Country, 166	I	3,449	549	1,300	394	5,692
Cross Country,213	J	3,449	696	1,376	394	5,915
Pettaconsett Ave, 295	K	3,449	696	1,462	394	6,001

(1) assumes 68 percent development of industrial and commercial wastewater flow

Population and Land Use Sewer Segment ID	Node	S. East Cranston 2045 Pop.	West Cranston 2045 Pop.	Total 2045 Pop.	S. East Cranston Comm. (acres)	West ranston Comm. (acres)	Total Comm. (acres)	S. East ranston Ind. (acres)	West Cranston Ind. (acres)	Total Ind. (acres)
Belvedere, 249	A	8,169	11,890	20,059	68.6	0	68.6	19.5	139.5	159
Hoffman, 269	B	8,188	11,890	20,078	68.6	0	68.6	19.5	139.5	159
Jennings, 278	C	8,317	11,890	20,207	74.9	0	74.9	19.5	139.5	159
Kennedy, 343	D	8,320	11,890	20,210	74.9	0	74.9	19.5	139.5	159
Cross Contry, 273	E	8,397	11,890	20,287	74.9	0	74.9	19.5	139.5	159
Cross Contry, 193	F	8,684	11,890	20,574	74.9	0	74.9	19.5	139.5	159
Cross Contry, 125	G	8,687	11,890	20,577	74.9	0	74.9	19.5	139.5	159
Cross Contry, 99	H	9,172	11,890	21,062	102.5	0	102.5	19.5	139.5	159
Cross Contry, 166	I	9,278	11,890	21,168	102.5	0	102.5	19.5	139.5	159
Cross Contry, 213	J	9,278	11,890	21,168	130	0	130	28.8	139.5	168.3
Pettaconsett Ave, 295	K	9,278	11,890	21,168	130	0	130	39.3	139.5	178.8

2045 ADF, mgd (1)		Residential	Commercial	Industrial	Infiltration	Total
Belvedere, 249	A	2.006	0.259	0.917	0.802	3.98
Hoffman, 269	B	2.008	0.259	0.917	0.803	3.99
Jennings, 278	C	2.021	0.283	0.917	0.808	4.03
Kennedy, 343	D	2.021	0.283	0.917	0.808	4.03
Cross Contry, 273	E	2.029	0.283	0.917	0.811	4.04
Cross Contry, 193	F	2.057	0.283	0.917	0.823	4.08
Cross Contry, 125	G	2.058	0.283	0.917	0.823	4.08
Cross Contry, 99	H	2.106	0.387	0.917	0.842	4.25
Cross Contry, 166	I	2.117	0.387	0.917	0.847	4.27
Cross Contry, 213	J	2.117	0.491	0.971	0.847	4.43
Pettaconsett Ave, 295	K	2.117	0.491	1.032	0.847	4.49

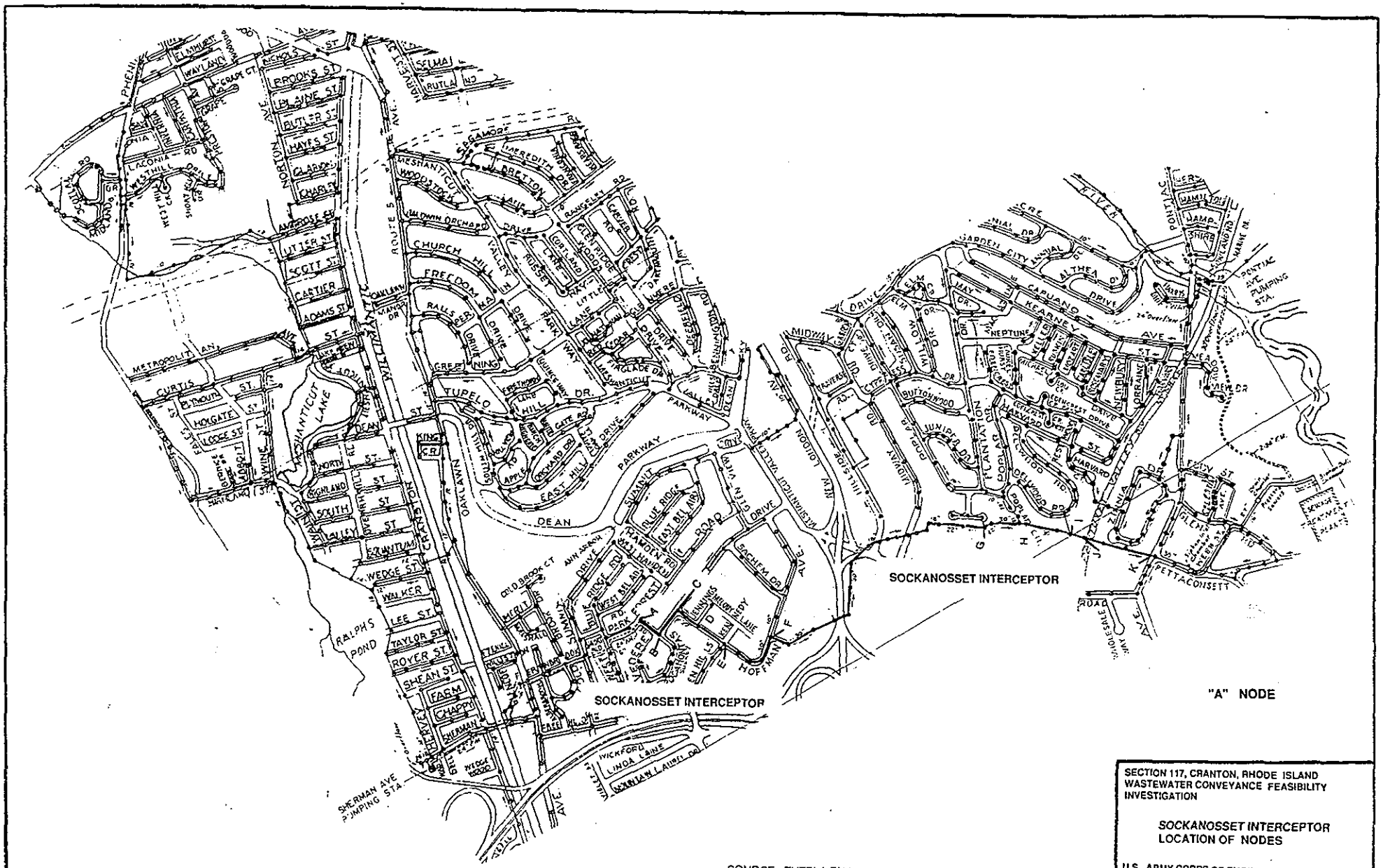
2045 Peak FLow, mgd (1)		Residential	Commercial	Industrial	Infiltration	Total
Belvedere, 249	A	6.820	0.778	2.752	0.802	11.153
Hoffman, 269	B	6.827	0.778	2.752	0.803	11.160
Jennings, 278	C	6.870	0.849	2.752	0.808	11.280
Kennedy, 343	D	6.871	0.849	2.752	0.808	11.281
Cross Contry, 273	E	6.898	0.849	2.752	0.811	11.311
Cross Contry, 193	F	6.995	0.849	2.752	0.823	11.420
Cross Contry, 125	G	6.996	0.849	2.752	0.823	11.421
Cross Contry, 99	H	6.950	1.162	2.752	0.842	11.708
Cross Contry, 166	I	6.985	1.162	2.752	0.847	11.747
Cross Contry, 213	J	6.985	1.474	2.913	0.847	12.220
Pettaconsett Ave, 295	K	6.985	1.474	3.095	0.847	12.401

2045 Peak Flow, gpm (1)		Residential	Commercial	Industrial	Infiltration	Total
Belvedere, 249	A	4,736	540	1,911	557	7,745
Hoffman, 269	B	4,741	540	1,911	558	7,750
Jennings, 278	C	4,771	590	1,911	561	7,834
Kennedy, 343	D	4,772	590	1,911	561	7,834
Cross Contry, 273	E	4,790	590	1,911	564	7,855
Cross Contry, 193	F	4,858	590	1,911	572	7,930
Cross Contry, 125	G	4,858	590	1,911	572	7,931
Cross Contry, 99	H	4,827	807	1,911	585	8,130
Cross Contry, 166	I	4,851	807	1,911	588	8,158
Cross Contry, 213	J	4,851	1,024	2,023	588	8,486
Pettaconsett Ave, 295	K	4,851	1,024	2,149	588	8,612

(1) Assumes 100 percent development of industrial and commercial wastewater flow.

Service Area, 3, Option A, 2015 and 2045 Projected Peak Wastewater Flow

Sewer Segment ID	Howard Center	Howard Industry	Capuano Landfill	Infiltration	Howard Center (gpm)	Howard Industry (gpm)	Capuano Landfill (gpm)	Infiltration (gpm)	Total (gpm)
	(percent of projected site flow)								
Pontiac Ave - Sharpe Drive									
A-32	20%	0%	0%	20%	458	0	0	10	468
32-31	20%	0%	0%	20%	458	0	0	10	468
31-30	20%	2%	0%	20%	458	45	0	10	514
30-29	20%	5%	0%	20%	458	113	0	10	581
29-28	20%	10%	0%	20%	458	226	0	10	694
28-27	20%	15%	100%	20%	458	339	42	10	849
27-26	20%	20%	100%	20%	458	452	42	10	962
26-25	20%	20%	100%	20%	458	452	42	10	962
25-24	20%	25%	100%	20%	458	565	42	10	1,075
24-23	20%	30%	100%	20%	458	678	42	10	1,188
Ross Simmons Drive									
23-33	20%	35%	100%	20%	458	791	42	10	1,301
33-34	20%	35%	100%	20%	458	791	42	10	1,301
34-35	20%	35%	100%	20%	458	791	42	10	1,301
35-36	20%	40%	100%	20%	458	904	42	10	1,414
36-37	20%	40%	100%	20%	458	904	42	10	1,414
37-38	20%	45%	100%	20%	458	1,017	42	10	1,527
38-39	20%	45%	100%	20%	458	1,017	42	10	1,527
39-13	20%	50%	100%	20%	458	1,130	42	10	1,640
Pontiac Ave									
1a-1	75%	0%	0%	75%	1,719	0	0	37	1,756
1-2	75%	0%	0%	75%	1,719	0	0	37	1,756
2-3	75%	0%	0%	75%	1,719	0	0	37	1,756
3-4	75%	0%	0%	75%	1,719	0	0	37	1,756
4-5	75%	0%	0%	75%	1,719	0	0	37	1,756
5-6	75%	0%	0%	75%	1,719	0	0	37	1,756
Kenney Drive to Ross Simmons Drive									
6-7	75%	2%	0%	75%	1,719	45	0	37	1,801
7-8	75%	5%	0%	75%	1,719	113	0	37	1,869
8-9	75%	10%	0%	75%	1,719	226	0	37	1,982
9-10	75%	15%	0%	75%	1,719	339	0	37	2,095
10-11	80%	20%	0%	80%	1,833	452	0	40	2,325
11-12	80%	20%	0%	80%	1,833	452	0	40	2,325
12-13	80%	20%	0%	80%	1,833	452	0	40	2,325
Kenney Drive from Ross Simmons Drive to Slater Road									
13-13a	100%	70%	100%	100%	2,292	1,582	42	50	3,965
13a-14	100%	70%	100%	100%	2,292	1,582	42	50	3,965
14-15	100%	70%	100%	100%	2,292	1,582	42	50	3,965
15-16	100%	70%	100%	100%	2,292	1,582	42	50	3,965
16-17	100%	70%	100%	100%	2,292	1,582	42	50	3,965
17-18	100%	70%	100%	100%	2,292	1,582	42	50	3,965
18-19	100%	70%	100%	100%	2,292	1,582	42	50	3,965
19-40	100%	70%	100%	100%	2,292	1,582	42	50	3,965
40-41	100%	70%	100%	100%	2,292	1,582	42	50	3,965
41-42	100%	70%	100%	100%	2,292	1,582	42	50	3,965
42-43	100%	70%	100%	100%	2,292	1,582	42	50	3,965
43-44	100%	70%	100%	100%	2,292	1,582	42	50	3,965
44-45	100%	70%	100%	100%	2,292	1,582	42	50	3,965
45-46	100%	70%	100%	100%	2,292	1,582	42	50	3,965
Kenney Drive from Slater Road to pump station									
46-47	100%	100%	100%	100%	2,292	2,260	42	50	4,643
47-H.P.S.	100%	100%	100%	100%	2,292	2,260	42	50	4,643



SOURCE: TUTELA ENGINEERING ASSOCIATES, FEBRUARY 25, 1993

SECTION 117, CRANTON, RHODE ISLAND
WASTEWATER CONVEYANCE FEASIBILITY INVESTIGATION

SOCKANOSSET INTERCEPTOR
LOCATION OF NODES

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION

AUGUST 1993

FIGURE A-1

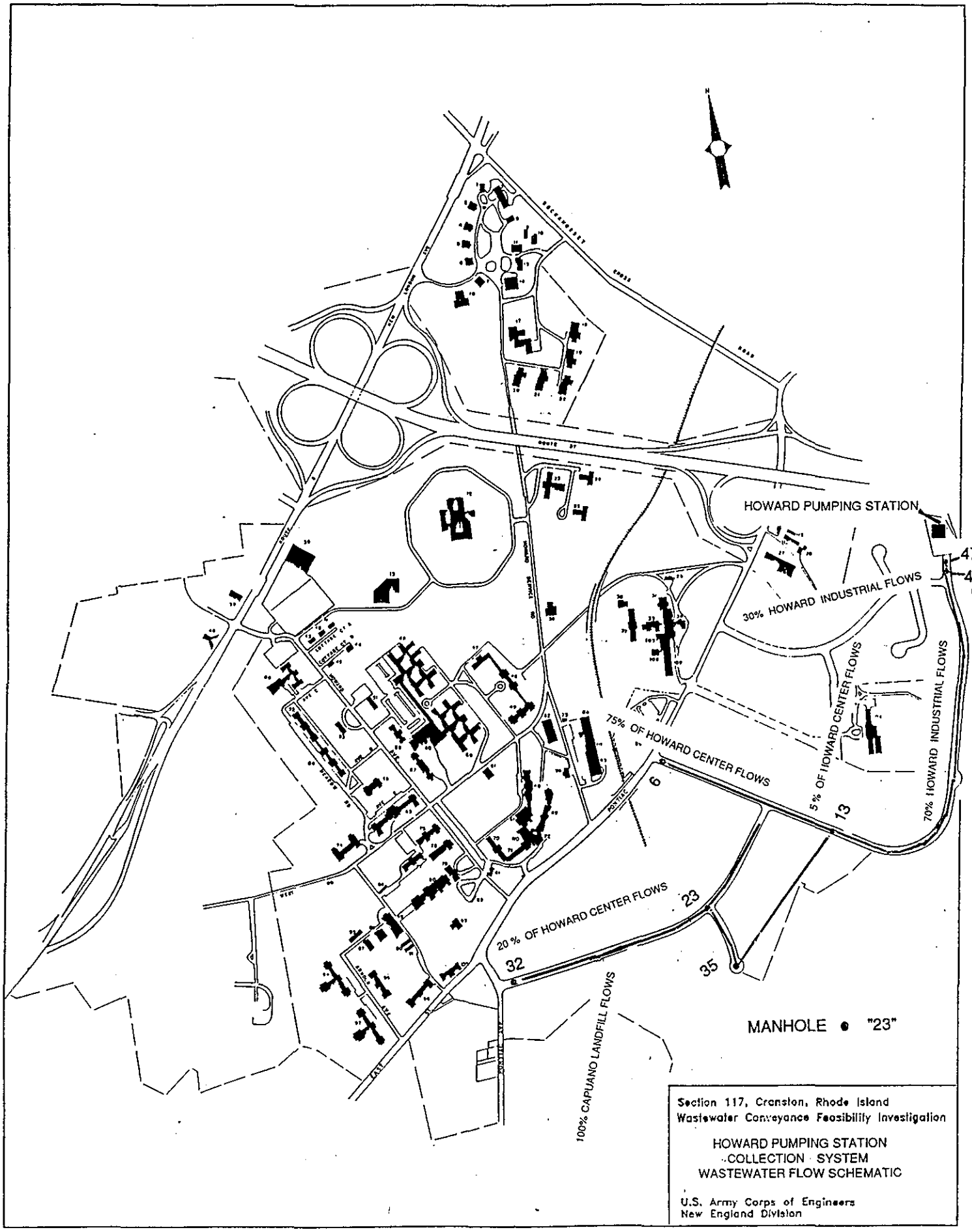

HOWARD PUMPING STATION
47
46
30% HOWARD INDUSTRIAL FLOWS
70% HOWARD INDUSTRIAL FLOWS
5% OF HOWARD CENTER FLOWS
75% OF HOWARD CENTER FLOWS
6
13
23
20 % OF HOWARD CENTER FLOWS
32
35
100% CAPUANO LANDFILL FLOWS
MANHOLE • "23"
Section 117, Cranston, Rhode Island
Wastewater Conveyance Feasibility Investigation
HOWARD PUMPING STATION
COLLECTION SYSTEM
WASTEWATER FLOW SCHEMATIC
U.S. Army Corps of Engineers
New England Division

FIGURE A-2

ATTACHMENT 2

WEST CRANSTON TRUNK SEWERS

After the location of the trunk sewer lines in west Cranston were determined, it was necessary to compute the wastewater flow to the trunk sewers. Wastewater was assumed to enter the trunk lines at different points, called nodes. The location of the nodes selected for this calculation are shown in Figure B-1.

The approximate drainage area for each node was determined on the 5-foot, 1"=200 FT contour mapping provided by the city. The zoning and land use assumed in an area was based on the city's zoning map and the future land use map in the City of Cranston Comprehensive Plan.

Average day flows for each node were calculated based on the projected number of housing units at build-out of an area, a density of 3 persons per unit, and an average daily wastewater flow factor of 100 gallons per capita per day. Allowable infiltration was estimated at 40 gallons per capita per day. Industrial flow from the Tilcon Gammino area was based on the area of the site and a wastewater flow factor of 5,770 gpd.

The resulting population calculation was within four percent of the population calculated by Tutela Engineering Associates, Inc. for the Facility Plan. The population was balanced to preserve this earlier estimate.

Once an estimate of the flows for the year 2045 were found, a percentage of expected development was applied to each individual area in order to estimate the flows for the year 2015. Assumptions concerning expected development and sewer service area are consistent with growth projected by Tutela Engineering Associates, Inc. in the city's Facility Plan.

The peak flow at a node was based on a peaking factor found as described in the report section "Projected Flows to Wastewater Collection System".

WESTERN CRANSTON SERVICE AREA FLOWS: 2015

	ADF gpd	Peak Flow gpd	Peak Flow gpm
Powerline/Phenix/ Natick Line			
Node A	0	0	0.0
Node B	0	0	0.0
Node C	0	0	0.0
Node D	0	0	0.0
Node E	12546	57353	39.8
Node F	34201	156347	108.6
Node G	114968	509142	353.6
Node H	141892	597974	415.3
Comstock Line			
Node A	29970	137006	95.1
Node B	51814	236866	164.5
Node C	86211	394105	273.7
Node D	161344	668425	464.2
Node E	166537	689940	479.1
Node F	269922	1041130	723.0 *
Node G	315133	1170492	812.8 *
Tilcon Line			
Node A	43744	199973	138.9
Node B	153965	648852	450.6
Node C	707966	2307468	1602.4
Node D	707966	2307468	1602.4
Node E	727117	2373966	1648.6
Node F	781731	2562841	1779.8
Brookdale Line			
Node A	1105210	3594565	2496.2 *
Node B	1120198	4015285	2788.4 *
Node C	1306586	4109571	2853.9 *

* Note: If flows from the Phenix Line go to the Comstock Line instead of the Natick Line projected peak flow year 2015 to these nodes are:

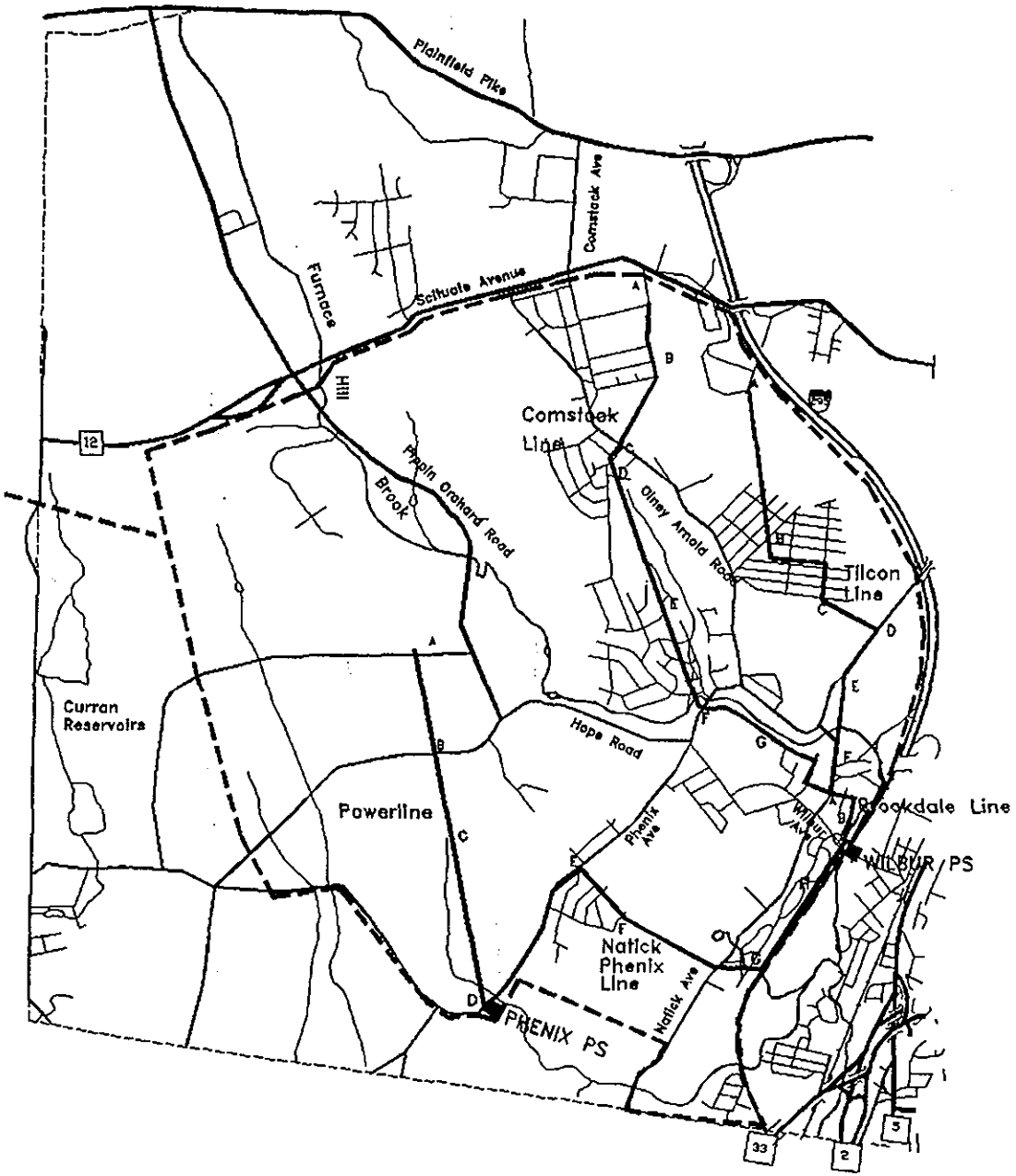
Comstock	Node F	Projected Peak Flow (gpm)	815
Comstock	Node G	Projected Peak Flow (gpm)	901
Brookdale	Node A	Projected Peak Flow (gpm)	2,579
Brookdale	Node B	Projected Peak Flow (gpm)	2,616
Brookdale	Node C	Projected Peak Flow (gpm)	2,854

WESTERN CRANSTON SERVICE AREA FLOWS: 2045

	ADF gpd	Peak Flow gpd	Peak Flow gpm
Powerline/Phenix/ Natick Line			
Node A	57735	263933	183.3
Node B	96160	439589	305.3
Node C	156559	659784	458.2
Node D	210888	836019	580.6
Node E	240408	935872	649.9
Node F	291360	1123818	780.4
Node G	444804	1620359	1125.2
Node H	471729	1684746	1170.0
Comstock Line			
Node A	70518	322368	223.9
Node B	121916	535560	371.9
Node C	232961	915204	635.6
Node D	463884	1673296	1162.0
Node E	476103	1700369	1180.8
Node F	786258	2583420	1794.0 *
Node G	831468	2672577	1856.0 *
Tilcon Line			
Node A	102927	470524	326.8
Node B	213148	852592	592.1
Node C	1024722	3286122	2282.0
Node D	1024722	3286122	2282.0
Node E	1043873	3353508	2328.8
Node F	1098487	3526125	2448.7
Brookdale Line			
Node A	1938302	5976819	4150.6 *
Node B	1953289	6023922	4183.3 *
Node C	2469515	7408545	5144.8 *

* Note: If flows from the Phenix Line go to the Comstock Line instead of the Natick Line projected peak flow year 2045 to these nodes are:

Comstock	Node F	Projected Peak Flow (gpm)	2,352
Comstock	Node G	Projected Peak Flow (gpm)	2,451
Brookdale	Node A	Projected Peak Flow (gpm)	4,645
Brookdale	Node B	Projected Peak Flow (gpm)	4,676
Brookdale	Node C	Projected Peak Flow (gpm)	5,145



APPROXIMATE TRUNK SEWER SERVICE AREA

"A" NODE

NOT TO SCALE

Section 117, Cranston, Rhode Island
Wastewater Conveyance Feasibility Investigation

WEST CRANSTON
TRUNK SEWERS SCHEMATIC

U.S. Army Corps of Engineers
New England Division
August 1993

FIGURE B-1

APPENDIX G

Task 4 - Review of Information on Cranston's Wastewater Treatment Facility Capacity

REVIEW OF
CRANSTON, RHODE ISLAND
WASTEWATER TREATMENT FACILITY CAPACITY

PREPARED BY
HYDRAULICS AND WATER QUALITY BRANCH
WATER CONTROL DIVISION
ENGINEERING DIRECTORATE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

JULY 1993

REVIEW OF
CRANSTON, RHODE ISLAND
WASTEWATER TREATMENT FACILITY CAPACITY

TABLE OF CONTENTS

Paragraph	Subject	Page
1	SUMMARY	G-1
2	INTRODUCTION	G-1
3	RIDEM'S ROLE	G-3
4	PERMIT AND CONSENT DECREE	G-4
5	RECEIVING STREAM	G-5
6	INDUSTRIAL PRETREATMENT PROGRAM	G-7
7	LOCAL LIMITS METHODOLOGY	G-8
8	CHARACTERIZATION OF WASTEWATERS	
	a. General	G-10
	b. Current Wastewater Flowrates	G-10
	c. Projected Wastewater Flowrates	G-11
9	WASTEWATER TREATMENT FACILITY	
	a. General	G-13
	b. Hydraulic and Pollutant Loading	G-13
	c. Operation and Layout	G-15
	d. Solids and Residuals Handling	G-18
10	ADVANCED TREATMENT	
	a. General	G-18
	b. Regional Alternatives	G-18
	c. Denitrification, Phosphorous, and Metals Removal	G-19
	d. Projected Solids Production	G-19
	e. Other Requirements	G-21
11	CONCLUSIONS	G-20
12	REFERENCES	G-21

LIST OF TABLES

Table	Subject	Page
1	Permit Limitations for Metal Concentrations	G-6
2	1992 Projected Design Flow (MGD)	G-12
3	1976 Projected Design Flow (MGD)	G-14
4	Comparison of Old, Interim and New Permit Concentration Limitations for BOD, TSS and Ammonia	G-16

LIST OF FIGURES

Number	Title	Follows Page
1	Location Map	G-3
2	WWTF Site Plan	G-16
3	Process Flow Schematic	G-16
4	Hydraulic Profile	G-16

The current overall study includes efforts to assess the need for expanded wastewater conveyance capacity, review of information on the WWTF capacity, prepare feasibility level designs and assessments of alternatives, select a proposed project, and prepare a preliminary design and baseline cost estimate of the proposed project. The current overall study looks at expected future wastewater flows, means to convey these flows, and the ability of the WWTF to treat them. This report considers the WWTF. The other subjects will be addressed separately.

The city of Cranston's wastewater treatment system is comprised of a collection system and a wastewater treatment facility. The collection system consists of approximately 260 miles of main line sanitary sewer, 8 miles of force main, and 20 pump stations. The purpose of this report is to determine the ability of Cranston's WWTF to accept additional flows and still meet the requirements of its discharge permit.

For this report, the Corps reviewed the city of Cranston's information, for the most part prepared by its consultant, Tutela Engineering Associates, Inc. (TEA), to evaluate the capabilities of the WWTF and Cranston's methodology for setting local discharge limits. These limits are the amount of pollutants industries are allowed to discharge to the municipal collection system. They are set for pollutants in excess of background concentrations so the total pollutant load will not exceed the city's water quality based RIPDES permit limits. These latter limits define what can legally be discharged by the WWTF to the Pawtuxet River.

Study site flows, projected to total an average of 4.8 MGD in the year 2015, would utilize a large portion of the facility's 10.7 MGD current excess capacity. The current permit limit is 23 MGD. The data in this report are based on the 1992 average daily flow of 12.3 MGD. The existing WWTF is also underloaded with respect to original design 5-day biochemical oxygen demand (BOD) and total suspended solids (TSS) loadings.

The WWTF provides good secondary treatment and met the conditions of its original permit. However, the 1989 RIPDES permit set new discharge limitations which can only be achieved through advanced treatment. The new RIPDES permit imposed more stringent seasonal limits for BOD and TSS and new limits for ammonia, chlorine residual, metals, total cyanide and tetrachloroethylene. The permit also required daily monitoring for nitrite, nitrate, and phosphorus and monthly monitoring for trichloroethylene and

1,1,1,trichloroethane in anticipation of future Rhode Island Department of Environmental Management's Division of Water Resources (RIDEM) policies.

A civil action complaint entered by RIDEM alleging the city has been or will be in violation of Rhode Island General Laws by discharging effluent into the Pawtuxet River from its WWTF without meeting the conditions of its RIPDES permit, was settled by a Consent Decree and Judgement issued by the State of Rhode Island in 1990. The Consent Decree involves the city in a regional effort to improve water quality in the Pawtuxet River by considering alternatives for advanced treatment of secondary effluents from either or both Warwick and West Warwick in addition to its own. Locations of Cranston, Warwick and West Warwick WWTFs are shown in figure 1. Of all alternatives considered for advanced treatment, only single stage nitrification would preclude acceptance of flow related to this study because modification of existing unused tankage would use up excess capacity. The city submitted its preliminary draft Wastewater Facility Plan to RIDEM in April 1992. Since then, the city received RIDEM's comments and conducted various investigations. At this time, no decision on which alternative to pursue has been made.

Until the city and RIDEM finalize permit requirements and treatment standards, the Corps cannot even say the WWTF will be able to treat existing flows adequately. The Corps perceives that in order to meet water quality based effluent limits, the city will have to impose additional restrictions on metals concentrations and total loadings contributed by existing and potential new users, and possibly install metals removal facilities at the WWTF. There are additional unresolved issues concerning disposal of sludge, incinerator emission standards, and future phosphorus removal and denitrification requirements.

3. RIDEM'S ROLE

In its comments on the Section 22 Investigation, RIDEM referred to the proposed interceptor project as a significant modification of the wastewater system for which the sponsors must demonstrate consistency with the city's comprehensive Wastewater Facility Plan. RIDEM's Division of Water Resources sets discharge permit limits for publicly owned treatment works (POTW) and reviews comprehensive wastewater

facility plans for approvals of facility upgrades, expansions and modifications. POTWs are required to comprehensively plan water pollution control projects to accommodate population growth and economic development, and meet regulatory requirements and regional goals.

RIDEM and EPA Region I comments called for project sponsors to conduct a wastewater characterization study. This would include a Toxicity Characteristic Leaching Procedure (TCLP) test. RIDEM would review data to determine if changes in the composition of the facility's influent warrant modification of the permit. EPA's 21 February 1991 comments recommend project sponsors commission an independent consultant to determine if the facility can achieve proposed advanced treatment standards.

4. PERMIT AND CONSENT DECREE

Currently, the city operates the WWTF under interim effluent limitations and monitoring requirements. These are specified in the Consent Decree and Judgement (Consent Decree) that was issued by the State of Rhode Island on November 26, 1990. The Consent Decree includes provisions for modifying the permit and Consent Decree Order. The Order can be terminated when the city achieves compliance with the final permit limitations for a period of one year.

The city's Judicial Consent Decree Compliance Plan, dated October 1990, calls for it to develop a site specific bioassay program for evaluation of effluent toxicity, develop a chlorine residual compliance methodology, analyze alternatives for regional and individual advanced wastewater treatment facilities, conduct studies to assess non-point pollution and inflow/infiltration, and continue with its industrial pretreatment program. RIDEM agreed to conduct an evaluation of sediment oxygen demand of benthic deposits in the Pawtuxet River. When these studies are completed, their results will influence final effluent limitations for the Cranston WWTF.

In a fact sheet accompanying RIPDES permit RI01000013, RIDEM explains the basis of permit effluent limits. "Average Monthly" and "Average Weekly" BOD and TSS limitations for November 1 through May 31 and pH limitations are based on secondary treatment requirements of the Clean Water Act as defined in 40 CFR 133.102. "Maximum Daily" BOD and TSS limitations and limitations for settleable solids, fecal coliform, and chlorine residual are based on Rhode Island Requirements for Publicly Owned Treatment Works. Limits for cyanide, and tetrachloroethylene are based on the State's

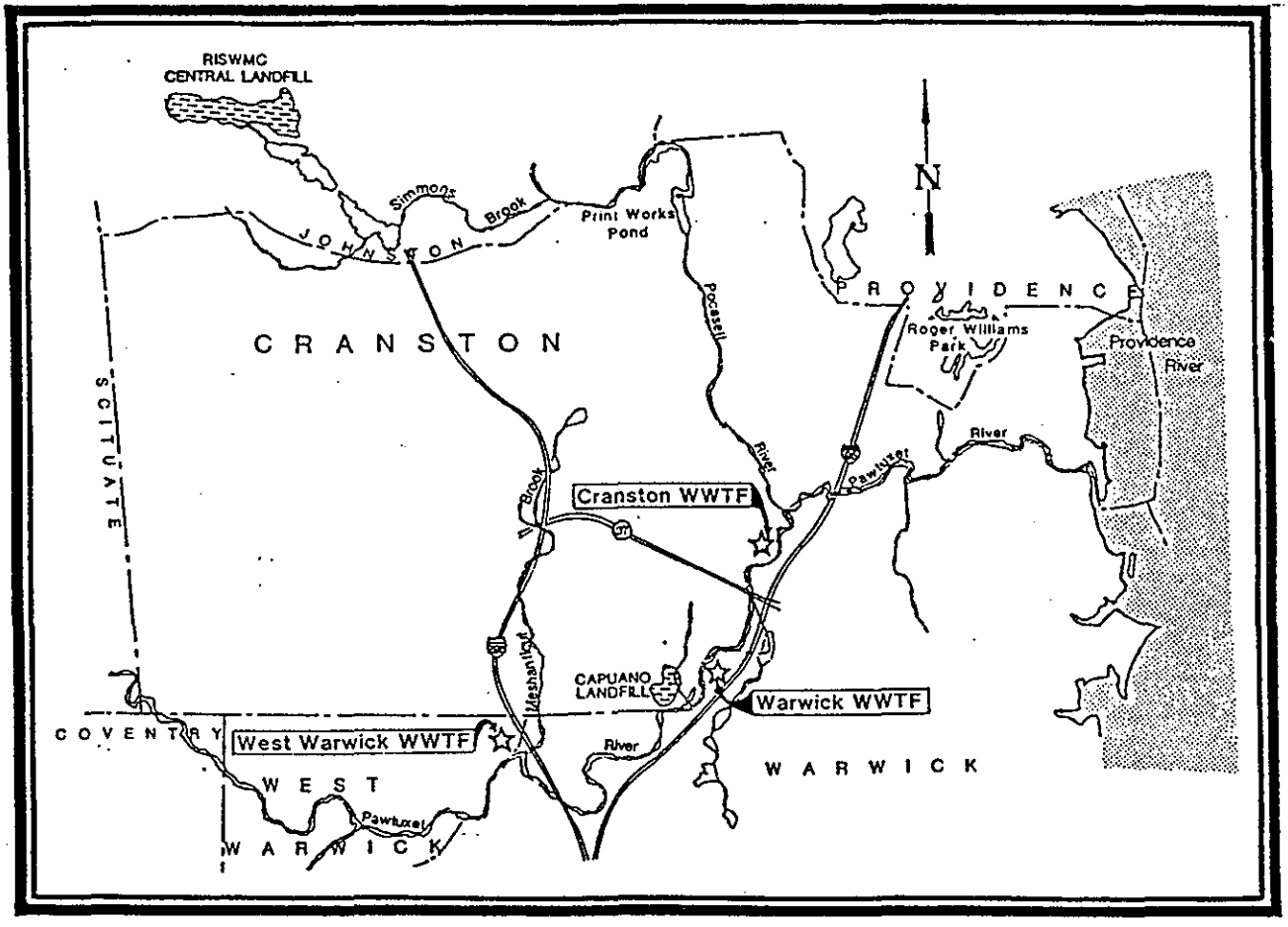


Figure 1

Location Map

Source: Tutela Engineering Associates, Inc.

Water Quality Regulations. Limits for silver, copper, lead, cadmium, chromium, and nickel as well as BOD, TSS, dissolved oxygen and ammonia for June 1 through October 31 are derived from "A Study of the Water Quality of the Pawtuxet River; Chemical Monitoring and Computer Modeling of Pollutants, Modeling of dissolved oxygen (DO) in Transient Flow Conditions, the Pawtuxet computer model; A Waste Load Allocation to DO/BOD Dynamics of the Pawtuxet River, Fate and Transport of Heavy Metals in the Pawtuxet River" commissioned by RIDEM. Also, although no permit limitations were established for total phosphorus, total nitrate, total nitrite, and trichloroethylene and 1,1,1 trichloroethane, monitoring requirements were imposed for the purpose of collecting data in anticipation of pending changes to RIDEM regulations. Table 1 shows interim and final permit limits for metals.

5. RECEIVING STREAM

The Pawtuxet River serves as the receiving stream for three POTWs; Cranston, Warwick, and West Warwick (see figure 1), and industrial discharges as well as urban runoff and benthic deposits.* Low dissolved oxygen levels at critical flow periods result in failure to consistently achieve class "C" water quality designation in the main stem. In comments to the Section 22 Investigation Report, EPA Region I's Water Quality Section summarized from the Rhode Island 1990 "State of the State's Waters" report:

> Biological monitoring at two stations on the Pawtuxet River (including one at the U.S. Geological Survey's gage in Cranston) over the past decade indicates the presence of a compromised benthic community (primarily pollution tolerant and intermediate species)... Although several waterbodies in the study area suffer from adverse water quality and have been given "C" classifications by RIDEM, Division of Water Resources, the goal of the Clean Water Act is for waterbodies to meet "fishable/swimmable" criteria or to be designated Class "B" or better.

In summary, water quality goals for the Pawtuxet River, anti-backsliding and anti-degradation policies, and the apparent infeasibility of alternatives for out-of-basin disposal of Cranston's effluent impose tight constraints for regulators as they set compliance standards for Pawtuxet River dischargers. RIDEM is requiring ammonia reduction from all three POTWs in order to reduce the oxygen demand exerted by their effluents. Reductions in metals,

*** It should be noted that the city has always been concerned that providing advanced wastewater treatment may not assure obtaining the desired water quality classification for the river due to additional point and non-point sources of pollution.**

Table 1 Permit Limitations for Metal Concentrations				
	Interim, ug/L		Final, ug/L	
	Ave Monthly	Max Daily	Ave Monthly	Max Daily
Zinc, Total	140	250	125	140
Silver, Total	13	50	BDL (1.0)	BDL (1.0)
Copper, Total	70	190	10	15
Lead, Total	18	37	BDL (3.0)	BDL (3.0)
Cadmium, Total	5	16	1.1	3.9
Chromium, Total	320	1280	320	1280
Nickel, Total	260	960	200	800
Cyanide, Total	208	650	10	40
Tetrachloro -ethylene	20	77	20	40

*NOTE: BDL means below detection limit.

chlorine residual, and organic compounds are called for to reduce possible adverse impacts on aquatic life in the river.

6. INDUSTRIAL PRETREATMENT PROGRAM

The National Pretreatment Program, established under the Clean Water Act, requires POTWs to control toxic pollutants discharged into sewer systems that may interfere with, pass through or otherwise upset the POTW's treatment process. This is typically accomplished through Sewer Use Ordinances. To implement general prohibitions and national categorical standards for pretreatment, Cranston calculated the amounts of pollutants industries are allowed to discharge to the WWTF. Cranston established concentration limits for cadmium, chromium, copper, lead, nickel, silver, zinc, total cyanides, and total toxic organics. These concentration limits are called local limits. They apply to about 60 of the 300 potential industrial dischargers regulated by Cranston's Industrial Pretreatment Program, and typically exceed domestic background concentrations by one or two orders of magnitude.

An industry may propose to discharge into Cranston's sewers any substance for which there are no discharge limits in Cranston's WWTF permit. If proposed discharge concentrations exceed background levels, the industry must show that the proposed discharge will not interfere with treatment processes at the facility or aquatic life in the river. It is usually easier for the industry to eliminate the substance from its waste stream. From 1985 to 1991, Cranston's Industrial Pretreatment Program reported a 63 percent decrease in pollutant loading while facility flows remained relatively constant.

Cranston is in the process of amending its Sewer Use Ordinance to strengthen prohibitions against discharging toxic or hazardous wastes to the system. The current ordinance became effective 26 August 1985 and was revised 20 June 1990. Permit requirements are being expanded to require all industrial users to comply with any and all applicable pretreatment standards and requirements, including but not limited to, EPA Categorical Pretreatment Standards [Title 40 Code of Federal Regulations Subchapter N], national Prohibited Discharges (general and specific) [Title 40 Code of Federal Regulations Parts 403.5 (a) and (b)] and all requirements of the Federal EPA General Pretreatment Regulations for Existing and New Sources of Pollution. [Title 40 Code of Federal Regulations Part 403.12].

Reducing its liability under the Comprehensive Environmental Resource Conservation Act (CERCLA, Superfund) and the Resource Conservation and Recovery Act (RCRA) regulations is in Cranston's own best interest. The city does not intend to allow CERCLA wastes to be discharged without pretreatment to nonhazardous levels. It will incorporate these specific requirements in its Industrial Pretreatment Program. These will include expanding the list of parameters subject to compliance inspection to all pollutants existing in a potential CERCLA waste. In the event an industry proposed to discharge a substance for which no local limits have been established, Cranston will conduct a specific analysis of pretreatment requirements to prevent pass through, inhibition, and sludge contamination in its WWTF, and develop enforcement activities to ensure compliance.

7. *LOCAL LIMITS METHODOLOGY*

Cranston uses two methods for determining local limits: One deals with parameters listed in its discharge permit, and the other applies to all other parameters that an industry may wish to discharge in concentrations greater than background concentrations. Background concentrations were analyzed from collection system samples taken from manholes in residential areas as part of the city's Industrial Pretreatment Program. The allowable headworks loading (in pounds per day), for each parameter for which there is a numerical concentration limit in its RIPDES discharge permit, is determined from the RIPDES permit limit concentration, the WWTF removal efficiency for that parameter, and the current average monthly WWTF flowrate. From the allowable headworks loading, the city subtracts the loading contributed at residential background concentrations by nonindustrial flows. Cranston can allow specially designated industrial users to discharge the remainder, if any. By dividing this remainder by the flowrate at which specially permitted and monitored Significant Industrial Users (SIUs) discharge the particular parameter, the city establishes the local limit concentration. At present, SIUs contribute about 5 percent of the total WWTF influent.

For parameters for which there are no established limits, Cranston requires the particular industry to show that its proposed discharge will not interfere with treatment processes at the facility or aquatic life in the river. It is usually easier for the industry to eliminate the substance from its waste stream.

These methods for computing local limits are adequate for protecting against pollutant pass through, interference

with treatment processes, and sludge contamination. However, this methodology for setting local limits allows industry to always discharge pollutants in at least background concentrations. If the final WWTF discharge permit sets effluent limitations so low that background levels of contaminants cause the permit to be violated, a new method of computing local limits may be required.

Cranston presented a local limits analysis in its Amendment to the 1976 draft Wastewater Facility Plan, prepared by Tutela Engineering Associates, Inc. (TEA), in April 1992. This demonstrated that current local limits are adequate for meeting average interim permit limits at existing flow conditions and with the addition of the projected initial flow of 0.1 MGD from the RISWMC Central Landfill in Johnston, Rhode Island. TEA's analysis showed interim permit limits and WWTF removal efficiencies were adequate to support total loadings derived from approximately 0.6 MGD of existing flow from SIUs at local limit concentrations, and approximately 12.6 MGD of non-industrial flow at residential background concentrations. However, there are problems with "spikes" of high metals concentrations which can cause daily discharge limits to be exceeded. Origins of these metal spikes are undocumented but are suspected to involve transitory problems at industries discharging to the sewer system.

The existing local limits methodology ensures that the addition of future flows may increase the amount of certain compounds discharged to the river, but will not increase their concentration. For example, in the event a parameter, such as copper, is in the WWTF's effluent in concentrations higher than allowed by the final permit, the methodology for setting local limits ensures industrial users cannot discharge copper at any concentrations higher than background levels. Therefore, at worst, the local limits will ensure that future flows will not increase copper concentrations in the effluent. Future flows would increase the total amount of copper entering the Pawtuxet River; if this was considered more important than copper concentration, it would increase harm done.

In neither the Amendment to the 1976 Wastewater Facility Plan nor the preliminary draft Wastewater Facility Plan did Cranston address the possible need for reductions in current local limits in order to meet final permit limits. To the Corps, based on monitoring data presented by the city in its Industrial Pretreatment Program report, it appears the city will have difficulty meeting its final permit limitations for silver, copper, lead, cadmium and

cyanide unless it reduces the local limits under the Industrial Pretreatment Program, modifies the facility's treatment processes to increase metals removal or obtains a relaxation of permit limitations. In these documents, Cranston did not propose methods for enhancing WWTF removal efficiencies or abating residential background concentrations as adjuncts or alternatives to reducing local limits.

The degree to which further reductions in local limits would negatively affect the city's ability to attract and retain industries is a matter for economic analysis under the comprehensive facility planning process and deliberations with RIDEM, EPA Region I, and neighboring communities regarding water quality based permit limits. It is not within the scope of this report.

8. CHARACTERIZATION OF WASTEWATERS

a. General. Cranston's WWTF deals with a typical blend of residential, industrial, and institutional flows. There are no unusual hydraulic or pollutant loadings that make the wastewater particularly difficult to treat.

b. Current Wastewater Flowrates. In 1991, the total average daily flow of 13.4 MGD was comprised of approximately 48 percent residential; 22 percent industrial, commercial, or institutional; 29 percent inflow and infiltration; and 1 percent septage. Four percent of the total flow is attributed to Significant Industrial Users (SIUs). All of the approximately 60 SIUs are subject to local limits under Cranston's Sewer Use Ordinance and among them, 17 are subject to EPA categorical pretreatment standards for electroplating, metal finishing, plastic molding and forming, and copper forming.

From 1976 to 1992, the wastewater from industrial, commercial, and institutional sources increased by 80 percent. This is nearly twice the rate of total flow increases in this time span. Increases in industrial, commercial and institutional flow from 17 to 22 percent of total flow are attributed to the development of Howard Industrial Park and connection of the State Institution complex to Cranston's collection system. Aggregate data on wastewater quality for these categories of flow are not presented in the current Wastewater Facility Plan, although compliance monitoring data was collected for most industries and is presented for each industry in the Industrial Pretreatment Program report.

c. Projected Wastewater Flowrates. Cranston's projections for reaching the design flow of 23 MGD by the year 2015 are shown in table 2. Approximately 53 percent, or 12.1 MGD, of this flow is projected to be industrial, commercial, and institutional. Projected rate of increase of today's flow from these categories is 300 percent.

Although impacts of non-domestic components of flow will be significant, Cranston's preliminary draft Wastewater Facility Plan did not compare either the current or projected composition of industrial, institutional and commercial wastewaters to domestic sewage. This is difficult to estimate for projected flows, because of variation in industries and uncertainties as to economic, regulatory and technological factors affecting implementation of recycle process systems. However, the draft is being updated and the projected pollutant loadings will be addressed.

Study sites considered in the Corps evaluation are projected to contribute approximately 4.8 MGD by the year 2015. This includes approximately 0.7 MGD domestic wastewater from West Cranston and North West Cranston residential areas; 1.1 MGD from Howard State Institutional Center; 2.2 MGD commercial and industrial flow from Howard Industrial Park, Tilcon Gammino Industrial Area, North West Cranston Industrial Area, and Johnston Industrial Area; 0.3 MGD from infiltration and inflows; and 0.5 MGD from landfills. The Corps estimated total flows of 0.4 MGD for RISWMC's Central Landfill, 0.035 MGD for Vinagro Site, and 0.06 MGD for Capuano Site. (Although the preliminary draft Wastewater Facility Plan does not include approximately 0.18 MGD in flows from Johnston Industrial Area and Capuano and Vinagro landfills, a portion of the industrial flow projected in the preliminary draft Wastewater Facility Plan is assumed to be substituted by these flows, for purposes of estimating hydraulic capacity requirements.)

Estimates of flows from landfills include 0.22 MGD for discharge of treated groundwater from Central Landfill, and lesser amounts from the other two. Regulatory agencies studying the Central Landfill, Vinagro Site and Capuano Site have not reached any decisions as to how to treat contaminated groundwater, much less how much flow to send to the Cranston WWTF, if any. Studies of Central Landfill have shown definite groundwater contamination, and EPA plans to sign a Record of Decision (ROD) before the first quarter of 1994. State and federal regulatory agencies have completed preliminary studies of Capuano and Vinagro sites, but have not determined if they will require groundwater remediation at either.

Table 2 1992 Projected Design Flow (MGD)			
	1991	2015	2045
Domestic	6.4	7.4	8.6
State Institutions	1.4	1.5	1.5
Central Landfill	0.0	0.4	0.4
Howard Industrial Park	0.4	1.4	1.4
Other Industry	2.2	8.8	13.0
Non Excessive I/I	2.7	3.0	3.6
Septage	0.1	0.1	0.1
Sub Total	13.2	22.6	28.6
I/I To Be Eliminated	1.1	0.0	0.0
Total	14.3	22.6	28.6
		Say 23	Say 29

Source: 1992 Draft Preliminary Wastewater Facility Plan

9. WASTEWATER TREATMENT FACILITY

a. General. Cranston's WWTF is a fairly typical secondary treatment facility. Primary treatment is provided with clarifiers, and secondary treatment with activated sludge. Sludge and grease are incinerated on site, and residuals are landfilled off site. The facility includes a laboratory and control room. The facility is well designed, well run, and has a good amount of area available for expansion. Cranston's current 23 MGD average flow capacity WWTF was built adjacent to an earlier one at 140 Pettaconsett Avenue. When the facility went on line in 1983, the average daily flow was 11.5 MGD. In 1992, the average daily flow was 12.3 MGD. Cranston operated the WWTF until June 1989, when it entered in agreement with the contract operating firm Professional Services Group (PSG) to operate the facility. The city retains ownership.

The description of the design, present and projected hydraulic and solids loading, special requirements and estimated ability of the existing facility to handle future changes are summarized here. It is not within the Corps scope of work under this task to conduct an extensive evaluation of either the existing treatment facility or proposed upgraded facility.

b. Hydraulic and Pollutant Loading. Structures, process equipment, and electrical systems were designed and built to treat 60,000 pounds of 5-day biochemical oxygen demand (BOD) and 37,500 pounds of total suspended solids (TSS) at an average design flow of 23 MGD. Design maximum daily flow is 36 MGD and design hydraulic capacity is 44 MGD. The highest daily flow of 30.9 MGD occurred in April 1987 under flooding conditions.

Table 3 shows original flow projections according to various use categories developed for the design year 2000 by Universal Engineering Corporation in the 1976 draft Waste-Water Facility plan. The facility's current hydraulic loading leaves an excess capacity of 40 percent relative to design average daily flow of 23 MGD. In 1980, this excess capacity was 50 percent. In terms of BOD and TSS loadings, the facility's current excess capacity is 55 and 32 percent, respectively.

Design pollutant loadings included provisions for 20,000 pounds of BOD and 2,252 pounds of TSS in 1.8 MGD industrial wastewater flow from Ciba-Geigy Corporation. Since then, Ciba-Geigy discontinued operations in Cranston and released its reserve capacity. The old permit, which

Table 3 1976 Projected Design Flow (MGD)				
	1975	1980	2000	2030
Domestic	6.5	6.9	9.0	11.0
State Institutions	--	1.1	1.1	1.1
Ciba-Geigy	--	1.8	1.8	1.8
Howard Industrial Park	--	0.3	1.4	1.4
Other Industrial	2.2	3.2	7.7	14.3
Special Infiltration	2.5	1.5	1.7	2.2
SUBTOTAL	11.2	14.8	22.7 SAY 23	31.8 SAY 32
Infiltration to be Eliminated	0.0	1.9	1.9	1.9
TOTAL	11.2	16.7	24.6	33.9 SAY 34

Source: 1976 Draft Wastewater Facility Plan

expired in 1985, had discharge limitations for conventional pollutant parameters of BOD and TSS as shown in table 4 for comparison with current requirements.

Average BOD removal was 89 percent and average TSS removal was 90 percent according to 1983 to 1990 effluent quality data presented in the preliminary draft Wastewater Facility Plan. For that period, the mean BOD concentration was 16 mg/l with a standard deviation of 9 mg/l, and the mean TSS concentration was 16 mg/l with a standard deviation of 11 mg/l. Average monthly effluent exceeded 30 mg/l in either parameter only three times.

The city's data for 1981 through 1991 shows that while influent flow, loadings and concentrations of conventional pollutants fluctuate considerably from year to year, the following trend is apparent: Flowrates, influent loadings and influent concentrations of BOD and TSS increased, while effluent loadings and concentrations of these parameters decreased. These improvements in treatment efficiency were no doubt spurred by progressively more stringent permit requirements and are an indication of a well-run WWTF.

c. Operation and Layout. The Corps bases its description on a field trip it conducted to the facility in January 1993 and information from Tutela Engineering Associates, Inc. The WWTF site plan is shown in figure 2, process flow schematic in figure 3, and hydraulic profile in figure 4.

Headworks receive facility influent from an interceptor referred to as "the siphon", two 24" diameter force mains, and septage. Some flow enters the facility directly on the second floor while the rest is lifted by three 5,200 gpm screw pumps. A trough and wall opening anticipates a fourth screw pump but lacks machinery.

Preliminary treatment consists of 2 mechanically cleaned bar racks and one manual bar rack; 2 grit removal tanks, each with a rake and screw conveyor for grit removal; and two induced-air, grease flotation tanks. The odor control system was not operational at the time of visit.

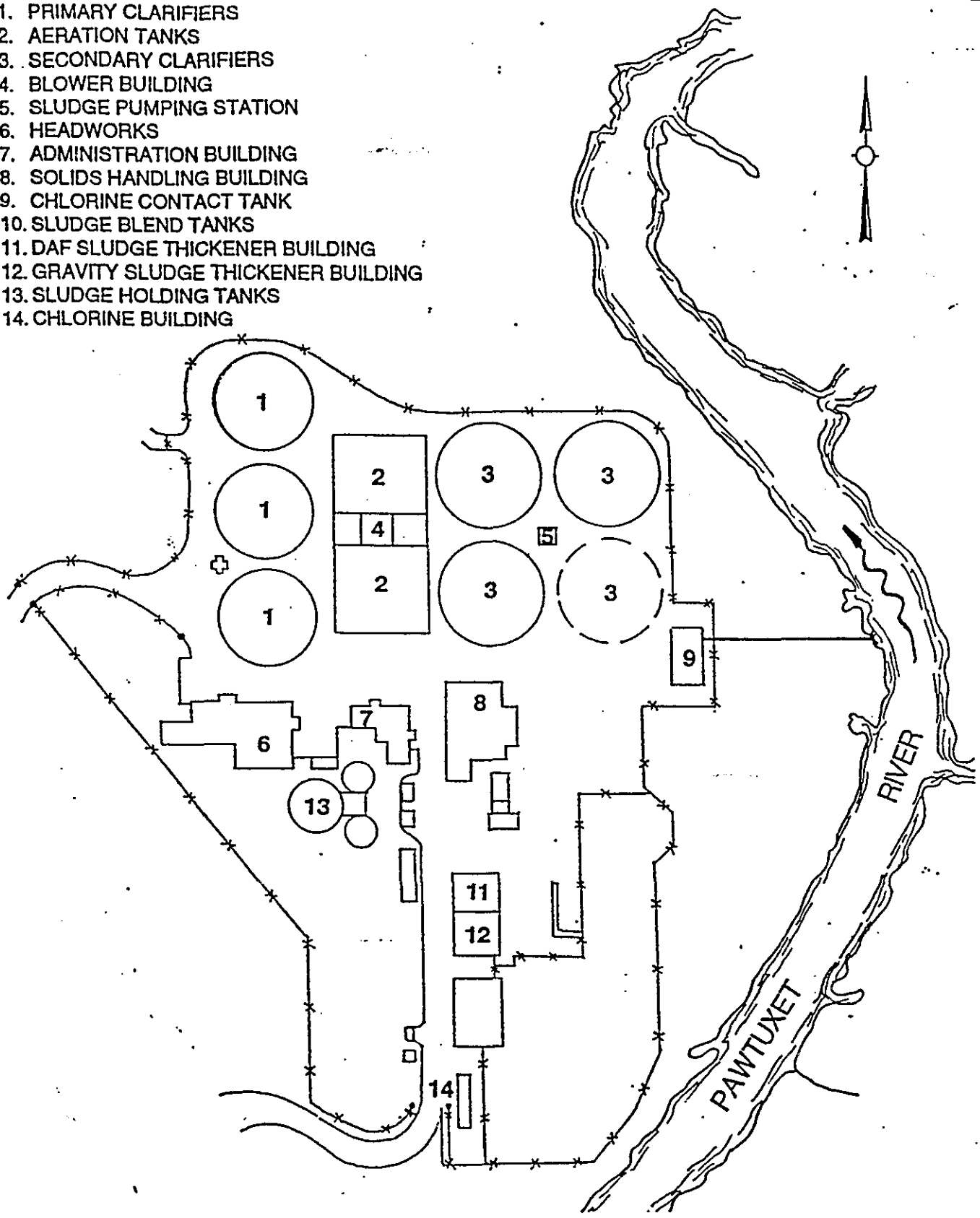
Two of three circular, center-feed, primary clarifiers are on line. The third clarifier is used only to divert storm flow to prevent hydraulic overloading. The operational mode is to return waste activated sludge solids to the primary clarifiers to co-settle with primary sludge. Two of four aeration basins are presently on line. A total of three blowers, of which only one was on line at time of visit, supply air to three submerged turbine mechanical aerators in

Table 4

Comparison of old, interim and new permit concentration limitations for BOD, TSS and Ammonia

Time Frame and Parameter	Average Monthly, ug/L			Average Weekly, ug/L			Maximum Daily, ug/L		
	BOD	TSS	NH_3-N	BOD	TSS	NH_3-N	BOD	TSS	NH_3-N
Old Permit	30	30	N/A	45	45	N/A	50	50	N/A
Interim Permit	Same as Final								
Final Permit:									
Nov 1 to May 31	30	30	Mon-itor	45	45	Mon-itor	50	50	Mon-itor
June 1 to 30 and Oct. 1 to 31	15	25	3	15	25	3	15	30	5
July 1 to Sept 30	10	20	2	10	20	2	15	30	3

1. PRIMARY CLARIFIERS
2. AERATION TANKS
3. SECONDARY CLARIFIERS
4. BLOWER BUILDING
5. SLUDGE PUMPING STATION
6. HEADWORKS
7. ADMINISTRATION BUILDING
8. SOLIDS HANDLING BUILDING
9. CHLORINE CONTACT TANK
10. SLUDGE BLEND TANKS
11. DAF SLUDGE THICKENER BUILDING
12. GRAVITY SLUDGE THICKENER BUILDING
13. SLUDGE HOLDING TANKS
14. CHLORINE BUILDING



Source:

1992 Draft Preliminary Wastewater Facility Plan

CITY OF CRANSTON, RHODE ISLAND
WASTEWATER TREATMENT FACILITY PLAN

SITE PLAN

Tutela Engineering Associates, Inc.
RHODE ISLAND MASSACHUSETTS

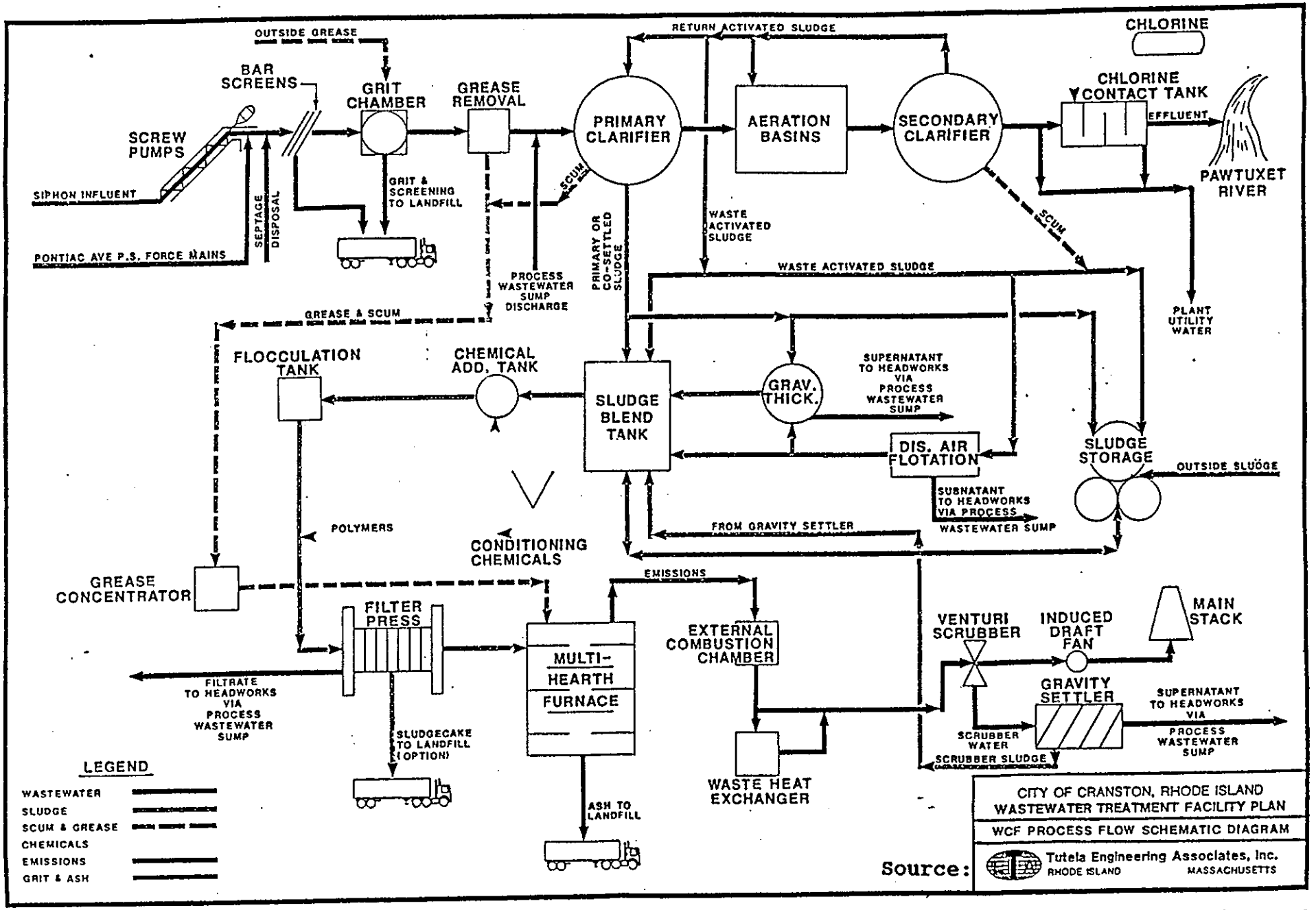
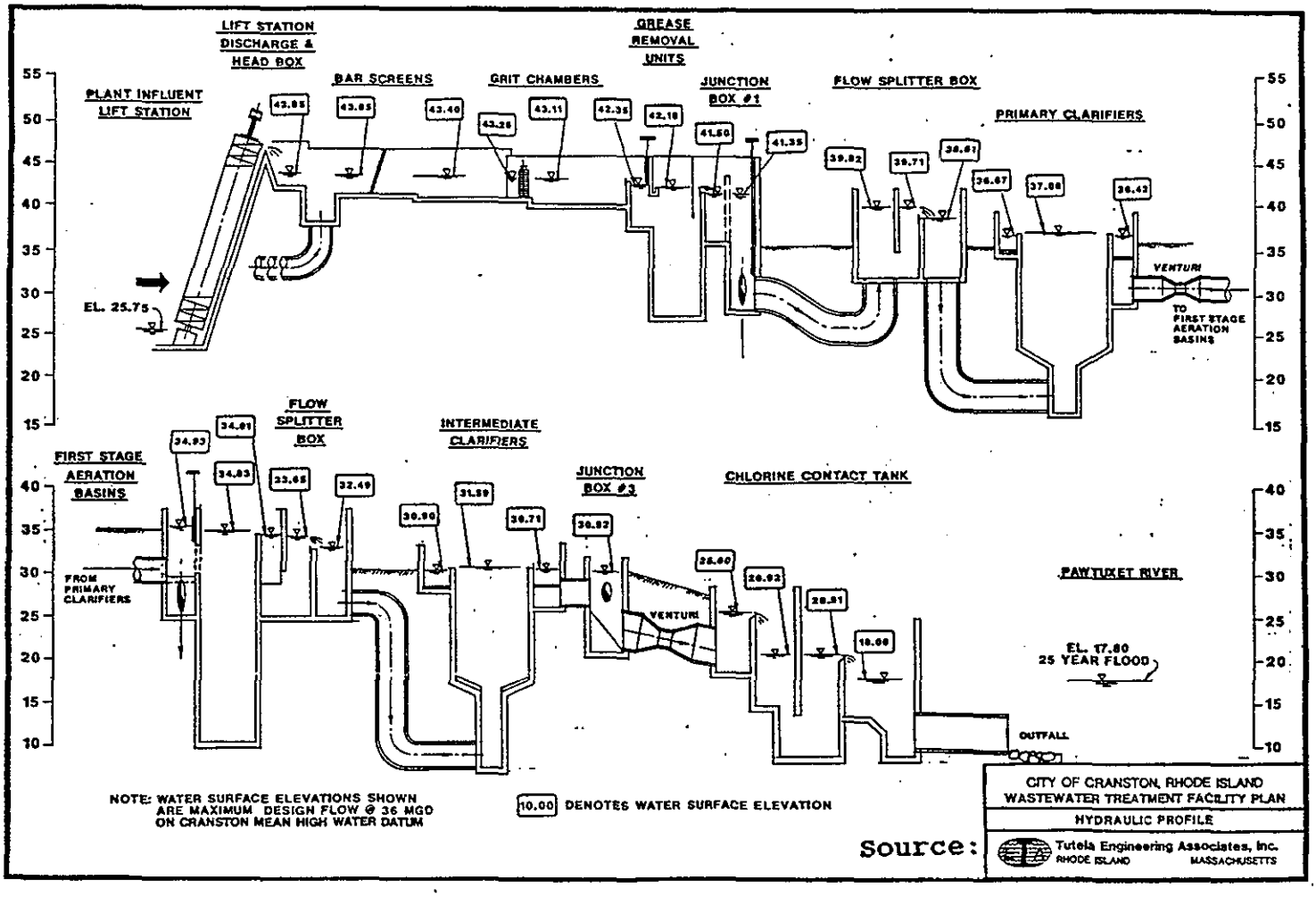

OUTSIDE GREASE
RETURN ACTIVATED SLUDGE
CHLORINE
BAR SCREENS
GRIT CHAMBER
GREASE REMOVAL
PRIMARY CLARIFIER
AERATION BASINS
SECONDARY CLARIFIER
CHLORINE CONTACT TANK
EFFLUENT
PAWTUXET RIVER
SCREW PUMPS
SIPHON INFLUENT
PONTIAC AVE P.S. FORCE MAINS
SEPTAGE DISPOSAL
GRIT & SCREENING TO LANDFILL
SCUM
PRIMARY OR CO-SETTLED SLUDGE
WASTE ACTIVATED SLUDGE
WASTE ACTIVATED SLUDGE
PROCESS WASTEWATER SUMP DISCHARGE
GREASE & SCUM
PLANT UTILITY WATER
FLOCCULATION TANK
CHEMICAL ADD. TANK
SLUDGE BLEND TANK
GRAV. THICK.
SUPERNATANT TO HEADWORKS VIA PROCESS WASTEWATER SUMP
DIS. AIR FLOTATION
SLUDGE STORAGE
OUTSIDE SLUDGE
SUBNATANT TO HEADWORKS VIA PROCESS WASTEWATER SUMP
FROM GRAVITY SETTLER
POLYMERS
CONDITIONING CHEMICALS
GREASE CONCENTRATOR
EMISSIONS
FILTER PRESS
MULTI-HEARTH FURNACE
EXTERNAL COMBUSTION CHAMBER
VENTURI SCRUBBER
INDUCED DRAFT FAN
MAIN STACK
GRAVITY SETTLER
SUPERNATANT TO HEADWORKS VIA PROCESS WASTEWATER SUMP
FILTRATE TO HEADWORKS VIA PROCESS WASTEWATER SUMP
SLUDGECAKE TO LANDFILL (OPTION)
SCRUBBER WATER
SCRUBBER SLUDGE
WASTE HEAT EXCHANGER
ASH TO LANDFILL
LEGEND
WASTEWATER
SLUDGE
SCUM & GREASE
CHEMICALS
EMISSIONS
GRIT & ASH
CITY OF CRANSTON, RHODE ISLAND
WASTEWATER TREATMENT FACILITY PLAN
WCF PROCESS FLOW SCHEMATIC DIAGRAM
Source:
Tutela Engineering Associates, Inc.
RHODE ISLAND
MASSACHUSETTS

Figure 3



Source:

Figure 4

each basin. The aeration system is designed as a conventional activated sludge system.

Secondary sludge is settled out in two of four circular, center-feed, final clarifiers. The third tank is off line, and the center mechanism of the fourth tank was never installed. Based on settled solids and mixed liquor characteristics, varying portions of secondary sludge are returned to aeration basins and primary clarifiers. Final clarifier overflow is disinfected in chlorine contact tanks. Chlorine is injected in the influent box and anti-foaming agent is dripped into the mixing chamber. Facility effluent is discharged to the Pawtuxet River at outfall No. 001.

An underground gallery houses a sludge transfer pumping station and aeration blowers. The pipe gallery includes an unused return line for future filter backwash flow, anticipated in previous designs. The final Wastewater Facility Plan will include consideration for use of the system for the proposed advanced treatment processes.

Co-settled sludge drawn from primary clarifiers is stored in sludge holding tanks together with sludge accepted from other municipalities. Sludge flows by gravity to the sludge blend tanks and is pumped into the solids handling building for dewatering. Air from the blend tank passes through a potassium permanganate odor control system. PSG chooses not to utilize the gravity thickener and dissolved air flotation units. PSG adds polymer, as a conditioning agent, to the sludge prior to dewatering it in the solids handling building. Dewatering is by three recessed plate frame presses. Hoppers and conveyor systems feed sludge cake to one or both multiple hearth incinerators at a rate of about 960 pounds (dry) per hour to the 14 feet 3 inch multiple hearth furnace and about 1,735 pounds (dry) to the 18 feet 9 inch multiple hearth furnace. Incinerators are equipped with a scrubber, and controlled from an incinerator instrumentation room.

The main electrical transformer is located south of the sludge holding tanks. Smaller transformers and an emergency generator are located between the administration building and the headworks.

Operational mode during an electrical power outage, using on site standby power, consists of lifting wastewater into the facility; passing it through grit removal and grease flotation tanks; storing sludge in the clarifiers or holding tanks; and chlorinating the effluent. No aeration, dewatering or incineration is used.

Advanced treatment facilities are currently being planned to meet seasonal ammonia limits under the final permit. Only monitoring will be required during winter months.

d. Solids and Residuals Handling. In 1991, the facility dewatered and incinerated a total of 13,900 tons of wet sludge cake, consisting of approximately 25% solids. In the current process, sludge is produced at the rate of 0.6 to 0.8 tons of dry solids per million gallons wastewater treated. Of 3,500 tons of dry sludge solids disposed in 1991, 80 percent were generated on site by Cranston's wastewater treatment process. The remainder was municipal sludge the city accepted from other communities. Cranston pays PSG an extra fee to dewater and incinerate this outside sludge. In the event that process changes, such as advanced treatment, result in increased sludge production, the city would reduce or cancel contract amounts from other communities to obtain additional capacity for itself.

The facility accepts residential septage and septage analyzed and evaluated to be of a residential nature. Residual sludge ash from sludge incineration, and screenings and grit from preliminary treatment are disposed of at RISWMC's Central Landfill in Johnston, RI. Grease is concentrated and incinerated on site.

10. ADVANCED TREATMENT

a. General. In order to meet the requirements of RIDEM's final discharge permits, advanced treatment will be required. This treatment will likely include removal of ammonia and chlorine residual. Removal of nitrogen, phosphorus, metals, and organic compounds may also be required. New regulations being considered by EPA and the State of Rhode Island may also affect methods for disposing of waste solids. To meet these future requirements, Cranston is evaluating treating only its own waste or entering into a regional advanced treatment plan with Warwick and West Warwick. Of the alternatives likely to be implemented, none would preclude treating projected future flows from western Cranston. However, any increase in flow will increase the cost of advanced treatment and disposal.

b. Regional Alternatives. Projected conditions are based on information presented in the 1992 preliminary draft Wastewater Facility Plan. In this document, Tutela Engineering Associates, Inc. (TEA) presents an evaluation of various scenarios for regional and individual advanced treatment alternatives for meeting discharge permit limitations. These included generating and ranking a number of alternatives for

regional advanced treatment of Warwick, West Warwick, and Cranston flows. For example, a regional pipeline to convey effluents to the Providence River, for the purpose of entirely eliminating discharges to the Pawtuxet River, was considered but rejected as too costly and problematic.

TEA's evaluation of alternatives determined that Warwick and West Warwick sites are too restricted to treat a second community's flow. On the other hand, Cranston has adequate siting available for advanced treatment facilities to handle secondary effluent flows in addition to its own, provided phosphorus removal is conducted at the other communities' secondary facilities. However, Cranston needs to maintain availability of WWTF site area for other future improvements, such as denitrification, phosphorus removal or physical/ chemical methods for metals toxicity removal. Therefore, only compact treatment technologies that utilize space efficiently could be pursued. Within these constraints, eight regional alternatives and one individual alternative were selected and supported by the communities and RIDEM for further consideration.

TEA conducted a review of compact advanced treatment technologies and performed pilot studies at the Cranston WWTF site. TEA recommended use of biological aerated filters to achieve ammonia removal and sulfonation to eliminate residual aquatic toxicity due to chlorine. Based on pilot studies for these processes, TEA developed conceptual design criteria for various flow scenarios to nitrify and dechlorinate secondary wastewater effluent up to 41 MGD average daily flow and 69 MGD maximum daily flow.

c. Denitrification, Phosphorus and Metals Removal. The above recommended technologies do not provide denitrification, phosphorus removal, or metals removal. Proposals for denitrification and phosphorus removal are only mentioned in the preliminary draft Wastewater Facility Plan to the extent that TEA advises the city to reserve space at the WWTF site and prepare conceptual designs in anticipation of RIDEM requirements. The effects of metals on activated sludge and other process operations is not addressed. Also, the final effluent quality of combined flows from Warwick, West Warwick and Cranston is not estimated or assessed in terms of permit limitations except for BOD, TSS and ammonia. The current RIDES permit does not specify limits for nitrite, nitrate, and phosphorus, but does require Cranston to monitor and analyze the effluent for these parameters.

d. Projected Solids Production. The draft preliminary Wastewater Facility Plan indicates sludge production levels

for advanced wastewater treatment facilities, servicing all three communities, could easily be handled within the available capacity of Cranston's large incinerator. Additional sludge generated by advanced treatment could range from 0.7 to 22.0 tons per day, depending on the type of treatment, flows, and other factors such as process, temperature, etc. For example, nitrification, denitrification, and phosphorus removal could generate as much as an additional 17.4 tons per day of dry sludge at the design flowrate of 23 MGD. This would approximately double the sludge production compared to current operations. The additional study site flows being considered by the Corps may increase the volume of solids to be disposed, but are not expected to change the quality of the solids.

e. Other Requirements. The draft plan does not discuss composition of residual sludge ash and residuals disposal under recently issued new sludge regulations and possibly stricter future incinerator emissions and air quality issues. The city, through TEA, has indicated it is planning a program to reduce cyanide in the scrubber return water.

11. CONCLUSIONS

From a review of Cranston's draft preliminary Wastewater Facility Plan and other related reports, the Corps determined that the existing WWTF has adequate hydraulic capacity to accommodate flows from the study sites we are evaluating. However, since neither final RIPDES permit limits nor mandated WWTF improvements have been defined by RIDEM, the Corps cannot determine if the WWTF will have treatment capacity adequate for accommodating flows from these study sites. It is the city of Cranston's responsibility to assure compliance with current and future RIPDES permit limits for its WWTF.

The Corps determined that the city's methodology and analysis for setting local limits are adequate to meet interim RIPDES permit limits, protect against pollutant pass through to the Pawtuxet River, prevent sludge contamination and interference with treatment processes. However, if final RIPDES permit limits are so low that background levels of contaminants cause the permit to be violated, a new method of computing local limits may be required, whether or not study site wastewater flows are included in flows to Cranston's WWTF.

RIDEM has expressed concern about the city's ability to adequately control influent concentrations of metals and organics to Cranston's WWTF from industrial and domestic sources. The local limits for industrial dischargers consist

of concentration limits which exceed domestic background concentrations. The city may have to evaluate options and implement control mechanisms to achieve final permit limitations for metals and organics under present as well as projected flow conditions that include flows from study sites.

This report was based on information provided by Cranston and EPA's Central Landfill documents as of February 15, 1993. Cranston's final comprehensive Wastewater Facility Plan documents should include resolution of the Corps's concerns about the feasibility of introducing additional flows to the WWTF.

In comments to the Section 22 Wastewater Investigation, EPA Region I and RIDEM encouraged the project sponsors to perform certain actions, such as a wastewater characterization study and analysis of WWTF performance by an independent consultant. However, it is likely that any future analyses of the WWTF capacity, local limits, or RIPDES permit limits that project sponsors would conduct would also depend entirely on documents prepared by the city of Cranston and RIDEM. The Corps is not a party to Cranston's obligation under its RIPDES permit nor to any deliberation and negotiations with regulatory authorities about its RIPDES permit.

12. REFERENCES

a. "Wastewater Treatment Facility Plan," draft prepared for the city of Cranston, Rhode Island, 1976, by Universal Engineering Corporation.

b. "Sewer Use Ordinance," city of Cranston, Rhode Island, effective August 26, 1985, revised June 20, 1990.

c. "Consent Decree and Judgement, State of Rhode Island Versus city of Cranston, RI, C.A. No. 90-6678," effective November 26, 1990.

d. "Sewer Use Ordinance," draft, city of Cranston, RI, revised February 21, 1992.

e. "Wastewater Facility Plan Interim Report on Regional Versus Individual Alternatives," prepared for city of Cranston, March 19, 1991, by Tutela Engineering Associates, Inc., Providence, RI.

f. "Amendment to 1976 Wastewater Facility Plan," prepared for city of Cranston, Rhode Island, April 1992, by Tutela Engineering Associates, Inc., Providence, RI.

g. "Wastewater Facility Plan," preliminary draft prepared for city of Cranston, Rhode Island, Volumes I and II, April 1992, by Tutela Engineering Associates, Inc., Providence, RI.

h. City of Rhode Island Industrial Wastewater Discharge Permit No. 1808 to RI Solid Waste Management Corp. (RISWMC) located at 65 Shun Pike, Johnston, RI 02919, effective August 27, 1992.

i. "Annual Report on Industrial Pretreatment Program," prepared for city of Cranston, RI, October 1992, by Tutela Engineering Associates, Inc., Providence, RI.

j. Authorization to Discharge under the Rhode Island Pollutant Discharge Elimination System. Permit No. RI 01000013 issued on May 1, 1989 to the city of Cranston, RI to discharge to the Pawtuxet River from Cranston Water Control Facility, 140 Pettaconsett Avenue.

APPENDIX H

Task 5 - Identification of Existing Sewer System Capacity

SECTION 117, CRANSTON, RHODE ISLAND
WASTEWATER CONVEYANCE SYSTEM FEASIBILITY INVESTIGATION

FEASIBILITY REPORT APPENDIX
TASK 5
IDENTIFICATION OF EXISTING SEWER SYSTEM CAPACITY

BY
ENVIRONMENTAL ENGINEERING & HYDRAULICS BRANCH
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NEW ENGLAND DIVISION, CORPS OF ENGINEERS
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JANUARY 1994

(additional text modifications on May 10, 1994)

TABLE OF CONTENTS

Section	Subject	Page
1	SUMMARY	H-1
2	INRODUCTION	
	a. Background	H-1
	b. Study Sites	H-2
	c. Study Areas	H-3
	d. Description of Cranston's Sewer System	H-3
	e. Existing Sewer Systems for Study Sites	H-4
3	SEWERS	H-5
	a. Criteria	H-5
	b. Manning's "n" Values	H-5
	c. Results	H-5
4	PUMP STATIONS	H-6
5	INFILTRATION AND INFLOW	H-6

FEASIBILITY REPORT APPENDIX
TASK 5 - IDENTIFICATION OF EXISTING SEWER SYSTEM CAPACITY
CRANSTON, RHODE ISLAND

1. SUMMARY

This report presents capacities of existing main sewers and pump stations that could carry flows from the study sites being examined in the Cranston, Rhode Island Feasibility Investigation.

2. INTRODUCTION

a. Background. This is an appendix to a feasibility study of a proposed regional wastewater conveyance system for Cranston. In May 1992, NED issued a preliminary report entitled, "Section 22, Cranston, Rhode Island, Wastewater Investigation." This 1992 report estimated future additional flows from western Cranston, including the Central Landfill in Johnston, to the wastewater treatment facility (WWTF), and mapped possible means to improve the city's wastewater conveyance system. The Section 22 study indicated a new sewer interceptor, or modifications to the existing system, initially appeared feasible to convey regional flows to the WWTF, and recommended a detailed study to determine the most effective design from cost and environmental standpoints.

On 21 December 1992, NED signed a cost-sharing agreement with Cranston to perform a feasibility investigation of its wastewater conveyance system. This feasibility study included assessing the need for expanded wastewater conveyance capacity, reviewing the WWTF capacity, preparing feasibility level designs and assessments of alternatives, selecting a proposed project, and preparing a preliminary design and cost estimate.

To accomplish this work, the study was broken down into 16 tasks. Task 5, "Identification of Existing Sewer System Capacity," examined capacities of portions of the system expected to receive significant increases in flow by the years 2015 and 2045 from study sites. This task contained three parts. The first was a review of data on the existing sewer system. This included reviewing information provided by the city on the existing sewer system, conducting a reconnaissance visit of the area, reviewing plans the city may have in progress for changes, and reviewing information provided by the city and State on infiltration and inflow in the existing sewer system and the Howard Center. The second part of task 5 was a hydraulic assessment of the existing sewer system. This included determining the existing

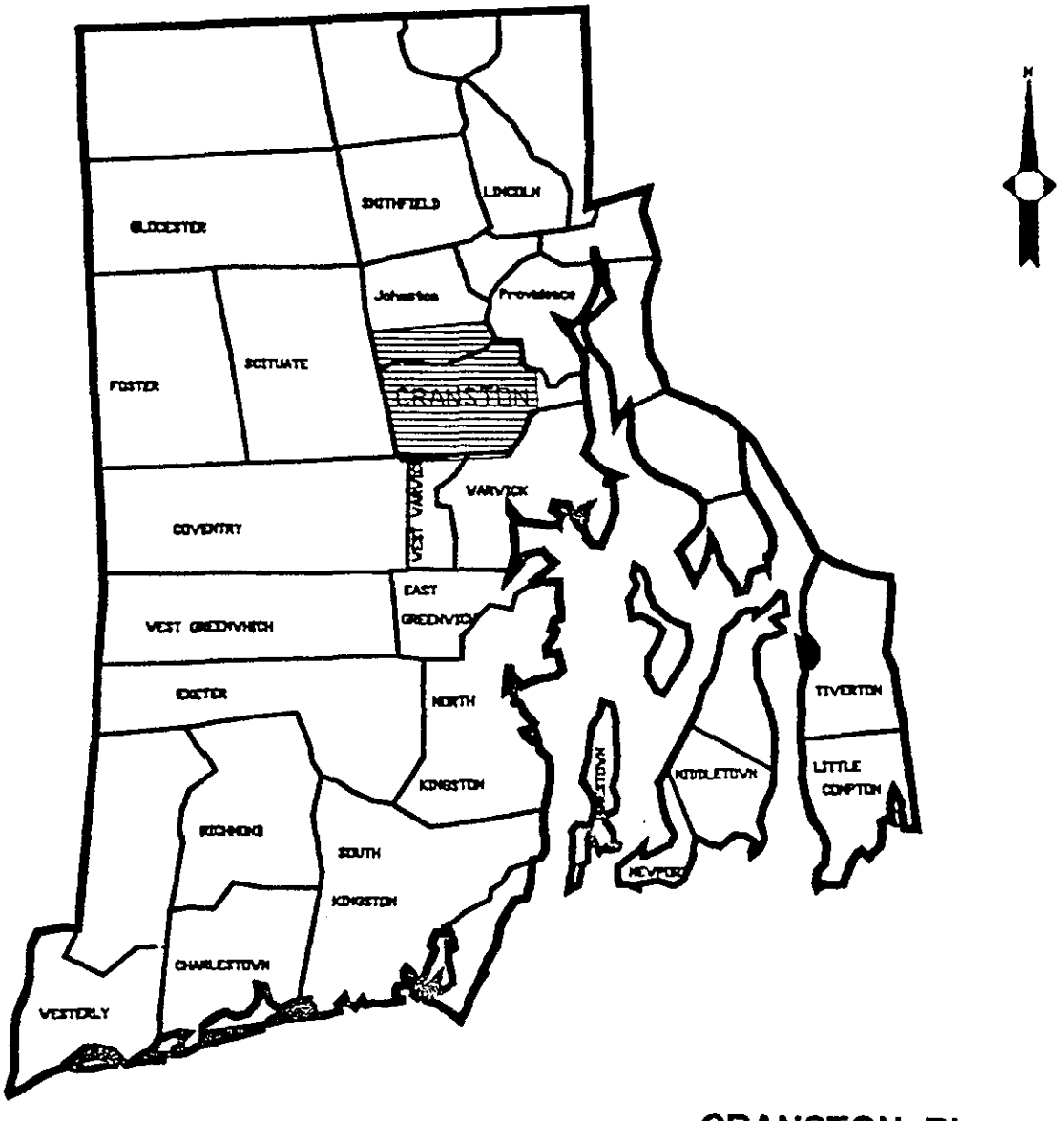
hydraulic capacities of main sewers and pumps for portions of the existing system that could carry flows from the study sites. The third part of this task defined what was expected from Cranston in the form of "local sponsor services."

This report deals primarily with the second part of task 5. Capacities for many segments were previously computed for the Section 22 study. This feasibility study involves a review and refinement of past work, based on additional information supplied by the city and its consultant, Tutela Engineering Associates (TEA), and analysis of additional lines not previously examined.

b. Study Site. Cranston is a medium-sized city immediately south of Providence, Rhode Island, on the western side of Narragansett Bay. It borders Warwick and West Warwick on the south, Scituate on the west, and Johnston on the northwest. In addition to Cranston, the study area includes land in parts of Johnston, including the Central Landfill, that contribute or are likely to contribute flows to the Cranston WWTF. Because eastern Cranston is largely fully developed, most changes to the system will occur in western parts of the city. However, those parts of eastern Cranston's sewer system that may need upgrading to carry flows from western Cranston are included in this study. Figures 1 and 2 show the location of Cranston and the study area.

Interstate Highway 295 roughly divides Cranston into eastern and western sections. The eastern part is largely fully developed and sewered. The only areas where major additional development are expected are the Howard Center and Industrial Park between Route 2 and the Pawtuxet River. The Howard Center is expected to grow through expansion of State institutions, and further industrial development is expected in the Howard Industrial Park. Additionally, the Capuano site is in this area; this landfill may have future leachate collection flows which will be added to the Cranston sewer system. Otherwise, increases in wastewater flows from new development in eastern Cranston will be relatively small compared to western Cranston.

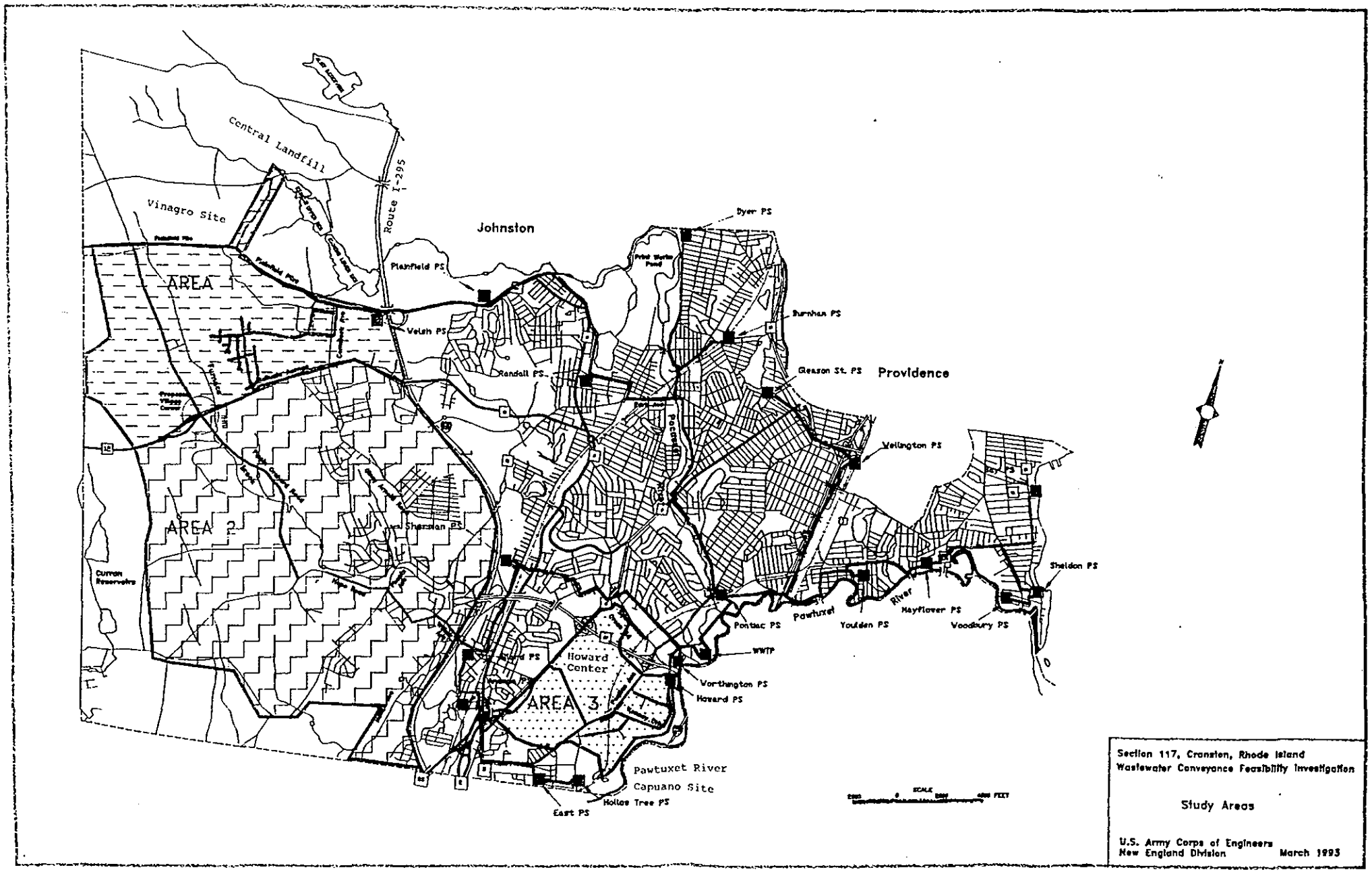
Western Cranston is less developed and largely unsewered. Consequently, this is where most additional flows will be generated. Many developed areas here use septic systems in poor soil; consequently, it is likely these will be tied into the future sewer system. In addition to future residential and commercial development, the Central Landfill and Vinagro Site may possibly contribute groundwater leachate flows to the sewer system.



CRANSTON, RI

LOCATION MAP

FIGURE 1



Section 117, Cranston, Rhode Island
Wastewater Conveyance Feasibility Investigation

Study Areas

U.S. Army Corps of Engineers
New England Division
March 1993

FIGURE 2

c. Study Areas. Study sites in Cranston and Johnston, divided into three study areas for purposes of this report, are displayed in figure 2.

(1) Area 1. This area includes residential, industrial, and commercial areas along Plainfield Pike, Comstock Parkway, and the proposed Village Center in northwest Cranston; flows from proposed industrial land in Johnston; and flows from Vinagro and Central Landfills.

(2) Area 2. This area includes residential, commercial, and industrial flows from west Cranston.

(3) Area 3. This area includes flows from the Howard Center, Howard Industrial Park, and Capuano Landfill.

d. Description of Cranston's Sewer System

(1) General. Construction of Cranston's sewer system began as a WPA project in 1939, and much of the eastern part of the city was sewered by 1942. The present system is composed entirely of sanitary sewers; there are no combined storm and sanitary sewers. As of 1993, there were 260 miles of trunk sewers, 8 miles of force mains, 128 miles of service laterals, and 6,200 manholes. Pipe materials include vitrified clay, asbestos-cement, concrete, ductile iron, and poly-vinyl chloride. Average depth of cover over sewers is 10 feet, with a minimum of 4 and maximum of 24 feet.

(2) Pump Stations. There are 20 pumping stations in the Cranston sewer system plus one smaller ejector station. The Welsh pumping station (soon to be replaced by the I-295 station) is the only one west of Route I-295.

(3) Variable Grade Sewer. An unusual feature of the Cranston sewer system is a 3-mile force main-variable grade sewer from the Welsh pump station to Cranston Street (near the Randall pump station). Variable grade sewers (VGS) are typically small in diameter (2 to 8 inches) and can be a low-cost alternative for sewering developed areas. Their small diameter, minimum cover, and flexibility of alignment can result in considerable cost savings over conventional designs. However, their small diameters, and low spots in variable grades, make these sewers vulnerable to deposition and clogging if not adequately maintained. Consequently, they typically carry only wastewater that has been clarified in septic tanks. These types of VGS have been used for many years. What makes this VGS unusual is its large diameter of 14 inches, and that it accepts wastewater using mechanical

screens at the pump station to remove material which might clog the lines. No lateral connections are allowed along its entire length to prevent blockages from unclarified wastewaters entering the system. Flows from intervening areas are picked up by an older conventional sewer system which parallels the VGS. Most flow to this VGS is from the Central Landfill and industrial areas along Plainfield Pike; conventional residential flow is only a small part of the total.

A second more conventional VGS carries flows from the Briggs Farm Elementary School on Wilbur Avenue, east of Pippin Orchard Road. Made of 7,600 feet of 4-inch PVC pipe, this VGS carries clarified flows from the school's septic tank to a gravity sewer on Wilbur Avenue east of I-295. The system was constructed in 1992.

(4) Pipe Sleeve. There is a pipe sleeve under I-295 near Wilbur Avenue which could carry sewer lines from western Cranston across the Interstate. It is important because its position is downhill from most of area 2, making it the logical place to consider routing a collector line for that area.

There is a second pipe sleeve under I-295 between Valley View Circle and Woodlawn Drive, near Cranston's border with West Warwick. However, its location makes it unlikely to be used in this study.

e. Existing Sewer Systems for Study Sites

(1) Area 1. There is a gravity sewer carrying flows along Plainfield Pike to the Welsh pumping station. This line, which is mostly 10-inch diameter pipe, carries flows from the Central Landfill, development along Plainfield Pike, and some residential areas south of Plainfield Pike; otherwise, area 1 is unsewered.

Flows from the Welsh pump station go to the Plainfield station. From Plainfield they are pumped to the Randall station which sends them to the Pontiac station where they are pumped to the WWTF. When the I-295 pump station is completed, it will send flows through the new 14-inch VGS. This line will bypass the Plainfield and Randall pump stations, and discharge to the gravity sewer on Cranston Street that flows into the Pocasset River Interceptor, which ultimately feeds the Pontiac pump station. The bypassed stations and lines will continue collecting flows from intervening areas.

(2) Area 2. Except for the existing 4-inch variable grade sewer from the Briggs Elementary School, this area is

entirely unsewered. When sewers are constructed, a likely route for the flow will be from a new pump station and force main along Turner Avenue to Summit and Park Forest where it would connect with gravity sewers leading to the Sockanosset Interceptor and the Cranston WWTF.

(3) Area 3. The Howard Center and Howard Industrial Park are serviced by existing sewer lines, which may have to be extended and upgraded to carry future flows from these areas. Howard Center and Industrial Park flows go by gravity lines to the Howard pump station, which sends them to the WWTF. The Capuano site does not add any flows to the Cranston collection and treatment system, but might at some future date. These flows would either go with the Howard flows, or be sent west to small stations feeding the Sherman pump station, which sends its flows to the WWTF.

3. SEWERS

a. Criteria. Criteria for sewer lines were taken from "Guides for the Design of Wastewater Treatment Works, 1980 Edition" (TR-16) prepared by the New England Interstate Water Pollution Control Commission; "Gravity Sanitary Sewer Design and Construction," 1982, by the American Society of Civil Engineers and the Water Pollution Control Federation; and city of Cranston Sewer Use Ordinance, revised 21 February 1992. TR-16 criteria included a minimum velocity for full pipe flow of 2 feet per second (fps), and a maximum velocity not greater than 12 fps under any flow conditions. City of Cranston criteria includes that pipes 21 inches diameter and smaller should not flow more than 0.6 full, and pipes larger than 21 inches should not be more than 0.7 full. Force mains should have a minimum velocity of 2 fps at design average flow conditions, and maximum velocities not greater than 10 fps.

b. Manning's "n" Values. Pipe capacities were computed using the standard Manning's formula. Manning's "n" values were derived from pipe flow capacity information supplied by TEA. Where "n" values were not available, they were estimated at 0.013 in accordance with recommendations in TR-16. Generally, "n" values were between 0.013 to 0.0135, although some ranged as high as 0.015.

c. Results. Capacities of sewers and force mains that would convey flows from study sites were computed by spreadsheet analysis, and are included in tables A-1 through A-3.

4. PUMP STATIONS

Using information supplied by TEA, pump station capacities were tabulated and compiled in table 1.

TABLE 1

SUMMARY OF INVESTIGATION OF PUMP STATION CAPACITIES

Pump Stations Considered	Number of Pumps	Pump Output at Station Capacity (gpm)	Total Station Capacity* (gpm)
Proposed I-295	3	1,360	2,720
Plainfield	2	500	500
Randall	2	1,220	1,220
Pontiac	2 3	5,500 3,700	16,600
Howard	4	1,000	3,000
WWTF Influent	3	5,200	10,400

*"Total Station Capacity" is computed with all but one of the largest pumps in service. It is the maximum dependable capacity the station can maintain.

5. INFILTRATION AND INFLOW

TEA performed an infiltration and inflow (I/I) study of the Cranston sewer system, and prepared a preliminary draft report in January 1993. According to this report, the system's age and the number of deteriorated pipe connections and manholes, cause excessive I/I compared to EPA guidelines. Peak observed infiltration rate was equivalent to 91 gallons per capita per day (gpcd), while EPA guidelines consider anything in excess of 50 gpcd as excessive. Peak inflow was equivalent to 376 gpcd, exceeding EPA guidelines of 275 gpcd. Under peak I/I conditions, infiltration in excess of EPA

limits amounts to over 2 mgd, and excess inflow is greater than 6 mgd. Wastewater flows to the Cranston WWTF are projected to increase to 23 mgd by the year 2015. However, the excessive I/I could restrict ability of the WWTF to handle projected inflows.

TEA indicates in their draft report that most I/I comes from deteriorated pipe connections and manholes. With the exception of extreme eastern portions of the city and some areas close to the Pontiac pump station and Cranston WWTF, most of the city is in areas of potentially excessive I/I. The Howard Center and Industrial Park are included in areas of potentially excessive I/I. TEA found a correlation between Pawtuxet River levels and wastewater flows at the treatment facility. This indicated lines close to the river, particularly the 39-inch Pawtuxet interceptor, are likely sources of excessive I/I.

As measured by peak total daily flow, inflow to the Cranston sewer system is not excessive. TEA reported that maximum total daily flow in 1990 was 16.4 mgd, equivalent to an average wastewater flow of 245 gallons per capita per day (gpcd). This is less than the 275 gpcd limit established by EPA for nonexcessive inflow. TEA reviewed treatment plant performance during 1990, and found performance generally unaffected by storm flows. No direct correlation was found between storm events and performance problems that occurred.

However, TEA was not convinced peak total daily flow was the best measure of excessive inflow. Consequently, they examined peak hourly flows during rainstorms during periods of low flow in the system. Twenty-five rainfall events between 1983 and 1991 were examined. The most intense was 1.42 inches per hour, resulting in a peak wastewater flow of 25.2 mgd. The EPA allowable daily inflow value of 275 gpcd amounts to only 18.4 mgd for Cranston.

This event occurred on 1 August 1985, following four days with no more than a trace of rain. River and groundwater levels were low indicating minimal infiltration. TEA reported that sewer flow rose rapidly following the rain, indicating excessive inflow conditions. If such an event occurred during a period of high groundwater and domestic loading, TEA concluded that excessive hydraulic loading could occur in the collection and treatment components of the system, leading to overflows or discharges of inadequately-treated wastewater.

The Corps analyzed occurrence frequency of a 1.42-inch per hour rainfall event. Using U.S. Weather Bureau Technical

Paper No. 40, "Rainfall Frequency Atlas of the United States," May 1961, figure 3 was prepared showing frequency of 1-hour rainfall events for central Rhode Island. Figure 3 shows a 1.42-inch per hour intensity rainfall occurring on an average once every 3 to 4 years. Probability of such an event, occurring during a period of high groundwater, is estimated as once every 5 to 10 years. At least once a year, on average, a lesser amount of rainfall will cause inflow in excess of EPA limits.

There is also a prior I/I study dealing only with the Rhode Island Medical Center and Correctional Buildings, which are now part of the Howard Center. This March 1979 report, prepared by F.N. Zaino and Associates, concluded that a major I/I problem existed at these buildings.

The city's draft I/I report (TEA, Jan. 1993) stated that infiltration was not excessive in the Sockanosset interceptor or the sewer lines directly connected to it, but data were insufficient to quantify inflow. An earlier 1975 report found no significant amounts of inflow into this line. Pavement reconstruction and inserts at many of the interceptor's manholes in 1981 should have eliminated what little inflow remained. However, at an 18 March 1994 meeting with the Corps, TEA suggested there may be an I/I problem in this area.

TEA provided the Corps with flow records for the WWTF siphon, and the Sherman, Howard, and Worthington pumping stations from 10 to 15 March 1994. During that period, high flows were recorded at the siphon and its tributary pump stations; these flows indicated a large amount of I/I was entering the Sockanosset intercepter. Total rainfall on 9 and 10 March was 2.58 inches; using U.S. Department of Commerce Technical Paper No. 40, "Rainfall Frequency Atlas of the United States," 1961, this was estimated to be about a 1-year event. On 10 March, flows at the siphon meter exceeded the 10 mgd upper limit of the recording chart for most of the day. TEA estimates peak flow on that day was between 10 and 15 mgd; total flow was at least 10 million gallons. Total flows recorded at the Sherman, Howard, and Worthington pump stations on that day were 4.8, 3.0 and 0.04 million gallons, respectively. The sum of these pump station flows was 7.8 million gallons which indicates that 2.2 to 7.2 million gallons of flow originated in the Sockanosset intercepter tributary area; averaged over the day, this is equivalent to 1,500 to 5,000 gpm. On 11 March, total flow from the 3 pump stations was 4.67 million gallons while 6.73 were recorded at the siphon indicating that 2.06 million gallons, equivalent to 1,430 gpm, were coming from direct discharge to the Sockanosset interceptor. The difference between pump station and siphon flows on 12 March was 1.02 million gallons equivalent to 710 gpm. By March 13, flows at the siphon had decreased and estimated flow from the interceptor's tributary area was

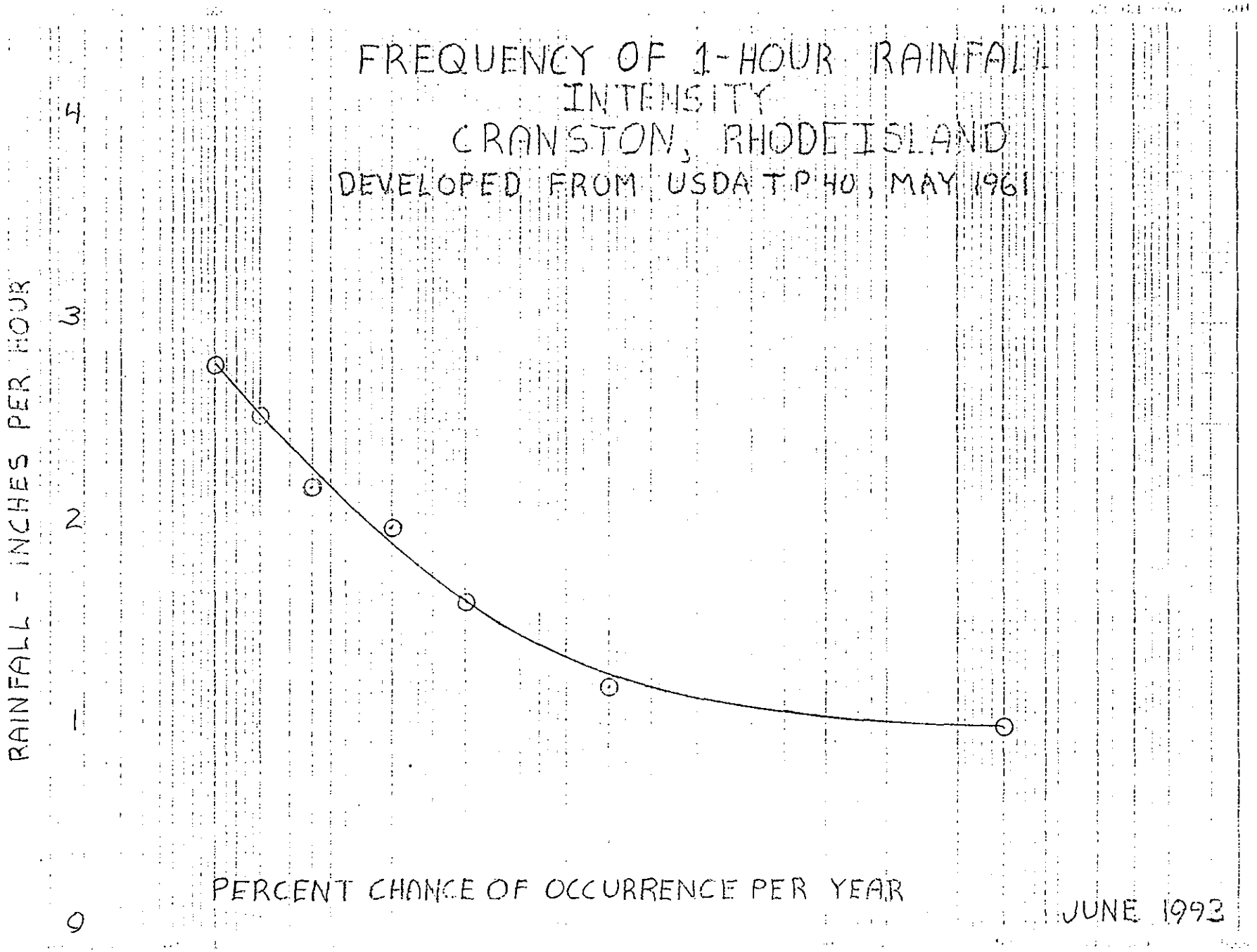

FREQUENCY OF 1-HOUR RAINFALL
INTENSITY
CRANSTON, RHODE ISLAND
DEVELOPED FROM USDA TP 40, MAY 1961
RAINFALL - INCHES PER HOUR
4
3
2
1
0
PERCENT CHANCE OF OCCURRENCE PER YEAR
JUNE 1993

Figure 3

240 gpm. Normally, wastewater flows directly into the Sockanosset intercepter are small; consequently, high flows directly into the Sockanosset intercepter indicate a large amount of I/I.

Projections for the city sewer system indicate flows from gravity sewers directly to the interceptor should be less than 400 gpm. TEA estimated the sewered population at 1,200 persons, and existing and potential land use of 60 acres of commercial and 20 acres of industrial development (TEA, Wastewater Flows Letter Report, Feb. 1993). Using flow factors developed by TEA of 100 gallons per capita day (gpcd) of wastewater, 40 gpcd of I/I, 3,780 gallons per day per acre (gpda) of commercial development, 5,770 gpda of industrial development, and that two-thirds of industrially and commercially zoned land was developed, gives a flow of 280 gpm. This is in general agreement with flows measured on 13 March 1994, and an indication that inflow rather than infiltration may have been the primary cause of high flows on 10 March.

Flows from 1992 (TEA, Feb. 1993) were used as background levels for comparison with 10 March 1994 flows. Average daily flows (ADF) in 1992 at the Sherman, Howard, and Worthington pump stations were 870, 820, and 20 gpm, respectively. This totals 1,710 gpm which was greater than the 1,490 gpm ADF measured at the siphon. The finding of less flow at the siphon than at the 3 stations pumping to the siphon indicates poor flow measurements at one or more of these stations. This also suggests that flows directly into the Sockanosset are normally small.

Data collected on 10 March indicate flows into the interceptor could exceed EPA criteria for allowable I/I. EPA considers inflow in excess of 275 gpcd and infiltration in excess of 50 gpcd excessive; these would allow less than 300 gpm I/I into the Sockanosset. TEA's estimate of 40 gpcd of I/I amounts to 30 gpm. Flows on 10 and 11 March 1994 indicate I/I of over 1,000 gpm would definitely be in excess of EPA guidelines.

Although flow records from 10 through 12 March strongly appear to indicate a problem with I/I in the Sockanosset interceptor or its tributary area, additional flow measurements and data analysis would be required for confirmation. TEA indicated to the Corps that there may be problems with the meters at the siphon and pump stations which could be causing misleading estimates of the I/I problem.

The city is studying the I/I problem under a Consent Decree because existing process equipment at the Cranston WWTF is unable to meet established discharge limits in the 1989 Rhode Island Discharge Elimination System permit. The draft infiltration and inflow report, released by TEA in 1993, indicates areas where a detailed sewer system evalua-

tion study should be performed to determine which areas should be rehabilitated. In correspondence with the Corps, TEA has emphasized that all excessive I/I is targeted for elimination. If excessive I/I problems are not addressed, they could interfere with the sewer system's ability to carry projected future flows, and the WWTF's ability to treat them.

ATTACHMENT A

EXISTING SEWER SYSTEM CAPACITY

TABLES A-1 THROUGH A-3

TABLE A-1
EXISTING CRANSTON SEWER SYSTEM
AREA 1

Segment	n	Pipe Size (in)	Pipe Size (ft)	Length (ft)	Area (ft^2)	Slope (ft/ft)	Pipe Capacity Flow (cfs)	Pipe Capacity Flow (gpm)	Design Depth for Flow	Design Capacity (gpm)
Cranston Street		End of Force Main/VGS from I-295 Pump Station								
108	0.01315	2x18	1.50	180.0	1.77	0.0040	13.13	5,890	0.6	3960
109	0.01315	2x18	1.50	44.5	1.77	0.0040	13.13	5,890	0.6	3960
110	0.01315	2x18	1.50	286.7	1.77	0.0040	13.13	5,890	0.6	3960
111	0.01315	2x18	1.50	270.7	1.77	0.0040	13.13	5,890	0.6	3960
112	0.0136	2x18	1.50	19.0	1.77	0.0063/.004	15.93	6,470	0.6	4340
Park Ave.										
113	0.01305	24	2.00	279.8	3.14	0.0030	12.34	5,540	0.7	4630
114	0.01305	24	2.00	274.2	3.14	0.0030	12.34	5,540	0.7	4630
115	0.01305	24	2.00	239.3	3.14	0.0030	12.34	5,540	0.7	4630
116	0.01305	24	2.00	180.7	3.14	0.0032	12.74	5,720	0.7	4790
117	0.01305	24	2.00	151.4	3.14	0.0030	12.34	5,540	0.7	4630
118	0.01305	24	2.00	100.6	3.14	0.0030	12.34	5,540	0.7	4630
119	0.01305	24	2.00	247.2	3.14	0.0030	12.34	5,540	0.7	4630
120	0.01309	24	2.00	220.8	3.14	0.0207	32.31	14,500	0.7	12130
121	0.013	24	2.00	212.6	3.14	0.0353	42.49	19,070	0.7	15960
122	0.013	24	2.00	188.9	3.14	0.0386	44.43	19,940	0.7	16690
123	0.01305	24	2.00	243.6	3.14	0.0050	15.93	7,150	0.7	5980
124	0.013	24	2.00	80.0	3.14	0.1000	71.51	32,090	0.7	26860
125	0.013	24	2.00	22.1	3.14	0.1000	71.51	32,090	0.7	26860
Pocasset Interceptor										
Deborah Way, Cross Country										
126	0.01301	39	3.25	166.5	8.30	0.0045	55.33	24,830	0.7	20780
127	0.0135	39	3.25	307.6	8.30	0.0020	35.55	15,950	0.7	13350
128	0.0135	39	3.25	273.5	8.30	0.0020	35.55	15,950	0.7	13350
129	0.0135	39	3.25	275.0	8.30	0.0020	35.55	15,950	0.7	13350
130	0.0135	39	3.25	198.0	8.30	0.0020	35.55	15,950	0.7	13350
131	0.0135	39	3.25	196.7	8.30	0.0023	38.12	17,110	0.7	14310
132	0.0135	39	3.25	241.8	8.30	0.0016	31.79	14,270	0.7	11940
133	0.0135	39	3.25	295.7	8.30	0.0020	35.55	15,950	0.7	13350

TABLE A-1 (Cont.)
EXISTING CRANSTON SEWER SYSTEM
AREA 1

Segment	n	Pipe Size (in)	Pipe Size (ft)	Length (ft)	Area (ft^2)	Slope (ft/ft)	Pipe Capacity Flow (cfs)	Pipe Capacity Flow (gpm)	Design Depth for Flow	Design Capacity (gpm)
134	0.0135	39	3.25	283.2	8.30	0.0020	35.55	15,950	0.7	13350
135	0.0135	39	3.25	319.1	8.30	0.0020	35.55	15,950	0.7	13350
136	0.0135	39	3.25	335.1	8.30	0.0019	34.65	15,550	0.7	13010
137	0.0135	39	3.25	328.3	8.30	0.0020	35.55	15,950	0.7	13350
138	0.0135	39	3.25	255.4	8.30	0.0020	35.55	15,950	0.7	13350
139	0.0135	39	3.25	249.6	8.30	0.0020	35.55	15,950	0.7	13350
140	0.0135	39	3.25	258.9	8.30	0.0020	35.55	15,950	0.7	13350
141	0.0135	39	3.25	296.5	8.30	0.0020	35.55	15,950	0.7	13350
142	0.0135	39	3.25	289.8	8.30	0.0016	31.79	14,270	0.7	11940
143	0.0135	39	3.25	235.3	8.30	0.0016	31.79	14,270	0.7	11940
144	0.0135	39	3.25	244.9	8.30	0.0016	31.79	14,270	0.7	11940
145	0.0135	39	3.25	28.0	8.30	0.0016	31.79	14,270	0.7	11940
146	0.0135	39	3.25	207.1	8.30	0.0017	32.67	14,660	0.7	12270
Knollwood Rd.										
147	0.0135	39	3.25	170.1	8.30	0.0021	36.42	16,350	0.7	13680
148	0.0135	39	3.25	111.7	8.30	0.0017	32.77	14,710	0.7	12310
Reservoir Ave.										
149	0.0135	39	3.25	23.0	8.30	0.0011	26.36	11,830	0.7	9900
150	0.0135	39	3.25	246.8	8.30	0.0012	27.19	12,200	0.7	10210
151	0.0135	39	3.25	23.7	8.30	0.0016	31.79	14,270	0.7	11940
Delway Rd.										
152	0.013	42	3.50	322.3	9.62	0.0015	38.95	17,480	0.7	14630
153	0.0131	42	3.50	325.7	9.62	0.0165	128.20	57,540	0.7	48150
154	0.013	42	3.50	333.4	9.62	0.0015	38.95	17,480	0.7	14630
155	0.013	42	3.50	171.8	9.62	0.0015	38.95	17,480	0.7	14630
Intervale Rd, Cross Country										
156	0.013	42	3.50	336.4	9.62	0.0015	38.95	17,480	0.7	14630
157	0.013	42	3.50	324.7	9.62	0.0015	38.95	17,480	0.7	14630
158	0.013	42	3.50	325.6	9.62	0.0015	38.95	17,480	0.7	14630
159	0.013	42	3.50	244.7	9.62	0.0015	38.95	17,480	0.7	14630

TABLE A-1 (Cont.)
EXISTING CRANSTON SEWER SYSTEM
AREA 1

Segment	n	Pipe Size (in)	Pipe Size (ft)	Length (ft)	Area (ft^2)	Slope (ft/ft)	Pipe Capacity Flow (cfs)	Pipe Capacity Flow (gpm)	Design Depth for Flow	Design Capacity (gpm)
160	0.0131	42	3.50	325.3	9.62	0.0040	63.12	28,330	0.7	23710
161	0.01312	42	3.50	209.3	9.62	0.0121	109.62	49,200	0.7	41170
162	0.013	42	3.50	253.8	9.62	0.0020	44.98	20,190	0.7	16890
163	0.013	42	3.50	278.1	9.62	0.0020	44.98	20,190	0.7	16890
164	0.013	42	3.50	330.0	9.62	0.0020	44.98	20,190	0.7	16890
165	0.013	42	3.50	256.8	9.62	0.0020	44.98	20,190	0.7	16890
166	0.013	42	3.50	261.3	9.62	0.0020	44.98	20,190	0.7	16890
167	0.013	42	3.50	297.4	9.62	0.0020	44.98	20,190	0.7	16890
168	0.013	42	3.50	189.0	9.62	0.0020	44.98	20,190	0.7	16890
169	0.013	42	3.50	181.9	9.62	0.0022	47.17	21,170	0.7	17720
170	0.013	42	3.50	126.8	9.62	0.0032	56.89	25,530	0.7	21370
Pontiac Ave.										
171	0.013	42	3.50	225.0	9.62	0.0020	44.98	20,190	0.7	16890
172	0.013	42	3.50	13.0	9.62	0.0290	171.27	76,870	0.7	64320
		Flows enter Pontiac Pumping Station								

TABLE A-2
EXISTING CRANSTON SEWER SYSTEM
AREA 2

Segment	n	Pipe Size (in)	Pipe Size (ft)	Length (ft)	Area (ft^2)	Slope (ft/ft)	Pipe Capacity Flow (cfs)	Pipe Capacity Flow (gpm)	Design Depth for Flow	Design Capacity (gpm)
GRAVITY LINE FROM INTERSECTION OF PARK FOREST RD AND SUMMIT AVE										
Park Forest										
2+48.7	0.0149	30	2.500	248.7	4.909	0.0015	13.80	6,190	0.7	5,180
Belvedere										
16+20.0	0.0149	30	2.500	269.2	4.909	0.0017	14.95	6,710	0.7	5,610
Hoffman										
13+50.8	0.0149	30	2.500	278.0	4.909	0.0018	15.32	6,880	0.7	5,750
Jennings										
10+72.8	0.0149	30	2.500	343.4	4.909	0.0026	18.21	8,170	0.7	6,840
Kennedy										
7+29.4	0.0149	30	2.500	272.9	4.909	0.0125	40.05	17,970	0.7	15,040
4+56.5	0.0149	30	2.500	91.6	4.909	0.0046	24.22	10,870	0.7	9,100
3+64.9	0.0149	30	2.500	91.9	4.909	0.0026	18.28	8,200	0.7	6,870
2+73.0	0.0149	30	2.500	273.0	4.909	0.0027	18.75	8,420	0.7	7,040
Cross Country										
74+50.9	0.0149	30	2.500	192.7	4.909	0.0034	20.78	9,320	0.7	7,800
72+58.2	0.0149	30	2.500	313.0	4.909	0.0029	19.29	8,660	0.7	7,240
69+45.2	0.0149	30	2.500	311.6	4.909	0.0036	21.35	9,580	0.7	8,020
New London Ave.										
66+31.0	0.0149	30	2.500	154.4	4.909	0.0021	16.29	7,310	0.7	6,120
64+76.6	0.0149	30	2.500	275.2	4.909	0.0027	18.55	8,330	0.7	6,970
62+01.4	0.0149	30	2.500	263.2	4.909	0.0035	21.04	9,440	0.7	7,900
59+38.2	0.0149	22	1.833	228.5	2.640	0.0187	21.41	9,610	0.7	8,040
57+09.7	0.0149	18	1.500	111.9	1.767	0.0482	20.11	9,020	0.6	6,070
55+97.8	0.0149	18	1.500	98.1	1.767	0.0482	20.12	9,030	0.6	6,070
54+99.7	0.0149	18	1.500	98.2	1.767	0.0532	21.12	9,480	0.6	6,380
54+01.5	0.0149	18	1.500	101.7	1.767	0.0511	20.72	9,300	0.6	6,250
Midway Road										
52+99.8	0.0149	18	1.500	102.1	1.767	0.0484	20.15	9,040	0.6	6,080
51+97.7	0.0149	18	1.500	122.1	1.767	0.0486	20.19	9,060	0.6	6,090

TABLE A-2 (Cont.)
EXISTING CRANSTON SEWER SYSTEM
AREA 2

Segment	n	Pipe Size (in)	Pipe Size (ft)	Length (ft)	Area (ft^2)	Slope (ft/ft)	Pipe Capacity Flow (cfs)	Pipe Capacity Flow (gpm)	Design Depth for Flow	Design Capacity (gpm)
50+75.6	0.0149	18	1.500	80.2	1.767	0.0325	16.53	7,420	0.6	4,990
49+95.4	0.0149	18	1.500	87.9	1.767	0.0371	17.64	7,920	0.6	5,330
49+07.5	0.0149	22	1.833	253.7	2.640	0.0140	18.53	8,320	0.7	6,960
46+53.8	0.0149	22	1.833	254.3	2.640	0.0188	21.45	9,630	0.7	8,060
43+99.5	0.0149	22	1.833	124.8	2.640	0.0383	30.62	13,740	0.7	11,500
42+65.3	0.0149	30	2.500	314.0	4.909	0.0037	21.65	9,720	0.7	8,130
39+51.3	0.0149	30	2.500	98.5	4.909	0.0011	11.95	5,370	0.7	4,490
38+52.8	0.0149	30	2.500	303.3	4.909	0.0023	17.19	7,710	0.7	6,450
35+49.5	0.0149	30	2.500	143.1	4.909	0.0028	18.91	8,490	0.7	7,100
34+06.4	0.0149	30	2.500	166.4	4.909	0.0027	18.60	8,350	0.7	6,990
32+40.0	0.0149	30	2.500	213.4	4.909	0.0022	16.79	7,530	0.7	6,300
30+26.6	0.0149	30	2.500	313.6	4.909	0.0026	18.29	8,210	0.7	6,870
Pettaconsett Ave.										
27+13.0	0.0149	30	2.500	315.5	4.909	0.0027	18.57	8,330	0.7	6,970
23+97.5	0.0149	30	2.500	294.5	4.909	0.0023	17.32	7,770	0.7	6,500
21+03.0	0.0149	30	2.500	61.0	4.909	0.0064	28.60	12,840	0.7	10,740
Siphons										
20+34.3	0.015	27	2.250	1314*				12,400		
20+34.3	0.015	16	1.333	1248*				3,150		

*Effective pipe lengths.

TABLE A-3
EXISTING CRANSTON SEWER SYSTEM
AREA 3

Segment	n	Pipe Size (in)	Pipe Size (ft)	Length (ft)	Area (ft^2)	Slope (ft/ft)	Pipe Capacity Flow (cfs)	Pipe Capacity Flow (gpm)	Design Depth for Flow	Design Capacity (gpm)
HOWARD PUMP STATION										
Pontiac Ave-Sharpe Drive										
A-32	0.013	12	1.000	205	0.785	0.0030	1.95	880	0.6	590
32-32	0.013	12	1.000	205	0.785	0.0030	1.95	880	0.6	590
31-30	0.013	12	1.000	196	0.785	0.0183	4.82	2,160	0.6	1450
30-29	0.013	12	1.000	296	0.785	0.0613	8.82	3,960	0.6	2660
29-28	0.013	12	1.000	296	0.785	0.0693	9.38	4,210	0.6	2830
28-27	0.013	12	1.000	246	0.785	0.0388	7.02	3,150	0.6	2120
27-26	0.013	12	1.000	146	0.785	0.0177	4.74	2,130	0.6	1430
26-25	0.013	12	1.000	146	0.785	0.0406	7.18	3,220	0.6	2170
25-24	0.013	15	1.250	198	1.227	0.0022	3.03	1,360	0.6	910
24-23	0.013	15	1.250	246	1.227	0.0021	2.96	1,330	0.6	890
Going down Ross + Simmons Drive										
23-33	0.013	15	1.250	241	1.227	0.0037	3.93	1,760	0.6	1190
33-34	0.013	15	1.250	332	1.227	0.0032	3.65	1,640	0.6	1100
34-35	0.013	15	1.250	145	1.227	0.0018	2.74	1,230	0.6	830
35-36	0.013	15	1.250	296	1.227	0.0015	2.50	1,120	0.6	750
36-37	0.013	15	1.250	296	1.227	0.0015	2.50	1,120	0.6	750
37-38	0.013	15	1.250	296	1.227	0.0015	2.50	1,120	0.6	750
38-39	0.013	15	1.250	241	1.227	0.0015	2.50	1,120	0.6	750
39-13	0.013	15	1.250	239	1.227	0.0015	2.50	1,120	0.6	750
Pontiac Ave										
1a-1	0.013	15	1.250	240	1.227	0.0050	4.57	2,050	0.6	1380
1-2	0.013	15	1.250	196	1.227	0.0050	4.57	2,050	0.6	1380
2-3	0.013	15	1.250	256	1.227	0.0520	14.73	6,610	0.6	4450
3-4	0.013	15	1.250	248	1.227	0.0758	17.77	7,980	0.6	5370
4-5	0.013	21	1.750	162	2.405	0.0011	5.30	2,380	0.6	1600
5-6	0.013	24	2.000	236	3.142	0.0013	8.00	3,590	0.7	3000
Continuing on Kenney Drive										
6-7	0.013	21	1.750	246	2.405	0.0012	5.49	2,460	0.6	1660

TABLE A-3 (Cont.)
EXISTING CRANSTON SEWER SYSTEM
AREA 3

Segment	n	Pipe Size (in)	Pipe Size (ft)	Length (ft)	Area (ft^2)	Slope (ft/ft)	Pipe Capacity Flow (cfs)	Pipe Capacity Flow (gpm)	Design Depth for Flow	Design Capacity (gpm)
7-8	0.013	21	1.750	296	2.405	0.0012	5.49	2,460	0.6	1660
8-9	0.013	21	1.750	246	2.405	0.0012	5.49	2,460	0.6	1660
9-10	0.013	21	1.750	296	2.405	0.0012	5.49	2,460	0.6	1660
10-11	0.013	21	1.750	246	2.405	0.0012	5.49	2,460	0.6	1660
11-12	0.013	21	1.750	206	2.405	0.0221	23.55	10,570	0.6	7110
12-13	0.013	21	1.750	196	2.405	0.0221	23.55	10,570	0.6	7110
13-13a	0.013	24	2.000	296	3.142	0.0012	7.83	3,520	0.7	2940
13a-14	0.013	24	2.000	146	3.142	0.0012	7.83	3,520	0.7	2940
14-15	0.013	24	2.000	136	3.142	0.0012	7.83	3,520	0.7	2940
15-16	0.013	24	2.000	178	3.142	0.0012	7.83	3,520	0.7	2940
16-17	0.013	24	2.000	193	3.142	0.0012	7.83	3,520	0.7	2940
17-18	0.013	24	2.000	174	3.142	0.0012	7.83	3,520	0.7	2940
18-19	0.013	24	2.000	230	3.142	0.0012	7.83	3,520	0.7	2940
19-40	0.013	24	2.000	296	3.142	0.0012	7.83	3,520	0.7	2940
40-41	0.013	24	2.000	296	3.142	0.0012	7.83	3,520	0.7	2940
41-42	0.013	24	2.000	296	3.142	0.0014	8.46	3,800	0.7	3180
42-43	0.013	24	2.000	196	3.142	0.0155	28.15	12,640	0.7	10570
43-44	0.013	24	2.000	196	3.142	0.0128	25.59	11,480	0.7	9610
44-45	0.013	24	2.000	258	3.142	0.0015	8.76	3,930	0.7	3290
45-46	0.013	24	2.000	217	3.142	0.0010	7.15	3,210	0.7	2690
46-47	0.013	24	2.000	270	3.142	0.0010	7.15	3,210	0.7	2690
47-H.P.S.	0.013	24	2.000	30	3.142	0.0010	7.15	3,210	0.7	2690
		Flows Enter Howard Pump Station								
Force Main	0.013	14	1.167	1,885	1.069	Variable	12.8	5,760	1	5760
		Flows Enter Siphons								

APPENDIX I

Task 7 and 9 - Report on Feasibility Level Design and Cost Estimates for Wastewater Conveyance Options

Section 117, Cranston Rhode Island
Wastewater Conveyance Feasibility Study

REVISED DRAFT

Task 7 and 9 - Report on Feasibility Level Design and Cost Estimates for Wastewater Conveyance Options

Department of the Army
Corps of Engineers, New England Division
Waltham, Massachusetts

May 1994

(additional text changes July 1994)

TABLE OF CONTENTS

	PAGE
INTRODUCTION	I-1
STUDY SITES	I-1
GENERAL DESCRIPTION OF STUDY OPTIONS	I-1
FEASIBILITY DESIGN	I-6
OPTION 1A	I-6
OPTION 1B	I-8
OPTION 1C	I-9
OPTION 2A	I-9
OPTION 2B	I-10
OPTION 2C	I-11
OPTION 2D	I-12
OPTION 3A	I-14
FEASIBILITY COST ESTIMATES	I-16

ATTACHMENT 1 HYDRAULIC ANALYSES

ATTACHMENT 2 SURCHARGE EVALUATION

ATTACHMENT 3 FEASIBILITY DESIGN OF PUMP STATIONS

ATTACHMENT 4 PRELIMINARY ESTIMATE OF REAL ESTATE COSTS

ATTACHMENT 5 PRELIMINARY ESTIMATE OF PROJECT AND OPERATION AND MAINTENANCE COSTS

LIST OF TABLES

		PAGE
TABLE 1	LIST OF STUDY OPTIONS	I-2
TABLE 2	SUMMARY OF CAPITAL COSTS FOR FEASIBILITY STUDY OPTIONS	I-18
TABLE 3	SUMMARY OF OPERATION AND MAINTENANCE COSTS FOR FEASIBILITY STUDY OPTIONS	I-20

LIST OF PLATES

		FOLLOWS PAGE
PLATE 1	EAST CRANSTON (SOUTH) - SEWERS AND PUMPING STATIONS	I-3
PLATE 2	WEST CRANSTON (SOUTH) - SEWERS AND PUMPING STATIONS	I-3
PLATE 3	WEST CRANSTON (NORTH) - SEWERS AND PUMPING STATIONS	I-3
PLATE 4	EAST CRANSTON (NORTH) - SEWERS AND PUMPING STATIONS	I-3

INTRODUCTION

This is a report on Task 7 "Feasibility Level Design of Alternatives" and Task 9 "Cost Estimates for Alternatives" for the Section 117, Cranston, Rhode Island, Wastewater Conveyance Feasibility Study. The city and the Corps met on August 17, 1993 to review the layout of the feasibility study options. After that meeting, the Corps proceeded to complete the feasibility design and develop cost estimates for the study options.

STUDY SITES

Study sites are grouped into three service areas for development of wastewater conveyance options. These areas were delineated based on the city's plans for sewer service in west and northwest Cranston.

Service Area 1. This area is located in northwest Cranston and southern Johnston. The area in Cranston is bounded by Scituate Avenue to the south and Plainfield Pike to the north. This area includes industrial and residential lands and the proposed Village Center located at the intersection of Pippin Orchard Road and Scituate Avenue. Service Area 1 also includes wastewater flows from proposed industrial land in Johnston north of Plainfield Pike and Central and Vinagro Landfills. The area proposed for sewer service is as delineated in the city's Facility Plan, except for industrial land in Johnston and the Vinagro Landfill. These sites are not included in the city's proposed service area.

Service Area 2. This area is located west of I-295 and south of Scituate Avenue and includes residential and industrial land. The area proposed for sewer service is as delineated in the city's Facility Plan. The area east of Pipin Orchard Road and the area east of the south portion of Phenix Avenue is an area of existing residential subdivision development. The area generally west of Pippin Orchard Road and west of the south portion of Phenix Avenue has fewer subdivisions and is an area zoned for two acre lots. This second area is proposed for sewer service after 2015 only where required to eliminate problems with faulty septic systems.

Service Area 3. This area is located in east Cranston and includes the Howard Center, the Howard Industrial Park, and the Capuano Landfill. These sites are within the city's existing sewer service area.

GENERAL DESCRIPTION OF STUDY OPTIONS

Various options were considered initially for conveying flows from service areas to the Cranston Wastewater Treatment Facility (WWTF). In consultation with the city, the following options were selected for feasibility analysis. Option 1A, 1B, and 1C address flows from Service Area 1. Options 2A, 2B, 2C, and 2D address flows from Service Area 2. Option 3A addresses flows from Service Area 3. Components of these options are listed in Table 1 and shown Plates on 1,2,3, and 4.

TABLE 1

LIST OF STUDY OPTIONS

OPTION 1A

Proposed Scituate pumping station

Proposed Scituate Avenue 6-inch force main/variable grade sewer (12,300 feet)

Existing I-295 pumping station

Existing 14-inch force main/variable grade sewer (16,000 feet)

Proposed Improvements to Cranston Street gravity sewer, replace 18-inch gravity sewer with 24-inch gravity sewer (800 feet) after the year 2015

Existing Park Avenue and Pocasset Interceptor gravity sewers

Proposed improvements to existing Pontiac pumping station

Proposed replacement of Pontiac force main with new 42-inch force main (2,770 feet) after the year 2015

OPTION 1B

Same as Option 1A, except improvements to Cranston Street gravity sewer are not required

OPTION 1C

Proposed Scituate pumping station and force main/variable grade sewer

OPTION 2A

Proposed Wilbur pumping station

Proposed Garden Hills 18-inch force main/variable grade sewer (14,100 feet)

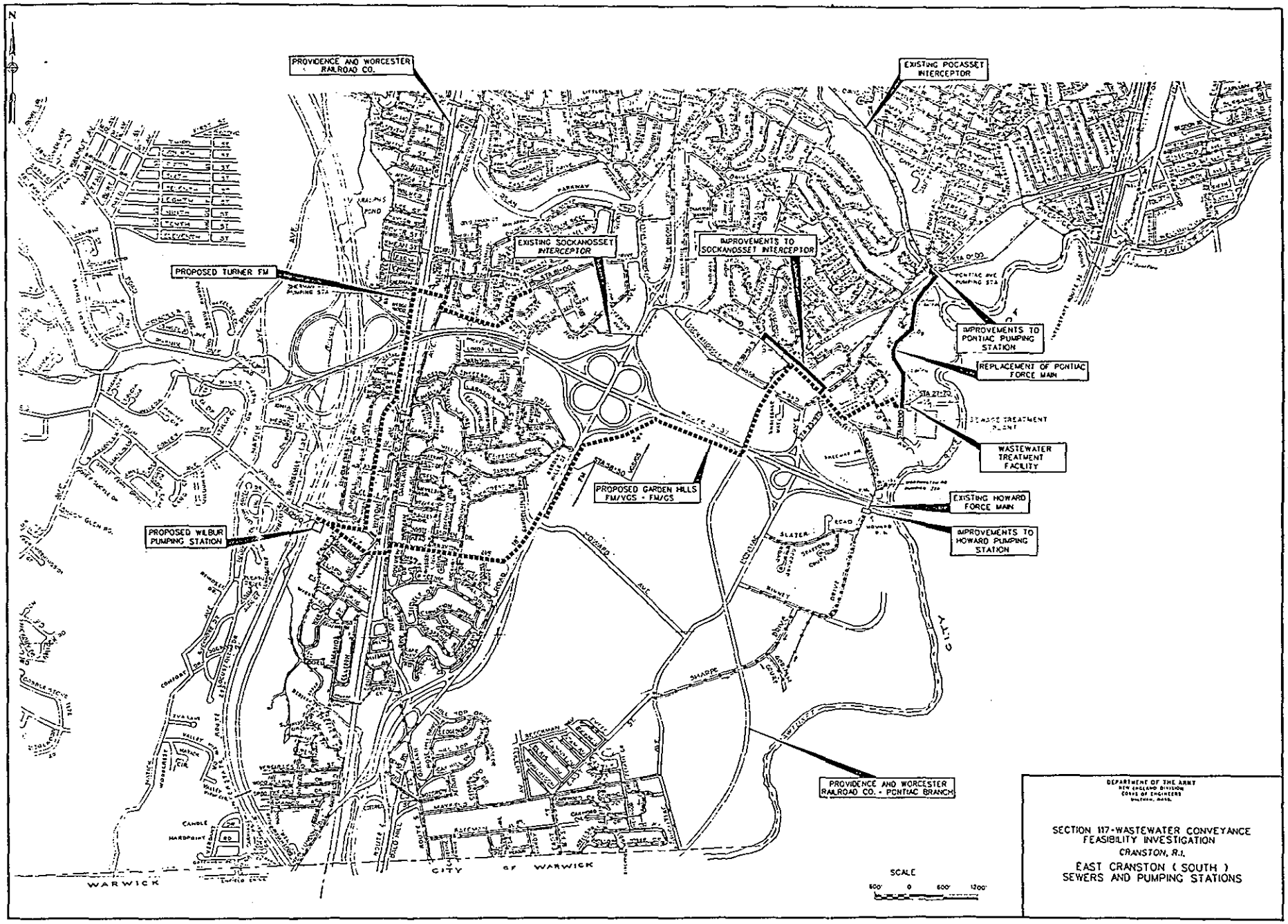
OPTION 2B

Proposed Wilbur pumping station

Proposed Garden Hills 18-inch force main (5,850 feet)

Proposed Garden Hills 24-inch gravity sewer (8,250 feet)

Proposed improvements to influent pumps at WWTF after 2015



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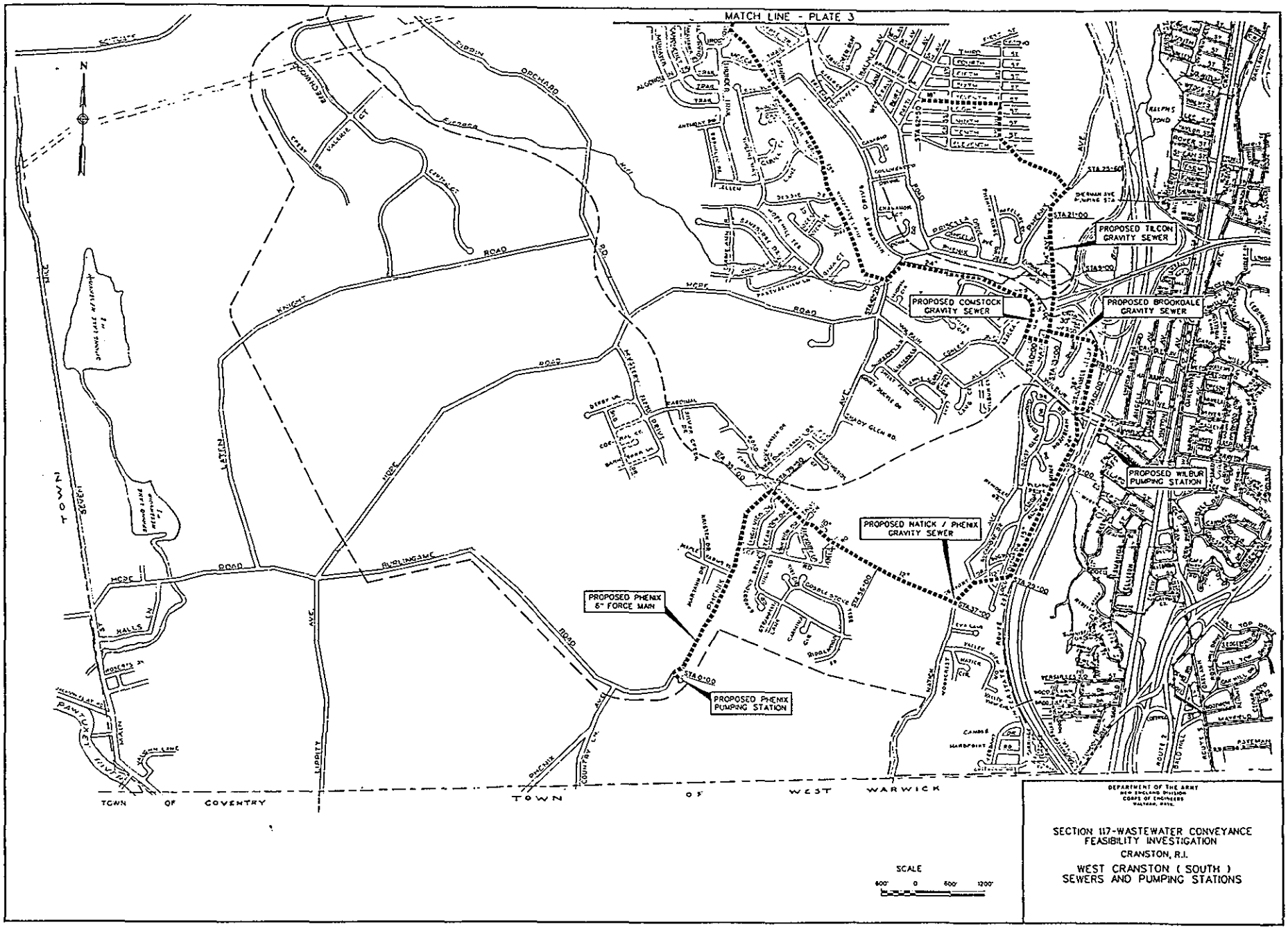
CRANSTON, R.I.

EAST CRANSTON (SOUTH)
SEWERS AND PUMPING STATIONS

PLATE 1



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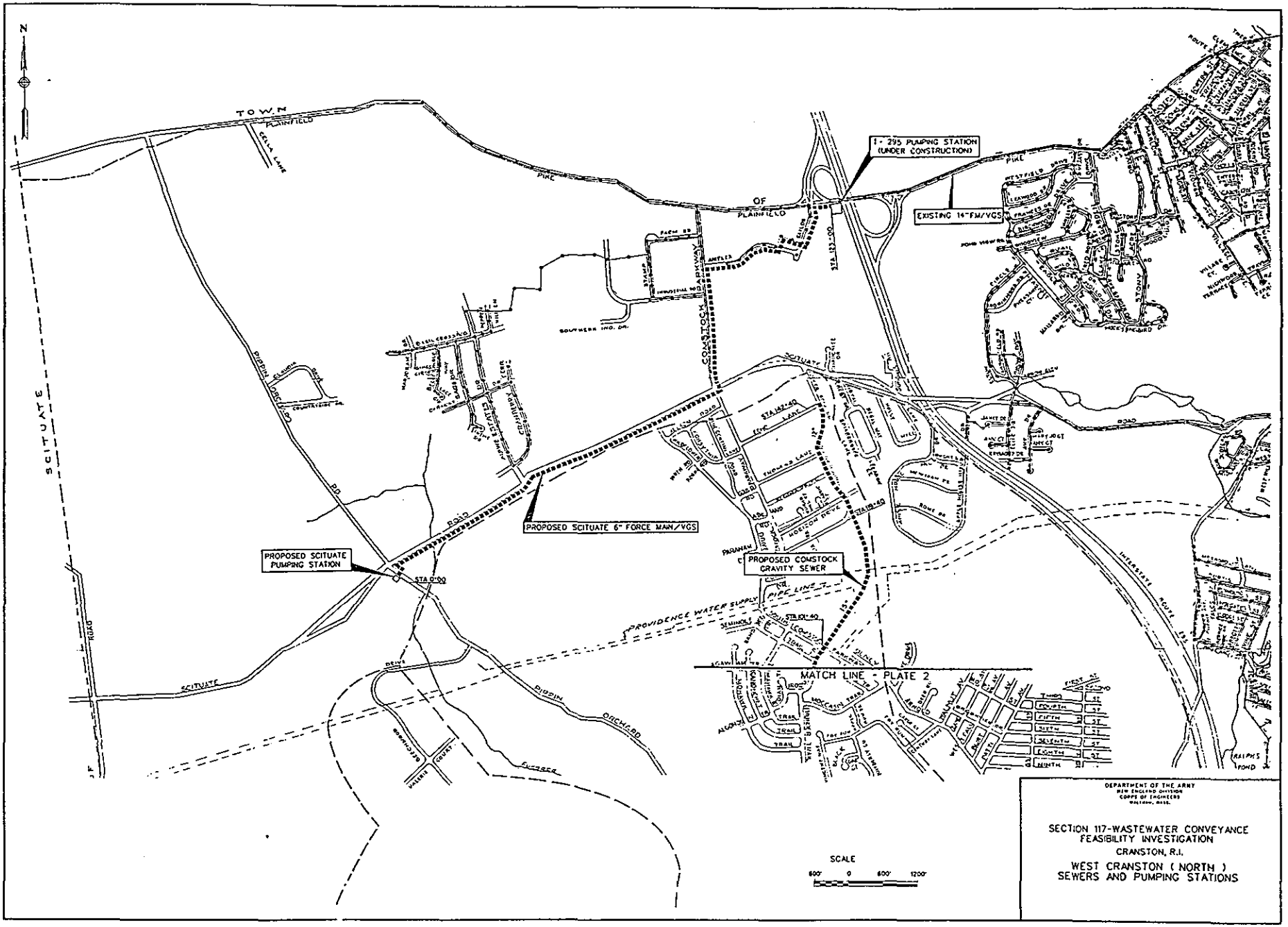
FEASIBILITY INVESTIGATION
CRANSTON, R.I.

WEST CRANSTON (SOUTH)
SEWERS AND PUMPING STATIONS

PLATE 2


I-295 PUMPING STATION (UNDER CONSTRUCTION)
EXISTING 14"FM/VGS
PROPOSED SCITUATE 6" FORCE MAIN/VGS
PROPOSED SCITUATE PUMPING STATION
PROPOSED COMSTOCK GRAVITY SEWER
MATCH LINE - PLATE 2
PROVIDENCE WATER SUPPLY PIPE LINE
TOWN OF PLAINFIELD PIKE
SCITUATE ROAD
COMSTOCK PARKWAY
INTERSTATE ROUTE 295
SCALE
600' 0 600' 1200'
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CORPS OF ENGINEERS
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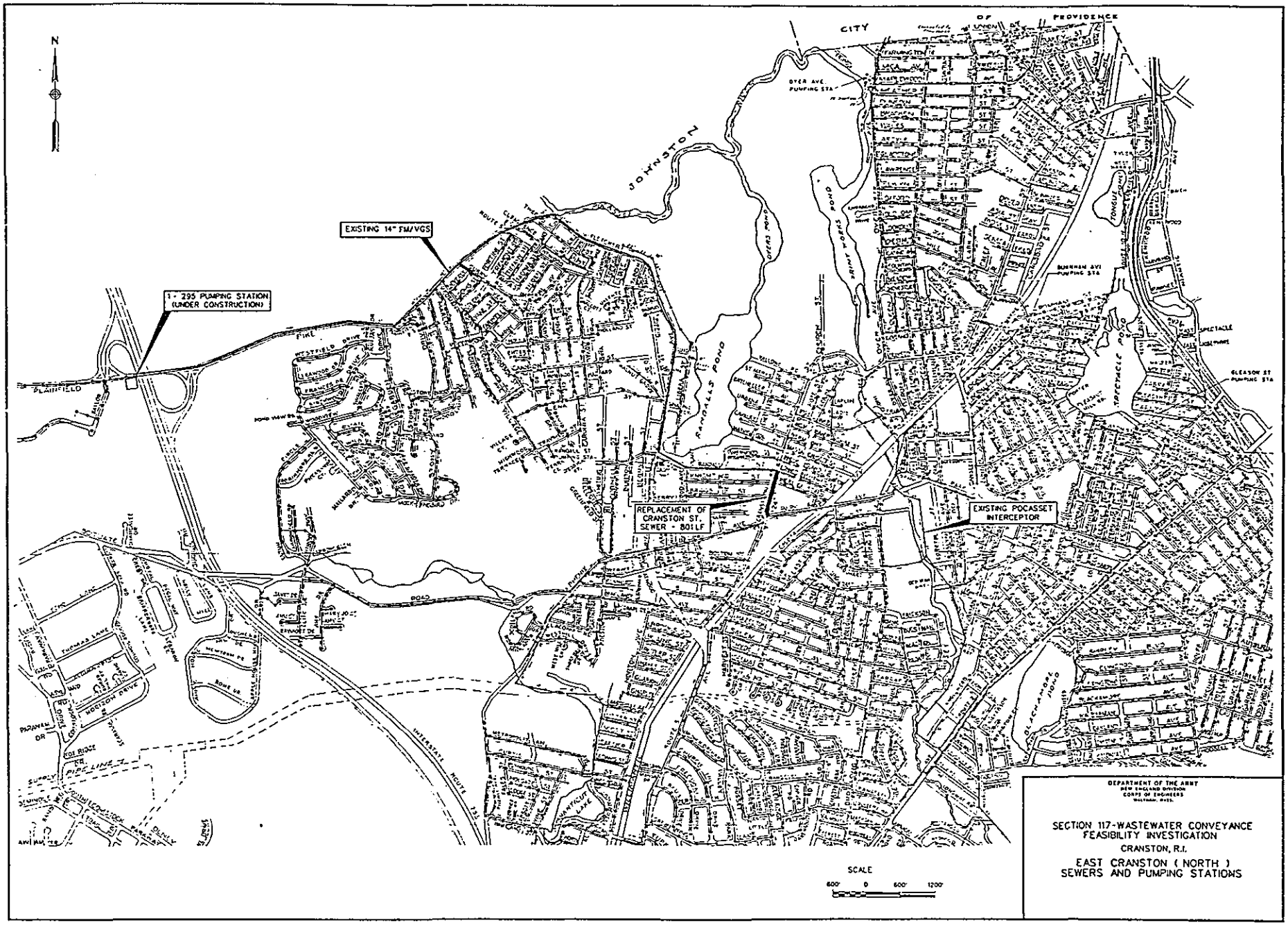
FEASIBILITY INVESTIGATION
CRANSTON, R.I.
WEST CRANSTON (NORTH)
SEWERS AND PUMPING STATIONS



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CRANSTON, R.I.

EAST CRANSTON (NORTH)
SEWERS AND PUMPING STATIONS

PLATE 4

TABLE 1

LIST OF STUDY OPTIONS (continued)

OPTION 2C

Proposed Wilbur pumping station

Proposed Turner 18-inch force main (8,100 feet)

Proposed improvements to Sockanosset Interceptor, construct additional 24-inch gravity sewer after 2015 (1,500 feet)

Proposed improvements to influent pumps at WWTF after 2015

OPTION 2D

Proposed Brookdale gravity trunk sewer, 36 and 30-inch (2,300 feet)

Proposed Tilcon gravity trunk sewer, 30, 24, and 18-inch (6,250 feet)

Proposed Comstock gravity trunk sewer, 24, 15, 12-inch (14,240 feet)

Proposed Natick/Phenix gravity trunk sewer, 24, 15, 10-inch (7,950 feet)

Proposed Phenix pumping station after 2015

Proposed Phenix Avenue 6-inch force main after 2015 (3,500 feet)

OPTION 3A

Existing Kenny Drive, Ross-Simmons Drive, and Sharpe Drive 12 to 24-inch gravity sewers (10,740 feet)

Proposed improvements to Howard pumping station

Existing Howard force main (1,885 feet) and WWTF influent pumps

Option 1A. This option provides for conveyance of projected wastewater flows from Service Area 1 to the WWTF through improvements and expansion of the existing sewerage system.

Under this option wastewater flows from Service Area 1 would be pumped from the I-295 pumping station (designed and scheduled for construction by the city in 1993/1994) into the existing 14-inch force main/variable grade sewer (FM/VGS) which discharges to the gravity sewer in Cranston Street. Wastewater would flow by gravity through sewers in Cranston Street, Park Avenue, and the Pocasset Interceptor to the Pontiac pumping station. Flows at the Pontiac pumping station would be pumped to the WWTF.

In addition, a new pumping station is required to collect flows from Service Area 1 in the area of Pipin Orchard Road and the Village Center. The city's facility plan proposes a new pumping station, the "Scituate Pumping Station", and a new force main/variable grade sewer from the pumping station to the I-295 pumping station (Wastewater Facility Plan Amendment, February 1993, Tutela Engineering Associates. Inc.).

New lateral sewers would also be required in Service Area 1 to collect future wastewater flows from currently unsewered areas. However, the design and cost of these are not included in this feasibility study.

Option 1B. This option is similar to Option 1A. However, projected wastewater flows for the Vinagro Landfill and the Johnston industrial area are not included.

Option 1C. This option is the new Scituate pumping station and 6-inch force main/variable grade sewer.

Option 2A. This option provides a connector system to convey projected wastewater flows from Service Area 2 to the WWTF. Wastewater would be pumped from a proposed pumping station located near I-295 and Wilbur Avenue through the proposed "Garden Hills" force main/variable grade sewer to the WWTF.

Option 2B. This option is considered as an alternative to Option 2A. The proposed Garden Hills force main/variable grade sewer of Option 2A is replaced with a proposed "Garden Hills" force main/gravity sewer.

Option 2C. This option is considered as an alternative to Option 2A and 2B. The proposed "Turner" force main replaces the Garden Hills sewer. The force main would discharge to the existing Sockanosset Interceptor on Belvedere Drive. Wastewater would flow by gravity through the interceptor to the "siphon" chamber and 16 and 27-inch sewers in Webb Street and into the influent screw pumps at the WWTF.

Option 2D. This option considers the location and cost of trunk sewers in Service Area 2 (west Cranston area). Flows from this area would flow to the proposed Wilbur pumping station. Trunk sewers considered include; the proposed Tilcon gravity sewer, the proposed Comstock gravity sewer, and the proposed Natick/Phenix trunk sewer. These trunk sewers would collect wastewater flows an area generally east of Pipin Orchard Road and east of the south portion of Phenix Avenue. In addition to the trunk sewers, lateral sewer lines would be required to collect existing and future wastewater flows from this area. However, design and cost of these are not included in this feasibility study.

Also, a pumping station and force main are proposed near the intersection of Phenix Avenue and Burlingame Road. However, the pumping station and force main are not required until the city proposes to sewer the area west of Pippin Orchard Road and west of the south portion of Phenix Avenue.

Option 3A. This option provides for conveyance of projected wastewater flows from Service Area 3 to the WWTF through improvements to the existing sewerage system. Wastewater flows would be conveyed by gravity through the existing main sewers in Kenny Drive, Ross-Simmons Drive, and Sharpe Drive to the Howard pumping station. Flows would be pumped through the Howard force main to the "siphon" chamber and 16 and 27-inch sewers in Webb Street into the influent screw pumps at the WWTF.

FEASIBILITY DESIGN

The following discusses the features of each option and the proposed location and alignments of pumping stations and sewers. Information was developed to allow for calculation of cost estimates and environmental assessments.

The hydraulic design of gravity sewers, pumping stations, force mains, and variable grade sewers is based upon projected average day and peak wastewater flows for the years 2015 and 2045. These projections are presented in the Task 3, "Identification of Wastewater Flows" report. The population projections and the majority of the wastewater flow calculations were provided by the city of Cranston's engineering consultant Tutela Engineering Associates, Inc (TEA). This information was developed by TEA for the city's Wastewater Facility Plan. Hydraulic analysis of the feasibility study options is included as Attachment 1. Evaluation of projected sewer surcharges is included as Attachment 2. Feasibility design of pumping stations is included as Attachment 3. Alignments of study options are shown on Plates 1,2,3, and 4.

OPTION 1A

Scituate Pumping Station and 6-inch force main/variable grade sewer. The proposed station location is near the intersection of Pippin Orchard Road and Scituate Avenue. There appears to be sufficient undeveloped land at this site for a pump station. The station would be cast-in-place concrete with separate wet and dry wells. A manually cleaned bar rack would be installed. The station would house two constant speed sewage pumps and appropriate mechanical and electrical equipment. Selected pump capacity is 500 gpm at 95 feet total dynamic head (TDH). An emergency generator (40 KW) would be housed in a separate enclosure. The pumps would discharge to a 6-inch force main/variable grade sewer (VGS) located at a minimum cover of 5 feet which would convey flows to the I-295 pumping station. An alternative to the described custom built station may be a package pumping station.

The 6-inch PVC force main/VGS (about 12,300 feet in length) would be located in Scituate Avenue, Comstock Parkway, Amflex Drive, and Sailor Way. The first 3,000 feet of force main lifts wastewater about 40 feet. The remaining pipe is a variable grade sewer. Three automatic air release manholes located at relative high points and two cleanout manholes have been included in the design. The sewer is off-road for about 600 feet between Amflex Drive and Sailor Way. This is the location of an existing city sewer easement. The reasonableness of increasing the width of the easement versus construction of the force/main variable grade sewer in the road in this area will be considered.

I-295 Pumping Station. The station has been designed by Tutela Engineering Associates, Inc. and is scheduled for construction by the city. The station is located adjacent to I-295 and Plainfield Pike just south of the existing Welsh pumping station. (Ultimately the Welsh pumping station will be demolished.) The station is to be cast-in-place concrete with separate wet and dry wells. A bar rack with automatic raking mechanism is to be installed. The station is to house three sewage pumps and an emergency generator. Selected pump capacity is 1,890 gpm at 57 feet TDH.

The station is designed to accommodate year 2015 and 2045 average daily and peak flows for northwest Cranston and Central Landfill, but not flows from Johnston and Vinagro. If these flows occur, peak hourly flow in the year 2015 would be increased by about 20 gpm and in 2045 by about 290 gpm. If the possibility of slightly higher flows are to be accommodated, the pump specifications for the station would need to be modified to reflect the higher flows before the pumps are purchased by the city.

Existing 14-inch Force main/VGS. The I-295 pumping station would discharge into an existing 14-inch, 16,000 feet force main/VGS. This new line and additional gravity sewers feeding the Welsh pumping station were constructed by the city during 1988-1991. In February 1993, the city submitted a Facility Plan Amendment to the Rhode Island Department of Environmental Management for this modification to the existing sewer system. The force main/VGS is not currently in use by the city.

Cranston Street Gravity Sewer. The force main/VGS discharges into twin 18-inch gravity sewers in Cranston Street. These sewers also convey wastewater from east Cranston. The original 18-inch sewer was constructed in the early 1940's and the twin 18-inch sewer was constructed in 1986. Evaluation of pipe capacity versus projected peak hourly flows in the years 2015 and 2045 indicated that flows exceed pipe capacity in the year 2045. Calculated surcharge is expected to impact existing service connections. This would require the replacement of about 800 feet of the 18-inch sewer with 24-inch reinforced concrete gravity line and the addition of 6 sanitary sewer manholes before 2045. Surcharge conditions would not occur if flows from the Johnston and Vinagro Landfill project sites were eliminated. With no surcharge, the existing sewer would be adequate and no modifications would be required.

Park Avenue Gravity Sewer. The gravity sewers in Cranston Street discharge to the 24-inch gravity sewer in Park Avenue. Evaluation of pipe capacity versus projected peak hourly flows in the years 2015 and 2045 indicated that projected flows exceed pipe capacity for about 1,500 feet of pipe. However, this surcharge is expected to impact only one existing service connection. Thus, pipe replacement is not included in the cost for the option. Service connections should be monitored and replacement options reconsidered in the event of unacceptable surcharges.

Pocasset Interceptor. The gravity sewer in Park Avenue discharge to the Pocasset interceptor. This sewer was constructed in the early 1940's. Evaluation of pipe capacity versus projected peak hourly flows in the years 2015 and 2045 indicated that projected flows in 2045 exceed pipe capacity in about 270 feet of pipe in Reservoir Avenue. However, surcharge is not expected to impact service connections. Thus pipe replacement is not included in the cost for the option. However, there may be excessive infiltration in this interceptor (Tutela Engineering Associates, Inc. "Draft Infiltration/Inflow Study", January, 1993). This problem if present would need to be corrected by the city.

Pontiac Pumping Station and Force Mains. The Pocasset interceptor discharges to the Pontiac pumping station. This pumping station is located northeast of the Pocasset River on Pontiac Avenue and was constructed in the early 1940's. The pumping station has separate wet and dry wells. The pumping station has five sewage pumps, two variable speed, and three constant speed pumps. The pumps discharge to two 24-inch force mains about 2,770 feet in length. An emergency generator is located outside of the station. The existing station capacity is 16,600 gpm.

Existing peak flow to the station is 15,500 gpm. Projected peak hourly design flow for the year 2015 is about 21,000 gpm and in the year 2045 is about 26,100 gpm. Improvements to the pumping station to meet the year 2015 flow condition include rebuilding the three constant speed pumps by installing larger impellers, larger motors, and larger bearing frames. This would result in five pumps with a capacity of 5,250 gpm at 78 feet TDH. Also the existing generator would be replaced with a new 600 KW unit. Improvements to meet the year 2045 flow condition include replacing the existing force mains with a new 42-inch force main and trimming the impellers of the 5 sewage pumps to adjust the pump capacity to 6,525 gpm at 60 feet TDH.

The new 42-inch force main would be located in the existing 35 foot wide city sewer easement for the existing force mains. A portion of the easement may need to be widened.

OPTION 1B

Scituate Pumping Station and 6-inch VGS. Same as Option 1A.

I-295 Pumping Station. See Option 1A for description. Pumps would be selected to handle projected flows from northwest Cranston and Central Landfill.

Existing 14-inch VGS. Same as Option 1A.

Cranston Street Gravity Sewer. See Option 1A description. Existing sewer lines are expected to have sufficient capacity to convey projected flows and sewer replacement is not required.

Park Avenue Gravity Sewer. See Option 1A description.

Pocasset Interceptor. See Option 1A description. The gravity sewer in Park Avenue discharge to the Pocasset interceptor. Evaluation of pipe capacity versus projected peak hourly flows in year 2015 and 2045 indicated that projected flows in the year 2045 exceed pipe capacity in about 270 feet of pipe in Reservoir Avenue. However, calculated surcharge is not expected to impact service connections. Thus, pipe replacement is not included in the cost for this option.

Pontiac Pumping Station and Force Mains. Same as Option 1A.

OPTION 1C

Scituate Pumping Station and 6-inch force main/VGS. Same as Option 1A.

OPTION 2A

Wilbur Pumping Station. The station location considered for feasibility cost purposes is east of I-295 and south of Wilbur Avenue. However, since that analyses a location in the I-295 median north of Wilbur Avenue is being considered.

Inflows to the station would be through a proposed 36-inch gravity sewer in the existing sewer sleeve under I-295 north of Wilbur Avenue (see Option 2D, Brookdale gravity trunk sewer). The sewer sleeve invert is about 25 feet below the ground surface. This results in a deep station to accommodate the gravity sewer. The station could be made shallower by designing the gravity sewer as a siphon through the sewer sleeve. This modification has not been evaluated but is recommended for consideration in future studies.

The station would be cast-in-place-concrete with separate wet and dry wells. For study purposes, it was assumed a comminutor and manually cleaned bar rack would be installed at the Wilbur pumping station. An alternative to the comminutor is a mechanically cleaned bar rack.

The station would house three sewage pumps and appropriate mechanical and electrical equipment. Peak flow to the pump station is estimated at 2,830 gpm in 2015 and 5,144 gpm in 2045. Total estimated pumping head at the 2015 peak flow rate is about 194 feet and at the 2045 peak flow rate is about 235 feet. Initially, two pumps would be installed. Space would be provided for a third pump to be added when increased flows warrant. Pumps would be operated at variable speeds to match outflow to inflow. However, when inflows are low and result in velocities in the VGS of less than 2 feet per second or in peak velocities insufficient to resuspend solids a lower limit on the pumping rate may need to be considered to minimize deposition. An emergency generator (350 KW) would be installed in a separate enclosure.

The station location is close to existing residential development and the 100-year floodplain. A location to avoid neighborhood impacts is within the median of I-295 north of Wilbur Avenue. Construction of the pump station in the 100 year flood plain requires that the structure have the lowest floor elevated above the base flood elevation or together with attendant utility and sanitary functions, be floodproofed below the base flood level. In addition, it is required that the station be fully operational and accessible during a 25-year flood event.

Garden Hills 18-inch Force Main/Variable Grade Sewer. The Wilbur pumping station discharges into a proposed 18-inch diameter PVC force main/VGS (14,100 feet in length). The first 5,850 feet of sewer is a force main which lifts the wastewater about 155 feet. The remaining pipe is a variable grade sewer that follows topography and would be constructed at minimum cover. The sewer contains four automatic air release manholes and two cleanout manholes.

The sewer would be located in Wilbur Avenue and Brayton Avenue and alongside and across New London Avenue (Route 2). From New London Avenue

Garden Hills 18-inch Force Main/Variable Grade Sewer. The Wilbur pumping station discharges into a proposed 18-inch diameter PVC force main/VGS
the sewer is located cross-country between Route 37 and prison facilities on the Howard Center state institutional property. Leaving state property the sewer is located in the abandoned Providence and Worcester Railroad right-of-way until it meets the city's exiting sewer easement for the Sockanosset interceptor. New sewer easements would be required along New London Avenue, Howard Center property, and the railroad. The existing city easement which is about 25 feet wide and contains a 30-inch gravity sewer may need to be expanded about 5 feet.

At the end of the easement the sewer crosses Pontiac Avenue and is located in Pettaconsett Avenue and Webb Street until it reaches the WWTF. The sewer could discharge to the head box of the WWTF or to the WWTF influent pumps.

OPTION 2B

Wilbur Pumping Station. The Wilbur pump station would be the same as described in Option 2A.

Garden Hills 18-inch Force Main/24-inch Gravity Sewer. This sewer follows the same alignments as Option 1B, Garden Hills force main/(VGS). The Wilbur pumping station discharges to a proposed 5,850 foot 18-inch PVC force main which would lift wastewater about 155 feet to a high point on New London Avenue. At the high point the force main would discharge to a new gravity interceptor. The interceptor comprises about 8,250 feet of reinforced concrete gravity sewer and contains 38 sanitary sewer manholes. The depth of the gravity sewer would vary depending on the topography along the alignment with a maximum depth of approximately 21 feet.

WWTF Influent Pumps. Wastewater flows from the gravity sewer would be pumped to the head box of the WWTF by the influent pumps. At present these are three Archimedes screw pumps each with a flow capacity of about 5,200 gpm. This would allow for a total inflow of about 10,400 gpm with one as back-up. These pumps were purchased by the city in 1980. It appears the existing pumps should be able to handle the year 2015 peak flow conditions. However, to accommodate the year 2045 peak flow conditions a fourth screw pump may need to be added.

OPTION 2C

Wilbur Pumping Station. The Wilbur pump station would be the same as described in Option 2A except the pumping head for 2015 and 2045 peak flow conditions would be about 30 and 20 feet less, respectively than the pumping head at these flows for Option 2A and 2B.

Turner Force Main. The Wilbur pumping station would discharge into a proposed 8,100 feet, 18-inch diameter PVC force main which contains three automatic air release manholes at relative high points. The proposed sewer alignment is in Wilbur Avenue, Turner Avenue, Cranston Avenue, Sherman Avenue, Oaklawn Avenue, Freehold Street, and Belvedere Drive. In the first 2,800 feet the sewer lifts the wastewater about 60 feet to a high point on Turner Avenue, the sewer then drops about 25 feet to a low point on Cranston Street. At Sherman Avenue the sewer lifts the wastewater about 80 feet to a high point on Belvedere Drive. Along this alignment, there should be adequate locations for construction of interconnections to existing gravity sewers for maintenance purposes. For about 400 feet, between Freehold Street and Belvedere Drive the sewer is located in a road that does not appear to be a city street and an easement may be required. In Belvedere Street the sewer discharges into the existing 30-inch gravity interceptor.

An alternative location for a portion of the force main would be in the abandoned Providence and Worcester railroad right-of-way instead of in Turner Avenue and Cranston Street. However, the need for possible interconnections to existing gravity sewers would need to be assessed and an easement would be required. An alternative to Turner Avenue would be to locate the sewer in Vinton Avenue. This street appears to have fewer homes and may have decreased neighborhood impacts during construction.

Sockanosset Interceptor. The proposed force main discharges to the about 7,000-feet existing Sockanosset gravity interceptor. This interceptor was constructed in 1961 to conveys flows from southeast Cranston. Hydraulic analyses of sewer capacity and comparison to projected year 2015 peak flows indicated a small amount, less than 0.1 foot of surcharge, might occur in a 90 feet sewer segment. This surcharge is not expected to impact wastewater conveyance.

Comparison of pipe capacity to year 2045 peak flows indicated, about 3,450 feet of sewer would be surcharged. Calculated surcharge is about 0.5 foot or less. Calculated surcharge is expected to impact service connections north of Pontiac Avenue. In order to avoid this potential problem an additional 24-inch reinforced concrete gravity sewer (about 1,500 feet) and 8 sanitary sewer manholes could be added in this area in the future (after 2015). The addition would be located in the existing 25-feet wide easement that contains the existing 30-inch interceptor. The easement would be expanded by about 5 feet.

The interceptor discharges to the "siphon" chamber and the 16 and 27-inch sewers in Webb Street. These sewers are expected to have sufficient capacity to convey the flows to the WWTF influent pumps.

WWTF Influent Pumps. As discussed in OPTION 2B, it appears the existing pumps should be able to handle the year 2015 peak flow conditions. However, in order to accommodate the year 2045 peak flow conditions a fourth screw pump may need to be added.

OPTION 2D

This includes trunk sewers to collect flows in west Cranston, Service Area 2 and deliver them to the proposed Wilbur pumping station. Four trunk sewers were investigated the "Brookdale", the "Tilcon", the "Comstock", and the "Natick/Phenix" sewers. Also a "Phenix" pumping station and force main are assessed. Routing trunk sewers through existing and proposed residential areas will require detailed consideration of site specific conditions.

Brookdale Gravity Trunk Sewer. The 30 and 36-inch diameter sewer is about 2,300 feet in length. The trunk sewer is located in Herod Street and then goes off-road between Herod and the end of Brookdale Street. The sewer runs between Brookdale and Meshanticut Brook and crosses the brook to the sewer sleeve and the Wilbur pumping station. Several sewer easements would be required between Herod Street and the pumping station. This trunk sewer would collect flows from the other three trunk sewers and from local areas. Laterals to collect flows from local areas would be constructed by the city.

Tilcon Gravity Trunk Sewer. The 30, 24, and 18-inch diameter sewer is about 6,250 feet in length. The trunk sewer is located in Natick Avenue from the intersection with Herod Street north to Phenix Avenue. About 600 feet north of the intersection of Phenix Road and Natick Avenue the sewer goes northwest and is located on property associated with a gravel mining operation. A sewer easement would be required in this area. This is an area of future industrial and residential development. This trunk sewer would collect flows from areas along Olney Arnold Road and areas north of the gravel pit and south of Scituate Avenue. Lateral sewer systems to convey flows from these areas to the trunk sewer would be constructed by the city.

Although the trunk sewer has been assumed to extend through the gravel operation to paper streets proposed by the city, future roadway or site topography in this area is not known. Thus, design and construction of this trunk sewer should terminate at the end of Natick Avenue and extension of the sewer be considered when this area is actually developed.

Comstock Gravity Trunk Sewer. The 24, 15, and 12-inch diameter sewer is about 14,240 feet in length. The trunk sewer is located in Natick Avenue for a short distance then crosses through residential lots to Hines Farm Road. The sewer is located in Hines Farm Road for about 1,200 feet and then goes off-road and is located south of Furnace Hill Brook along the rear of residential lots. The sewer crosses Furnace Hill Brook to Phenix Avenue and is located in Phenix Avenue and Kimberly Lane until it goes off-road and is located west of an unnamed tributary to Furnace Hill Brook along the rear of residential lots. From here the sewer is located in Iroquois Trail, undeveloped lots, across the Providence Water Supply pipeline, and in Council Rock Road. Many new sewer easements would be required to construct this trunk sewer.

This sewer would collect flows from areas near Hines Farm Road, Wilbur Avenue, Phenix Avenue (north of Glenham Road and south of Hillcrest Drive), Kimberley Lane, and east of Pipin Orchard Road. Lateral sewer systems to convey flows from these areas to the trunk sewer would be constructed by the city.

Natick/Phenix Trunk Sewer. The 24, 15, 12, and 10-inch diameter sewer is about 7,950 feet in length. The first 3,500 feet of the trunk sewer is located along the rear of residential lots in the Natick Village subdivision. An alternative alignment may be to locate the sewer in Locust Glen Drive. Then the sewer crosses Natick Avenue, goes cross-country (about 2,500 feet) in an undeveloped area to Glenham Road. Several sewer easements would be required to construct the sewer between Natick Avenue and Glenham Road.

This sewer would collect flows from areas near Natick Village, Natick Avenue (south of Wilbur Avenue), and Glenham Road. This sewer would also convey future flows (after 2015) from the Phenix pumping station. Lateral sewer systems to convey flows from these areas to the trunk sewer would be constructed by the city.

Phenix Pumping Station and Force Main. The proposed station location is about 1,200 feet northwest of the intersection of Phenix Avenue and Burlingame Road near an unnamed brook. However, the final pump station location would depend on the development of lateral sewer systems and roadways. This pump station would collect flows from areas west of Pipin Orchard Road and west of the southern end of Phenix Avenue. However, these areas are not expected to be provided with sewer service until after 2015 and only where required to eliminate problems with faulty septic systems. Extensive lateral sewer systems would be required. Most of this area is zoned A-80 and septic systems may be adequate. Also the Cranston Country Club Golf course occupies the land area just north of the pump station.

As previously stated, the development of the Phenix Avenue pumping station and associated sewer laterals will depend on need. Future studies may identify alternative discharge locations depending on the distribution and occurrence of new development in this area.

There appears to be sufficient undeveloped land in this area for location of a pump station. However, the terrain is irregular and heavily wooded. The station would be similar to the Scituate Avenue pumping station in Option 1A, as the projected flows are similar. The station would house two constant speed sewage pumps and appropriate mechanical and electrical equipment. Selected pump capacity is 581 gpm and 162 TDH. A manually cleaned bar rack would be installed. An emergency generator would be located outside the building. An alternative to the described custom built station may be a package pumping station.

Pumps would discharge to a PVC force main which would lift the wastewater about 75 feet to the Natick/Phenix trunk sewer. The force main, about 3,500 feet in length, containing one automatic air release manhole, would be located in Phenix Avenue.

OPTION 3A

Kenny Drive, Ross-Simmons Drive, and Sharpe Drive Gravity Sewers. The gravity sewers in Sharpe Drive, Ross-Simmons Drive, and Kenny Drive convey flows from the industries in the area and from the Howard Center to the Howard pumping station. There are about 10,700 feet of 12-inch to 24-inch gravity sewer constructed in the late 1970's during the construction of the Howard Industrial Park. Evaluation of pipe capacity versus projected peak flow for the year 2015 indicated that flows may exceed pipe capacity in about 4,900 feet of sewer. However, surcharge is not expected to impact existing service connections. Peak design flows are not expected to increase after the year 2015.

Projected industrial flows to segments of the sewer are based on the size of the contributing area and an assumed wastewater flow factor of 5,770 gpd/acre. Actual flows may differ from assumed values. The decision to upgrade these sewers can best be decided based on flow monitoring data. It is suggested that the city begin to monitor flows through these sewers to document existing conditions and to be able to anticipate future problems.

Howard Pumping Station and Force Main. This station was constructed in the late 1970's and is located at the end of Kenny Drive in the Howard Industrial Park. The pumping station has separate wet and dry wells. The city is planning to modify the pump station by installing a climbing bar screen on the incoming sewer line to prevent clogging of pumps with rags from the Howard Center.

The pumping station has four sewage pumps and the existing station capacity is 3,000 gpm. The pumps discharge to a 1,885-feet long, 14-inch diameter force main. An emergency generator is located inside the building.

The existing peak flow to the pump station is estimated at 2,600 gpm. Projected peak hourly design flow for the year 2015 is about 4,640 gpm. Improvements to the pump station to convey projected flows include replacement of the four existing pumps and motors, replacement of the seal water system, and installation of a new generator (275 KW) outside the pump station. The four new pumps would be identical. Each pump would have design points of 1,550 gpm at 113 feet TDH and 2,300 gpm at 62 feet TDH. The existing force main is adequate to convey projected flows.

The force main discharges to the "siphon" chamber and 16 and 27-inch sewers in Webb Street and from here flows are conveyed to the influent pump at the WWTF. These sewers and the WWTF influent pumps are expected to have sufficient capacity to convey projected flows.

FEASIBILITY COST ESTIMATES

Both project and operation and maintenance cost estimates were developed for feasibility study options. These cost estimates are for purposes of the feasibility study only. Project costs include construction costs; real estate costs; engineering and design fees; and construction management fees.

Construction costs for sewers were developed based on an estimation of the cost of excavation, earth support, temporary pavement, control and diversion of water, and other site work; cost of materials including sewer pipe and manholes; and traffic control and environmental protection. Construction costs for the pump stations also included structure costs and mechanical and electrical equipment costs. Construction costs include an allowance of twenty percent for contingencies.

Real estate costs include temporary construction easements, permanent sewer easements, fee acquisition of pump station property, and land acquisition costs. Land values for easements and fee acquisition were based on a review of real estate sales data for Cranston and review of the proposed sewer alignments and pump station locations. A 30 foot width is assumed for new permanent sewer easements and 20 foot width for temporary sewer construction easements. Land acquisition costs include costs for mapping, surveying, legal description, title evidence, appraisal, negotiations, closing, and administrative costs. The acquisition costs are estimated at $7,000 per ownership. The number of ownerships were estimated based on the city's assessor maps. Preliminary estimates of real estate costs are included in Attachment 4.

Engineering and design fees were estimated at 9.0 percent of the basic construction cost plus contingencies for initial project cost estimates and at 10.5 percent for additional improvements needed after 2015. Selected percentages and cost estimates are included in Attachment 5.

Construction management includes supervision and administration costs during construction and were estimated at six percent of the basic construction cost plus contingencies.

Operation and Maintenance costs for new pump stations (Wilbur, Scituate, and Phenix) were based on an estimate of annual energy costs and an estimate of materials and labor costs. Annual energy costs for the new pump stations include a consideration of lighting, ventilation, heating, and pumping requirements. Operation and Maintenance costs for existing pumping stations (Pontiac, Howard, I-295, and WWTF influent pumps) were based on the differential cost to pump additional wastewater flows. For these stations, it was assumed that labor and materials costs would not increase substantially over existing conditions as a result of the additional flows.

For both new and existing stations the cost of electricity was assumed to be eleven cents per kilowatt-hour. This price was obtained from the Narragansett Electric Company. Annual labor and materials costs for new stations were estimated from cost information contained in the U.S. EPA "Innovative and Alternative Assessment Manual", 1980. Cost curve information was updated to current price level using the ENR index for October 1993.

Annual pumping costs were determined using the mean of the average daily flows for two periods: 1995-2015, 2016-2045. The average daily flow for the year 1995 was assumed to be the existing average daily flow at the station. The average daily flows for the years 2015 and 2045 were the projected flows presented in Task 3, "Identification of Wastewater Flows Report". Projected flows for Pontiac pumping station and the WWTF influent pumps include increased flows from east Cranston as well as from west Cranston.

Operation and Maintenance costs for the gravity sewers and force mains were estimated based on the above referenced EPA manual. Operation and maintenance costs for force main/variable grade sewers were assumed to be the same as for gravity sewers.

Preliminary feasibility project cost and operation and maintenance cost estimates for study options are presented in Appendix E and summarized in Table 2 and Table 3.

TABLE 2
SUMMARY OF PROJECT COSTS FOR FEASIBILTY STUDY OPTIONS
IN OCTOBER 1993 DOLLARS

		Project Cost*	Additional Cost* after 2015
OPTION 1A			
Scituate pumping station		$563,700	$0
Scituate 6-inch force main/VGS		$1,300,900	$0
Existing I-295 pumping station		$0	$0
Existing 14-inch force main/VGS		$0	$0
Improvements to Cranston St. gravity sewer (after 2015)		$0	$133,800
Existing Park Avenue and Pocasset Int. sewers		$0	$0
Improvements to existing Pontiac pumping station		$419,400	$89,800
Replace Existing Pontiac force main (after 2015)		$0	$731,300
Subtotal		$2,284,000	$954,900
Total (not discounted)	$3,238,900		
OPTION 1B			
Scituate pumping station		$563,700	$0
Scituate 6-inch force main/VGS		$1,300,900	$0
Existing I-295 pumping station		$0	$0
Existing 14-inch force main/VGS		$0	$0
Improvements to Cranston Street gravity sewer		$0	$0
Existing Park Avenue and Pocasset Int. sewers		$0	$0
Improvements to existing Pontiac pumping station		$419,400	$89,800
Replace Existing Pontiac force main (after 2015)		$0	$731,300
Subtotal		$2,284,000	$821,100
Total (not discounted)	$3,105,100		
OPTION 1C			
Scituate pumping station		$563,700	$0
Scituate 6-inch force main/VGS		$1,300,900	$0
Subtotal		$1,864,600	$0
Total (not discounted)	$1,864,600		
OPTION 2A			
Wilbur pumping station		$2,520,500	$305,500
Garden Hills 18-inch force main/VGS		$2,174,300	$0
Subtotal		$4,694,800	$305,500
Total (not discounted)	$5,000,300		

*Project Costs include 20% contingencies, engineering and design fees, construction management fees, and real estate costs.

TABLE 2 (continued)
SUMMARY OF PROJECT COSTS FOR FEASIBILTY STUDY OPTIONS
IN OCTOBER 1993 DOLLARS

		Project Cost*	Additonal Cost* after 2015
OPTION 2B			
Wilbur pumping station		$2,520,500	$305,500
Garden Hills 18-inch force main, 24-inch gravity sewer		$2,222,600	$0
Improvements to influent pumps at WWTF (after 2015)		$0	$90,900
Subtotal		$4,743,100	$396,400
Total (not discounted)	$5,139,500		
OPTION 2C			
Wilbur pumping station		$2,520,500	$305,500
Turner 18-inch force main		$1,121,600	$0
Improvements Sockanosset Interceptor (after 2015)		$0	$284,300
Improvements to influent pumps at WWTF (after 2015)		$0	$90,900
Subtotal		$3,642,100	$680,700
Total (not discounted)	$4,322,800		
OPTION 2D			
Brookdale gravity trunk sewer		$440,900	$0
Tilcon gravity trunk sewer		$756,300	$0
Comstock gravity trunk sewer		$1,855,300	$0
Natick/Phenix gravity trunk sewer		$1,229,500	$0
Phenix pumping station (after 2015)		$0	$531,100
Phenix 6-inch force main (after 2015)		$0	$246,000
Subtotal		$4,282,000	$777,100
Total (not discounted)	$5,059,100		
OPTION 3A			
Existing Kenny Drive, Ross-Simmons Drive, and Sharpe Drive gravity Sewers		$0	$0
Improvements to Howard pumping station		$243,700	$0
Existing Howard force main and WWTF influent pumps		$0	$0
Subtotal		$243,700	$0
Total (not discounted)	$243,700		

*Project Costs include 20% contingencies, engineering and design fees, construction management fees, and real estate costs.

TABLE 3
SUMMARY OF O&M COSTS FOR FEASIBILTY STUDY OPTIONS
IN OCTOBER 1993 DOLLARS

	O&M Annual cost 1995-2015	O&M Annual cost 2016-2045
OPTION 1A		
Scituate pumping station	$15,700	$18,500
Scituate 6-inch force main/VGS	$2,000	$2,000
Existing I-295 pumping station	$3,800 *	$9,700 *
Existing 14-inch force main/VGS	$0	$0
Improvements to Cranston St. gravity sewer (after 2015)	$0	$0
Existing Park Avenue and Pocasset Int. sewers	$0	$0
Improvements to existing Pontiac pumping station	$46,000 *	$68,300 *
Replace existing Pontiac force main	$0	$0
Total	$67,500	$98,500
OPTION 1B		
Scituate pumping station	$15,700	$18,500
Scituate 6-inch force main/VGS	$2,000	$2,000
Existing I-295 pumping station	$3,000 *	$8,000 *
Existing 14-inch force main/VGS	$0	$0
Improvements to Cranston Street gravity sewer	$0	$0
Existing Park Avenue and Pocasset Int. sewers	$0	$0
Improvements to existing Pontiac pumping station	$46,000 *	$68,300 *
Replace Existing Pontiac force main (after 2015)	$0	$0
Total	$66,700	$96,800
OPTION 1C		
Scituate pumping station	$15,700	$18,500
Scituate 6-inch force main/VGS	$2,000	$2,000
Total	$17,700	$20,500
OPTION 2A		
Wilbur pumping station	$50,200	$94,200
Garden Hills 18-inch force main/VGS	$3,500	$3,500
Total	$53,700	$97,700
OPTION 2B		
Wilbur pumping station	$50,200	$94,200
Garden Hills 18-inch force main, 24-inch gravity sewer	$2,700	$2,700
Improvements to influent pumps at WWTF (after 2015)	$2,700 *	$7,900 *
Total	$55,600	$104,800

* differential cost for increased flow

TABLE 3 (continued)
SUMMARY OF O&M COSTS FOR FEASIBILTY STUDY OPTIONS
IN OCTOBER 1993 DOLLARS

	O&M Annual cost 1995–2015	O&M Annual cost 2016–2045
OPTION 2C		
Wilbur pumping station	$43,100	$74,500
Turner 18–inch force main	$2,000	$2,000
Improvements Sockanosset Interceptor (after 2015)	$0	$0
Improvements to influent pumps at WWTF (after 2015)	$2,700 *	$7,900 *
Total	$47,800	$84,400
OPTION 2D		
Brookdale gravity trunk sewer	$500	$500
Tilcon gravity trunk sewer	$1,300	$1,300
Comstock gravity trunk sewer	$2,800	$2,800
Natick/Phenix gravity trunk sewer	$1,400	$1,400
Phenix pumping station (after 2015)	$0	$18,900
Phenix 6–inch force main/VGS (after 2015)	$0	$240
Total	$6,000	$25,140
OPTION 3A		
Existing Kenny Drive, Ross–Simmons Drive, and Sharpe Drive gravity sewers	$0	$0
Improvements to Howard pumping station	$21,600 *	$21,600 *
Existing Howard force main and WWTF influent pumps	$2,300 *	$4,600 *
Total	$23,900	$26,200

* differential cost for increased flow

ATTACHMENT 1

HYDRAULIC ANALYSIS

CRANSTON, RHODE ISLAND
FEASIBILITY REPORT APPENDIX
DESIGN OF ALTERNATIVES
TASK 7C - HYDRAULIC ANALYSES

1. SUMMARY

This report presents results of hydraulic analyses of gravity mains, force mains, and pump stations included in the options being considered in the Feasibility Investiga tion. Capacities of existing sewers were analyzed and reported separately in "Feasibility Report Appendix, Identification of Existing Sewer System Capacity." This report used information from previous reports to calculate pipe sizes for proposed new sewers, surcharge levels and replacement pipe sizes for overloaded existing gravity sewers, and horsepower requirements for new force mains.

2. INTRODUCTION

a. Background. This is an appendix to a feasibility study of a proposed regional wastewater conveyance system for Cranston, Rhode Island. In May 1992, NED issued a preliminary report entitled, "Section 22, Cranston, Rhode Island, Wastewater Investigation." This report estimated future additional flows from western Cranston, including the Central Landfill in Johnston, to the wastewater treatment facility (WWTF), and mapped possible means to improve the city's wastewater conveyance system. The Section 22 study indicated a new sewer interceptor or modifications to the existing system initially appeared feasible to convey regional flows to the WWTF, and recommended a detailed study to determine which design is most effective from cost and environmental standpoints.

On 21 December 1992, NED signed a cost-sharing agreement with Cranston to perform a feasibility investigation of the city's wastewater conveyance system. This feasibility study includes assessing the need for expanded wastewater conveyance capacity, reviewing the WWTF capacity, preparing feasibility level designs and assessments of alternatives, selecting a proposed project, and preparing a preliminary design and cost estimate.

To accomplish this work, the study was broken down into 16 tasks. Capacities of existing sewer lines which would receive flows from the study areas were analyzed in task 5 and reported in "Feasibility Report Appendix, Identification

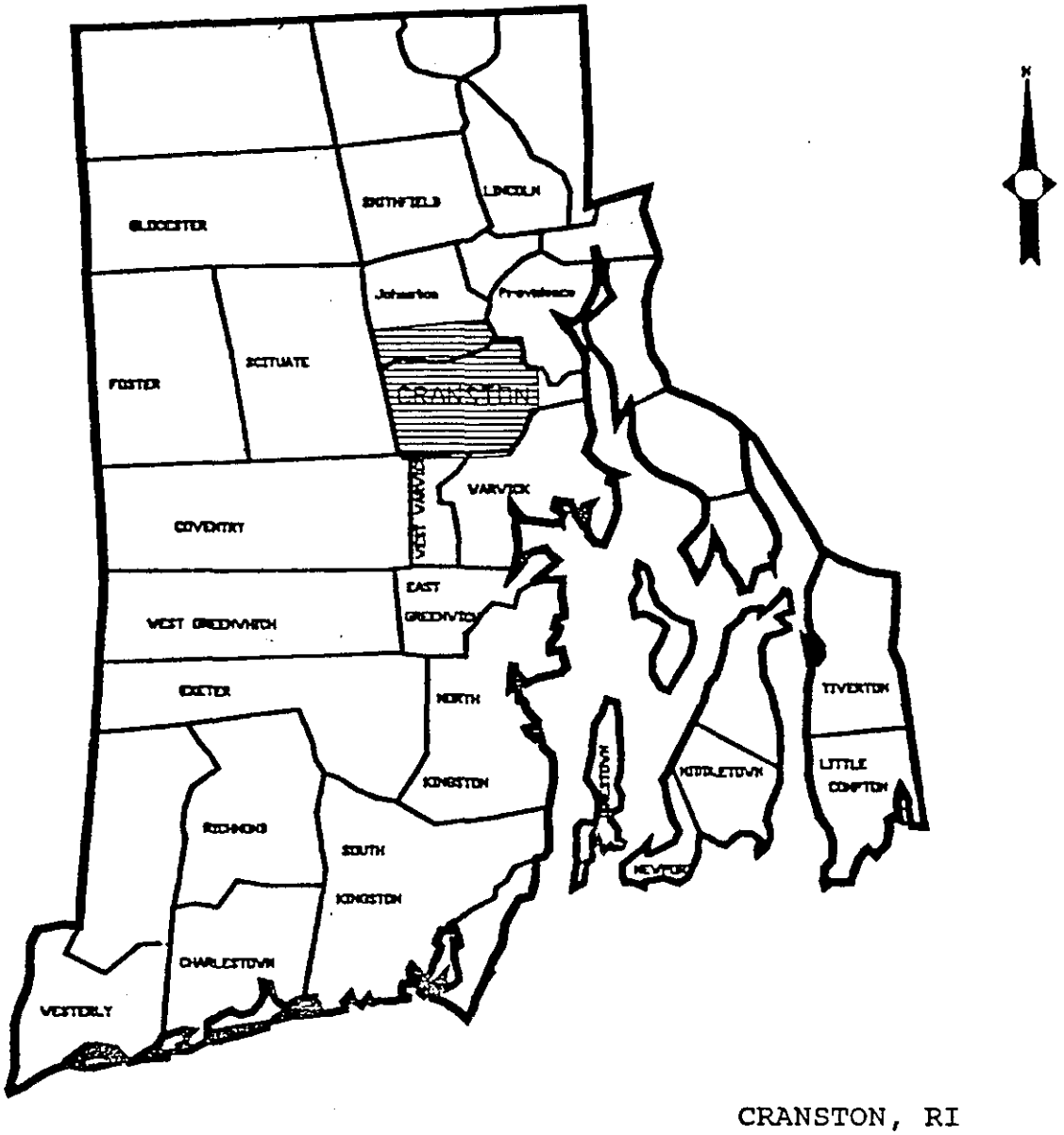
of Existing Sewer System Capacity, Cranston, Rhode Island." Task 7, "Feasibility Level Design of Alternatives," examined options for upgrading Cranston's wastewater conveyance system in the identified study area. This task had five parts: Civil Requirements, Geotechnical, Hydraulic Analysis, Pump Station Design, and Local Sponsor Services. This report deals with task 7c, Hydraulic Analysis, and provides feasibility level hydraulic analysis of gravity mains, force mains, and pump stations for the different options. Information on the existing wastewater conveyance system, and existing and projected flows was supplied by the city and the city's consultant Tutela Engineering Associates (TEA).

b. Study Site. Cranston is a medium-sized city immediately south of Providence, Rhode Island, on the western side of Narragansett Bay. It borders Warwick and West Warwick on the south, Scituate on the west, and Johnston on the northwest. In addition to Cranston, the study area encompasses land in parts of Johnston, including the Central Landfill, that contributes or is likely to contribute flow to the Cranston WWTF. Figures 1 and 2 show the location of Cranston and the study area.

Interstate Highway 295 roughly divides Cranston into eastern and western sections. The eastern half is largely fully developed and sewered. The only areas where major additional development is expected are the Howard Center and Industrial Park between Route 2 and the Pawtuxet River. The Howard Center is expected to grow through expansion of State institutions, and further industrial development is expected in the Howard Industrial Park. Additionally, the Capuano site is in this area; this landfill may have future leachate collection flows which will be added to the Cranston sewer system. Otherwise, increases in wastewater flows from new development in eastern Cranston will be relatively small compared to western Cranston.

Western Cranston is less developed and largely unsewered. Consequently, this is where most additional flows will be generated. Many developed areas in western Cranston use septic systems in poor soil; consequently, it is likely these will be tied into the future sewer system. In addition to future residential and commercial development, the Central Landfill and Vinagro Site may possibly contribute groundwater leachate flows to the sewer system.

c. Study Areas. The study sites in Cranston and Johnston were divided into three areas for the purpose of this report, and are displayed in figure 2.

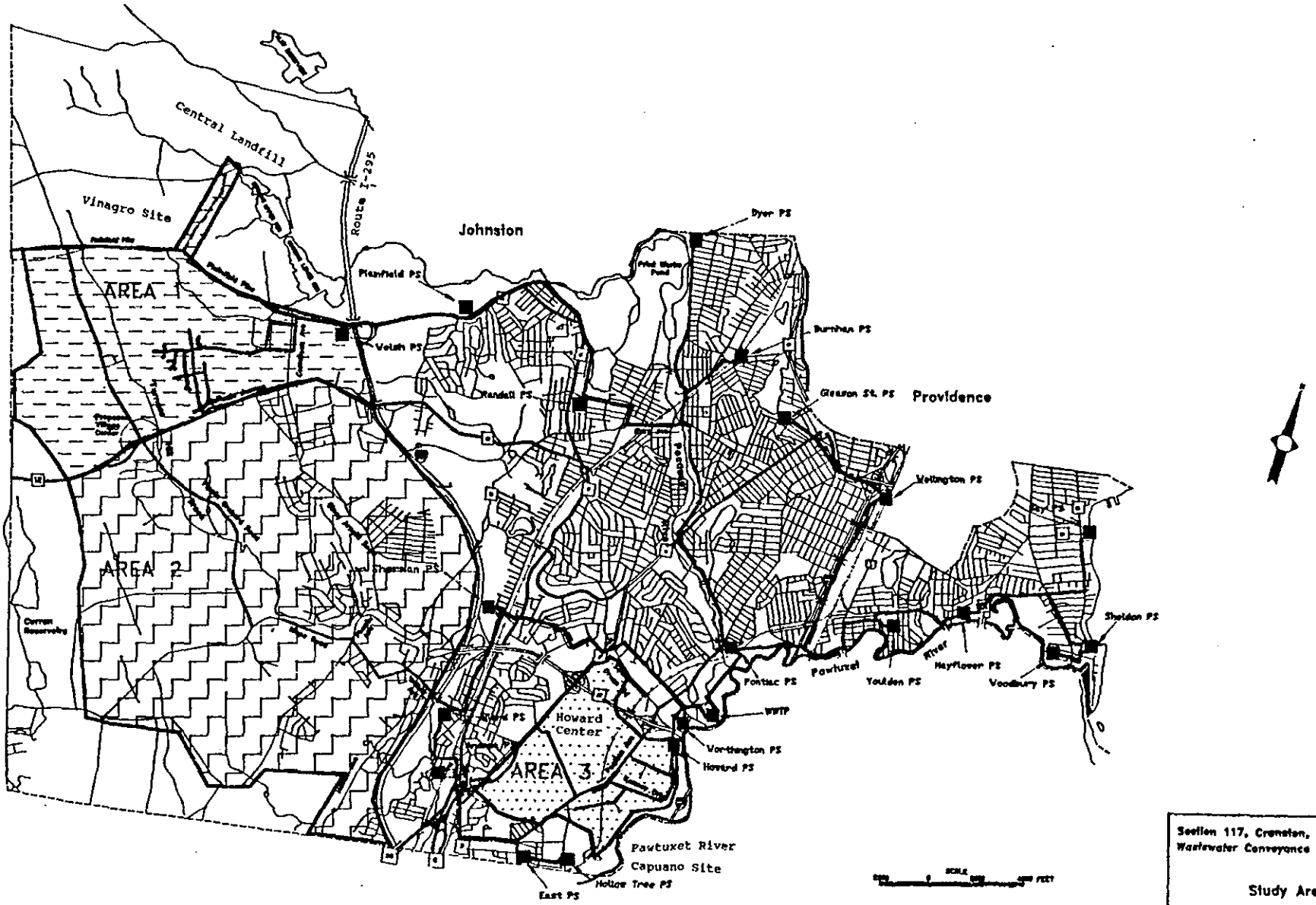


CRANSTON, RI

FEASIBILITY INVESTIGATION

STUDY AREA

FIGURE 1



Section 117, Cranston, Rhode Island
Wastewater Conveyance Feasibility Investigation

Study Areas

U.S. Army Corps of Engineers
New England Division
March 1993

FIGURE 2

(1) Area 1. This area includes residential, industrial, and commercial areas along Plainfield Pike, Comstock Parkway, and the proposed Village Center in northwest Cranston; flows from proposed industrial land in Johnston; and flows from Vinagro and Central Landfills.

(2) Area 2. This area includes residential, commercial, and industrial flows from West Cranston.

(3) Area 3. This area includes flows from the Howard Center, Howard Industrial Park, and Capuano Landfill.

d. Study Options. A large number of options were considered, but in consultation with the city, the number of options under task 7 was set at seven. Three options (1A, 1B, and 1C) were analyzed for carrying flows from service area 1, four options (2A through 2D) for area 2, and one option (3A) for area 3. All options considered flow projections, developed in earlier tasks, for years 2015 and 2045.

Option 1A provides for conveyance of projected wastewater flows from northwest Cranston, proposed Village Center, Central Landfill, Vinagro, and Johnston sites, as well as projected flows from east Cranston. This option involves upgrading existing sewers and pump stations. It includes a new Scituate pump station and force main to convey Village Center flows to the I-295 pump station, and examining capacity of existing sewers from Plainfield Pike to the Pocasset River Interceptor to the WWTF, and pump stations including I-295, and Pontiac Avenue stations (see figure 2).

Option 1B includes the same conditions as option 1A, except projected flows from Vinagro and Johnston sites are not included.

Option 1C considers the Scituate pumping station and force main/variable grade sewer. Projected flows are the same as in options 1A and 1B.

Options 2A through 2D provide for conveyance of projected flows from the proposed Wilbur pump station district in west Cranston, as well as projected flows from east Cranston. Option 2D involves a trunk sewer to collect flows from service area 2 and deliver them to the proposed Wilbur pump station. Options 2A, 2B, and 2C provide for conveyance of flows from the Wilbur station to the WWTF.

Option 2A takes the Wilbur pump station flows by VGS through Garden Hills and cross country to the WWTF. Option 2B takes the same flows by the same route, but pumps only to the highest point along the route, using gravity sewers the

remaining distance to the WWTF. Option 2C involves pumping through a new force main up Turner Avenue to tie into existing gravity sewers, beginning on Park Forest Drive and running through the existing Sockanosset gravity interceptor to the WWTF.

Option 3A provides for conveyance of projected flows from the Howard Center, the Howard Industrial Park, and the Capuano site. This option examines existing sewers from Pontiac Avenue through the Howard pump station to the WWTF.

Figure 3 displays the study options.

3. SEWERS

a. Criteria. Criteria for sewer lines were taken from "Guides for the Design of Wastewater Treatment Works, 1980 Edition" (TR-16) prepared by the New England Interstate Water Pollution Control Commission; "Gravity Sanitary Sewer Design and Construction," 1982, by the American Society of Civil Engineers and the Water Pollution Control Federation; and city of Cranston Sewer Use Ordinance, revised 21 February 1992. TR-16 criteria included a minimum velocity for full pipe flow of 2 feet per second (fps), and a maximum velocity not greater than 12 fps under any flow conditions. City of Cranston criteria included that pipes 21 inches diameter and smaller should not flow more than 0.6 full, and pipes larger than 21 inches should not be more than 0.7 full. Force mains should have a minimum velocity of 2 fps at design average flow conditions and maximum velocities not greater than 10 fps.

b. Manning's "n" Values. Pipe capacities for existing pipes were computed in task 5. Task 7 examined capacities of proposed gravity lines using a Manning's "n" value estimated at 0.013 in accordance with recommendations in TR-16. Proposed force mains and all variable grade sewers (VGS) made of plastic pipe. Friction factors for plastic pipe were taken from Manufacturer's literature, specifically, "PVC & CPVC Extruded Pipe Duct and Shapes," by Harvel Plastics, Inc., 1989. Manning's "n" values were calculated from tables of friction loss per 100 feet of pipe for varying flows. Computed "n" values ranged from 0.0075 to 0.0099.

c. Surcharge. When peak estimated flows in gravity lines exceeded design flow, resulting manhole surcharges were computed by two methods. The first was to consider only pipe hydraulic friction losses; the second method also included manhole losses. Friction losses were computed between manholes using Manning's equation. Surcharges were considered cumulative, i.e., surcharge at manhole "A" was equal to the

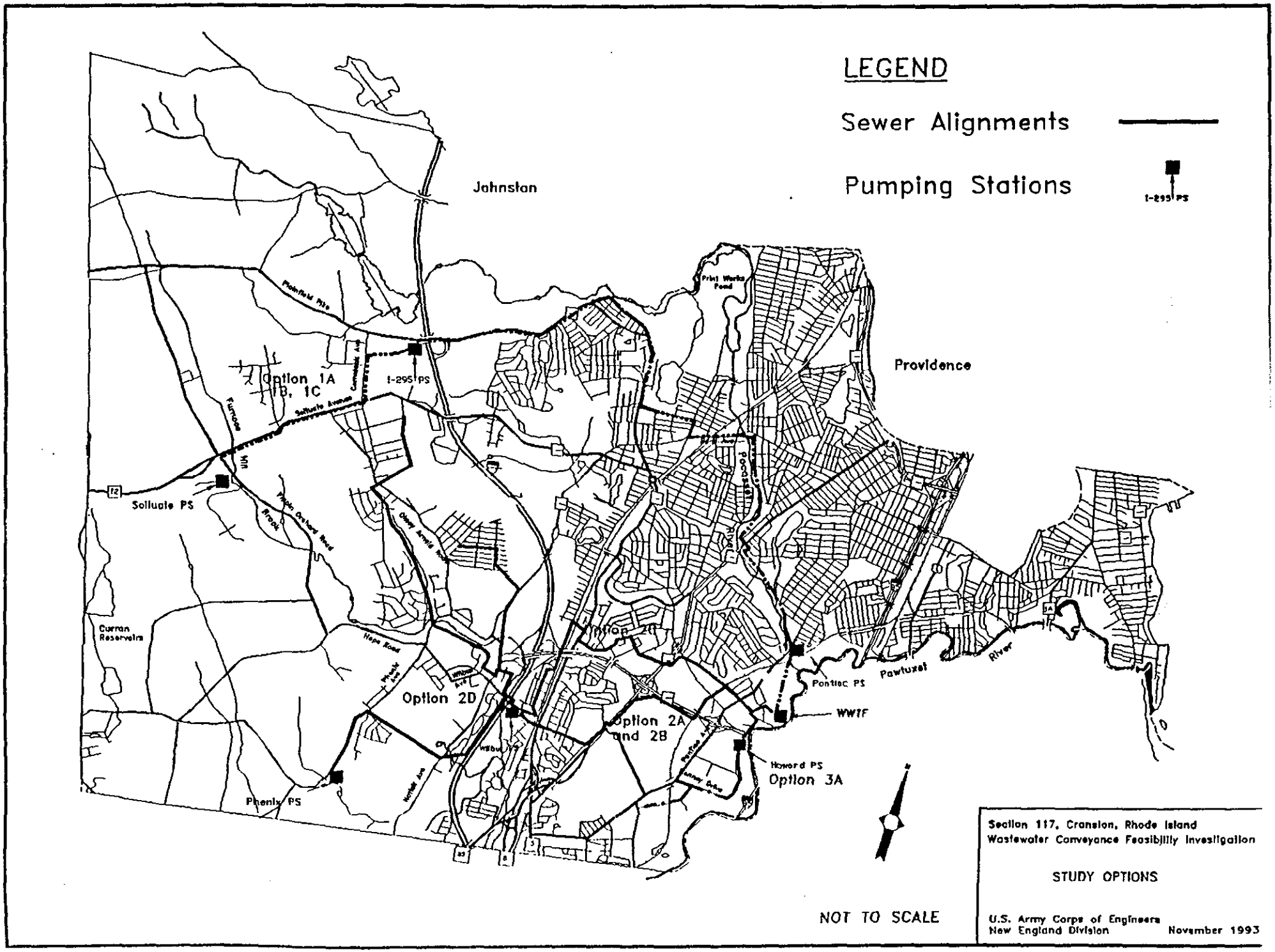

LEGEND
Sewer Alignments
Pumping Stations
I-295 PS
Johnston
Providence
Print Works Pond
Plainfield Pike
Option 1A
1B, 1C
I-295 PS
Soliuate Avenue
Furnace Hill Brook
Soliuate PS
Pippin Orchard Road
Olney Arnold Road
Curran Reservoirs
Hope Road
Option 2D
Option 2A
and 2B
Pontiac PS
WWTF
Pawtuxet
River
Howard PS
Option 3A
Phenix PS
NOT TO SCALE
Section 117, Cranston, Rhode Island
Wastewater Conveyance Feasibility Investigation
STUDY OPTIONS
U.S. Army Corps of Engineers
New England Division
November 1993

FIGURE 3

excess of pipe friction over grade change from manhole "B" to "A" plus the cumulative surcharge at "B."

It is common practice in sewer design to ignore manhole losses and compute surcharge solely on pipe friction, on the principle that manhole losses are small and less than the uncertainties in computations of pipe friction losses. Manhole losses are small because manholes inverts are shaped so the bottom half of the sewer line runs through the manhole; consequently, resulting expansion and contraction losses do not involve the full flow. Furthermore, the short length of the manhole also helps prevent full exit and entrance losses from developing. However, to be conservative in this study, surcharges including manhole losses, as well as pipe friction, were computed also. Manhole losses were computed using the orifice equation with an orifice coefficient of 0.8. Because manhole losses are generally small, both expansion and contraction losses were assumed to be included in the 0.8 orifice coefficient.

d. Replacement Pipe Sizes. Where analyses showed pipe segments to be surcharged, replacement pipes were sized to carry projected peak flows at design depths. This meant that pipes 21 inches diameter and smaller should not flow more than 0.6 full, and pipes larger than 21 inches should not be more than 0.7 full. Replacement pipes were assumed to have same Manning's "n" values as existing pipes. Calculated replacement pipe diameters were the minimum necessary to carry projected flows at design depths; no effort was made to determine availability of pipe sizes.

e. New Pipes. In areas where new gravity sewer lines are needed, such as western Cranston, these pipes were set to carry peak flows at design depth. Under task 7a, prepared by others, a conceptual layout of gravity sewer mains was developed. Peak flows were estimated for these pipes at "nodes" that were typically 1,000 to 2,000 feet apart. For the purpose of calculating required pipe diameters, sewer slopes were estimated by taking one-half the slope between surface elevations at these nodes. Although the average slope of gravity lines between nodes will be approximately equal to the average slope between surface elevations at nodes, the slopes of installed pipes will not be uniform. Experience has shown that pipe diameters computed using one-half the surface slope are reasonably close to the diameters that will be selected when detailed design of sewers and manholes is performed.

Figure 4 shows locations of "nodes" used in analyses of new sewer lines for Western Cranston.

f. Pump Stations. Hydraulic analysis of pump stations in task 7c was limited to computations of head losses in the force mains. At least three different pipe sizes were analyzed for each force main. Sizing of pumps and motors, and final selection of force main sizes were part of task 7d, performed by others. Criteria for sizing force mains and variable grade sewers included that average flows should not be less than 2 fps to minimize deposition, and peak flows should be at least 3.5 fps to resuspend solids which collect in low spots in the VGS, but not greater than 12 fps to minimize scour.

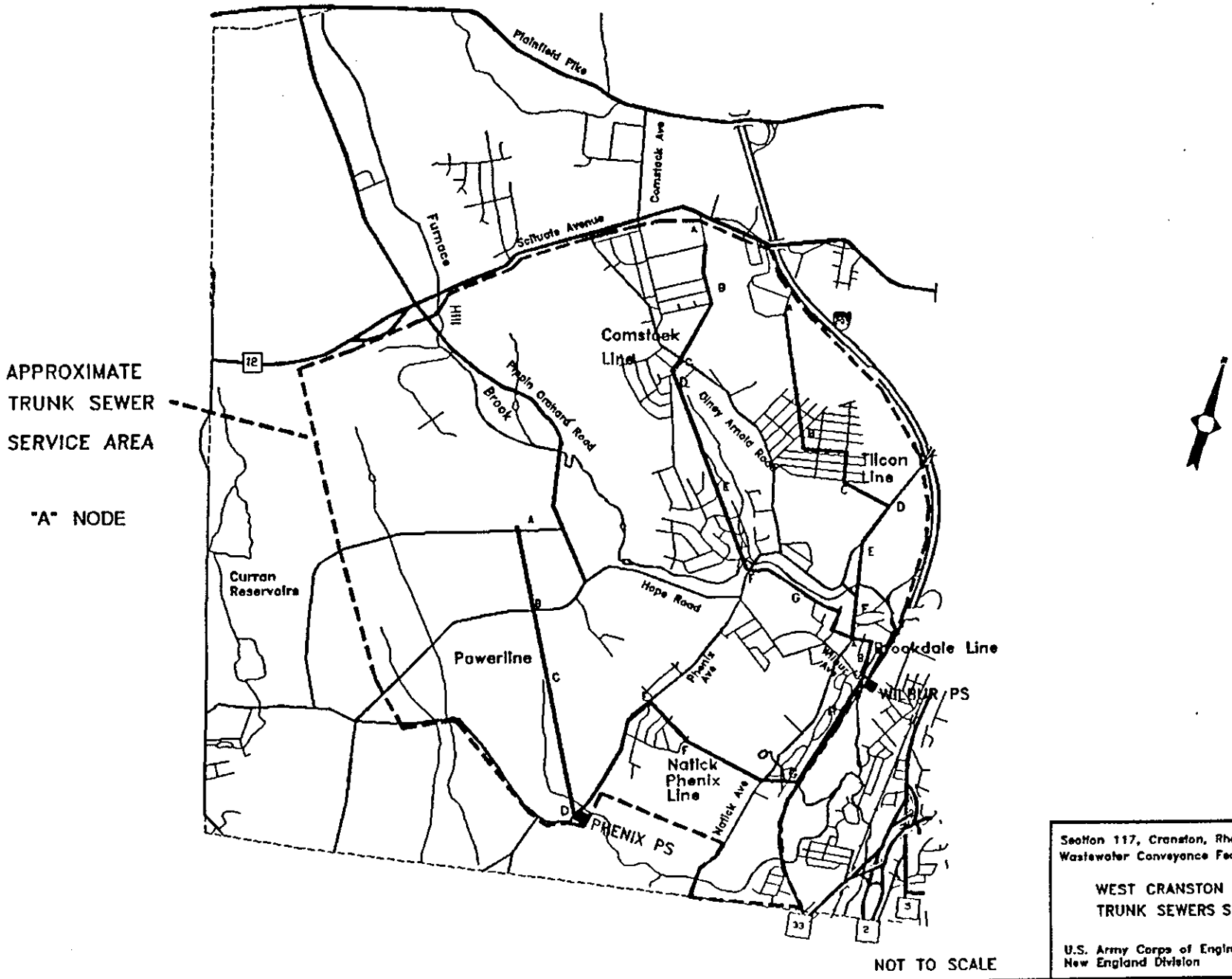
When a force main was designed to rise to a high spot and then slope downward to the terminus, conditions were checked to determine the controlling condition. In some cases, the elevation change from the high spot to the terminus was greater than hydraulic friction along that distance. Under that condition, head loss in pumping to the high spot was the controlling condition. If friction loss from the high spot to the end was greater than the drop in elevation over that distance, then the controlling condition was friction loss over the full length of the force main plus the elevation difference between two ends of the pipe.

4. RESULTS

Tables 1 through 6 give results for Option 1A. Table 1 contains analyses of proposed force main/variable grade sewer (VGS) from the proposed Scituate pump station to the I-295 pump station. Table 2 examines the existing force main/VGS from the I-295 pump station to the gravity sewer on Cranston Street. Table 3 gives capacities, surcharges, and replacement pipe sizes to prevent surcharging for gravity sewers from the end of the I-295 force main/VGS to the Pontiac pump station for conditions through the year 2015. Table 4 looks at the same gravity sewers in table 3, but through the year 2045. There are two 18-inch gravity sewers in Cranston Street that would need replacing to prevent unacceptable surcharging by the year 2045; table 4 includes replacing both pipes with a larger one; table 5 looks at just replacing one pipe. Table 6 examines capacity of the Pontiac pump station force main and possible larger replacement pipes.

There is no separate analysis of option 1C. Results in table 1 of option 1A apply to option 1C.

Tables 7 through 11 look at the same conditions as above for Option 1B; however, there is no separate analysis of replacing only one of Cranston Street's twin 18-inch sewers. Results in table 5 of Option 1A would apply to Option 1B.



Section 117, Cranston, Rhode Island
Wastewater Conveyance Feasibility Investigation

WEST CRANSTON
TRUNK SEWERS SCHEMATIC

U.S. Army Corps of Engineers
New England Division
August 1993

FIGURE 4

Option 2A, which involves constructing a force main/VGS from the proposed Wilbur pump station through Garden Hills to the WWTF, is examined in table 12.

Option 2B involves a force main from the Wilbur pump station through Garden Hills to a proposed gravity sewer to the WWTF. Table 13 examines the force main, and table 14 gives minimum required sizes for the gravity sewer.

Option 2C involves a force main from the Wilbur pump station along Turner Avenue to an existing gravity sewer to the WWTF. Table 15 examines the force main. Table 16 examines capacity of the existing gravity sewer through the year 2015, and table 17 looks through the year 2045. Table 18 examines adding a second line to the existing 30-inch gravity sewer rather than replacing sections that would experience unacceptable surcharging by 2045.

Option 2D examines trunk sewer lines to collect flows from area 2 (western Cranston) and deliver them to the proposed Wilbur pump station. Table 19 gives minimum pipe sizes necessary for the Brookdale trunk sewer, table 20 does the same for the Tilcon trunk sewer, and table 21 for the Comstock/Furnace Hill trunk sewer. Table 22 examines possible pipe diameters for a force main from the proposed Phenix pump station. Table 23 gives minimum pipe sizes for the powerline trunk sewer, and table 24 gives minimum sizes for the Natick/Phenix trunk sewer.

Option 3A examines main gravity sewers feeding the Howard pump station, and the force main from that station to the WWTF. Table 25 gives capacities of the gravity sewers, expected surcharges, and replacement pipe sizes to prevent unacceptable surcharging. Table 26 examines capacities of replacement pipe sizes for the Howard pump station force main.

TABLE 1

OPTION 1A
FORCE MAIN/VGS FROM PROPOSED SCITUATE PUMP STATION
TO I-295 PUMP STATION
YEAR 2015 FLOWS

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	High Point Elev. (ft)
4 Sch 40	3.998	289	66	400	265	438
6 Sch 40	6.031	289	66	400	265	438
8 Sch 40	7.943	289	66	400	265	438

Elev Head (ft)	Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
-135	12,300	0.0078	7.4	2.0	508	374
-135	3,500*	0.0087	3.2	1.0	20	58*
-135	3,500*	0.0093	1.9	0.0	5	43*

*Controlling condition is effort to pump to high point elevation.

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 1 (Cont.)

OPTION 1A
VARIABLE GRADE SEWER FROM PROPOSED SCITUATE PUMP STATION
TO I-295 PUMP STATION
YEAR 2045 FLOWS

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	High Point Elev. (ft)
4 Sch 40	3.998	504	112	400	265	438
6 Sch 40	6.031	504	112	400	265	438
8 Sch 40	7.943	504	112	400	265	438

Elev Head (ft)	Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
-135	12,300	0.0075	12.9	3.0	1430	1295
-135	3,500*	0.0081	5.7	1.0	54	91*
-135	3,500*	0.0087	3.3	1.0	14	7*

*Controlling condition is effort to pump to high point elevation.

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 2

OPTION 1A
FORCE MAIN/VGS FROM I-295 PUMP STATION

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	High Point Elev. (ft)
			Year 1992			
14 Sch 40	13.072	530	264	280	310	310
			Year 2015			
14 Sch 40	13.072	2,095	811	280	310	310
			Year 2045			
14 Sch 40	13.072	3,020	1,100	280	310	310

Elev Head (ft)	Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
			Year 1992			
30	1,148*	0.0099	1.3	1	0.5	30
			Year 2015			
30	1,148	0.0082	5.0	2	5.0	35
			Year 2045			
30	1,148	0.0079	7.2	3	9.6	40

*Length to high point, as controlling condition occurs when pumping to that point rather than the full 15,878 feet of pipe.

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 3

OPTION 1A - YEAR 2015
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Manhole Station	Pipe Size (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe Pipe Diameter (inches)	Replacement Pipe Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Cranston Street											
108	801	2x18	180.0	5,890	3,960	4,850					
109	621	2x18	44.5	5,890	3,960	4,850					
110	576	2x18	286.7	5,890	3,960	4,850					
111	290	2x18	270.7	5,890	3,960	4,850					
112	19	2x18	19.0	6,470	4,340	4,850					
	0.00										
Park Ave.											
113	0.00	24	279.8	5,540	4,630	5,630	26	5,740	0.11	1	11
114	280	24	274.2	5,540	4,630	5,630	26	5,740	0.08	1	11
115	554	24	239.3	5,540	4,630	5,630	26	5,740	0.05	1	10
116	793	24	180.7	5,720	4,790	5,630	26	5,920	0.03	1	10
117	974	24	151.4	5,540	4,630	5,630	26	5,740	0.05	1	11
118	1125	24	100.6	5,540	4,630	5,630	26	5,740	0.03	0	12
119	1226	24	247.2	5,540	4,630	5,630	26	5,740	0.02	0.2	11
120	1473	24	220.8	14,500	12,130	5,630					
121	1694	24	212.6	19,070	15,960	5,630					
122	1907	24	188.9	19,940	16,690	5,630					
123	2095	24	243.6	7,150	5,980	5,770					
124	2339	24	80.0	32,090	26,860	5,770					
125		24	22.1	32,090	26,860	5,770					
Pocasset Interceptor											
Deborah Way, Cross Country											
126		39	166.5	24,830	20,780	9,220					
127		39	307.6	15,950	13,350	9,220					
128		39	273.5	15,950	13,350	9,220					
129		39	275.0	15,950	13,350	9,220					
130		39	198.0	15,950	13,350	9,220					

TABLE 3 (Cont.)

OPTION 1A - YEAR 2015
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Manhole Station	Pipe Size (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe: Pipe Diameter (inches)	Replacement Pipe: Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
131		39	196.7	17,110	14,310	9,400					
132		39	241.8	14,270	11,940	9,400					
133		39	295.7	15,950	13,350	9,400					
134		39	283.2	15,950	13,350	10,000					
135		39	319.1	15,950	13,350	10,000					
136		39	335.1	15,550	13,010	10,000					
137		39	328.3	15,950	13,350	10,000					
138		39	255.4	15,950	13,350	10,000					
139		39	249.6	15,950	13,350	10,000					
140		39	258.9	15,950	13,350	10,000					
141		39	296.5	15,950	13,350	10,000					
142		39	289.8	14,270	11,940	10,530					
143		39	235.3	14,270	11,940	11,130					
144		39	244.9	14,270	11,940	11,130					
145		39	28.0	14,270	11,940	11,130					
146		39	207.1	14,660	12,270	11,130					
Knollwood Rd.											
147		39	170.1	16,350	13,680	11,130					
148		39	111.7	14,710	12,310	11,130					
Reservoir Ave.											
149	5388	39	23.0	11,830	9,900	11,620					
150	5365	39	246.8	12,200	10,210	11,620					
151	5118.0	39	23.7	14,270	11,940	11,620					
Delway Rd.											
152	5094	42	322.3	17,480	14,630	11,620					
153		42	325.7	57,540	48,150	11,620					
154		42	333.4	17,480	14,630	11,620					
155		42	171.8	17,480	14,630	11,620					

TABLE 3 (Cont.)

OPTION 1A - YEAR 2015

IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Manhole Station	Pipe Size (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe: Pipe Diameter (inches)	Replacement Pipe: Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Intervale Rd, Cross Country											
156		42	336.4	17,480	14,630	11,820					
157		42	324.7	17,480	14,630	11,820					
158		42	325.6	17,480	14,630	12,440					
159		42	244.7	17,480	14,630	12,440					
160		42	325.3	28,330	23,710	12,440					
161		42	209.3	49,200	41,170	12,440					
162		42	253.8	20,190	16,890	13,540					
163		42	278.1	20,190	16,890	13,540					
164		42	330.0	20,190	16,890	13,540					
165		42	256.8	20,190	16,890	13,540					
166		42	261.3	20,190	16,890	13,540					
167		42	297.4	20,190	16,890	13,540					
168		42	189.0	20,190	16,890	13,810					
169		42	181.9	21,170	17,720	13,810					
170		42	126.8	25,530	21,370	13,810					
Pontiac Ave.											
171		42	225.0	20,190	16,890	13,870					
172		42	13.0	76,870	64,320	13,950					
Pawtuxet interceptor											
	Flows enter Pontiac Pumping Station										

TABLE 4

OPTION 1A - YEAR 2045
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Manhole Station	Pipe Size (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe Pipe Diameter (inches)	Replacement Pipe Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Cranston Street											
108	801	2x18	180.0	5,890	3,960	6,090	26	6,570	2.3	5	9
109	621	2x18	44.5	5,890	3,960	6,090	26	6,570	2.2	5	9
110	576	2x18	286.7	5,890	3,960	6,090	26	6,570	2.2	5	9
111	290	2x18	270.7	5,890	3,960	6,090	26	6,570	2.2	5	9
112	19	2x18	19.0	6,470	4,340	6,090	26	6,570	2.1	4	
	0.00										
Park Ave.											
113	0.00	24	279.8	5,540	4,630	6,730	28	6,990	2.1	4	11
114	280	24	274.2	5,540	4,630	6,730	28	6,990	1.7	3	11
115	554	24	239.3	5,540	4,630	6,730	28	6,990	1.3	3	10
116	793	24	180.7	5,720	4,790	6,730	28	7,220	0.9	2	10
117	974	24	151.4	5,540	4,630	6,730	28	6,990	0.7	2	11
118	1125	24	100.6	5,540	4,630	6,730	28	6,990	0.5	1	12
119	1226	24	247.2	5,540	4,630	6,730	28	6,990	0.4	0.6	11
120	1473	24	220.8	14,500	12,130	6,730					
121	1694	24	212.6	19,070	15,960	6,730					
122	1907	24	188.9	19,940	16,690	6,850					
123	2095	24	243.6	7,150	5,980	6,850					
124	2339	24	80.0	32,090	26,860	6,850					
125		24	22.1	32,090	26,860	6,850					
Deborah Way, Cross Country											
126		39	166.5	24,830	20,780	11,220					
127		39	307.6	15,950	13,350	11,220					
128		39	273.5	15,950	13,350	11,220					
129		39	275.0	15,950	13,350	11,220					
130		39	198.0	15,950	13,350	11,220					
131		39	196.7	17,110	14,310	11,350					

TABLE 4 (Cont.)

OPTION 1A - YEAR 2045
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Manhole Station	Pipe Size (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe: Pipe Diameter (inches)	Replacement Pipe: Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
132		39	241.8	14,270	11,940	11,350					
133		39	295.7	15,950	13,350	11,350					
134		39	283.2	15,950	13,350	12,030					
135		39	319.1	15,950	13,350	12,030					
136		39	335.1	15,550	13,010	12,030					
137		39	328.3	15,950	13,350	12,030					
138		39	255.4	15,950	13,350	12,030					
139		39	249.6	15,950	13,350	12,030					
140		39	258.9	15,950	13,350	12,030					
141		39	296.5	15,950	13,350	12,030					
142		39	289.8	14,270	11,940	12,630					
143		39	235.3	14,270	11,940	13,300					
144		39	244.9	14,270	11,940	13,300					
145		39	28.0	14,270	11,940	13,300					
146		39	207.1	14,660	12,270	13,300					
Knollwood Rd.											
147		39	170.1	16,350	13,680	13,300					
148		39	111.7	14,710	12,310	13,300					
Reservoir Ave.											
149	5388	39	23.0	11,830	9,900	13,810	45	14,500	0.09	0.8	16
150	5365	39	246.8	12,200	10,210	13,810	44	14,080	0.08	0.4	16
151	5118.0	39	23.7	14,270	11,940	13,810					
Delway Rd.											
152	5094	42	322.3	17,480	14,630	13,810					
153		42	325.7	57,540	48,150	13,810					
154		42	333.4	17,480	14,630	13,810					
155		42	171.8	17,480	14,630	13,810					

TABLE 4 (Cont.)

OPTION 1A - YEAR 2045

IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Manhole Station	Pipe Size (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe: Pipe Diameter (inches)	Replacement Pipe: Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Intervale Rd, Cross Country											
156		42	336.4	17,480	14,630	14,020					
157		42	324.7	17,480	14,630	14,020					
158		42	325.6	17,480	14,630	14,760					
159		42	244.7	17,480	14,630	14,760					
160		42	325.3	28,330	23,710	14,760					
161		42	209.3	49,200	41,170	14,760					
162		42	253.8	20,190	16,890	16,000					
163		42	278.1	20,190	16,890	16,000					
164		42	330.0	20,190	16,890	16,000					
165		42	256.8	20,190	16,890	16,000					
166		42	261.3	20,190	16,890	16,000					
167		42	297.4	20,190	16,890	16,000					
168		42	189.0	20,190	16,890	16,090					
169		42	181.9	21,170	17,720	16,090					
170		42	126.8	25,530	21,370	16,090					
Pontiac Ave.											
171		42	225.0	20,190	16,890	16,110					
172		42	13.0	76,870	64,320	16,420					
Pawtuxet interceptor											
	Flows enter Pontiac Pumping Station										

TABLE 5

OPTION 1A - YEAR 2045
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION
CONSIDERATION OF REPLACEMENT OF ONLY ONE OF TWO 18-INCH LINES IN CRANSTON STREET

Segment	Manhole Station	Pipe Size (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe: Pipe Diameter (inches)	Replacement Pipe: Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Cranston Street											
108	801	2x18	180.0	5,890	3,930	6,090	22	6,260	2.3	5	9
109	621	2x18	44.5	5,890	3,930	6,090	22	6,260	2.2	5	9
110	576	2x18	286.7	5,890	3,930	6,090	22	6,260	2.2	5	9
111	290	2x18	270.7	5,890	3,930	6,090	22	6,260	2.2	5	9
112	19	2x18	19.0	5,700	3,800	6,090	22	6,260	2.1	4	

TABLE 6

OPTION 1A
FORCE MAIN FROM PONTIAC PUMP STATION
INCLUDING FLOWS FROM VINAGRO AND JOHNSTON SITES

Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	Elev. Head. (ft)
		Year 1992			
2x24	15,468	5,730	13	30	17
		Year 2015			
2x24	21,000	9,580	13	30	17
36	21,000	9,580	13	30	17
36	21,000	9,580	13	30	17
42	21,000	9,580	13	30	17
42	21,000	9,580	13	30	17
		Year 2045			
2x24	26,100	11,700	13	30	17
36	26,100	11,700	13	30	17
36	26,100	11,700	13	30	17
42	26,100	11,700	13	30	17
42	26,100	11,700	13	30	17

TABLE 6 (Cont.)

OPTION 1A
FORCE MAIN FROM PONTIAC PUMP STATION

Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
		Year 1992			
2,770	0.013	5.5	2.0	16	33
		Year 2015			
2,770	0.013	7.4	3.0	30	47
2,770	0.013	6.6	3.0	14	31
2,770	0.010	6.6	3.0	8	25
2,770	0.013	4.9	2.0	6	23
2,770	0.010	4.9	2.0	4	21
		Year 2045			
2,770	0.013	9.3	4.0	46	63
2,770	0.013	8.2	4.0	21	38
2,770	0.010	8.2	4.0	12	29
2,770	0.013	6.0	3.0	9	26
2,770	0.010	6.0	3.0	5	22

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 7

OPTION 1B
FORCE MAIN/VGS FROM PROPOSED SCITUATE PUMP STATION
TO I-295 PUMP STATION
YEAR 2015 FLOWS

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	High Point Elev. (ft)
4 Sch 40	3.998	289	66	400	265	438
6 Sch 40	6.031	289	66	400	265	438
8 Sch 40	7.943	289	66	400	265	438

Elev Head (ft)	Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
-135	12,300	0.0078	7.4	2.0	508	374
-135	3,500*	0.0087	3.2	1.0	20	58*
-135	3,500*	0.0093	1.9	0.0	5	43*

*Controlling condition is effort to pump to high point elevation.

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 7 (Cont.)

OPTION 1B
FORCE MAIN/VGS FROM PROPOSED SCITUATE PUMP STATION
TO I-295 PUMP STATION
YEAR 2045 FLOWS

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	High Point Elev. (ft)
4 Sch 40	3.998	504	112	400	265	438
6 Sch 40	6.031	504	112	400	265	438
8 Sch 40	7.943	504	112	400	265	438

Elev Head (ft)	Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
-135	12,300	0.0075	12.9	3.0	1430	1295
-135	12,300	0.0081	5.7	1.0	186	51
-135	3,500*	0.0087	3.3	1.0	14	7*

*Controlling condition is effort to pump to high point elevation.

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 8

OPTION 1B
VARIABLE GRADE SEWER FROM I-295 PUMP STATION

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	High Point Elev. (ft)
			Year 1992			
14 Sch 40	13.072	530	264	280	310	310
			Year 2015			
14 Sch 40	13.072	1,890	726	280	310	310
			Year 2045			
14 Sch 40	13.072	2,720	981	280	310	310

Elev Head (ft)	Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
			Year 1992			
30	1,148*	0.0099	1.3	1.0	0.5	30
			Year 2015			
30	1,148	0.0082	4.5	2.0	4.0	34
			Year 2045			
30	1,148	0.0079	6.5	2.0	7.8	38

*Controlling condition is effort to pump through 1,148 feet to the high point rather than the full 15,878 feet of pipe.

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 9

OPTION 1B - YEAR 2015
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Pipe (in)	Length (ft)	Pipe Capacity Flow (gpm)	Design Capacity (gpm)	System Flow (gpm)	Replace Pipe Dia (inches)	Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Cranston Street										
108	2x18	180.0	5,890	3,930	4,650					
109	2x18	44.5	5,890	3,930	4,650					
110	2x18	286.7	5,890	3,930	4,650					
111	2x18	270.7	5,890	3,930	4,650					
112	2x18	19.0	7,150	4,770	4,650					
Park Ave.										
113	24	279.8	5,540	4,630	5,430					
114	24	274.2	5,540	4,630	5,430					
115	24	239.3	5,540	4,630	5,430					
116	24	180.7	5,720	4,790	5,430					
117	24	151.4	5,540	4,630	5,430					
118	24	100.6	5,540	4,630	5,430					
119	24	247.2	5,540	4,630	5,430					
120	24	220.8	14,500	12,130	5,430					
121	24	212.6	19,070	15,960	5,430					
122	24	188.9	19,940	16,690	5,430					
123	24	243.6	7,150	5,980	5,570					
124	24	80.0	32,090	26,860	5,570					
125	24	22.1	32,090	26,860	5,570					
Pocasset Interceptor - Deborah Way, Cross Country										
126	39	166.5	24,830	20,780	9,020					
127	39	307.6	15,950	13,350	9,020					
128	39	273.5	15,950	13,350	9,020					
129	39	275.0	15,950	13,350	9,020					
130	39	198.0	15,950	13,350	9,020					
131	39	196.7	17,110	14,310	9,200					
132	39	241.8	14,270	11,940	9,200					

TABLE 9 (Cont.)

OPTION 1B - YEAR 2015
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Pipe (in)	Length (ft)	Pipe Capacity Flow (gpm)	Design Capacity (gpm)	System Flow (gpm)	Replace Pipe Dia (inches)	Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Pocasset Interceptor - Deborah Way, Cross Country (Cont.)										
133	39	295.7	15,950	13,350	9,200					
134	39	283.2	15,950	13,350	9,800					
135	39	319.1	15,950	13,350	9,800					
136	39	335.1	15,550	13,010	9,800					
137	39	328.3	15,950	13,350	9,800					
138	39	255.4	15,950	13,350	9,800					
139	39	249.6	15,950	13,350	9,800					
140	39	258.9	15,950	13,350	9,800					
141	39	296.5	15,950	13,350	9,800					
142	39	289.8	14,270	11,940	10,330					
143	39	235.3	14,270	11,940	10,930					
144	39	244.9	14,270	11,940	10,930					
145	39	28.0	14,270	11,940	10,930					
146	39	207.1	14,660	12,270	10,930					
Knollwood Rd.										
147	39	170.1	16,350	13,680	10,930					
148	39	111.7	14,710	12,310	10,930					
Reservoir Ave.										
149	39	23.0	11,830	9,900	11,420					
150	39	246.8	12,200	10,210	11,420					
151	39	23.7	14,270	11,940	11,420					
Delway Rd.										
152	42	322.3	17,480	14,630	11,420					
153	42	325.7	57,540	48,150	11,420					
154	42	333.4	17,480	14,630	11,420					
155	42	171.8	17,480	14,630	11,420					

TABLE 9 (Cont.)

OPTION 1B - YEAR 2015
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Pipe (in)	Length (ft)	Pipe Capacity Flow (gpm)	Design Capacity (gpm)	System Flow (gpm)	Replace Pipe Dia (inches)	Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Intervale Rd, Cross Country										
156	42	336.4	17,480	14,630	11,620					
157	42	324.7	17,480	14,630	11,620					
158	42	325.6	17,480	14,630	12,240					
159	42	244.7	17,480	14,630	12,240					
160	42	325.3	28,330	23,710	12,240					
161	42	209.3	49,200	41,170	12,240					
162	42	253.8	20,190	16,890	13,340					
163	42	278.1	20,190	16,890	13,340					
164	42	330.0	20,190	16,890	13,340					
165	42	256.8	20,190	16,890	13,340					
166	42	261.3	20,190	16,890	13,340					
167	42	297.4	20,190	16,890	13,340					
168	42	189.0	20,190	16,890	13,610					
169	42	181.9	21,170	17,720	13,610					
170	42	126.8	25,530	21,370	13,610					
Pontiac Ave.										
171	42	225.0	20,190	16,890	13,670					
172	42	13.0	76,870	64,320	13,750					

Pawtuxet Interceptor

Flows enter Pontiac Pumping Station

TABLE 10 (Cont.)

OPTION 1B - YEAR 2045
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Pipe (in)	Length (ft)	Pipe Capacity Flow (gpm)	Design Capacity (gpm)	System Flow (gpm)	Replace Pipe Dia (inches)	Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Cranston Street										
108	2x18	180.0	5,890	3,930	5,800					
109	2x18	44.5	5,890	3,930	5,800					
110	2x18	286.7	5,890	3,930	5,800					
111	2x18	270.7	5,890	3,930	5,800					
112	2x18	19.0	7,150	4,770	5,800					
Park Ave.										
113	24	279.8	5,540	4,630	6,440			1.5	3	11
114	24	274.2	5,540	4,630	6,440			1.2	2	11
115	24	239.3	5,540	4,630	6,440			0.9	2	10
116	24	180.7	5,720	4,790	6,440			0.7	1	10
117	24	151.4	5,540	4,630	6,440			0.5	1	11
118	24	100.6	5,540	4,630	6,440			0.4	1	12
119	24	247.2	5,540	4,630	6,440			0.3	0.5	11
120	24	220.8	14,500	12,130	6,440					
121	24	212.6	19,070	15,960	6,440					
122	24	188.9	19,940	16,690	6,440					
123	24	243.6	7,150	5,980	6,560					
124	24	80.0	32,090	26,860	6,560					
125	24	22.1	32,090	26,860	6,560					
Pocasset Interceptor - Deborah Way, Cross Country										
126	39	166.5	24,830	20,780	10,930					
127	39	307.6	15,950	13,350	10,930					
128	39	273.5	15,950	13,350	10,930					
129	39	275.0	15,950	13,350	10,930					
130	39	198.0	15,950	13,350	10,930					
131	39	196.7	17,110	14,310	11,060					
132	39	241.8	14,270	11,940	11,060					

TABLE 10 (Cont.)

OPTION 1B - YEAR 2045
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Pipe (in)	Length (ft)	Pipe Capacity Flow (gpm)	Design Capacity (gpm)	System Flow (gpm)	Replace Pipe Dia (inches)	Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Pocasset Interceptor - Deborah Way, Cross Country (Cont.)										
133	39	295.7	15,950	13,350	11,060					
134	39	283.2	15,950	13,350	11,740					
135	39	319.1	15,950	13,350	11,740					
136	39	335.1	15,550	13,010	11,740					
137	39	328.3	15,950	13,350	11,740					
138	39	255.4	15,950	13,350	11,740					
139	39	249.6	15,950	13,350	11,740					
140	39	258.9	15,950	13,350	11,740					
141	39	296.5	15,950	13,350	11,740					
142	39	289.8	14,270	11,940	12,340					
143	39	235.3	14,270	11,940	13,010					
144	39	244.9	14,270	11,940	13,010					
145	39	28.0	14,270	11,940	13,010					
146	39	207.1	14,660	12,270	13,010					
Knollwood Rd.										
147	39	170.1	16,350	13,680	13,010					
148	39	111.7	14,710	12,310	13,010					
Reservoir Ave.										
149	39	23.0	11,830	9,900	13,520			0.07	0.7	16
150	39	246.8	12,200	10,210	13,520			0.07	0.4	16
151	39	23.7	14,270	11,940	13,520					
Delway Rd.										
152	42	322.3	17,480	14,630	13,520					
153	42	325.7	57,540	48,150	13,520					
154	42	333.4	17,480	14,630	13,520					
155	42	171.8	17,480	14,630	13,520					

TABLE 10 (Cont.)

OPTION 1B - YEAR 2045
IMPROVEMENTS IN GRAVITY SEWERS FROM I-295 VGS TO PONTIAC PUMP STATION

Segment	Pipe (in)	Length (ft)	Pipe Capacity Flow (gpm)	Design Capacity (gpm)	System Flow (gpm)	Replace Pipe Dia (inches)	Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Intervale Rd, Cross Country										
156	42	336.4	17,480	14,630	13,730					
157	42	324.7	17,480	14,630	13,730					
158	42	325.6	17,480	14,630	14,470					
159	42	244.7	17,480	14,630	14,470					
160	42	325.3	28,330	23,710	14,470					
161	42	209.3	49,200	41,170	14,470					
162	42	253.8	20,190	16,890	15,710					
163	42	278.1	20,190	16,890	15,710					
164	42	330.0	20,190	16,890	15,710					
165	42	256.8	20,190	16,890	15,710					
166	42	261.3	20,190	16,890	15,710					
167	42	297.4	20,190	16,890	15,710					
168	42	189.0	20,190	16,890	15,800					
169	42	181.9	21,170	17,720	15,800					
170	42	126.8	25,530	21,370	15,800					
Pontiac Ave.										
171	42	225.0	20,190	16,890	15,820					
172	42	13.0	76,870	64,320	16,130					

Pawtuxet Interceptor

Flows enter Pontiac Pumping Station

TABLE 11

OPTION 1B
FORCE MAIN FROM PONTIAC PUMP STATION

Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	Elev. Head. (ft)
		Year 1992			
2x24	15,468	5,730	13	30	17
		Year 2015			
2x24	20,900	9,490	13	30	17
36	20,900	9,490	13	30	17
36	20,900	9,490	13	30	17
42	20,900	9,490	13	30	17
42	20,900	9,490	13	30	17
		Year 2045			
2x24	25,800	11,500	13	30	17
36	25,800	11,500	13	30	17
36	25,800	11,500	13	30	17
42	25,800	11,500	13	30	17
42	25,800	11,500	13	30	17

TABLE 11 (Cont.)

OPTION 1B
FORCE MAIN FROM PONTIAC PUMP STATION

Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
		Year 1992			
2,770	0.0130	5.5	2.0	16	33
		Year 2015			
2,770	0.0130	7.4	3.0	29	46
2,770	0.0130	6.6	3.0	14	31
2,770	0.0100	6.6	3.0	8	25
2,770	0.0130	4.8	2.0	6	23
2,770	0.0100	4.8	2.0	4	21
		Year 2045			
2,770	0.0130	9.1	4.0	45	62
2,770	0.0130	8.1	4.0	21	38
2,770	0.0100	8.1	4.0	12	29
2,770	0.0130	6.0	3.0	9	26
2,770	0.0100	6.0	3.0	5	22

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 12

OPTION 2A
FORCE MAIN/VGS FROM WILBUR PUMP STATION
TO WWTF VIA GARDEN HILLS

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	Peak Elev (ft)
16 Sch 40	14.94	2,830	906	25	182	182
16 Sch 40	14.94	5,140	1715	25	182	182
18 Sch 80	16.014	2,830	906	25	182	182
18 Sch 80	16.014	5,140	1715	25	182	182

Elev Head (ft)	Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
157	5,850*	0.00902	5.2	2.0	26.7	184
157	5,850*	0.00848	9.4	3.0	77.9	235
157	5,850*	0.0092	4.5	1.0	19.2	176
157	5,850*	0.0088	8.2	3.0	57.9	215

*Controlling condition is the effort required to pump through 5,850 feet to the high point, rather than through the full 14,000-foot length of the VGS.

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual vel-ocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 13

OPTION 2B
FORCE MAIN FROM WILBUR PUMP STATION
TO GARDEN HILLS GRAVITY SEWER

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	Peak Elev (ft)
16 Sch 40	14.940	2,830	906	25	182	182
16 Sch 40	14.940	5,140	1715	25	182	182
18 Sch 80	16.014	2,830	906	25	182	182
18 Sch 80	16.014	5,140	1715	25	182	182

Elev Head (ft)	Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
157	5,850	0.00902	5.2	2.0	27	184
157	5,850	0.00848	9.4	3.0	80	237
157	5,850	0.0092	4.5	1.0	20	177
157	5,850	0.0088	8.2	3.0	59	216

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 14

OPTION 2B
MINIMUM REQUIRED NEW PIPE SIZES
GARDEN HILLS LINE
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
58+40			179	5,140	0.0400	0.0200	18
69+40	1100		135		0.0353	0.0177	18
81+00	1160		94		0.0093	0.0046	22
86+40	540		89		0.0417	0.0208	18
90+00	360		74		0.0033	0.0017	27
93+00	300		73		0.0406	0.0203	18
96+20	320		60		0.0147	0.0073	21
103+70	750		49		0.0086	0.0043	22
117+60	1390		37		0.0030	0.0015	27
127+60	1000		34		0.0300	0.0150	18
128+60	100		31		0.0017	0.0008	30
134+60	600		30		0.0274	0.0137	18
139+90	530		16				

TABLE 15

OPTION 2C
FORCE MAIN FROM PROPOSED WILBUR PUMP STATION
TO SOCANOSSET INTERCEPTOR VIA TURNER AVE

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	Elev. Head. (ft)
16 Sch 40	14.940	2,830	906	25	141	116
16 Sch 40	14.940	5,140	1715	25	141	116
18 Sch 80	16.014	2,830	906	25	141	116
18 Sch 80	16.014	5,140	1715	25	141	116

Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
8,100	0.00902	5.2	2	38	154
8,100	0.00848	9.4	3	111	227
8,100	0.00920	4.5	1	27	143
8,100	0.00880	8.2	3	82	198

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 16

OPTION 2C - YEAR 2015 FLOWS
IMPROVEMENTS TO SOCKANOSSET INTERCEPTOR

Segment	Manhole Station	Pipe (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe Pipe Diameter (inches)	Replacement Pipe Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Gravity Line from Intersection of Park Forest Rd and Summit Ave.											
Park Forest											
Belvedere	248.7	30	248.7	6,190	5,180	5,320					
	0.0										
Hoffman	1620.0	30	269.2	6,710	5,610	5,325					
Jennings	1350.8	30	278.0	6,880	5,750	5,395					
Kennedy	1072.8	30	343.4	8,170	6,840	5,395					
Kennedy	729.4										
MH	729.4	30	272.9	17,970	15,040	5,420					
MH	456.5	30	91.6	10,870	9,100	5,420					
MH	364.9	30	91.9	8,200	6,870	5,420					
Cross Country	273.0	30	273.0	8,420	7,040	5,420					
Cross Country	0.0										
MH	7450.9	30	192.7	9,320	7,800	5,500					
MH	7258.2	30	313.0	8,660	7,240	5,500					
N Lndn A	6945.2	30	311.6	9,580	8,020	5,500					
	6633.6										
MH	6631.0	30	154.4	7,310	6,120	5,500					
MH	6476.6	30	275.2	8,330	6,970	5,500					
MH	6201.4	30	263.2	9,440	7,900	5,500					
	5938.2										
MH	5938.2	22	228.5	9,610	8,040	5,500					
	5709.7										
MH	5709.7	18	111.9	9,020	6,070	5,500					
	5597.8										
MH	5597.8	18	98.1	9,030	6,070	5,500					
	5499.7										

TABLE 16 (Cont.)

OPTION 2C - YEAR 2015 FLOWS
IMPROVEMENTS TO SOCKANOSSET INTERCEPTOR

Segment	Manhole Station	Pipe (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe Pipe Diameter (inches)	Replacement Pipe Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
MH	5499.7	18	98.2	9,480	6,380	5,500					
	5401.5										
MH	5401.5	18	101.7	9,300	6,250	5,500					
Midway R	5299.8										
MH	5299.8	18	102.1	9,040	6,080	5,500					
	5197.7										
MH	5197.7	18	122.1	9,060	6,090	5,500					
	5075.6										
MH	5075.6	18	80.2	7,420	4,990	5,500					
MH	4995.4	18	87.9	7,920	5,330	5,500					
	4907.5										
MH	4907.5	22	253.7	8,320	6,960	5,500					
MH	4653.8	22	254.3	9,630	8,060	5,500					
	4399.5										
MH	4399.5	22	124.8	13,740	11,500	5,500					
	4274.7										
MH	4265.3	30	314.0	9,720	8,130	5,500					
MH	3951.3	30	98.5	5,370	4,490	5,680	36	7,300	0.01	0.1	4
MH	3852.8	30	303.3	7,710	6,450	5,680					
MH	3549.5	30	143.1	8,490	7,100	5,680					
MH	3406.4	30	166.4	8,350	6,990	5,710					
MH	3240.0	30	213.4	7,530	6,300	5,930					
MH	3026.6	30	313.6	8,210	6,870	5,930					

TABLE 16 (Cont.)

OPTION 2C - YEAR 2015 FLOWS
IMPROVEMENTS TO SOCKANOSSET INTERCEPTOR

Segment	Manhole Station	Pipe (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe Pipe Diameter (inches)	Replacement Pipe Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Pettaconsett	2713.0										
MH		30	315.5	8,330	6,970	5,930					
MH	2397.5	30	294.5	7,770	6,500	6,020					
MH	2103.0	30	61.0	12,840	10,740	6,020					
	2042.0										
Siphon	2034.3	27	1314*	12,400							
	800.0										
	2034.3	16	1248*	3,150							
Total Siphon	800.0			15,200							

*Effective pipe lengths.

TABLE 17

OPTION 2C - YEAR 2045 FLOWS
IMPROVEMENTS TO SOCKANOSSET INTERCEPTOR

Segment	Manhole Station	Pipe (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe Pipe Diameter (inches)	Replacement Pipe Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Gravity Line from Intersection of Park Forest Rd and Summit Ave.											
Park Forest											
Belvedere	248.7	30	248.7	6,190	5,180	7,740	35	7,820	0.5	0.70	5
	0.0										
Hoffman	1620.0	30	269.2	6,710	5,610	7,750	34	7,840	0.3	0.3	9
Jennings	1350.8	30	278.0	6,880	5,750	7,830	34	8,030	0.2	0.3	11
Kennedy	1072.8	30	343.4	8,170	6,840	7,830					
Kennedy	729.4										
MH	729.4	30	272.9	17,970	15,040	7,860					
MH	456.5	30	91.6	10,870	9,100	7,860					
MH	364.9	30	91.9	8,200	6,870	7,860	32	8,150	0	0.2	3
Cross Country	273.0	30	273.0	8,420	7,040	7,860	32	8,360	0	0.1	5
Cross Country	0.0										
MH	7450.9	30	192.7	9,320	7,800	7,930					
MH	7258.2	30	313.0	8,660	7,240	7,930					
N Lndn A	6945.2	30	311.6	9,580	8,020	7,930					
	6633.6										
MH	6631.0	30	154.4	7,310	6,120	7,930	34	8,540	0.1	0.2	5
MH	6476.6	30	275.2	8,330	6,970	7,930					
MH	6201.4	30	263.2	9,440	7,900	7,930					
	5938.2										
MH	5938.2	22	228.5	9,610	8,040	7,930					
	5709.7										
MH	5709.7	18	111.9	9,020	6,070	7,930					
	5597.8										
MH	5597.8	18	98.1	9,030	6,070	7,930					
	5499.7										

TABLE 17 (Cont.)

OPTION 2C - YEAR 2045 FLOWS
IMPROVEMENTS TO SOCKANOSSET INTERCEPTOR

Segment	Manhole Station	Pipe (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe Pipe Diameter (inches)	Replacement Pipe Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
MH	5499.7	18	98.2	9,480	6,380	7,930					
	5401.5										
MH	5401.5	18	101.7	9,300	6,250	7,930					
Midway R	5299.8										
MH	5299.8	18	102.1	9,040	6,080	7,930					
	5197.7										
MH	5197.7	18	122.1	9,060	6,090	7,930	20	8,070	0	0.04	10
	5075.6										
MH	5075.6	18	80.2	7,420	4,990	7,930	22	10,600	0.38	1.19	7
MH	4995.4	18	87.9	7,920	5,330	7,930	21	8,030	0.01	0.58	7
	4907.5										
MH	4907.5	22	253.7	8,320	6,960	7,930					
MH	4653.8	22	254.3	9,630	8,060	7,930					
	4399.5										
MH	4399.5	22	124.8	13,740	11,500	7,930					
	4274.7										
MH	4265.3	30	314.0	9,720	8,130	7,930					
MH	3951.3	30	98.5	5,370	4,490	8,130	38	8,430	0.5	1.9	4
MH	3852.8	30	303.3	7,710	6,450	8,130	33	8,320	0.4	1.6	4
MH	3549.5	30	143.1	8,490	7,100	8,130	32	8,440	0.3	1.3	9
MH	3406.4	30	166.4	8,350	6,990	8,160	32	8,300	0.4	1.2	9
MH	3240.0	30	213.4	7,530	6,300	8,490	34	8,800	0.4	1.0	9
MH	3026.6	30	313.6	8,210	6,870	8,490	33	8,860	0.2	0.7	4

TABLE 17 (Cont.)

OPTION 2C - YEAR 2045 FLOWS
IMPROVEMENTS TO SOCKANOSSET INTERCEPTOR

Segment	Manhole Station	Pipe (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe Pipe Diameter (inches)	Replacement Pipe Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Pettaconsett	2713.0	30	315.5	8,330	6,970	8,490	33	8,990	0.2	0.5	4
	2397.5	30	294.5	7,770	6,500	8,610	34	9,080	0.2	0.3	18
	2103.0	30	61.0	12,840	10,740	8,610					
	2042.0										
Siphon	2034.3	27	1314*	12,400							
	800.0										
	2034.3	16	1248*	3,150							
Total Siphon	800.0			15,200							

*Effective pipe lengths.

TABLE 18

OPTION 2C - YEAR 2045 FLOWS
IMPROVEMENTS TO SOCKANOSSET INTERCEPTOR
ANALYSIS CONSIDERING ADDING A SECOND PIPE RATHER THAN REPLACING THE SURCHARGED 30-INCH SEWER

Segment	Manhole Station	Pipe (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe: Pipe Diameter (inches)	Replacement Pipe: Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
MH	4265.3	30	314.0	9,720	8,130	7,930					
MH	3951.3	30	98.5	5,370	4,490	8,130	24	8,430	0.5	1.9	4
MH	3852.8	30	303.3	7,710	6,450	8,130	24	8,320	0.4	1.6	4
MH	3549.5	30	143.1	8,490	7,100	8,130	24	8,440	0.3	1.3	9
MH	3406.4	30	166.4	8,350	6,990	8,160	24	8,300	0.4	1.2	9
MH	3240.0	30	213.4	7,530	6,300	8,490	24	8,800	0.4	1.0	9
MH	3026.6	30	313.6	8,210	6,870	8,490	24	8,860	0.2	0.7	4
Pettaconsett	2713.0	30	315.5	8,330	6,970	8,490	24	8,990	0.2	0.5	4
	2397.5	30	294.5	7,770	6,500	8,610	24	9,080	0.2	0.3	18
	2103.0	30	61.0	12,840	10,740	8,610					
	2042.0										
Siphon	2034.3	27	1314*	12,400							
	800.0										
	2034.3	16	1248*	3,150							
Total Siphon	800.0			15,200							

*Effective pipe lengths.

TABLE 19

OPTION 2D
MINIMUM REQUIRED NEW PIPE SIZES
WESTERN CRANSTON - BROOKDALE TRUNK SEWER
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
22+50		A	59	4,150			
19+80	270		55		0.0148		22
16+80	300		48		0.0233		22
13+80	300		52		-0.0133		22
12+50	130		45		0.0538		22
9+50	300	B	42	4,180	0.0100	0.0065	22
7+30	220		52		-0.0455		33
4+30	300		51		0.0033		33
1+30	300	C	50	5,140	0.0033	-0.0049	33
0+00	130	D					

TABLE 20

OPTION 2D
MINIMUM REQUIRED NEW PIPE SIZES
WESTERN CRANSTON - TILCON TRUNK SEWER
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
96+30		A	238	327			
94+70	160		235		0.0188		10
91+70	300		235		0.0000		10
88+70	300		235		0.0000		10
85+70	300		232		0.0100		10
82+70	300		232		0.0000		10
79+70	300		232		0.0000		10
76+70	300		230		0.0067		10
73+70	300		235		-0.0167		10
72+50	120		235		0.0000		10
70+10	240		210		0.1042		10
67+60	250		212		-0.0080		10
65+10	250		196		0.0640		10
62+50	260	B	170	592	0.1000	0.0109	10
61+50	100		170		0.0000		16
58+30	320		167		0.0094		16
55+30	300		172		-0.0167		16
52+30	300		157		0.0500		16
49+30	300		142		0.0500		16
46+40	290		127		0.0517		16
44+80	160		125		0.0125		16
41+80	300		120		0.0167		16
38+80	300		120		0.0000		16

TABLE 20 (Cont.)

OPTION 2D
MINIMUM REQUIRED NEW PIPE SIZES
WESTERN CRANSTON - TILCON TRUNK SEWER
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
37+60	120	C	107	2,280	0.1083	0.0127	16
34+60	300		92		0.0500		15
31+60	300		78		0.0467		15
28+60	300		77		0.0033		15
25+60	300	D	73	2,280	0.0133	0.0142	15
24+00	160		70		0.0188		18
21+00	300	E	66	2,320	0.0133	0.0076	18
18+00	300		61		0.0167		21
15+00	300		62		-0.0033		21
12+00	300		64		-0.0067		21
9+00	300	F	59	2,450	0.0167	0.0029	21
6+00	300		63		-0.0133		27
3+00	300		63		0.0000		27
0+00	300	A	60		0.0100	-0.0006	27

TABLE 21

OPTION 2D
MINIMUM REQUIRED NEW PIPE SIZES
WESTERN CRANSTON - COMSTOCK/FURNACE HILL TRUNK SEWER
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
142+40		A	300	224			
140+50	190						12
137+50	300						12
135+50	200						12
131+40	410						12
128+40	300						12
125+40	300						12
122+40	300						12
119+40	300	B	290	372	0.0043	0.0022	12
116+40	300						14
113+40	300						14
110+40	300						14
107+40	300						14
104+40	300						14
101+40	300	C	279	636	0.0062	0.0031	14
99+00	240		277		0.0083		15
96+20	280	D	275	1,160	0.0071	0.0038	15
93+00	320		267		0.0250		16
90+00	300		264		0.0100		16
87+00	300		255		0.0300		16
85+40	160		255		0.0000		16
82+40	300		255		0.0000		16
79+40	300		260		-0.0167		16
76+40	300		255		0.0167		16

TABLE 21 (Cont.)

OPTION 2D
MINIMUM REQUIRED NEW PIPE SIZES
WESTERN CRANSTON - COMSTOCK/FURNACE HILL TRUNK SEWER
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
73+60	280	E	257	1,180	-0.0071	0.0035	16
70+60	300		257		0.0000		14
67+60	300		250		0.0233		14
64+60	300		245		0.0167		14
61+60	300		235		0.0333		14
58+60	300		230		0.0167		14
55+60	300		220		0.0333		14
52+60	300		205		0.0500		14
49+60	300		204		0.0033		14
46+80	280		190		0.0500		14
44+30	250		170		0.0800		14
42+20	210	F	150	1,790	0.0952	0.0205	14
39+00	320		149		0.0031		22
36+50	250		140		0.0360		22
35+70	80		140		0.0000		22
32+70	300		142		-0.0067		22
29+70	300		140		0.0067		22
26+70	300		140		0.0000		22

TABLE 21 (Cont.)

OPTION 2D
MINIMUM REQUIRED NEW PIPE SIZES
WESTERN CRANSTON - COMSTOCK/FURNACE HILL TRUNK SEWER
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
23+70	300	G	151	1,860	-0.0367	-0.0002	22
20+70	300		140		0.0367		22
19+00	170		135		0.0294		22
16+00	300		132		0.0100		22
14+70	130		132		0.0000		22
12+30	240		120		0.0500		22
9+30	300		95		0.0833		22
6+30	300		92		0.0100		22
3+40	290		90		0.0069		22
1+40	200		59		0.1550		22
0+00	140	A	60		-0.0071	0.0192	22

TABLE 22

OPTION 2D
FORCE MAIN FROM PROPOSED PHENIX PUMP STATION
(Node "D" to "E" on the Powerline/Phenix/Natick Line)
YEAR 2045 FLOWS

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	High Point Elev. (ft)
4 Sch 40	3.998	581	146	235	310	310
6 Sch 40	6.031	581	146	235	310	310
8 Sch 40	7.943	581	146	235	310	310

Elev Head (ft)	Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
75	3,500	0.0078	14.8	4	585	660
75	3,500	0.0087	6.5	2	81	156
75	3,500	0.0093	3.8	1	21	96

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

TABLE 23

OPTION 2D
MINIMUM REQUIRED NEW PIPE SIZES
WESTERN CRANSTON - POWERLINE TRUNK SEWER
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
82+10		A	315	183			
81+80	30		313		0.0667		8
79+80	200		308		0.0250		8
76+80	300		304		0.0133		8
73+80	300		303		0.0033		8
70+80	300		299		0.0133		8
67+80	300		295		0.0133		8
64+80	300		290		0.0167		8
61+80	300	B	287	305	0.0100	0.0069	8
60+00	180		281		0.0333		10
57+00	300		277		0.0133		10
54+00	300		273		0.0133		10
51+00	300		270		0.0100		10
48+00	300		269		0.0033		10
45+00	300		266		0.0100		10
42+00	300	C	264	458	0.0067	0.0058	10
39+00	300		261		0.0100		12
36+00	300		258		0.0100		12
33+00	300		257		0.0033		12
30+00	300		256		0.0033		12
27+00	300		254		0.0067		12
24+00	300		253		0.0033		12
21+00	300		254		-0.0033		12
18+00	300		252		0.0067		12
15+00	300		248		0.0133		12
12+00	300		244		0.0133		12
9+00	300		244		0.0000		12

TABLE 23 (Cont.)

OPTION 2D
MINIMUM REQUIRED NEW PIPE SIZES
WESTERN CRANSTON - POWERLINE TRUNK SEWER
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
6+00	300		245		-0.0033		12
3+00	300		242		0.0100		12
0+00	300	D	235	581	0.0233	0.0035	12

TABLE 24

OPTION 2D
MINIMUM REQUIRED NEW PIPE SIZES
WESTERN CRANSTON - NATICK/PHENIX TRUNK SEWER
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
79+50		E	291	650			
77+80	170		290		0.0059		10
74+80	300		277		0.0433		10
71+80	300		268		0.0300		10
68+80	300		255		0.0433		10
65+80	300		239		0.0533		10
62+80	300		250		-0.0367		10
59+80	300		218		0.1067		10
59+00	80		207		0.1375		10
56+00	300	F	170	780	0.1233	0.0257	10
53+00	300		140		0.1000		12
50+00	300		127		0.0433		12
47+00	300		118		0.0300		12
44+00	300		95		0.0767		12
41+00	300		80		0.0500		12
40+00	100		77		0.0300		12
37+00	300		64		0.0433		12
35+30	170		70		-0.0353		12
32+00	330		67		0.0091		12
29+00	300	G	65	1,130	0.0067	0.0194	12
27+00	200		65		0.0000		14
24+00	300		65		0.0000		14
21+00	300		55		0.0333		14
18+00	300		40		0.0500		14
15+00	300		36		0.0133		14
12+20	280		36		0.0000		14

TABLE 24 (Cont.)

OPTION 2D
MINIMUM REQUIRED NEW PIPE SIZES
WESTERN CRANSTON - NATICK/PHENIX TRUNK SEWER
YEAR 2045

Manhole Station	Dist (ft)	Node	Approx. Surface Elev	Peak Flow (gpm)	Slope (ft/ft)	1/2 Node Slope (ft/ft)	Pipe Size (inches)
11+00	120	H	36	1,170	0.0000	0.0081	14
9+00	200		41		-0.0250		20
6+00	300		41		0.0000		20
3+00	300		40		0.0033		20
0+00	300	C	50		-0.0333	-0.0064	20

TABLE 25

OPTION 3A
IMPROVEMENTS TO GRAVITY SEWERS TO HOWARD PUMP STATION
YEARS 2015 & 2045

Segment	Pipe (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe: Pipe Diameter (inches)	Replacement Pipe: Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Howard Center Area										
Pontiac Ave-Sharpe Drive										
A-32	12	205	880	590	468					
32-32	12	205	880	590	468					
31-30	12	196	2,160	1450	514					
30-29	12	296	3,960	2660	581					
29-28	12	296	4,210	2830	694					
28-27	12	246	3,150	2120	849					
27-26	12	146	2,130	1430	962					
26-25	12	146	3,220	2170	962					
25-24	15	198	1,360	910	1,075					
24-23	15	246	1,330	890	1,188					
Ross + Simmons Drive										
23-33	15	241	1,760	1190	1,301					
33-34	15	332	1,640	1100	1,301					
34-35	15	145	1,230	830	1,301	18	1340	1.6	2.5	5
35-36	15	296	1,120	750	1,414	20	1630	1.6	2.3	3
36-37	15	296	1,120	750	1,414	20	1630	1.4	1.9	5
37-38	15	296	1,120	750	1,527	20	1630	1.1	1.4	10
38-39	15	241	1,120	750	1,527	20	1630	0.7	0.9	16
39-13	15	239	1,120	750	1,640	21	1850	0.4	0.4	20
Pontiac Ave										
1a-1	15	240	2,050	1380	1,756					
1-2	15	196	2,050	1380	1,756					
2-3	15	256	6,610	4450	1,756					
3-4	15	248	7,980	5370	1,756					
4-5	21	162	2,380	1600	1,756					

TABLE 25 (Cont.)

OPTION 3A
IMPROVEMENTS TO GRAVITY SEWERS TO HOWARD PUMP STATION
YEARS 2015 & 2045

Segment	Pipe (in)	Length (ft)	Full Pipe Capacity (gpm)	Design Pipe Capacity (gpm)	Expected Flow (gpm)	Replacement Pipe Pipe Diameter (inches)	Replacement Pipe Design Capacity (gpm)	Cumulative Friction Surcharge (feet)	Cumulative Manhole & Friction Surcharge (feet)	Surface Cover (feet)
Pontiac Ave (Cont.)										
5-6	24	236	3,590	3000	1,756					
Kenney Drive										
6-7	21	246	2,460	1660	1,801					
7-8	21	296	2,460	1660	1,869					
8-9	21	246	2,460	1660	1,982					
9-10	21	296	2,460	1660	2,095					
10-11	21	246	2,460	1660	2,325					
11-12	21	206	10,570	7110	2,325					
12-13	21	196	10,570	7110	2,325					
13-13a	24	296	3,520	2940	3,965	30	5780	0.7	2	29
13a-14	24	146	3,520	2940	3,965	30	5780	0.7	2	20
14-15	24	136	3,520	2940	3,965	30	5780	0.6	2	16
15-16	24	178	3,520	2940	3,965	30	5780	0.6	1	14
16-17	24	193	3,520	2940	3,965	30	5780	0.5	1.2	14
17-18	24	174	3,520	2940	3,965	30	5780	0.4	1.0	15
18-19	24	230	3,520	2940	3,965	30	5780	0.4	0.8	17
19-40	24	296	3,520	2940	3,965	30	5780	0.3	0.5	19
40-41	24	296	3,520	2940	3,965	30	5780	0.2	0.3	17
41-42	24	296	3,800	3180	3,965	30	5780	0.1	0.0	14
42-43	24	196	12,640	10570	3,965			0.1	0	7
43-44	24	196	11,480	9610	3,965			0.1	0	5
44-45	24	258	3,930	3290	3,965	30	6460	0.1	1.0	6
45-46	24	217	3,210	2690	3,965	30	5280	0.1	0.9	7
Kenney Drive from Slater Road to pump station										
46-47	24	270	3,210	2690	4,643	30	5280	0.3	0.6	7
47-H.P.S.	24	30	3,210	2690	4,643	30	4870	0.0	0.0	10

TABLE 26

FORCE MAIN FROM HOWARD PUMP STATION

VGS Nominal Dia. (in)	VGS Inside Dia. (in)	Peak Flow (gpm)	Average Flow (gpm)	Assumed Intake Elev. (ft)	Discharge Elev. (ft)	Elev. Head. (ft)
			Year 1992			
14 Sch 40	13.072	2,615	817	20	41	21
			Year 2015			
14 Sch 40	13.072	4,640	1,610	20	41	21
16 Sch 40	14.940	4,640	1,610	20	41	21
18 Sch 80	16.014	4,640	1,610	20	41	21
			Year 2045			
14 Sch 40	13.072	4,640	1,610	20	41	21
16 Sch 40	14.940	4,640	1,610	20	41	21
18 Sch 80	16.014	4,640	1,610	20	41	21

Pipe Length (ft)	Manning's n	Peak Flow Velocity (fps)	Average Flow Velocity (fps)	Friction Head (ft)	Total Head (ft)
		Year 1992			
1,885	0.0088	6.3	2.0	14.6	36
		Year 2015			
1,885	0.0083	11.1	4.0	41.0	62
1,885	0.0086	8.5	3.0	21.6	43
1,885	0.0089	7.4	3.0	16.0	37
		Year 2045			
1,885	0.0083	11.1	4.0	41.0	62
1,885	0.0086	8.5	3.0	21.6	43
1,885	0.0089	7.4	3.0	16.0	37

Note: Listed peak and average velocities assume projected flows are pumped through the force main at the rates they enter the station, Actual velocities in the force main will depend on factors including wet well size, pump type, and operational plans.

ATTACHMENT 2

SURCHARGE EVALUATION

Introduction

Surcharges of existing sewer lines were determined during hydraulic analysis of feasibility study options. As a result it was necessary to determine which of these lines might need to be replaced to carry projected 2015 and 2045 flows.

Methodology

The determination to replace sections of existing sewers was made by comparing depths of service connections and main sewers obtained from sewer plans provided by the city with projected flows and estimated surcharges expected by the years 2015 and 2045. Sewer plans used for this analysis are referred to on the attached tables.

This analysis assumes no major grade changes occur between cover at the sewer line and cover at the service connection.

Where the estimated pipe friction surcharge exceeded the elevation of service connections it was deemed necessary to replace the existing sewer with a larger one or add a second sewer.

Estimated surcharges resulting from pipe friction coupled with manhole losses did not exceed the top elevations of manholes in the affected sections.

Tables containing information on affected sewer sections, depth of sewer, depth of service connection, and expected surcharges are attached. Tables are organized by feasibility study options.

Option 1A- Pocasset Valley Sewer System

Cranston Street - Based on projected peak hourly flows in 2015 and 2045, no surcharge is calculated in 2015 and a maximum of 2.3 feet of pipe friction surcharge was calculated in 2045. There are two 18-inch diameter sewers in the street. The length of sewer is about 800 feet. The sewers have about 9 feet of cover. Calculated 2045 pipe friction surcharge is expected to impact twenty service connection. It is suggested that one of the 18-inch diameter sewers be replaced with a 24-inch diameter sewer.

Park Avenue - Based on projected peak hourly flows in 2015 and 2045, a maximum of 0.1 foot of pipe friction surcharge was calculated in 2015 and 2.1 feet in 2045. There is about 1,500 feet of 24-inch diameter sewer, at a minimum depth of about 10 feet below cover. Calculated 2015 pipe friction surcharge is not expected to exceed the depth of the listed service connections. Calculated 2045 pipe friction surcharge is expected to exceed the depth of one listed service connection between manholes stations 279.76 and 553.94. It is suggested that this 24-inch diameter sewer be left as it is and flows be monitored.

Reservoir Avenue - Based on projected peak hourly flows in 2015 and 2045, no surcharge is calculated in 2015 and about 0.1 foot of pipe friction surcharge is calculated in 2045. This sewer is at a minimum depth of 11 feet below top of cover. The depths of the two service connections are unknown, however it is assumed that they would not be impacted by the estimated surcharge.

Option 1B - Pocasset Valley Sewer System

Cranston Street - Based on projected peak hourly flows in 2015 and 2045, no surcharge is calculated.

Park Avenue - Based on projected peak hourly flows in 2015 and 2045, no surcharge is calculated in 2015, a maximum of 1.5 feet of pipe friction surcharge is calculated in 2045. Calculated 2045 pipe friction surcharge is not expected to exceed the depth of listed service connection.

Reservoir Avenue - Based on projected peak hourly flows in 2015 and 2045, no surcharge is calculated in 2015 and a maximum of 0.1 feet of pipe friction surcharge is calculated in 2045. The depths of the two service connections are not listed on the sewer plan. however it is assumed that they would not be impacted by the estimated surcharge.

Option 2C- Sockanosset Interceptor

Park Forest Road down Surrey Drive - Based on projected peak hourly flows in 2015 and 2045, no surcharge is calculated in 2015 and a maximum of 0.5 foot of pipe friction surcharge is calculated in 2045. There are about 250 feet of 30-inch diameter sewer, at a minimum depth of 5.5 feet below cover. Calculated pipe friction surcharge is not expected to exceed the depth of listed service connections.

Belvedere Drive - Based on projected peak hourly flows in 2015 and 2045, no surcharge is calculated to occur in 2015 and about a 0.3 foot of pipe friction surcharge is calculated to occur in 2045. There are about 270 feet of 30-inch diameter sewer, at a minimum depth of about 9 feet below cover. Calculated pipe friction surcharge is not expected to exceed the depth of listed service connections.

Hoffman Avenue - Based on projected peak hourly flows in 2015 and 2045, no surcharge was calculated in 2015 and a maximum of 0.2 foot of pipe friction surcharge is calculated in 2045. There is about 1,350 feet of 30-inch diameter sewer, at a minimum depth of about 3.5 feet of cover. Calculated pipe friction surcharge is not expected to exceed the depth of listed service connections.

New London Avenue - Based on projected peak hourly flows in 2015 and 2045, no pipe friction surcharge is calculated in 2015, and about 0.1 foot of pipe friction surcharge is calculated in 2045. This sewer has about 5.5 feet of cover. There are no service connections listed in this segment.

Cross-country east of Midway Road - Based on projected peak hourly flows in 2015 and 2045, no pipe friction surcharge is calculated in 2015 and a maximum of 0.4 feet of pipe friction surcharge is calculated in 2045. A portion of the 18-inch sewer segment goes through a steel sleeve under a 42-inch water main. There are no service connections listed in this segment.

Cross-country west of Delwood Road to west of Pontiac Avenue - Based on projected peak hourly flows in 2015 and 2045, about 0.1 foot of pipe friction surcharge is calculated in 2015 and a maximum of 0.5 foot of pipe friction surcharge is calculated in 2045. This 30-inch, sewer line is at a minimum depth of about 4 feet below cover. Calculated pipe friction surcharge is expected to exceed the depth of three listed service connections. However, depth of the service connections relative to depths of the sewer should be verified because service connections are listed at a greater depth than the sewer. Assuming these service connections are near the depth of the sewer line, it is suggested that a second sewer line be added (about 1,500 feet of 24-inch gravity sewer).

West of Pontiac Avenue to Pettaconsett Avenue - Based on projected peak hourly flows in 2015 and 2045, no surcharge is calculated in 2015 and about 0.2 feet of surcharge is calculated in 2045. This sewer has a minimum depth of 4 feet of cover. Calculated pipe friction surcharge is not expected to exceed the depth of listed service connections.

Option 3A - Howard Pump Station District

Ross-Simons Drive to Kenny Drive - Based on projected peak hourly flows in 2015 (no change in 2045), a maximum of about 1.6 feet of pipe friction surcharge is calculated in the gravity sewers from the end of Ross-Simons Drive to Kenny Drive. There are about 1,500 feet of 15-inch diameter sewer at a minimum depth of about 3 feet and a maximum depth of about 24 feet of cover. The sewer appears to run cross-country from the end of Ross-Simons Drive to Kenny Drive. No sewer connections are listed on the sewer plan.

Kenny Drive - Based on peak hourly flows in 2015 (no change in 2045), a maximum of about 0.7 foot of pipe friction surcharge was calculated to occur in a portion of the gravity sewer in Kenny Drive. There are about 3,400 feet of 24-inch diameter sewer at a minimum depth of about 5 feet and a maximum depth of about 24 feet of cover. Calculated pipe friction surcharge is not expected to exceed the depth of the two listed service connections.

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ATTACHMENT A

Option 1A
Pocasset Valley Sewer System
Future Surchage in existing Cranston sewers

Manhole ID	Manhole Station		Downstream Sewer Size (inch)	Length of Line (feet)	Service Connection Station	Depth to Crown of Sewer (feet)	Depth to Service Connection (feet)	Pipe Friction Surcharge 2015 (feet)	Pipe Friction Surcharge Plus Manhole Losses 2015 (feet)	Pipe Friction Surcharge 2045 (feet)	Pipe Friction Surcharge Plus Manhole Losses 2045 (feet)
Cranston Street											
108	800.96		2X18	180.0	--	9.0	--	0	0	2.3	5
	--		--	--	769.40	9.0	NA	0	0	2.3	5
	--		--	--	742.39	9.0	8.5	0	0	2.3 *	5
	--		--	--	709.91	9.0	8.5	0	0	2.3 *	5
	--		--	--	701.81	9.0	NA	0	0	2.3	5
	--		--	--	645.18	9.0	8.7	0	0	2.3 *	5
109	620.93		2X18	44.5	--	9.0	--	0	0	2.2	5
110	576.44		2X18	286.7	--	9.0	--	0	0	2.2	5
	--		--	--	556.62	9.0	NA	0	0	2.2	5
	--		--	--	524.31	9.0	NA	0	0	2.2	5
	--		--	--	475.40	9.0	9.0	0	0	2.2 *	5
	--		--	--	467.69	9.0	7.6	0	0	2.2 *	5
	--		--	--	427.24	9.0	7.2	0	0	2.2 *	5
	--		--	--	402.93	9.0	9.4	0	0	2.2 *	5
	--		--	--	370.62	9.0	8.0	0	0	2.2 *	5
	--		--	--	362.47	9.0	7.9	0	0	2.2 *	5
	--		--	--	326.12	9.0	7.3	0	0	2.2 *	5
	--		--	--	314.07	9.0	NA	0	0	2.2	5
111	289.76		2X18	270.7	--	9.0	--	0	0	2.2	5
	--		--	--	269.55	9.0	7.1	0	0	2.2 *	5
	--		--	--	249.84	9.0	8.8	0	0	2.2 *	5
	--		--	--	217.03	9.0	8.9	0	0	2.2 *	5
	--		--	--	209.03	9.0	NA	0	0	2.2	5
	--		--	--	184.64	9.0	8.7	0	0	2.2 *	5
	--		--	--	180.68	9.0	8.8	0	0	2.2 *	5
	--		--	--	147.97	9.0	7.9	0	0	2.2 *	5
	--		--	--	124.00	9.0	NA	0	0	2.2	5
	--		--	--	115.81	9.0	7.7	0	0	2.2 *	5
	--		--	--	91.63	9.0	7.7	0	0	2.2 *	5
	--		--	--	67.42	9.0	8.5	0	0	2.2 *	5
	--		--	--	26.96	8.9	8.4	0	0	2.2 *	5
112	19.02		2X18	19.0	--	9.0	--	0	0	2.1	4
113	0.00	drop manhole	--	--	--	--	--	0.11	1	2.1	4
				800.9							

Park Avenue										
113	0.00	24.0	279.8	--	11.0	--	0.11	1	2.1	4
	--	--	--	39.30	11.0	NA	0.11	1	2.1	4
	--	--	--	54.83	11.0	NA	0.11	1	2.1	4
	--	--	--	103.50	11.0	6.6	0.11	1	2.1	4
	--	--	--	151.23	11.0	7.3	0.11	1	2.1	4
	--	--	--	175.50	11.0	6.5	0.11	1	2.1	4
	--	--	--	207.58	11.0	NA	0.11	1	2.1	4
	--	--	--	239.55	11.0	7.5	0.11	1	2.1	4
	--	--	--	247.58	11.0	6.5	0.11	1	2.1	4
	--	--	--	271.66	11.0	7.2	0.11	1	2.1	4
114	279.76	24.0	274.2	--	10.9	--	0.08	1	1.7	3
	--	--	--	289.13	10.9	NA	0.08	1	1.7	3
	--	--	--	305.21	10.8	NA	0.08	1	1.7	3
	--	--	--	329.43	10.8	NA	0.08	1	1.7	3
	--	--	--	337.47	10.8	7.0	0.08	1	1.7	3
	--	--	--	377.57	10.8	9.4	0.08	1	1.7	3
	--	--	--	417.54	10.6	8.1	0.08	1	1.7	3
	--	--	--	433.71	10.6	5.5	0.08	1	1.7	3
	--	--	--	465.79	10.5	NA	0.08	1	1.7	3
	--	--	--	497.75	10.5	7.5	0.08	1	1.7	3
	--	--	--	529.87	10.4	7.9	0.08	1	1.7	3
115	553.94	24.0	239.3	--	10.4	--	0.05	1	1.3	3
	--	--	--	592.52	10.4	7.0	0.05	1	1.3	3
	--	--	--	600.62	10.4	7.5	0.05	1	1.3	3
	--	--	--	632.63	10.3	NA	0.05	1	1.3	3
	--	--	--	640.56	10.3	6.5	0.05	1	1.3	3
	--	--	--	672.79	10.3	7.2	0.05	1	1.3	3
	--	--	--	696.80	10.3	NA	0.05	1	1.3	3
	--	--	--	736.89	10.2	8.0	0.05	1	1.3	3
	--	--	--	785.14	10.2	7.3	0.05	1	1.3	3
116	793.24	24.0	180.7	--	10.2	--	0.03	1	0.9	2
	--	--	--	821.57	10.2	6.5	0.03	1	0.9	2
	--	--	--	829.55	10.3	NA	0.03	1	0.9	2
	--	--	--	877.48	10.8	NA	0.03	1	0.9	2
	--	--	--	909.83	11.0	NA	0.03	1	0.9	2
117	973.93	24.0	151.4	--	11.5	--	0.05	1	0.7	1
	--	--	--	1077.14	12.1	8.4	0.05	1	0.7	1
118	1125.34	24.0	100.6	--	11.9	--	0.03	0	0.5	1
	--	--	--	1178.65	11.4	6.6	0.03	0	0.5	1
119	1225.98	24.0	247.2	--	11.0	--	0.02	0.2	0.4	0.6
	--	--	--	1264.58	10.8	NA	0.02	0.2	0.4	0.6
	--	--	--	1280.62	10.8	NA	0.02	0.2	0.4	0.6
	--	--	--	1288.59	10.7	10.0	0.02	0.2	0.4	0.6
	--	--	--	1320.62	10.5	NA	0.02	0.2	0.4	0.6
	--	--	--	1344.68	10.2	7.2	0.02	0.2	0.4	0.6
	--	--	--	1352.85	10.1	NA	0.02	0.2	0.4	0.6

	--	--	--	1376.78	10.0	NA	0.02	0.2		0.4	0.6
	--	--	--	1392.73	9.9	7.5	0.02	0.2		0.4	0.6
120	1473.22	--	--	--	--	--	0	0		0.0	0.0
			1473.2								
Reservoir Avenue											
149	5387.80	39.0	23.0	--	12.8	--	0	0		0.09	0.8
150	5364.80	39.0	246.8	--	13.0	--	0	0		0.08	0.4
	--	--	--	5194.66	11.2	NA	0	0	NA	0.08	0.4
	--	--	--	5150.39	10.9	NA	0	0	NA	0.08	0.4
151	5118.00	--	--	--	11.0	--	0	0		0.00	0.0
			269.8								

Note: Sewer information from copy of record plans by Fay, Spofford and Thorndike Engineers
"Pocasset Valley Sewer System", dated July 11, 1941.
and plan and profile by Tutela Engineering Associates, Inc
"Sewerage Collection System Improvement, Cranston Street", dated February 1966
Note: Surcharge calculated at manholes and upstream manhole pipe friction surcharge assumed at service connection.
Note: Assumes no major grade change between top cover at sewer line and top cover at service connection.
Note: * indicates calculated surcharge may impact service connection
Note: NA indicates depth of service connection not listed on sewer plan.

Option 1B
Pocasset Valley Sewer System
Future Surchage in existing Cranston sewers

Manhole ID	Manhole Station		Downstream Sewer Size (inch)	Length of Line (feet)	Service Connection Station	Depth to Crown of Sewer (feet)	Depth to Service Connection (feet)	Pipe Friction Surcharge 2015 (feet)	Pipe Friction Surcharge Plus Manhole Losses 2015 (feet)	Pipe Friction Surcharge 2045 (feet)	Pipe Friction Surcharge Plus Manhole Losses 2045 (feet)
Park Avenue											
113	0.00	dropmanhole	24.0	279.8	--	11.0	--	0	0	1.5	3
	--		--	--	39.30	11.0	NA	0	0	1.5	3
	--		--	--	54.83	11.0	NA	0	0	1.5	3
	--		--	--	103.50	11.0	6.6	0	0	1.5	3
	--		--	--	151.23	11.0	7.3	0	0	1.5	3
	--		--	--	175.50	11.0	6.5	0	0	1.5	3
	--		--	--	207.58	11.0	NA	0	0	1.5	3
	--		--	--	239.55	11.0	7.5	0	0	1.5	3
	--		--	--	247.58	11.0	6.5	0	0	1.5	3
	--		--	--	271.[illegible]3	11.0	7.2	0	0	1.5	3
114	279.76		24.0	274.2	-	10.9	--	0	0	1.2	2
	--		--	--	289.13	10.9	NA	0	0	1.2	2
	--		--	--	305.21	10.8	NA	0	0	1.2	2
	--		--	--	329.43	10.8	NA	0	0	1.2	2
	--		--	--	337.47	10.8	7.0	0	0	1.2	2
	--		--	--	377.57	10.8	9.4	0	0	1.2	2
	--		--	--	417.54	10.6	8.1	0	0	1.2	2
	--		--	--	433.71	10.6	5.5	0	0	1.2	2
	--		--	--	465.79	10.5	NA	0	0	1.2	2
	--		--	--	497.75	10.5	7.5	0	0	1.2	2
	--		--	--	529.87	10.4	7.9	0	0	1.2	2
115	553.94		24.0	239.3	--	10.4	--	0	0	0.9	2
	--		--	--	592.52	10.4	7.0	0	0	0.9	2
	--		--	--	600.62	10.4	7.5	0	0	0.9	2
	--		--	--	632.63	10.3	NA	0	0	0.9	2
	--		--	--	640.56	10.3	6.5	0	0	0.9	2
	--		--	--	672.79	10.3	7.2	0	0	0.9	2
	--		--	--	696.80	10.3	NA	0	0	0.9	2
	--		--	--	736.89	10.2	8.0	0	0	0.9	2
	--		--	--	785.14	10.2	7.3	0	0	0.9	2
116	793.24		24.0	180.7	--	10.2	--	0	0	0.7	1
	--		--	--	821.57	10.2	6.5	0	0	0.7	1
	--		--	--	829.55	10.3	NA	0	0	0.7	1
	--		--	--	877.48	10.8	NA	0	0	0.7	1
	--		--	--	909.83	11.0	NA	0	0	0.7	1
117	973.93		24.0	151.4	--	11.5	--	0	0	0.5	1
	--		--	--	1077.14	12.1	8.4	0	0	0.5	1

118	1125.34	24.0	100.6	--	11.9	--	0	0	0.4	1
	--	--	--	1178.65	11.4	6.6	0	0	0.4	1
119	1225.98	24.0	247.2	--	11.0	--	0	0	0.3	0.5
	--	--	--	1264.58	10.8	NA	0	0	0.3	0.5
	--	--	--	1280.62	10.8	NA	0	0	0.3	0.5
	--	--	--	1288.59	10.7	10.0	0	0	0.3	0.5
	--	--	--	1320.62	10.5	NA	0	0	0.3	0.5
	--	--	--	1344.68	10.2	7.2	0	0	0.3	0.5
	--	--	--	1352.85	10.1	NA	0	0	0.3	0.5
	--	--	--	1376.78	10.0	NA	0	0	0.3	0.5
	--	--	--	1392.73	9.9	7.5	0	0	0.3	0.5
120	1473.22	--	--	--	--	--	0	0	0.0	0.0
			1473.2							
Reservoir Avenue										
149	5387.80	39.0	23.0	--	12.8	--	0	0	0.1	0.7
150	5364.80	39.0	246.8	--	13.0	--	0	0	0.1	0.4
	--	--	--	5194.66	11.2	NA	0	0	0.1	0.4
	--	--	--	5150.39	10.9	NA	0	0	0.1	0.4
151	5118.00	--	--	--	11.0	--	0	0	0.0	0.0
			269.8							

Note: Sewer information from copy of record plans by Fay, Spofford and Thorndike Engineers
"Pocasset Valley Sewer System", dated July 11, 1941.
and plan and profile by Tutela Engineering Associates, Inc
"Sewerage Collection System Improvement, Cranston Street", dated February 1966
Note: Surcharge calculated at manholes and upstream manhole pipe friction surcharge assumed at service connection
Note: Assumes no major grade change between top cover at sewer line and top cover at service connection.
Note: * indicates calculated surcharge may impact service connection
Note: NA indicates depth of service connection not listed on sewer plan.

Option 2C
Sockanosset Interceptor
Future Surcharge

Manhole ID	Manhole Station	Downstream Sewer Size (inch)	Length of Line (feet)	Service Connection Station	Depth to Crown of Sewer (feet)	Depth to Service Connection (feet)	Pipe Friction Surcharge 2015 (feet)	Pipe Friction Surcharge Plus Manhole Losses 2015 (feet)	Pipe Friction Surcharge 2045 (feet)	Pipe Friction Surcharge Plus Manhole Losses 2045 (feet)
Park Forest Road Down Surrey Drive										
	248.70	30.0	248.7	--	5.5	--	0	0	0.5	0.7
	--	--	--	158.50	6.6	NA	0	0	0.5	0.7
	--	--	--	151.00	6.9	5.5	0	0	0.5	0.7
	--	--	--	121.00	7.2	6.0	0	0	0.5	0.7
	--	--	--	58.50	8.7	7.5	0	0	0.5	0.7
	1620	--	--	--	--	--	0	0	0.3	0.3
Belvedere Drive										
	1620.00 drop manhole	30.0	269.2	--	9.1	--	0	0	0.3	0.3
	--	--	--	1542.00	9.9	7.5	0	0	0.3	0.3
	--	--	--	1467.50	10.3	7.5	0	0	0.3	0.3
	--	--	--	1362.50	11.2	6.5	0	0	0.3	0.3
	1350.80	--	--	--	--	--	0	0	0.2	0.3
Hoffman Avenue										
	1350.80	30.0	278.0	--	11.5	--	0	0	0.2	0.3
	--	--	--	1244.50	11.4	7.5	0	0	0.2	0.3
	--	--	--	1232.00	11.2	NA	0	0	0.2	0.3
	--	--	--	1154.50	10.9	9.0	0	0	0.2	0.3
	--	--	--	1139.50	10.8	NA	0	0	0.2	0.3
	1072.80	30.0	343.4	--	10.0	--	0	0	0	0
	729.40 drop manhole	30.0	272.9	--	8.0	--	0	0	0	0
	456.50	30.0	91.6	--	5.5	--	0	0	0	0
	364.90	30.0	91.9	--	3.5	--	0	0	0	0.2
	273.00	30.0	273.0	--	4.6	--	0	0	0	0.1
	7450.90	--	--	--	--	--	0	0	0	0
			1350.8							
New London Avenue										
	6631.00	30.0	154.4	--	5.5	--	0	0	0.1	0.2
	6476.60	--	--	--	--	--	0	0	0	0
Cross country just east of Midway Road										
	5197.70	18.0	122.1	--	6.0	--	0	0	0	0
	5075.60 drop manhole	18.0	80.2	--	4.8	--	0	0	0.4	1
	4995.4	18.0	87.9	--	7.5	--	0	0	0	0.6

4907.5 drop manhole	--	--	--	--	--	0	0	0	0.0
		290.2							
Cross country just south of Delwood Road to just west of Pontiac Avenue									
3951.30	30.0	98.5	--	3.8	--	0.01	0.1	0.5	2
3852.80	30.0	303.3	--	3.8	--	0	0	0.4	2
--	--	--	3852.80	3.8	3.3	0	0	0.4	2
--	--	--	3724.50	6.2	10.3	0	0	0.4 *	2
--	--	--	3642.00	10.0	8.0	0	0	0.4	2
3549.50	30.0	143.1	--	8.5	--	0	0	0.3	1
--	--	--	3549.50	8.5	8.0	0	0	0.3	1
--	--	--	3425.00	8.6	9.0	0	0	0.3 *	1
3406.40	30.0	166.4	--	9.4	--	0	0	0.4	1
--	--	--	3369.00	10.0	8.5	0	0	0.4	1
3240.00	30.0	213.4	--	9.0	--	0	0	0.4	1
--	--	--	3240.00	9.0	9.2	0	0	0.4 *	1
3026.60	30.0	313.6	--	4.0	--	0	0	0.2	0.7
2713.00	30.0	--	--	--	--	0	0	0.2	0.5
		1238.3							
Just west of Pontaic Avenue to Pettaconsett Avenue									
2713.00	30.0	315.5	--	4.0	--	0	0	0.2	0.5
--	--	--	2454.00	18.0	5.6	0	0	0.2	0.5
2397.50	30.0	294.5	--	17.6	--	0	0	0.2	0.3
--	--	--	2286.00	16.5	8.0	0	0	0.2	0.3
2103.00	30.0	--	--	--	--	0	0	0.0	0.0
		610							

Note: Sewer information from copy of Record Plan by Faye, Spofford and Thorndike Engineers "Meshanticut Valley Sewer System" dated February 7, 1961
Note: Surcharge calculated at manholes and upstream manhole pipe friction surcharge assumed at service connection.
Note: Assumes no major grade change between top cover at sewer line and top cover at service connection.
Note: * indicates calculated surcharge may impact service connection
Note: NA indicates depth of service connection not listed on sewer plan.

Option 3A
Howard Pump Station District
Future Surchage in existing Cranston sewers

Manhole ID	Manhole Station		Downstream Sewer Size (inch)	Length of Line (feet)	Service Connection Station	Depth to Crown of Sewer (feet)	Depth to Service Connection (feet)	Pipe Friction Surcharge 2015 (feet)	Pipe Friction Surcharge Plus Manhole Losses 2015 (feet)	Pipe Friction Surcharge 2045 (feet)	Pipe Friction Surcharge Plus Manhole Losses 2045 (feet)
End of Ross & Simmons Drive to Kenny Drive											
34	C580		15.0	145.0	--	5.6	--	1.6	3		
35	740		15.0	296.0	--	2.9	--	1.6	2		
36	1040		15.0	296.0	--	6.5	--	1.4	2	SAME AS FOR 2015	
37	1340		15.0	296.0	--	10.5	--	1.1	1		
38	1640		15.0	241.0	--	15.8	--	0.7	1		
39	1885		15.0	239.0	--	20.6	--	0.4	0		
13	B2810	drop manhole	--	--	--	23.8	--	0.7	2		
				1513.0							
Kenney Drive											
13	B2810	drop manhole	24.0	296.0		23.8	--	0.7	2		
					B2884	23.0	6.4	0.7	2		
13a	B3110		24.0	146.0	--	16.5	--	0.7	2		
14	B3260		24.0	136.0	--	13.1	--	0.6	2		
15	B3400		24.0	178.0	--	11.6	--	0.6	1		
16	B3580		24.0	193.0	--	11.6	--	0.5	1		
17	B3775		24.0	174.0	--	12.6	--	0.4	1		
18	B3950		24.0	230.0	--	14.2	--	0.4	0.8		
					B3954	14.2	8.1	0.4	0.8		
19	B4183		24.0	296.0	--	15.5	--	0.3	0.5		
40	4483		24.0	296.0	--	13.6	--	0.2	0.3		
41	4783		24.0	296.0	--	10.4	--	0.1	0.1		
42	5083		24.0	196.0	--	5.6	--	0.1	0.1		
43	5282		24.0	196.0	--	5.2	--	0.1	0.1		
44	5480		24.0	258.0	--	4.9	--	0.1	1.0		
45	5738		24.0	217.0	--	5.3	--	0.1	0.9		
46	5955		24.0	270.0	--	5.5	--	0.3	0.6		
47	6225		24.0	30.0	--	8.2	--	0	0		
HPS	--		--	--	--	--	--	--	--		
				3,408							

Note: Sewer information from copy of plans by Fenton G. Keyes Associates labeled
"Howard Development Corporation, Howard Industrial Park", date not on copy
Note: Surcharge calculated at manholes and upstream manhole pipe friction surcharge assumed at service connection
Note: Assumes no major grade change between top cover at sewer line and top cover at service connection.
Note: Assumes Slater Road discharges enter Kenny Drive at manhole 46
Note: * indicates calculated surcharge may impact service connection
Note: NA indicates depth of service connection not listed on sewer plan.

ATTACHMENT 3

FEASIBILITY DESIGN OF PUMPING STATIONS

TABLE OF CONTENTS

	PAGE
Introduction	I.3-1
Service Area 1	I.3-2
Scituate Pump Station	I.3-2
I-295 Pump Station	I.3-5
Pontiac Pump Station	I.3-6
Service Area 2	I.3-10
Phenix Pump Station	I.3-10
Wilbur Pump Station	I.3-13
Wastewater Treatment Facility Screw Pumps	I.3-17
Service Area 3	I.3-18
Howard Pump Station	I.3-18

INTRODUCTION

The selection of options to be included in the Cranston, Rhode Island Wastewater Conveyance System Feasibility Study identified six sewage pump stations for study. Required work included feasibility design of three new sewage pump stations and investigation of possible modifications to two existing sewage pump stations and possible modifications to a pump station which has been designed by others but not yet built.

This report provides a brief description of design recommendations and a list of major mechanical equipment required for each of the six sewage pump stations. The design focussed on sizing sewage pumps at each station based on projected average daily and peak wastewater flows for the years 2015 and 2045. Required pumping heads were estimated based on proposed force main/variable grade sewer (VGS) routes. Pipe diameters for proposed force mains/VGS were selected to minimize friction losses while at the same time maintaining recommended flushing velocities to resuspend settled solids.

Design of the station buildings, wet well storage, and station auxiliaries was based on requirements and guidelines contained in the following two documents:

1. TR-16, "Guides for the Design of Wastewater Treatment Works", prepared by the Technical Advisory Board of the New England Interstate Water Pollution Control Commission, 1980 ed.

2. "Design of Wastewater and Stormwater Pumping Stations", Manual of Practice No. FD-4, Water Pollution Control Federation, 1981.

Service Area 1

SCITUATE PUMP STATION (New)

Description of Options

For Service Area 1, Option A includes wastewater flows from the Johnston industrial area and Vinagro Landfill. Option B does not. Average daily and peak flows from the Scituate pump station are the same for either option as is proposed routing for the force main/VGS. Therefore, pump station design and cost will be identical for either option.

Pumping Considerations

Preliminary hydraulic analysis revealed that a 4" diameter polyvinyl chloride (PVC) force main/VGS would produce unacceptable friction losses at the 2045 peak design flow rate of 504 gallons per minute (gpm). Therefore, a 6" diameter force main/VGS was selected. In order to maintain velocities in the VGS pipe which would be adequate to resuspend settled solids and flush out low points, it will be necessary to operate the lift pumps at close to the peak design flow rate. Select two full size pumps, each with design capacity of 504 gpm and 95 feet Total Developed Head (TDH). Each pump will require a 25 horsepower (HP) motor driver. Pumps to be constant speed, float level controlled with an alternator.

Sump Sizing

Wet well sump size will be 1120 gallons based on 10 minutes of storage at the design average flow of 112 gpm. Under the worst case (which occurs when inflow rate is half of the outflow rate), the empty-fill cycle time will be approximately 9 minutes. Assuming the pumps alternate operation, the time between starts will be a minimum of 18 minutes per pump. This is equivalent to 3.33 starts per hour and should be acceptable. Most of the time, the pumps will be starting and stopping LESS frequently.

Station Design

Station will be cast-in-place concrete with separate wet and dry wells. A manually cleaned bar rack will be installed in the incoming sewer line. Minimum water level in the wet well will be above the centerline of the pump impellers. Vertical pumps and motors will be located on the lower level of the dry well, all other mechanical and electrical equipment will be located on the upper level. It is anticipated that the upper level will be above grade. Separate, forced ventilation systems will be provided for the wet and dry wells; it is assumed that the wet

SCITUATE PUMP STATION (New)

well will be ventilated continuously and the dry well intermittently. Heating will be provided for the dry well.

A motor control center will be provided. Alarm systems will be provided for intrusion detection, fire detection and equipment, and system malfunction. Telephone and communication lines will be provided. Indoor lighting fixtures will be industrial fluorescent vaportight. Outdoor lighting fixtures will be wall mounted high pressure sodium. Battery backed auxiliary lighting units will be provided in the dry well. Backup power will be provided in the form of a diesel powered emergency generator with automatic transfer switch. Generator will be housed in a separate enclosure.

The Scituate pumping station will be about 20 feet wide by 30 feet long and 15 feet deep. The generator enclosure will be slab on grade about 12 feet wide by 16 feet long. For feasibility study real estate cost purposes it is estimated that an approximately 10,000 square foot parcel of land will be required.

Service Area 1

SCITUATE PUMP STATION (New)

List of Major Mechanical Equipment (for years 2015 and 2045)

Qty.	Item
2	Centrifugal, non clog sewage pump, 4" suction and discharge, 3" solids handling capability, flow capacity 504 gpm, 25 HP motor, and integral seal water system.
1	Pump control system including: float level sensors and switches, and pump control panel. Panel to be UL listed and include pump circuit breakers, hand/off/auto switches, hour meters, pump running lights, alternator, control transformer, test buttons for float switches, and local and remote alarm contacts. Alarm signals to be provided for pump malfunction, high level in wet well, low level in wet well, high water level in dry well sump, loss of power, and loss of alarm transmission line.
1	Submersible sump pump, motor and controls, 1/2 HP.
1	Vent supply fan and ductwork for wet well, 500 cubic feet per minute (CFM), 1/8 HP motor.
1	Vent supply fan and ductwork for dry well, 1500 CFM, 1/2 HP motor.
Lot	Gas fired unit heaters or duct furnace, 90 thousand Btus per hour (MBH).
1	Diesel powered emergency generator and automatic transfer switch, 40 kilowatts (KW).
1	Fuel supply system for generator: 500 gallon double walled underground tank, 10 gallon day tank, vent pipes, fill pipe, fuel oil supply and return piping, remote level gage, and leak alarm system.

Service Area 1

I-295 PUMP STATION (Designed)

Description of Options

Peak flow from the I-295 pump station for Option A is 3018 gpm in the year 2045. For Option B, which does not include the Johnston and Vinagro flows, peak flow from the I-295 pump station in the year 2045 is 2724 gpm. The station has already been designed to handle average daily and peak flows for Option B. This analysis determined whether design changes and/or additional capital costs would be required to accommodate the additional flows from Johnston and Vinagro.

Pumping Considerations

Hydraulic analysis of the proposed 14" diameter PVC variable grade sewer was performed to determine required pump heads at the two peak flow rates for the year 2045. Plans for the proposed pump station show that flow is to be evenly divided between two pumps with a third installed pump as backup. A Yeomans model 6315 vertical dry pit sewage pump operated at 1160 revolutions per minute (rpm) will meet either design condition; therefore increasing the peak flow from 2724 to 3018 gpm should have no effect on the station cost. The pump specifications would have to be modified to reflect the change in pump design point before the pump is purchased if the greater flow is to be accommodated.

In addition to being able to meet the peak design conditions with two pumps operating, each pump must also be capable of pumping alone at a lower head without exceeding the manufacturer's recommended flow rate for that pump. The pump described above will also meet this requirement. Two design points should be specified for each pump.

Proposed Sump Capacity

Based on plans for the proposed pump station, the wet well sump capacity is adequate for the increased flows. Usable wet well sump capacity is approximately 13,000 gallons. This represents 12 minutes of storage at the average daily flow rate of 1096 gpm projected for the year 2045.

Service Area 1

PONTIAC PUMP STATION (Existing)

Description of Options

Peak flow from the Pontiac pump station for Option A is 26,086 gpm in the year 2045. For Option B, which does not include the Johnston and Vinagro flows, peak flow from the Pontiac pump station in the year 2045 is 25,836 gpm. The difference in the two flow rates is less than 1 percent. For the present analysis, it was assumed that this small difference in flow rate would not affect design and capital costs of the Pontiac pump station. Analysis of existing pump capabilities was based on the larger flow rate (Option A).

Pumping Considerations

Preliminary hydraulic analysis indicated that the two existing 24" force mains would pass the peak design flows for the year 2015 without producing unreasonable friction losses. By the year 2045 however, continuing to use the existing force mains will require increasing the speed of the existing pumps and doubling the horsepower of the pump motors and the station emergency generator. Installation of a 42" diameter force main to meet the 2045 flow condition would reduce capital expenditures at the pump station and would also dramatically reduce pump operating costs. In addition, one of the existing force mains is already 50 years old; by the year 2015, it may require replacement. The present analysis assumes that a 42" diameter force main will be installed after 2015 to accommodate the 2045 peak flows.

Peak design flow for the year 2015 is approximately 21,000 gpm. Required pumping head at this flow was calculated to be approximately 78 feet based on continued use of the two 24" diameter force mains. These conditions could be met by the existing pumps at the design speed of 875 rpm if the flow were divided such that the design point of the all the pumps was changed to 5250 gpm at 78 feet TDH. The existing variable speed pumps (present design point 5500 gpm at 73 feet TDH) would meet this design condition without changing either the impellers or the motors. The three constant speed pumps (present design point 3700 gpm at 67 feet TDH) would require larger impellers, larger motors (125 HP), and larger bearing frames. The existing pump flow and level control systems could probably be reused assuming that setpoints for starting and stopping the pumps can be adjusted to accommodate the different pump design points.

Service Area 1

PONTIAC PUMP STATION (Existing)

Peak design flow for the year 2045 is approximately 26,100 gpm. Required pumping head at this flow (based on installation of a new 42" diameter force main) was calculated to be approximately 60 feet. These conditions could be met by the existing pumps at the existing speed of 875 rpm if the design point was changed to 6525 gpm at 60 feet TDH for all the pumps. Impellers will require trimming; but the same size motors would be capable of pumping at the new flow and head conditions assuming they had already been changed as described above to meet the 2015 design conditions. Since the motors would not change, the same pump control system could be used; therefore, cost of a new control system has not been included in the analysis. However, we would recommend replacing the existing control system in 2015. By that time, new technology may be available which would increase the efficiency and reliability of pump operation, perhaps in a smaller package and at a relatively lower cost than today's variable frequency drive (VFD) controllers.

Existing Sump Capacity

The existing wet well sump capacity is approximately 15,000 gallons. This will provide 1.3 minutes of storage at the design average flow rate of 11,700 gpm. Minimum pump flow rate with one variable speed pump operating will be approximately 5000 gpm. Under the worst case (which occurs when inflow rate is half of the outflow rate), the empty-fill cycle time will be approximately 12 minutes. Assuming the two variable speed pumps alternate operation, the time between starts will be a minimum of 24 minutes per pump. This is equivalent to 2.5 starts per hour per pump. The existing motors seem to be operating without difficulty under these conditions so there should be no problem for the 2015 design or the 2045 design since the existing motors can be used on the variable speed pumps to meet both flows. Most of the time, the pumps will be starting and stopping LESS frequently.

Required Modifications to Existing Equipment

The existing emergency generator may not be adequate to back up four of the five pumps when the motor size of the three constant speed pumps is increased from 100 HP to 125 HP. A final recommendation will have to wait until more detailed design information is available on the motors and the pump control system. For this analysis, it has been assumed that a 600 kw unit will be required. It is also assumed that current regulations regarding noise will necessitate locating the

generator indoors. Therefore, a separate concrete block structure 22′ long by 14′ wide by 14′ high will be required to house the new generator adjacent to the existing pump station. Cost of a new fuel supply system for the generator has not been included because the existing fuel storage tank is of adequate capacity; however, it should be kept in mind that for environmental reasons, the existing underground tank should probably be replaced with a double walled tank and tank leak monitoring system.

If the pump control system is replaced for the 2045 design condition, modifications to the station heating system would be required. Much of the dry well heat in the winter appears to be provided by two large heat exchangers which extract waste heat from the variable speed fluid drives. Since these would be replaced by variable frequency drive controllers to meet the 2045 design conditions, new heaters or a duct furnace would have to be provided to take their place.

Service Area 1

PONTIAC PUMP STATION (Existing)

List of Major Mechanical Equipment (for year 2015)

Qty.	Item
3	Rebuild existing Yeomans 12622 sewage pump. Provide 22" impeller, No. 5 bearing frame and 125 HP, 875 rpm premium efficiency motor. New pump design flow capacity: 5250 gpm.
1	Diesel powered emergency generator and automatic transfer switch, 600 KW.

List of Major Mechanical Equipment (for year 2045)

Qty.	Item
5	Rebuild existing Yeomans 12622 sewage pump. Trim impellers. New pump design flow capacity: 6525 gpm.

Service Area 2

PHENIX PUMP STATION (New)

Description of Options

For Service Area 2, the average daily and peak design flows for Options A, B and C are identical. Proposed force main routing from the Phenix pump station is also the same for all three options. Therefore, pump station design and cost will be the same as well.

Pumping Considerations

No flow is projected at this station for the year 2015. Preliminary hydraulic analysis revealed that a 4" diameter force main would produce unacceptable friction losses at the 2045 peak design flow rate of 581 gpm. Therefore, a 6" diameter force main was selected. In order to maintain velocities in the force main, which would be adequate to resuspend settled solids, it will be necessary to operate the lift pumps at close to the peak design flow rate. Select two full size pumps, each with design capacity of 581 gpm and 162 feet TDH. Each pump will require a 50 HP motor driver. Pumps to be constant speed, float level controlled with an alternator.

Sump Sizing

Wet well sump size will be 1460 gallons based on 10 minutes of storage at the design average flow of 146 gpm. Under the worst case (which occurs when inflow rate is half of the outflow rate), the empty-fill cycle time will be approximately 10 minutes. Assuming the pumps alternate operation, the time between starts will be a minimum of 20 minutes per pump. This is equivalent to 3 starts per hour and should be acceptable. Most of the time, the pumps will be starting and stopping LESS frequently.

Station Design

Station will be cast-in-place concrete with separate wet and dry wells. A manually cleaned bar rack will be installed in the incoming sewer line. Minimum water level in the wet well will be above the centerline of the pump impellers. Vertical pumps and motors will be located on the lower level of the dry well, all other mechanical and electrical equipment will be located on the upper level. It is anticipated that the upper level will be above grade. Separate, forced ventilation systems will be provided for the wet and dry wells; it is assumed that the wet well will be ventilated continuously and the dry well

intermittently. Heating will be provided for the dry well.

A motor control center will be provided. Alarm systems will be provided for intrusion detection, fire detection and equipment, and system malfunction. Telephone and communication lines will be provided. Indoor lighting fixtures will be industrial fluorescent vaportight. Outdoor lighting fixtures will be wall mounted high pressure sodium. Battery backed auxiliary lighting units will be provided in the dry well. Backup power will be provided in the form of a diesel powered emergency generator with automatic transfer switch. Generator will be housed in a separate enclosure.

The Scituate pumping station will be about 20 feet wide by 30 feet long and 15 feet deep. The generator enclosure will be slab on grade about 12 feet wide by 16 feet long. For feasibility study real estate cost purposes it is estimated that an approximately 10,000 square foot parcel of land will be required.

Service Area 2

PHENIX PUMP STATION (New)

List of Major Mechanical Equipment (for year 2045)

Qty.	Item
2	Centrifugal, non clog sewage pump, 4" suction and discharge, 3" solids handling capability, flow capacity 581 gpm, 50 HP motor.
1	Pump control system including: float level sensors and switches, and pump control panel. Panel to be UL listed and include pump circuit breakers, hand/off/auto switches, hour meters, pump running lights, alternator, control transformer, test buttons for float switches, and local and remote alarm contacts. Alarm signals to be provided for pump malfunction, high level in wet well, low level in wet well, high water level in dry well sump, loss of power, and loss of alarm transmission line.
1	Duplex seal water system, 2 pumps, 1/2 HP each. Includes tank, valves and separate control/alarm panel.
1	Submersible sump pump, motor and controls, 1/2 HP.
1	Vent supply fan and ductwork for wet well, 500 CFM, 1/8 HP motor.
1	Vent supply fan and ductwork for dry well, 1500 CFM, 1/2 HP motor.
Lot	Gas fired unit heaters or duct furnace, 90 MBH.
1	Diesel powered emergency generator and automatic transfer switch, 70 KW.
1	Fuel supply system for generator: 500 gallon double walled underground tank, 10 gallon day tank, vent pipes, fill pipe, fuel oil supply and return piping, remote level gage, and leak alarm system.

Service Area 2

WILBUR PUMP STATION (New)

Description of Options

In Service Area 2, average daily and peak design flows from the Wilbur pump station are identical for Options A, B, and C. However, a different force main/VGS route is proposed for each option. Different force main routing results in different pumping head required for each option; however, the same pumps operating at variable speed could handle any of the three options. Pump station capital costs will be essentially the same for each option. Operating costs will vary between the options since pumping along the Garden Hills routes (Options A and B) uses more power to produce the higher pumping heads required.

Pumping Considerations

Preliminary hydraulic analysis revealed that a nominal 18" Schedule 80 PVC force main/VGS would pass peak design flows with reasonable friction losses while maintaining adequate flow velocities at average flow rates. Therefore, the 18" diameter force main/VGS was selected. (Schedule 80 PVC is recommended because of relatively high pump discharge pressures.)

For the 2015 design, a single pump operating at variable speed can meet the average-peak flow range of approximately 900 to 2830 gpm. Total pumping head at the peak flow rate ranges from 162-194 feet for the different options studied. The same size pump will work for all three options. The 2045 peak design flow of approximately 5144 gpm at either 219 or 235 feet can be met by two of these pumps operating in parallel.

Initially, two full sized pumps will be installed. Space will be left for a third pump to be added when increased flows warrant. Each pump will require a 250 HP motor driver. Pumps will be operated at variable speeds to match outflow to inflow; lead-lag operation will be automatically alternated.

Sump Sizing

Wet well sump size will be 7500 gallons. This will provide 4.4 minutes of storage at the design average flow rate of 1715 gpm. It is assumed that the minimum pump flow rate will be 1000 gpm. Under the worst case (which occurs when inflow rate is half of the outflow rate), the empty-fill cycle time will be approximately 30 minutes. Assuming the pumps alternate operation, the time between starts will be a minimum of 60 minutes per pump. This is equivalent to 1 start per hour and

should be acceptable. Most of the time, the pumps will be starting and stopping LESS frequently.

Station Design

Station will be cast-in-place concrete with separate wet and dry wells. A manually cleaned bar rack and comminutor will be installed in parallel in the incoming sewer line. Normally, flow will be directed through the comminutor; the rack is provided for backup when comminutor is being serviced. Minimum water level in the wet well will be above the centerline of the pump impellers. Vertical pumps and motors will be located on the lower level of the dry well, all other mechanical and electrical equipment will be located on the upper level. It is anticipated that the upper level will be above grade. Separate, forced ventilation systems will be provided for the wet and dry wells; it is assumed that the wet well will be ventilated continuously and the dry well intermittently. Heat will be supplied to the dry well.

A motor control center will be provided. Alarm systems will be provided for intrusion detection, fire detection and equipment, and system malfunction. Telephone and communication lines will be provided. Indoor lighting fixtures will be industrial fluorescent vaportight. Outdoor lighting fixtures will be wall mounted high pressure sodium. Battery backed auxiliary lighting units will be provided in the dry well.

Backup power will be provided in the form of a diesel powered emergency generator with automatic transfer switch. A 350 kw generator will be adequate to back up one of the two pumps installed initially. When the third pump is installed, a 600 kw generator will be required to back up two of the pumps. The generator will be housed in a separate enclosure sized to accommodate the larger unit.

The Wilbur pump station will be about 35 feet wide by 40 feet long and 30 feet deep. The generator enclosure will be slab on grade approximately 12 feet by 40 feet long. For feasibility study real estate cost purposes it is estimated that about 14,400 square foot parcel of land will be required.

Service Area 2

WILBUR PUMP STATION (New)

List of Major Mechanical Equipment (for year 2015)

Qty.	Item
2	Centrifugal, non clog sewage pump, 6" suction and discharge, 3" solids handling capability, flow capacity 2830 gpm, 250 HP motor with variable frequency drive controller.
1	Pump control system including: bubble level sensing system, and pump control panel. Panel to be UL listed and include pump circuit breakers, programmable controller for variable speed operation, hand/off/auto switches, hour meters, pump running lights, alternator, control transformer and local and remote alarm contacts. Alarm signals to be provided for pump malfunction, high level in wet well, low level in wet well, high water level in dry well sump, loss of power, and loss of alarm transmission line.
1	Duplex seal water system, 2 pumps, 1/2 HP each. Includes tank, valves and separate control/alarm panel.
2	Submersible sump pump, motor and controls, 1/2 HP.
1	Vent supply fan and ductwork for wet well, 1650 CFM, 1/4 HP motor.
1	Vent supply fan and ductwork for dry well, 4000 CFM, 1 HP motor.
Lot	Gas fired unit heaters (or duct furnace) total capacity 250 MBH.
1	Comminutor, 7.4 MGD capacity, 3 HP motor and automatic controls.
1	Diesel powered emergency generator and automatic transfer switch, 350 KW.
1	Fuel supply system for generator: 1000 gallon double walled underground tank, 25 gallon day tank, vent pipes, fill pipe, fuel oil supply and return piping, remote level gage, and leak alarm system.

Service Area 2

WILBUR PUMP STATION (New)

List of Additional Major Mechanical Equipment (for year 2045)

Qty.	Item
1	Centrifugal, non clog sewage pump, 6" suction and discharge, 3" solids handling capability, flow capacity 2565 gpm, 250 HP motor with VFD capability.
1	Modifications to pump control system to accommodate additional pump.
1	Diesel powered emergency generator and automatic transfer switch, 600 KW.

Service Area 2

WASTE WATER TREATMENT FACILITY SCREW PUMPS (Existing)

Description of Options

The wastewater flow from the Wilbur pump station (Service Area 2) will either be pumped directly to the head box of the Wastewater Treatment Facility (Option A), or it will be pumped to existing gravity sewer lines through which it will flow into the suction end of the existing Archimedes screw pumps (Options B and C). Capital costs of a new screw pump to meet the 2045 peak design flows will have to be included in Options B and C as explained below.

Existing Pumping Capacity

At present, there are three Archimedes screw pumps at the waste water treatment facility, each with a flow capacity of 5213 gallons per minute. This would allow a total inflow of 10,426 gpm with two pumps operating and one spare backup.

Peak Flows for the Year 2015

Projected peak flows into these pumps for the year 2015 are as follows: 6387 gpm without additional flows from Wilbur and Howard pump stations, 8370 gpm with additional flows from Howard but not Wilbur, 8607 gpm with additional flows from Wilbur but not Howard; and 10,444 gpm with additional flows from both Howard and Wilbur. It appears that the existing pumps should be able to handle flows for all of these conditions with two pumps operating, leaving the third pump as a backup.

Peak Flows for the Year 2045

Projected peak flows into the screw pumps for the year 2045 are as follows: 7065 gpm without additional flows from Wilbur and Howard pump stations, 9097 gpm with additional flows from Howard but not Wilbur, 11,186 gpm with additional flows from Wilbur but not Howard; and 12,425 gpm with additional flows from both Howard and Wilbur. It appears that in order to accommodate flows from the Wilbur station, a fourth screw pump would have to be added so as to maintain sufficient backup capacity if one of the pumps were out of service.

Service Area 3

HOWARD PUMP STATION (Existing)

Pumping Considerations

Preliminary hydraulic analysis showed that the existing 14" ductile iron force main would pass the peak design flows for the year 2015 without producing unreasonable friction losses. (Peak design flows do not increase after 2015.) Therefore, replacement of the existing force main is not necessary. At the peak design flow of approximately 4640 gpm, system resistance is 113 feet. Assuming three pumps would be operating at this flow rate, the design point for each pump would be 1550 gpm at 113 feet TDH.

The existing pumps are presently operating at close to maximum speed (1750 rpm). Based on the nameplate pump design point (1000 gpm at 62 feet TDH), manufacturers curves for this model pump indicate that the existing impeller diameter is close to the maximum (10"). Therefore, the pumps will have to be replaced. In addition to being able to meet the peak design conditions with three pumps operating, each pump must also be capable of pumping alone at a much lower head without exceeding the manufacturer's recommended flow rate for that pump. Two design points should be specified for each pump.

Four new pumps and motors will be required. The four pumps will be identical. Each pump will have design points of 1550 gpm at 113 feet TDH and 2300 gpm at 62 feet TDH. Motors will be 1750 rpm and 75 HP. Pumps will be operated at constant speed using the existing bubble level control system; operation will be automatically alternated between all four pumps. It is recommended that the existing seal water system be replaced with a new system furnished by the pump manufacturer to match seal water requirements of the new pumps.

Alternative Pumping Strategies

Since replacement of existing pumps and motors is required, the possibility of operating the pumps at variable speed was briefly investigated. Average to peak design flows could be handled by two pumps operating at variable speed with a third identical pump installed as a spare. These pumps would be of the same size as the pumps selected for constant speed operation except that the next size larger impeller would be required. A rough calculation of operating costs was performed based on the assumption that the flow into the pump station would be constant at the average design rate of 1610 gpm. There was no significant difference in operating costs between constant speed operation and variable speed operation using this assumption. Although one

less pump and motor would be required for variable speed operation, the capital cost savings would likely be offset by the increased capital cost of larger variable speed motors and the variable frequency drive controllers. Since the pump station was already built to accommodate four pumps, there would obviously be no capital cost savings attributable to reduced construction costs of a smaller building. Therefore, variable speed control at this pump station does not appear to be cost effective.

Existing Sump Capacity

The existing wet well sump capacity is approximately 6000 gallons. This will provide 3.7 minutes of storage at the design average flow rate of 1610 gpm. Pump flow rate with one pump operating will be approximately 2300 gpm. Under the worst case (which occurs when inflow rate is half of the outflow rate), the empty-fill cycle time will be approximately 10 minutes. Assuming the pumps alternate operation, the time between starts will be a minimum of 40 minutes per pump. This is equivalent to 1.5 starts per hour per pump and should be acceptable. Most of the time, the pumps will be starting and stopping LESS frequently.

Required Modifications to Existing Equipment

Since the city of Cranston is already going ahead with plans to install a climbing bar screen on the incoming sewer line at State expense, modifications to the existing screening apparatus are not included in this study. The size of the station sump pumps, bubbler system, ventilation systems and heating systems will not change; this equipment may be reused if it is in good condition. The existing diesel powered emergency generator and associated equipment will have to be replaced with a larger capacity unit due to the increase in the size of the pump motors. The new generator must be at least 275 kw. A unit of this size will not fit inside the existing building. It has been assumed that a separate concrete block structure approximately 20′ long by 12′ wide by 14′ high will be required to house the new generator adjacent to the existing pump station. Cost of a new fuel supply system for the generator has not been included because the existing fuel storage tank is of adequate capacity; however, for environmental reasons, the existing underground tank should probably be replaced with a double walled tank and tank leak monitoring system.

Service Area 3

HOWARD PUMP STATION (Existing)

List of Major Mechanical Equipment (for years 2015 and 2045)

Qty.	Item
4	Centrifugal, nonclog sewage pump, 6" suction and discharge, 3" solids handling capability, flow capacity 1550 gpm, 75 HP motor.
1	Pump control system including: tie in to existing bubble level sensing system, and pump control panel. Panel to be UL listed and include pump circuit breakers, hand/off/auto switches, hour meters, pump running lights, alternator, control transformer, and local and remote alarm contacts. Alarm signals to be provided for pump malfunction, high level in wet well, low level in wet well, high water level in dry well sump, loss of power, and loss of alarm transmission line.
1	Duplex seal water system, 2 pumps, 1/2 HP each. Includes tank, valves and separate control/alarm panel.
1	Diesel powered emergency generator and automatic transfer switch, 275 KW.

ATTACHMENT 4

PRELIMINARY ESTIMATE
OF REAL ESTATE COSTS

REAL ESTATE REQUIREMENTS

	length (ft)	width (ft)	Total area (SF)
OPTION 1A			
SCITUATE PUMP STATION			
land for pump station (fee acquistion)	100	100	10,000
temp PS construction easement	25	100	2,500

REAL ESTATE REQUIREMENT - SCITUATE PUMP STATION

FEE AQUISITION:		
(1 Ownerships)		
(10,000 SF x $2.00 PSF)	$20,000	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
(1 Ownerships)		
(2,500 SFx $2.00 PSF x 10% Return:)	$ 500	
CONTINGENCY: (25%)	$ 5,125	
SUBTOTAL		$25,625
ACQUISITION COSTS		
(1 Ownerships x $7,000 each)		$7,000
RELOCATION COSTS		
None		$0
SEVERANCE DAMAGES		
None		$0
TOTAL REAL ESTATE COST:		$32,625
	CALL	**$33,000**

	length (ft)	width (ft)	Total area (SF)
SCITUATE 6-INCH FORCE MAIN/VGS			
off road existing city easement 20 ft width expand to 30 ft width	600	10	6,000
off road new easement	-	-	-
temp staging area easement (use land at pump station)	-	-	-

REAL ESTATE REQUIREMENT

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(2 Ownerships)		
(6000 SF x $2.00 PSF x 90% Return:)	$10,800	
TEMPORARY EASEMENTS		
None	$ 0	
CONTINGENCY: (25%)	$ 2,700	
SUBTOTAL		$13,500
ACQUISITION COSTS		
(2 Ownerships x $7,000 each)		$14,000
RELOCATION COSTS		$ 0
None		
SEVERANCE DAMAGES		$ 0
None		
TOTAL REAL ESTATE COST:		$27,500
	CAll	**$27,500**

REAL ESTATE REQUIREMENTS

IMPROVE SEWERS IN CRANSTON STREET AND PARK AVENUE	length (ft)	width (ft)	Total area (SF)
length of improvements (in city street)	800	-	-
temp staging area easement	30	40	1,200

REAL ESTATE REQUIREMENT - IMPROVE SEWERS IN CRANSTON STREET

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
(1 Ownerships)		
(1,200 SF x $2.00 PSFx 10% Return:)	$ 240	
CONTINGENCY: (25%)	$ 60	
SUBTOTAL		$ 300
ACQUISITION COSTS		
(1 Ownerships x $7,000 each)		$7,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$7,300
	CALL	**$7,500**

MODIFY PONTIAC PUMP STATION	length (ft)	width (ft)	Total area (SF)
existing pump station no additional land required	-	-	-
temp staging area easement **(use land at pump station)**	-	-	-

REAL ESTATE REQUIREMENT - MODIFY PONTIAC PUMP STATION

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
None	$ 0	
CONTINGENCY: (25%)	$ 0	
SUBTOTAL		$ 0
ACQUISITION COSTS		
None		$ 0
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$ 0
	CALL	**$ 0**

REAL ESTATE REQUIREMENTS

IMPROVE PONTIAC FORCE MAIN, PUT IN NEW 42-INCH FORCEMAIN	length (ft)	width (ft)	Total area (SF)
off-road exist. city easement 35 ft width expand portion to 45 width	1,400	10	14,000
temp staging area easement (use existing city owned land in area)	-	-	-

REAL ESTATE REQUIREMENT - IMPROVE PONTIAC FORCE MAIN, PUT NEW 42-INCH FORCEMAIN

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(10 Ownerships)		
(14,000 SF x $2.00 PSF x 90% Return:)	$25,200	
TEMPORARY EASEMENTS		
None	$ 0	
CONTINGENCY: (25%)	$ 6,300	
SUBTOTAL		$31,500
ACQUISITION COSTS		
(10 Ownerships x $7,000 each)		$70,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$101,500
	CALL	**$101,500**

OPTION 1B SCITUATE PUMP STATION	length (ft)	width (ft)	Total area (SF)
land for pump station (fee acquisition)	100	100	10,000
temp PS construction easement	25	100	2,500

REAL ESTATE REQUIREMENT - SCITUATE PUMP STATION

FEE AQUISITION:		
(1 Ownerships)		
(10,000 SF x $2.00 PSF)	$20,000	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
(1 Ownerships)		
(2,500 SF x $2.00 x 10% Return:)	$ 500	
CONTINGENCY: (25%)	$ 5,215	
SUBTOTAL		$25,625
ACQUISITION COSTS		
(1 Ownerships x $7,000 each)		$ 7,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$32,625
	CALL	**$33,000**

REAL ESTATE REQUIREMENTS

SCITUATE 6-INCH FORCE MAIN/VGS	length (ft)	width (ft)	Total area (SF)
off road existing city easement 20 ft width expand to 30 ft width	600	10	6,000
off road new easement	-	-	-
temp staging area easement	-	-	-

REAL ESTATE REQUIREMENT

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(2 Ownerships)		
(6,000 SF x $2.00 PSF x 90% Return:)	$10,800	
TEMPORARY EASEMENTS		
None	$ 0	
CONTINGENCY: (25%)	$2,700	
SUBTOTAL		$13,500
ACQUISITION COSTS		
(2 Ownerships x $7,000 each)		$14,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$27,500
	CALL	**$27,500**

MODIFY PONTIAC PUMP STATION	length (ft)	width (ft)	Total area (SF)
existing pump station no additional land required	-	-	-
temp staging area easement (use land at pump station)	-	-	-

REAL ESTATE REQUIREMENT - MODIFY PONTIAC PUMP STATION

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
None	$ 0	
CONTINGENCY: (25%)	$ 0	
SUBTOTAL		$ 0
ACQUISITION COSTS		
None		$ 0
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$ 0

REAL ESTATE REQUIREMENTS

IMPROVE PONTIAC FORCE MAIN, PUT IN NEW 42-INCH FORCEMAIN	length (ft)	width (ft)	Total area (SF)
off-road exist. city easement 35 ft width expand portion to 45 width	1,400	10	14,000
temp staging area easement (use existing city owned land in area)	-	-	-

REAL ESTATE REQUIREMENT - IMPROVE PONTIAC FORCE MAIN, PUT NEW 42-INCH FORCEMAIN

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(10 Ownerships)		
(14,000 SF x $2.00 PSF x 90% Return:)	$25,200	
TEMPORARY EASEMENTS		
None	$ 0	
CONTINGENCY: (25%)	$ 6,300	
SUBTOTAL		$ 31,500
ACQUISITION COSTS		
(10 Ownerships x $7,000 each)		$ 70,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$101,500
	CALL	**$101,500**

OPTION 2A

WILBUR PUMP STATION	length (ft)	width (ft)	Total area (SF)
land for pump station	120	120	14,400
temp PS construction easement	25	120	3,000

REAL ESTATE REQUIREMENT - WILBUR PUMP STATION

FEE AQUISITION:		
(2 Ownerships)		
(14,400 SF x $1.50 PSF:)	$21,600	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
(1 Ownerships)		
(3,000 SF x $1.50 PSF x 10% Return:)	$ 450	
CONTINGENCY: (25%)	$ 5,512	
SUBTOTAL		$27,562
ACQUISITION COSTS		
(2 Ownerships x $7,000 each)		$14,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$41,562
	CALL	**$41,500**

REAL ESTATE REQUIREMENTS

GARDEN HILLS 18-INCH FORCE MAIN/VGS	length (ft)	width (ft)	Total area (SF)
off-road (new easement)	7,000	30	210,000
off-road existing city easement 25 ft width to 30 ft width	900	5	4,500
temp staging area	7000	20	140,000

REAL ESTATE REQUIREMENT

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(12 Ownerships)		
(214,500 SF x $1.50 PSF x 90% Return:)	$289,575	
TEMPORARY EASEMENTS		
(3 Ownerships)		
(140,000 SF x $1.50 PSF x 10% Return:)	$ 21,000	
CONTINGENCY: (25%)	$ 77,644	
SUBTOTAL		$388,219
ACQUISITION COSTS		
(12 Ownerships x $7,000 each)		$ 84,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$472,219
	CALL	**$472,500**

OPTION 2B

WILBUR PUMP STATION	length (ft)	width (ft)	Total area (SF)
land for pump station	120	120	14,400
temp PS construction easement	25	120	3,000

REAL ESTATE REQUIREMENT - WILBUR PUMP STATION

FEE AQUISITION:		
(2 Ownerships)		
(14,400 SF x $1.50 PSF:)	$21,600	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
(1 Ownerships)		
(3,000 SF x $1.50 PSF x 10% Return:)	$ 450	
CONTINGENCY: (25%)	$ 5,512	
SUBTOTAL		$27,562
ACQUISITION COSTS		
(2 Ownerships x $7,000 each)		$14,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$41,562
	CALL	**$41,500**

REAL ESTATE REQUIREMENTS

GARDEN HILLS 18-INCH FORCE MAIN/24-INCH GRAVITY SEWER	length (ft)	width (ft)	Total area (SF)
off-road (new easement)	7,000	30	210,000
off-road existing city easement 25 ft width to 30 ft width	900	5	4,500
temp staging area	7,000	20	140,000

REAL ESTATE REQUIREMENT - GARDEN HILLS 18-INCH FORCE MAIN/24-INCH GRAVITY SEWER

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(12 Ownerships)		
(214,500 SF x $1.50 PSF x 90% Return:)	$289,575	
TEMPORARY EASEMENTS		
(3 Ownerships)		
(140,000 SF x $1.50 PSF x 10% Return:)	$ 21,000	
CONTINGENCY: (25%)	$ 77,644	
SUBTOTAL		$388,219
ACQUISITION COSTS		
(12 Ownerships x $7,000 each)		$ 84,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$472,219
	CALL	**$472,500**

OPTION 2C

WILBUR PUMP STATION	length (ft)	width (ft)	Total area (SF)
land for pump station	120	120	14,400
temp PS construction easement	25	120	3,000

REAL ESTATE REQUIREMENT - WILBUR PUMP STATION

FEE AQUISITION:		
(2 Ownerships)		
(14,400 SF x $1.50)	$21,600	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
(1 Ownerships)		
(3,000 SF x $1.50 PSF x 10% Return:)	$ 450	
CONTINGENCY: (25%)	$ 5,512	
SUBTOTAL		$27,562
ACQUISITION COSTS		
(2 Ownerships x $7,000 each)		$14,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$41,562
	CALL	**$41,500**

REAL ESTATE REQUIREMENTS

TURNER AVE 18-INCH FORCE MAIN	length (ft)	width (ft)	Total area (sf)
off-road	400	30	12,000
on-road (all in city streets)	-	-	-
temp staging area	20	400	8,000

REAL ESTATE REQUIREMENT

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(1 Ownerships)		
(12,000 SF x $1.50 PSF x 90% Return:)	$16,200	
TEMPORARY EASEMENTS		
(1 Ownerships)		
(8,000 SF x $1.50 x 10% Return:)	$ 1,200	
CONTINGENCY: (25%)	$ 4,350	
SUBTOTAL		$21,750
ACQUISITION COSTS		
(1 Ownerships x $7,000 each)		$ 7,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$28,750
	CALL	**$29,000**

IMPROVE SOCKANOSSET INTERCEPTOR, REPLACE OR ADD GRAVITY SEWER	length (ft)	width (ft)	Total area (SF)
off-road existing city sewer easement 25 ft width expand to 30 ft	1200	5	6000
temp staging area	-	-	-

REAL ESTATE REQUIREMENT - IMPROVE SOCKANOSSET INTERCEPTOR, REPLACE OR ADD GRAVITY SEWER

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(14 Ownerships)		
(6000 SF x $2.00 PSF x 90% Return:)	$10,800	
TEMPORARY EASEMENTS		
None	$ 0	
CONTINGENCY: (25%)	$ 2,700	
SUBTOTAL		$ 13,500
ACQUISITION COSTS		
(14 Ownerships x $7,000 each)		$ 98,000
RELOCATION COSTS		
		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$111,500
	CALL	**$111,500**

REAL ESTATE REQUIREMENTS

OPTION 2D

BROOKDALE TRUNK SEWER, 30 AND 36 INCH GRAVITY SEWER	length (ft)	width (ft)	Total area (SF)
off road (new easement between Herod St. and Brookdale Ave.)	1400	30	42,000
temp staging area	1400	20	28,000

REAL ESTATE REQUIREMENT - BROOKDALE TRUNK SEWER, 30 AND 36 INCH GRAVITY SEWER

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(1 Ownerships)		
(42,000 SF x $2.00 PSF x 90% Return:)	$75,600	
TEMPORARY EASEMENTS		
(28,000 SF x 2.00 x 10%)	$5,600	
CONTINGENCY: (25%)	$20,300	
SUBTOTAL		$101,500
ACQUISITION COSTS		
(1 Ownerships x $7,000 each)		$ 7,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$108,500
	CALL	**$108,500**

TILCON TRUNK SEWER, 18, 24, AND 30 INCH GRAVITY SEWER	length (ft)	width (ft)	Total area (SF)
off road (new easement)	1,200	30	36,000
temp staging area	1,200	20	24,000

REAL ESTATE REQUIREMENT - TILCON TRUNK SEWER. 18, 24 AND 30 INCH GRAVITY SEWER

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(1 Ownerships)		
(36,000 SF x $1.50 PSF x 90% Return:)	$48,600	
TEMPORARY EASEMENTS		
(1 Ownerships)		
(24,000 SF x $1.50 PSF x 10% Return:)	$ 3,600	
CONTINGENCY: (25%)	$13,050	
SUBTOTAL		$65,250
ACQUISITION COSTS		
(1 Ownerships x $7,000 each)		$ 7,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$72,250
	CALL	**$72,500**

REAL ESTATE REQUIREMENTS

COMSTOCK\FURNACE HILL TRUNK SEWER, 12, 15 AND 24 INCH GRAVITY SEWER	length (ft)	width (ft)	Total area (SF)
off road (new easement)	6,500	30	195,000
temp staging area	6,500	20	130,000

REAL ESTATE REQUIREMENT - COMSTOCK\FURNACE HILL TRUNK SEWER, 12, 15, AND 24 INCH GRAVITY SEWER

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(24 Ownerships)		
(195,000 SF x $1.50 PSF x 90% Return:)	$263,250	
TEMPORARY EASEMENTS		
(24 Ownerships)		
(130,000 SF x $1.50 PSF x 10% Return:)	$ 19,500	
CONTINGENCY: (25%)	$ 70,688	
SUBTOTAL		$353,438
ACQUISITION COSTS		
(24 Ownerships x $7,000 each)		$168,000
RELOCATION COSTS		
None		$ 0
SEVERENCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$521,438
	CALL	**$521,500**

PHENIX PUMP STATION	length (ft)	width (ft)	Total area (SF)
land for pump station (fee acquistion)	100	100	10,000
temp PS construction easement	100	25	2,500

REAL ESTATE REQUIREMENT - PHENIX PUMP STATION

FEE AQUISITION:		
(1 Ownerships)		
(10,000 SF x $2.00 PSF)	$20,000	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
(1 Ownerships)		
(2,500 SF x $2.00 PSF x 10% Return:)	$ 500	
CONTINGENCY: (25%)	$ 5,125	
SUBTOTAL		$25,625
ACQUISITION COSTS		
(1 Ownerships x $7,000 each)		$ 7,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$32,625
	CALL	**$33,000**

REAL ESTATE REQUIREMENTS

PHENIX 6-INCH FORCE MAIN	length (ft)	width (ft)	Total area (SF)
all work in city streets	-	-	-
temp staging area	-	-	-

REAL ESTATE REQUIREMENT - PHENIX 6-INCH FORCE MAIN

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
None	$ 0	
CONTINGENCY: (25%)	$ 0	
SUBTOTAL		$ 0
ACQUISITION COSTS		
None		$ 0
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$ 0
	CALL	**$ 0**

NATICK PHENIX TRUNK SEWER	length (ft)	width (ft)	Total area (SF)
off road new	6,000	30	180,000
adjacent to Natick Village Complex	-	-	-
temp staging area	6,000	20	120,000

REAL ESTATE REQUIREMENT - NATICK PHENIX TRUNK SEWER

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
(26 Ownerships)		
(180,000 SF x $2.00 PSF x 90% Return:)	$324,000	
TEMPORARY EASEMENTS		
(26 Ownerships)		
(120,000 SF x $2.00 PSF x 10% Return:)	$ 24,000	
CONTINGENCY: (25%)	$ 87,000	
SUBTOTAL		$435,000
ACQUISITION COSTS		
(26 Ownerships x $7,000 each)		$182,000
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$617,000
	CALL	**$617,000**

REAL ESTATE REQUIREMENTS

OPTION 3A

	length (ft)	width (ft)	Total area
MODIFY HOWARD PUMP STATION			
modify existing pump station	-	-	-
temp staging area not required	-	-	-

REAL ESTATE REQUIREMENT - MODIFY HOWARD PUMP STATION

FEE AQUISITION:		
None	$ 0	
PERMANENT EASEMENTS		
None	$ 0	
TEMPORARY EASEMENTS		
None	$ 0	
CONTINGENCY: (25%)	$ 0	
SUBTOTAL		$ 0
ACQUISITION COSTS		
None		$ 0
RELOCATION COSTS		
None		$ 0
SEVERANCE DAMAGES		
None		$ 0
TOTAL REAL ESTATE COST:		$ 0

ATTACHMENT 5

PRELIMINARY ESTIMATE
OF PROJECT AND OPERATION
AND MAINTENANCE COSTS

Estimated Basic Construction Cost (inc. 20% contingencies) in October 1993 Dollars

	initial	after 2015
Option 1A		
Scituate pumping station	$461,500	$0
Scituate force main/VGS	$1,107,300	$0
I-295 pumping station	$0	$0
Existing 14-inch force main/VGS	$0	$0
Replace Cranston St sewer (after 2015)	$0	$108,400
Improve Pontiac pumping station	$364,700	$77,100
Replace Pontiac force main (after 2015)	$0	$540,600
Total	$1,933,500	$726,100
Option 1B		
Scituate pumping station	$461,500	$0
Scituate force main/VGS	$1,107,300	$0
I-295 pumping station	$0	$0
Existing 14-inch force main/VGS	$0	$0
Replace Cranston St sewer (after 2015)	$0	$0
Improve Pontiac pumping station	$364,700	$77,100
Replace Pontiac force main (after 2015)	$0	$540,600
Total	$1,933,500	$617,700
Option 1C		
Scituate pumping station	$461,500	$0
Scituate force main/VGS	$1,107,300	$0
Total	$1,568,800	$0
Option 2A		
Wilbur pumping station	$2,155,700	$262,300
Garden Hills force main/VGS	$1,479,800	$0
Total	$3,635,500	$262,300
Option 2B		
Wilbur pumping station	$2,155,700	$262,300
Garden Hills FM/gravity sewer	$1,521,800	$0
Improve WWTF influent pumps	$0	$78,000
Total	$3,677,500	$340,300
Option 2C		
Wilbur pumping station	$2,155,700	$262,300
Turner force main	$950,100	$0
Improve Sockanosset Int (after 2015)	$0	$148,300
Improve WWTF influent pumps	$0	$78,000
Total	$3,105,800	$488,600
Option 2D		
Brockdale sewer	$289,100	$0
Tilcon sewer	$594,600	$0
Comstock sewer	$1,159,800	$0
Natick/Phenix sewer	$532,600	$0
Phenix pumping station (after 2015)	$0	$427,500
Phenix force main (after 2015)	$0	$211,100
Total	$2,576,100	$638,600
Option 3A		
Existing Kenny Drive etc. sewer	$0	$0
Improve Howard Pump station	$211,900	$0
Total	$211,900	$0

CRANSTON, RI

WASTEWATER CONVEYANCE FEASIBILITY STUDY

(DECEMBER 1993)

OPTION	E&D (%)	S&A (%)	E&D + S&A (%)
Initial (all options)	9.0	6.0	15.0
After 2015 (all options)	10.5	6.0	16.5

Option 1A

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars

SCITUATE PUMPING STATION

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$461,500
Engineering and Design Cost	$41,500
Construction Management Cost	$27,700
Land Acquistion	$33,000
Total Estimated Cost	$563,700
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$15,700
Annual Cost 2016-2045	$18,500

SCITUATE 6-INCH FORCE MAIN/VARIABLE GRADE SEWER

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$1,107,300
Engineering and Design Cost	$99,700
Construction Management Cost	$66,400
Land Acquistion	$27,500
Total Estimated Cost	$1,300,900
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$2,000
Annual Cost 2016-2045	$2,000

I-295 PUMPING STATION

INITIAL COST	
Scheduled for construction by city	$0
OPERATION AND MAINTENANCE COST (Option 1A)	
Annual Cost 1995-2015 (*)	$3,800
Annual Cost 2016-2045 (*)	$9,700

* differential pumping costs for increased flow

Option 1A

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars (continued)

EXISTING 14-INCH FORCE MAIN/VARIABLE GRADE SEWER

INITIAL COST	$0
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$0
Annual Cost 2016-2045 (*)	$0
* differential costs for increased flow	

CRANSTON STREET, REPLACE 18-INCH GRAVITY SEWER WITH 24-INCH GRAVITY SEWER

ADDITONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$108,400
Engineering and Design Cost	$11,400
Construction Management Cost	$6,500
Land Acquistion	$7,500
Estimated Additional Cost	$133,800
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$0
Annual Cost 2016-2045 (*)	$0
* differential costs for increased flow	

PARK AVENUE AND POCASSET INTERCEPTOR GRAVITY SEWERS

INITIAL COST	$0
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$0
Annual Cost 2016-2045 (*)	$0
* differential costs for increased flow	

Option 1A

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars (continued)

IMPROVE EXISTING PONTIAC PUMPING STATION

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$364,700
Engineering and Design Cost	$32,800
Construction Management Cost	$21,900
Land Acquistion	$0
Total Estimated Cost	$419,400
ADDITONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$77,100
Engineering and Design Cost	$8,100
Construction Management Cost	$4,600
Land Acquistion	$0
Estimated Additional Cost	$89,800
OPERATION AND MAINTENANCE COST (*)	
Annual Cost 1995-2015	$46,000
Annual Cost 2016-2045	$68,300

* differential pumping costs for increased flow

REPLACE EXISTING PONTIAC FORCE MAINS WITH NEW 42-INCH FORCE MAIN

ADDITIONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$540,600
Engineering and Design Cost	$56,800
Construction Management Cost	$32,400
Land Acquistion	$101,500
Estimated Additional Cost	$731,300
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$0
Annual Cost 2016-2045 (*)	$0

* differential costs for increased flow

Option 1B

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars

SCITUATE PUMPING STATION

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$461,500
Engineering and Design Cost	$41,500
Construction Management Cost	$27,700
Land Acquistion	$33,000
Total Estimated Cost	$563,700
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$15,700
Annual Cost 2016-2045	$18,500

SCITUATE 6-INCH FORCE MAIN/VARIABLE GRADE SEWER

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$1,107,300
Engineering and Design Cost	$99,700
Construction Management Cost	$66,400
Land Acquistion	$27,500
Total Estimated Cost	$1,300,900
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$2,000
Annual Cost 2016-2045	$2,000

I-295 PUMPING STATION

INITIAL COST	
Scheduled for construction by city	$0
OPERATION AND MAINTENANCE COST (Option 1B)	
Annual Cost 1995-2015 (*)	$3,000
Annual Cost 2016-2045 (*)	$8,000

* differential pumping costs for increased flow

Option 1B

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars (continued)

EXISTING 14-INCH FORCE MAIN/VARIABLE GRADE SEWER

INITIAL COST	$0
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$0
Annual Cost 2016-2045 (*)	$0
* differential costs for increased flow	

CRANSTON STREET, REPLACE 18-INCH GRAVITY SEWER WITH 24-INCH GRAVITY SEWER

ADDITONAL COST AFTER YEAR 2015	$0
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$0
Annual Cost 2016-2045 (*)	$0
* differential costs for increased flow	

PARK AVENUE AND POCASSET INTERCEPTOR GRAVITY SEWERS

INITIAL COST	$0
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$0
Annual Cost 2016-2045 (*)	$0
* differential costs for increased flow	

Option 1B

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars (continued)

IMPROVE EXISTING PONTIAC PUMPING STATION

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$364,700
Engineering and Design Cost	$32,800
Construction Management Cost	$21,900
Land Acquistion	$0
Total Estimated Cost	$419,400
ADDITONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$77,100
Engineering and Design Cost	$8,100
Construction Management Cost	$4,600
Land Acquistion	$0
Estimated Additional Cost	$89,800
OPERATION AND MAINTENANCE COST (*)	
Annual Cost 1995–2015	$46,000
Annual Cost 2016–2045	$68,300

* differential pumping costs for increased flow

REPLACE EXISTING PONTIAC FORCE MAINS WITH NEW 42–INCH FORCE MAIN

ADDITIONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$540,600
Engineering and Design Cost	$56,800
Construction Management Cost	$32,400
Land Acquistion	$101,500
Estimated Additional Cost	$731,300
OPERATION AND MAINTENANCE COST	
Annual Cost 1995–2015 (*)	$0
Annual Cost 2016–2045 (*)	$0

* differential costs for increased flow

Option 1C

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars

SCITUATE PUMPING STATION

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$461,500
Engineering and Design Cost	$41,500
Construction Management Cost	$27,700
Land Acquistion	$33,000
Total Estimated Cost	$563,700
OPERATION AND MAINTENANCE COST	
Annual Cost 1995–2015	$15,700
Annual Cost 2016–2045	$18,500

SCITUATE 6-INCH FORCE MAIN/VARIABLE GRADE SEWER

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$1,107,300
Engineering and Design Cost	$99,700
Construction Management Cost	$66,400
Land Acquistion	$27,500
Total Estimated Cost	$1,300,900
OPERATION AND MAINTENANCE COST	
Annual Cost 1995–2015	$2,000
Annual Cost 2016–2045	$2,000

Option 2A

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars

WILBUR PUMPING STATION

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$2,155,700
Engineering and Design Cost	$194,000
Construction Management Cost	$129,300
Land Acquistion	$41,500
Total Estimated Cost	$2,520,500
ADDITIONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$262,300
Engineering and Design Cost	$27,500
Construction Management Cost	$15,700
Land Acquistion	$0
Estimated Additional Cost	$305,500
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$50,200
Annual Cost 2016-2045	$94,200

GARDEN HILLS 18-INCH FORCE MAIN/VARIABLE GRADE SEWER

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$1,479,800
Engineering and Design Cost	$133,200
Construction Management Cost	$88,800
Land Acquistion	$472,500
Total Estimated Cost	$2,174,300
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$3,500
Annual Cost 2016-2045	$3,500

Option 2B

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars

WILBUR PUMPING STATION

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$2,155,700
Engineering and Design Cost	$194,000
Construction Management Cost	$129,300
Land Acquistion	$41,500
Total Estimated Cost	$2,520,500
ADDITIONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$262,300
Engineering and Design Cost	$27,500
Construction Management Cost	$15,700
Land Acquistion	$0
Estimated Additional Cost	$305,500
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$50,200
Annual Cost 2016-2045	$94,200

GARDEN HILLS 18-INCH FORCE MAIN AND 24-INCH GRAVITY SEWER

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$1,521,800
Engineering and Design Cost	$137,000
Construction Management Cost	$91,300
Land Acquistion	$472,500
Total Estimated Cost	$2,222,600
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$2,700
Annual Cost 2016-2045	$2,700

WWTF INFLUENT PUMPS

ADDITIONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$78,000
Engineering and Design Cost	$8,200
Construction Management Cost	$4,700
Land Acquistion	$0
Estimated Additional Cost	$90,900
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$2,700
Annual Cost 2016-2045 (*)	$7,900

* differential pumping costs for increased flows

Option 2C

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars

WILBUR PUMPING STATION

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$2,155,700
Engineering and Design Cost	$194,000
Construction Management Cost	$129,300
Land Acquistion	$41,500
Total Estimated Cost	$2,520,500
ADDITIONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$262,300
Engineering and Design Cost	$27,500
Construction Management Cost	$15,700
Land Acquistion	$0
Estimated Additional Cost	$305,500
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$43,100
Annual Cost 2016-2045	$74,500

TURNER AVENUE 18-INCH FORCE MAIN

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$950,100
Engineering and Design Cost	$85,500
Construction Management Cost	$57,000
Land Acquistion	$29,000
Total Estimated Cost	$1,121,600
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$2,000
Annual Cost 2016-2045	$2,000

Option 2C

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars (continued)

IMPROVEMENTS SOCKANOSSET INTERCEPTOR

ADDITIONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$148,300
Engineering and Design Cost	$15,600
Construction Management Cost	$8,900
Land Acquistion	$111,500
Estimated Additional Cost	$284,300
OPERATION AND MAINTENANCE COST	
Annual Cost 1995–2015 (*)	$0
Annual Cost 2016–2045 (*)	$0

* differential pumping costs for increased flows

WWTF INFLUENT PUMPS

ADDITIONAL COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$78,000
Engineering and Design Cost	$8,200
Construction Management Cost	$4,700
Land Acquistion	$0
Estimated Additional Cost	$90,900
OPERATION AND MAINTENANCE COST	
Annual Cost 1995–2015 (*)	$2,700
Annual Cost 2016–2045 (*)	$7,900

* differential pumping costs for increased flows

Option 2D

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars

BROOKDALE GRAVITY SEWER

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$289,100
Engineering and Design Cost	$26,000
Construction Management Cost	$17,300
Land Acquistion	$108,500
Total Estimated Cost	$440,900
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$500
Annual Cost 2016-2045	$500

TILCON GRAVITY SEWER

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$594,600
Engineering and Design Cost	$53,500
Construction Management Cost	$35,700
Land Acquistion	$72,500
Total Estimated Cost	$756,300
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$1,300
Annual Cost 2016-2045	$1,300

COMSTOCK GRAVITY SEWER

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$1,159,800
Engineering and Design Cost	$104,400
Construction Management Cost	$69,600
Land Acquistion	$521,500
Total Estimated Cost	$1,855,300
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$2,800
Annual Cost 2016-2045	$2,800

Option 2D

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars (continued)

NATICK/PHENIX GRAVITY SEWER

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$532,600
Engineering and Design Cost	$47,900
Construction Management Cost	$32,000
Land Acquistion	$617,000
Total Estimated Cost	$1,229,500
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$1,400
Annual Cost 2016-2045	$1,400

PHENIX PUMPING STATION

ADDITIONAL PROJECT COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$427,500
Engineering and Design Cost	$44,900
Construction Management Cost	$25,700
Land Acquistion	$33,000
Estimated Additional Cost	$531,100
OPERATION AND MAINTENANCE COST (*)	
Annual Cost 1995-2015	$0
Annual Cost 2016-2045	$18,900

PHENIX 6-INCH FORCEMAIN

ADDITIONAL PROJECT COST AFTER YEAR 2015	
Estimated Basic Construction Cost (inc. 20% contingencies)	$211,100
Engineering and Design Cost	$22,200
Construction Management Cost	$12,700
Land Acquistion	$0
Estimated Additional Cost	$246,000
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015	$0
Annual Cost 2016-2045	$240

Option 3A

Estimated Project and Operation and Maintenance Costs in October 1993 Dollars

KENNY DRIVE, ROSS-SIMMONS DRIVE, AND SHARPE DRIVE

INITIAL COST	$0
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$0
Annual Cost 2016-2045 (*)	$0
* differential cost for increased flow	

IMPROVEMENTS TO HOWARD PUMPING STATION

INITIAL COST	
Estimated Basic Construction Cost (inc. 20% contingencies)	$211,900
Engineering and Design Cost	$19,100
Construction Management Cost	$12,700
Land Acquistion	$0
Total Estimated Cost	$243,700
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$21,600
Annual Cost 2016-2045 (*)	$21,600
* differential cost for increased flow	

EXISTING 14-INCH HOWARD FORCE MAIN

INITIAL COST	$0
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$0
Annual Cost 2016-2045 (*)	$0
* differential cost for increased flow	

WWTF INFLUENT PUMPS

INITIAL COST	$0
OPERATION AND MAINTENANCE COST	
Annual Cost 1995-2015 (*)	$2,300
Annual Cost 2016-2045 (*)	$4,600
* differential cost for increased flow	

APPENDIX J

Task 10b - Socio/Economic Assessment

Section 117, Cranston Rhode Island
Wastewater Conveyance Feasibility Investigation

Feasibility Report Appendix
Task 10b - Socio/Economic Assessment

Department of the Army
Corps of Engineers, New England Division
Waltham, Massachusetts

February 1994

TABLE OF CONTENTS

	Page
STUDY AREA	J-1
PROJECT NEED	J-1
STUDY OPTIONS	J-1
Service Area 1	J-1
Service Area 2	J-1
Service Area 3	J-2
IMPACT METHODOLOGY	J-3
WITHOUT PROJECT CONDITION	J-4
Land Use	J-4
Population	J-5
Labor Force	J-6
Income	J-6
Sales	J-7
Housing	J-7
Schools	J-8
Municipal Finances	J-9
Utilities	J-10
Public Safety	J-10
Transportation	J-10
WITH PROJECT CONDITION	J-11
Land Use	J-11
Population	J-12
Labor Force	J-12
Income	J-12
Sales	J-13
Housing	J-13
Schools	J-14
Municipal Finances	J-14
Utilities	J-16
Public Safety	J-16
Transportation	J-16
SUMMARY	J-17

LIST OF TABLES

Table 1	Federal Project Option Costs	J-15

The Socio/Economic Appendix analyzes the short and long term impacts of construction and operation of study options on economic resources. Resources under investigation include land use, population, labor force including both employed and unemployed, school enrollment, municipal finances, utilities, public safety and traffic.

STUDY AREA

The study area is defined as that area where impacts are felt. Impacts are described on three levels; the immediate service area, the local area, and the region. The immediate service areas are designated one ,two, and three. Service Area 1 includes residential, industrial and commercial areas along the Plainfield Pike, Comstock Parkway, and the proposed Village Center in northwest Cranston; proposed industrial land use in Johnston; and Vinagro and Central landfills. Service Area 2 includes residential and industrial land in west Cranston south of Scituate Avenue. Service Area 3, in east Cranston, includes the Howard Center, the Howard Industrial Park, and the Capuano Landfill. The local area includes these three service areas plus the remainder of Cranston. The region includes Cranston and the surrounding communities in Providence County.

PROJECT NEED

In Service Area 1 deficit wastewater conveyance capacity is projected at the Welsh pumping station, Cranston Street gravity sewer, and the Pontiac pumping station. The city is currently constructing the new high capacity I-295 pumping station to replace the Welsh pumping station. Also, planned centralized development at the proposed Village Center requires the extension of city sewers.

In Service Area 2 there is no existing sewer service except for a variable grade sewer sized to service only the Briggs Farm School on Hope Road. This area is projected to have around 3,963 residential housing units by 2045. Extension of the city's sewer system to this area will provide a solution to existing and future septic system failure.

In Service Area 3, deficit capacity is projected at the Howard pumping station.

STUDY OPTIONS

Service Area 1

In the without project condition (no Federal project) the city intends to provide improvements to the existing sewerage system to meet projected need. (Option 1B).

Wastewater flows from Service Area 1 would be pumped from the new I-295 pumping station into the existing 14-inch force main/variable grade sewer which discharges to the gravity sewer in Cranston Street. Wastewater would flow by gravity through sewers in Cranston Street, Park Avenue, and the Pocasset interceptor to the Pontiac pumping station.

A Federal Project (Option 1C) would consist only of the proposed new pumping station (Scituate) and force main/variable grade sewer required to collect flows in the area of the proposed Village Center. Also additional lateral sewers would be required in northwest Cranston. However, these are not part of the Federal project.

Service Area 2

The without project condition assumes that municipal sewer service would not be extended to this area.

In Service Area 2 there are 4 options under consideration for the federal project. Option 2A provides a connector system from Service Area 2 to convey projected wastewater flows to the Wastewater Treatment Facility (WWTF). Wastewater would be pumped from a proposed pumping station located near I-295 and Wilbur Avenue through the proposed Garden Hills force main/variable grade sewer (FM/VGS) to the WWTF. Option 2B is similar to Option 2A except that the Garden Hills force main/variable grade sewer is replaced with a proposed Garden Hills force main/gravity sewer. Option 2C would also carry projected flows from Service Area 2 but via the proposed Wilbur FM and discharge to the existing Sockanosset Interceptor on Belvedere Drive. The interceptor discharges to the siphon in Webb Street and into the influent screw pumps at the WWTF. Option 2D is comprised of four proposed West Cranston trunk sewers: the proposed Brookdale gravity sewer, the proposed Tilcon gravity sewer, the proposed Comstock gravity sewer, and the proposed Natick/Phenix trunk sewer, and a proposed pumping station and force main near the intersection of Phenix Avenue and Burlingame.

Option 2A, 2B, and 2C are mutually exclusive alternatives. Option 2C was selected as the federal project. This selection is discussed in the feasibility report. Also only portions of option 2D, the trunk sewers in west Cranston, were selected as the federal project. In addition, lateral sewers would be required in west Cranston, but these are not part of the Federal project.

Service Area 3

In the without project condition, the City of Cranston intends as wastewater flows increase to provide improvements to the existing sewerage system (Option 3A). Wastewater flows would be conveyed by gravity through the existing main sewers in Kenny Drive, Ross-Simmons Drive, and Sharpe Drive to the Howard pumping station. Flows would be pumped through the Howard force main to the siphon in Webb Street into the influent screw pumps at the WWTF.

There is no federal project options proposed for this area.

IMPACT METHODOLOGY

Socioeconomic impacts are developed for the with and without federal project condition. As described previously the impact areas considered are the immediate service areas, the city, and the region. Resources impacted on a wider level than the city include labor force, personal income, sales, population, school age population, and the housing market.

These impacts are estimated using the computer based Economic Impact Forecasting System (EIFS). Briefly, the EIFS employs a Keynesian multiplier approach where initial changes in spending generate additional spending rounds in the local economy. The total effect is found by aggregating the spending rounds. This analytic tool was developed by the US Army Construction Engineering and Research Laboratories (CERL) to assess the impact of base closings and other changes in troop strength on local economies and is considered applicable to assess the impact associated with increasing the city's sewer service.

Employment estimates are developed by dividing projected industrial acreage in use by the average employment density. Average employment density was developed using employment densities per acre found in "Land Use 2010, State Land Use Policies and Plans", State of Rhode Island, 1989 page 5.27. Employment Densities by Industry are:

Industry	Density Per Acre
Construction	5
Mfg	20
Transportation	10
Communications	40
Utilities	30
Wholesale	14
Insurance	60
Business Services	75

Based on existing economic development an average density of 19 workers per acre was developed for current and anticipated future development. This estimate was developed using the employment densities above for manufacturing, transportation, communications, utilities and wholesale trade. The densities were weighted by their relative employment proportion in the Cranston work force.

Assumptions regarding population growth and industrial and commercial growth were made by Tutela Engineering Associates (TEA) for the on-going Wastewater Treatment Facility Plan and have been adopted for this study in agreement with Cranston city officials. They seem to be reasonable. The annualized population growth rate between 1980 and 1990 was 0.6%. TEA's implicit rate is 0.3%. The Rhode Island Department of Economic Development's preliminary growth rate for employment between 1992 and 2000 is 9%. This translates into an annual growth rate of 1.1%. If we take the projected growth in employment of 8,000 in 2045 in west Cranston and add it to the Cranston average annual employment 23,189, the implied annual growth rate is approximately 0.6%. Thus the projected growth in population and employment seems reasonable.

WITHOUT PROJECT CONDITION

This section discusses the most likely future conditions without a federal project. The resources described include land use, population, labor force, income, sales,school enrollment, municipal financing including sewer rates, utilities, public safety and traffic. Future conditions with the Federal project are discussed in the following section.

Land Use

In 1990 land use in Cranston in acres by activity was (Draft Wastewater Facility Plan, Tutela Engineering Associates, April 1992)

Activity	Acres
Residential	6,822
Industrial	510
Transportation, Comm, & Utilities	272
Commercial	502
Institutional	826
Rec, Parks & Cem.	848
Farm	288
Undeveloped	5,840
Total	15,908.

Industrial Land Use - In Service Area 1, the Western Cranston Industrial Area is a 350 acre site located at the interchange of Interstate Route 295 and State Route 14. Currently, 27 firms and 2,200 employees are located within the park. The Cranston Office of Economic Development indicates that 162 acres are currently in use. In addition near the Plainfield Pike there are 30 acres that are currently commercially developed and another 30 acres that are not yet developed. By 2045, it is expected that there will be 470 acres of industrial/commercial development in northwest Cranston. This development is expected to occur with or without the federal project.

In nearby Johnston there are 100 acres that are currently undeveloped and it is expected that industrial development could occur there if the Town of Johnston could work out a plan with the City of Cranston to connect to the city's sewerage system.

In Service Area 2, industrial development consists of the Tilcon Gammino Gravel Pit. This site is comprised of approximately 140 acres and employs approximately 155 workers.

In Service Area 3, the Howard Industrial Park is one of two major industrial sites in Cranston. It is located in east Cranston at the interchange of Interstate 95 and State Route 37. The park is almost totally developed, today housing 38 companies with a workforce of approximately 3,000. There are about 190 acres devoted to industrial use at this site.

Residential Land Use - Currently west Cranston contains 3,330 acres of residential development . At full build out under existing zoning, there is expected to be about 5,800 acres of residential development, about 75 percent of west Cranston's total area of 7,700 acres (Comprehensive Plan, page 29).

Tutela Engineering Associates estimates about 1,075 acres of development will be in the I-295 pumping station district (Service Area 1) and 4,460 acres in the Wilbur pumping station district (Service Area 2) (Tutela Engineering Associates, Wastewater Flow Letter Report, February 25, 1993,). Residential development in west Cranston is expected to occur with or without the federal project.

Population

In 1990 Cranston ranked third in population among Rhode Island's 39 cities and towns. The Census population for Cranston in 1990 was 76,060. This represented a 5.7 % increase from the 1980 population of 71,992. Population for the years 1920 to 1990 are shown below:

Year	Population
1920	29,407
1930	42,911
1940	47,085
1950	55,060
1960	66,766
1970	74,287
1980	71,992
1990	76,060.

Tutela Engineering Associates projects a population of 83,020 people by the year 2015 and a population of 91,370 by 2045 under existing zoning conditions (Tutela Engineering Associates, Draft Wastewater Facility Plan, 1992). Most of this population increase is projected to take place in west Cranston.

In Service Area 1 (I-295 pumping station district) population is expected to increase to 1,775 in 2015 and to 3,220 in 2045. In Service Area 2 (Wilbur pumping station district), population is expected to increase to 8,799 in 2015 and 11,890 in 2045. No population increase is expected for Service Area 3 (Howard pumping station district). Population in Cranston is expected to increase with or without the Federal project.

Labor Force

In 1991 the resident Cranston labor force was comprised of 36,720 employed and 3,288 unemployed. The resident unemployment rate was 8.2 %. Labor force data for the period 1982 to 1991 is shown below:

Year	Total Employed	Unemployed	Labor Force	Unemployment rate
1982	32,182	3,631	35,831	10.1 %
1983	33,241	2,796	36,037	7.8 %
1984	35,245	1,827	37,072	4.9 %
1985	36,175	1,734	37,909	4.6 %
1986	37,031	1,485	38,516	3.9 %
1987	38,167	1,431	39,598	3.6 %
1988	39,052	1,185	40,237	2.9 %
1989	39,077	1,504	40,581	3.7 %
1990	37,399	2,565	39,964	6.4 %
1991	36,720	3,288	40,008	8.2 %

The unemployment rate dropped from 1982 until 1989 when it began to rise. There does not appear to be any major structural unemployment in Cranston. This would be indicated by persistently high unemployment rates. The unemployment rate seems to follow the business cycle.

As a result of sewer expansion by the City of Cranston (without project condition) it is estimated that in Service Area 1, by the year 2015, an additional 2,300 jobs will be created in the I-295 District. Job expansion is likely to continue in the I-295 district after 2015 culminating with an additional 3,000 jobs (over 2015 levels). If the City of Cranston and Johnston can reach an agreement regarding the connection of the industrial area in Johnston to the system, then 1,300 jobs would be created in Johnston by 2015 and if expansion of the system continues, an additional 600 jobs would be created over the 2015 level.

No job expansion is expected in Service Area 2 or Service Area 3 in the without project condition.

Income

The 1989 median family income for Cranston was $41,896. The annual payroll in 1992 for an average employment of 23,189 was $511,128,786. This employment occurred in 2,126 establishments in Cranston.

The job creation discussed for Service Area 1 in the without federal project condition means that an additional $62,451,000 of income will be created by 2015 in the I-295 district growing to an increase of $143,908,000 by 2045. In Johnston income growth will be $35,298,000 by 2015 and $51,590,000 by 2045.

Sales

Gross retail sales in 1990 were $962,033,000. There were 444 firms involved in the retail trade in Cranston in 1992. Gross retail sales for the period 1982 to 1990 are

Year	Sales
1982	$633,776,000
1983	633,640,000
1984	834,599,000
1985	1,014,432,000
1986	977,503,000
1987	1,091,791,000
1988	1,151,450,000
1989	1,107,884,000
1990	$962,033,000

In Providence County there were 3,903 firms involved in the retail trade in 1989.

Housing

According to the 1990 Census there was a total of 30,516 housing units in Cranston in 1990, of which, 29,349 were occupied. This would leave 1,167 units vacant. In 1980 there were 27,280 housing units in Cranston. The number of housing units increased by 3,236 units, or 11.9 % between 1980 and 1990.

In 1990, 16,619 of the 26,479 specified occupied housing units, or 62.8 %, were owner occupied. The median selling price of an existing single family home was $122,750. There were 9,860 specified housing units that were renter occupied and the median rent was $534 per month.

From 1980 to 1990, 3,447 housing units were authorized by building permits. The distribution by year is:

Year	Units
1980	151
1981	333
1982	111
1983	322
1984	423
1985	392
1986	356
1987	471
1988	547
1989	189
1990	152.

Anticipated and existing residential development by Service Area is shown below. It is assumed that the population per housing unit is 3 (Tutela Engineering Associates, Draft Wastewater Facility Plan, April 1992). This growth in housing units is assumed to be independent of the Federal project.

	Estimated Housing Units		
	1990	2015	2045
Service Area 1	190	592	1,073
Service Area 2	2,074	2,933	3,963

Schools

Cranston has 24 schools which had a total enrollment of 9,776 in September 1992. There are 18 elementary schools and 6 secondary schools. The School Department had 748 professional staff members. The School System had a student teacher ratio of approximately 13.1. The cost of operating the public school system in Cranston for the 1991-92 school year was $54,715,388.

Enrollment in the City's public school system for the past five school years and projected enrollments for the next five years in shown below:

School Year	Enrollment
1988-89	8,961
1989-90	9,154
1990-91	9,366
1991-92	9,621
1992-93	9,776
1993-94	10,250
1994-95	10,764
1995-96	11,187
1996-97	11,911
1997-98	12,135

School enrollment in west Cranston is anticipated to increase by 3,400 by the year 2015 and 5,800 by the year 2045.

It is anticipated (Comprehensive Plan, February 1992) that Cranston elementary schools will reach capacity by the 1995-1996 school year. Thus Cranston will need to realign grade structures that will allow for use of existing excess capacity in secondary grade buildings or embark on a construction program.

A new elementary school has been planned for west Cranston (Comprehensive Plan, Page 225). Construction cost has been estimated at $7 million. Additionally, the city estimates that it will cost approximately $1.5 million to acquire a 30 acre parcel for the school site. Thus total cost for the new school will be approximately $8.5 million. Land acquisition is anticipated in the next few years with construction phased in as enrollments warrant which is anticipated to be five years.

Municipal Finances

Revenues and expenditures for the fiscal year ending 1992 is shown below (Official Statement of the City of Cranston Rhode Island, June 1993, page 28):

Revenue	
General Property	$76,639,118
Intergovernmental and Departmental Revenue	25,821,965
Licenses and Permits	1,095,521
Fines and Interest on Late Payments	824,059
Interest on Investments	276,636
Other Revenues	3,640,652
Total	$107,297,951

Expenditures	
General Government	$ 2,487,099
Financial Administration	2,177,517
Public Safety	23,512,722
Public Works	9,953,598
Human Resources	6,771,789
Education	61,112,178
Sundry	1,280,238
Total	$107,295,141

Note: Revenues add to $108,297,951.

The Fiscal Year 1992-93 tax rate on real estate and tangible personal property was $36.84 per $1,000 of assessed valuation. The City's fiscal year 1992 property taxes were levied on June 1, 1991, on assessed valuation as of December 31, 1990. The last valuation of property was effective December 1983 at 94 % of market value at that time. The rate of assessment for the fiscal year ending June 30, 1992 was 65 % for real estate and 100 % for motor vehicles. Education expenditures were approximately 57 % of total expenditures for Fiscal Year 1992. Property taxes contributed approximately 71 % of total revenues.

Sewer assessments are deposited in the Sewer Enterprise Fund and are sufficient to cover the cost of the operation of the Wastewater Treatment Plant as well as debt service on city debt incurred for sewer purposes. As of August 1992 user fees are $185 per residential unit and are $0.55 or $0.813 per 100 cubic feet for commercial users depending on the type of commercial business. In the without Federal project condition sewer rates are likely to rise with the city's sewer system expansion.

The water rates for residential users are $0.64 per 100 cubic feet up to 400,000 cubic feet and $0.64 per 100 cubic feet for industrial users up to 400,000 cubic feet and $0.32 per 100 cubic feet over 400,000 cubic feet.

Utilities

Wastewater Treatment and Sewers - The city's Wastewater Treatment Facility (WWTF) was designed to treat an average daily flow of 23 million gallons per day. Currently the average daily flow is about 12.3 million gallons per day The City of Cranston is currently undergoing planning and design efforts to bring the WWTF into compliance with their discharge permit. Presently, almost 90 % of the population is served by sewers with over 225 miles of sanitary sewers.

In Service Area 1 the city is expanding its sewer system capacity to allow for greater flows from the I-295 pumping station district where in 1990 about 110 households were served. The population served in this district is expected to increase to 1,775 people by 2015 and 3,220 people by total build out in 2045.

In Service Area 2 in the without project condition it is assumed no new sewer service would be provided.

In Service Area 3, the Howard pumping station district, in the without project condition the city is expected to continue to provide sewer service to this area and schedule modifications as appropriate.

Water Service - The city's water needs are served by the city's Water Division for west Cranston, The Kent County Water Authority, and the Providence Water Supply Board. In addition to the city, the Providence Water Supply Board serves Providence, Johnston, North Providence, and parts of the City of Warwick and the Town of Smithfield. The primary source for these suppliers is Scituate Reservoir.

Public Safety

The Cranston Police Department has 215 employees including the chief and deputy chief.

The Fire Department has a force of 195 including chief, four deputy chiefs, twelve captains, twenty-six lieutenants, and 120 hose persons. The Fire Department provides emergency medical services including ALS (advanced life support). The City also has four fire stations staffed by volunteers. (Official Statement of the City of Cranston, RI, June, 1993 and City of Cranston Monograph.)

Currently west Cranston is served by volunteer fire companies. With residential growth in west Cranston, volunteer fire stations most likely will have to be converted to full-time manned stations in order to maintain adequate response time.

Transportation

Residential growth in west Cranston is expected to add 550 to 790 dwelling units a decade resulting in an estimated 3,500 peak hour trips by the year 2045 (Comprehensive Plan, page 194). To support this growth existing highway capacity will need to be enhanced by upgrading existing roadways and developing a new arterial corridor and a number of roadway cross-connections.

WITH PROJECT CONDITIONS

This section discusses the most likely future conditions for the socioeconomic resources identified in the previous section. These impacts are a result of construction of Federal project options. Federal project options are for extension of the city's sewer system to the proposed Village Center (Option 1C) in Service Area 1 and to other areas of west Cranston in Service Area 2 (either option 2A or 2B or 2C and option 2D). Service Area 3 is not discussed as there is no Federal project option proposed for this area.

Land Use

Industrial Land Use - In Service Area 1 no change in industrial land use is expected as a result of a Federal project.

In Service Area 2 with a federal project, industrial growth is anticipated to occur at the Tilcon Gammino gravel extraction site. This site comprises about 140 acres. Although the Tilcon Gammino's site is currently zoned for industrial use, there are some infrastructure improvements that would be needed for its continued use in this purpose. Access to the site along Natick Avenue and Phenix Avenue would need to be upgraded and adverse traffic impacts on residential neighborhoods would need to be mitigated. If access to Route 37 cannot be improved then this land may be developed for residential use (Comprehensive Plan, page 37). Thus industrial land use is not expected to be impacted by the project. However, with a project the Tilcon Gammino site will be able to change industrial use. For the feasibility study, it is assumed that full build out at the site will occur by the year 2045 with 68 %, or about two thirds, of this industrial growth occurring by the year 2015. This assumption was made by Tutela Engineering Associates in planning for the wastewater treatment facility. Thus 93 acres are expected to be developed by 2015 and 140 acres developed by 2045.

Residential Land Use - In Service Area 1 construction of the Scituate Pumping station and force main/variable sewer (Option 1C) would facilitate the establishment of a Village Center comprising 120 acres of residential development and a mix of commercial, public, civic, and institutional uses. (Comprehensive Plan, page 153).

In Service Area 2, a Federal project would not impact on residential land use as development is expected to occur with or without sewers. However, providing the framework for a sewer system in this area may facilitate the design of cluster residential development by providing an alternative to on-site septic systems. Cluster development permits the same number of dwelling units to be built on smaller lots while simultaneously designating common open space areas. The city's goal for cluster residential in west Cranston is 1,480 acres (Comprehensive Plan, page 30).

If the Village Center and cluster development concept is implemented as proposed in the City's Comprehensive Plan, this would allow for preservation 124 acres of open space and 370 acres of common open space in west Cranston.

Population

There are not expected to be any identifiable direct impacts on population from an extension of the sewer system in Service Areas 1 or 2. The city does not believe that the municipal sewer system should be used to influence residential development (Comprehensive Plan, page 153). Thus zoning requirements will be independent of the availability of city sewerage.

Due to secondary economic impacts, population in Providence County, which includes Cranston, is expected to increase due to job creation in Service Area 2 at the Tilcon Gammino site. This anticipated growth is an additional 4,400 people by 2045.

Labor Force

Long Term - In Service Area 1 the Federal project is not expected to impact on projected employment growth (see discussion under without project condition).

In Service Area 2, employment is estimated to increase by 1,800 in 2015 and by 2,700 in 2045. These increases are expected in the with project condition assuming road improvements are made to provide access to the Tilcon Gammino site from Route 37 (Comprehensive Plan, page 37 and discussions with the city planner).

Employment projections discussed in the previous paragraph are the direct impacts of industrial development that would be permitted with municipal sewerage. The indirect impacts of secondary spending rounds are expected to be felt over a wider area. In Providence County the following increases in employment of 2,800 and 4,100 are projected for the years 2015 and 2045.

Short Term - The short term project construction impacts on annual employment for Providence County are shown below. For the purpose of employment analysis, it is assumed that construction will take about two years for project completion.

Option	Employment
1C	20
2A with 2D	95
2B with 2D	96
2C with 2D	86

Income

Long Term - Projected changes in income are based on the current average annual income for the Cranston workforce. Income projections are obtained by multiplying the projected employment changes discussed above by the average annual wages for the employment mix that is anticipated to occur, $27,152 per employee. Again as with land use and employment this industrial growth is projected to occur only in the with project condition.

In Service Area 2 annual income is expected to increase by $48,874,000 in 2015 and to $73,312,000 by the year 2045 as a result of projected industrial growth at the Tilcon Gammino site. For Providence County, the total increase in annual income earned in this county as a result of the project is $66,443,000 and $99,664,000 for the years 2015 and 2045, respectively. As discussed above, projected income increases in Service Area 2 are dependent on road improvements to provide access to Route 37.

Short Term - The short term construction impacts on annual income for Providence County are shown below. For purpose of the income analysis, it is assumed that construction will take about two one years for project completion.

Option	Income
1C	$474,500
2A with 2D	$2,199,000
2B with 2D	$2,205,500
2C with 2D	$1,972,000

Sales

Long Term - Not enough information exists to estimate sales increase in Cranston. However, for Providence County, as a result of industrial growth in Service Area 2, it is estimated that direct sales will increase by $36,478,000 by the year 2015 with induced sales amounting to another $73,411,000 for a total sales impact of $109,889,000 annually. By the year 2045 this impact on spending is estimated to be $164,834,000 annually. Projected sales increases in Providence County as a result of growth in Service Area 2 are dependent on road improvements to provide access to Route 37.

Short Term - The short term construction impacts on annual sales for Providence County are shown below. For purpose of the sales analysis, it is estimated that construction will take approximately two years for project completion.

Option	Sales
1C	$1,553,000
2A with 2D	$7,193,500
2B with 2D	$7,216,000
2C with 2D	$6,452,000

Housing

Direct Impacts - The Federal project is not expected to have an impact on housing in any of the Service Areas. The City of Cranston does not wish to let the extent of municipal sewerage be a determining factor in their land use program.

Indirect Impacts - As a result of increased employment and income projected for the with federal project condition, there will be an increased demand for housing in Providence County. The increase in demand for owner occupied units and rental units is estimated for 2015 and for 2045.

Owner-occupied		Rental	
2015	2045	2015	2045
963	1,444	605	1,256

Indirect housing impacts depend on road improvements to provide access to the Tilcon Gammino site from Route 37.

Schools

Direct Impacts - As discussed above there are no anticipated impacts on population growth as a result of a Federal project.

Indirect Impacts - As a result of economic growth in Service Area 2 arising from a federal project, the number of school age children in Providence County is projected to increase. Projected increases in school enrollment for the county in year 2015 and year 2045 are 718 and 1,077 respectively. Again, school enrollment changes in Providence County as a result of the sewer project are dependent on road improvements to improve access to the Tilcon Gammino site.

Municipal Finances

Construction of a federal project will have financial impacts on the city. The city would pay 50 % of the first cost of construction, 100 % of all operation and maintenance costs and possibly 100 % of future improvement costs. In addition, the city will have to pay for the lateral sewer lines. The estimated cost of the laterals is $20 million (Comprehensive Plan, Page 225). Although this is a very rough estimate and is not developed to the extent of the interceptor cost estimate, it does provide an order of magnitude for this additional cost. The costs for options considered as part of a federal project are given below. Options 2A, 2B and 2C are mutually exclusive alternatives. Costs presented are in October 1993 dollars. The annualized first cost and total project cost is based on an interest rate of 7.75 % and a 50 year project life.

Table 1. Federal Project Option Costs

SERVICE AREA 1	
Option	1C
First Cost	$1,864,600
Future Improvements Cost	$ 0
Annualized First Cost	$ 148,100
Annual O&M	
1995 to 2015	$17,700
2016 to 2045	$20,500
Annualized Total Cost	$ 166,400

SERVICE AREA 2					
Option	2A	or	2B	or	2C
First Cost	$4,694,800		$4,743,100		$3,642,100
Future Improvements Cost	$ 305,500		$ 396,400		$ 680,700
Annualized First Cost	$ 376,500		$ 381,500		$ 297,600
Annual O&M					
1995 to 2015	$ 53,700		$ 55,600		$ 47,800
2016 to 2045	$ 97,700		$ 104,800		$ 84,400
Annualized Total Cost	$ 439,200		$ 447,200		$ 353,000

SERVICE AREA 2	
Option	2D
First Cost	$4,282,000
Future Improvements Cost	$ 777,100
Annualized First Cost	$ 349,500
Annual O&M Cost	
1995 to 2015	$ 6,000
2016 to 2045	$ 25,140
Annualized Total Cost	$ 359,400

The details on how this sewer project will be funded for the local share have not been worked out by the city. Sewer projects are not included in the Capital Budget, but funded through sewer enterprise bonds. Whether all sewer users will be assessed or only those receiving the hook-up has not yet been determined.

Utilities

Federal project options would allow the extension of sewer service to Service Area 2 and the Village Center in Service Area 1. However, the impact on water, electricity and other utilities is expected to be minor as these areas would develop with or without the project.

Public Safety

It is not anticipated that population will increase as a result of the project. Thus, there will be no impact on the operations of the fire and police departments in Cranston.

Transportation

Aside from some short-run traffic delays and detours, the additional work force increases should have only minor impacts on roads and highways in Cranston.

SUMMARY

The major socio/economic benefits and costs of the Federal project options considered are summarized below.

Option 1C

Construction of the Scituate Pumping station and force main/variable grade sewer (Option 1C) would allow the development of a Village Center near the intersection of Pippin Orchard Road and Scituate Avenue in Service Area 1. The Village Center would consist of centralized residential development and a mix of commercial, public, civic, and institutional uses. If the Village Center is developed as proposed in the city's Comprehensive Plan about 124 acres of open space could be preserved in west Cranston.

Options 2A or 2B or 2C with 2D

These options would have the same socio/economic effects. Construction of a new wastewater conveyance connector system to west Cranston (Service Area 2) would permit future economic development at the Tilcon Gammino. This growth assumes transportation access to the site is also improved. An estimated 1,800 jobs would be created by 2015 and 2,700 by 2045. The direct income effects in Service Area 2 would be $48,874,000 in 2015 and $73,312,000 in 2045. The total effect on income in Providence County is estimated to be $66,443,000 in 2015 and $99,664,000 in 2045. The total impact on sales in Providence County is estimated to be $109,889,000 by 2015 and $164,834,000 by 2045.

Also extending the sewer system to west Cranston residential area may facilitate the design of cluster residential development by providing an alternative to on-site septic systems. Cluster development permits the same number of dwelling units to be built on smaller lots while simultaneously designating common open space areas. The city's goal for cluster residential in west Cranston is 1,480 acres (Comprehensive Plan, page 30). If the city's goal is met about 370 acres could be preserved in common open space.

Federal Options Annualized Cost

Annualized project and operation and maintenance costs for 50 years at 7.75 % are:

Option 1C	$166,400
Option 2A	$439,200
Option 2B	$447,200
Option 2C	$353,000
Option 2D	$359,400

APPENDIX K

Task 10c - Water Quality and Hydrology Assessment

FEASIBILITY REPORT APPENDIX
WATER QUALITY AND HYDROLOGY ASSESSMENT
(TASK 10C)
CRANSTON, RHODE ISLAND

HYDRAULICS AND WATER QUALITY BRANCH
WATER CONTROL DIVISION
ENGINEERING DIRECTORATE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

FEBRUARY 1994

TABLE OF CONTENTS

Paragraph	Subject	Page
1	SUMMARY	K-1
2	SURFACE WATER QUALITY GENERAL	
	a. General Watershed	K-2
	b. Water Quality Classification	K-2
	c. Future Water Quality Classification	K-2
	d. Pawtuxet River	K-3
3	POLLUTION SOURCES	K-3
	a. Point Source Discharges	K-4
	b. Nonpoint Source Pollution	K-4
	c. Pawtuxet River Sediments	K-5
4	SURFACE WATER QUALITY CONDITIONS	
	a. Main Stem Pawtuxet River	K-5
	b. Tributaries--Pocasset River	K-6
	c. Tributaries--Meshanticut Brook	K-6
	d. Tributaries--Capuano Stream	K-7
	e. Tributaries--Interstate Highway Drainage	K-7
5	GROUNDWATER QUALITY	
	a. General	K-8
	b. Classification	K-8
	c. Quality	K-8
6	LANDFILLS	
	a. Introduction	K-9
	b. Central Landfill	K-9
	(1) Water Quality Classification	K-9
	(2) Surface Water Quality	K-9
	(3) Groundwater Quality	K-9

Paragraph	Subject	Page
	c. Vinagro Landfill	K-10
	(1) Water Quality Classification	K-10
	(2) Surface Water Quality	K-11
	(3) Groundwater Quality	K-11
	d. Capuano Landfill	K-11
	(1) Water Quality Classification	K-12
	(2) Surface Water Quality	K-12
	(3) Groundwater Quality	K-12
7	SEPTIC SYSTEMS	
	a. General	K-13
	b. Normal Systems	K-13
	(1) Design	K-13
	(2) Groundwater Contamination	K-14
	(3) Pathogens	K-14
	(4) Organic Compounds	K-14
	c. Failing Systems	K-15
	(1) Surface Water Contamination	K-15
	(2) Western Cranston	K-15
	(3) Groundwater Contamination	K-15
8	WATER QUALITY EFFECTS OF ALTERNATIVES	
	a. General	K-15
	b. Water Quality During Construction	K-16
	c. Specific Options	K-16
	d. Without Project Condition	K-17
9	HYDROLOGY	K-17
	REFERENCES	K-18

FEASIBILITY REPORT APPENDIX
WATER QUALITY AND HYDROLOGY ASSESSMENT
CRANSTON, RHODE ISLAND

1. SUMMARY

This report examines water quality in the Pawtuxet River and its tributaries in Cranston, Rhode Island, and assesses impacts of feasibility study alternatives on water quality and hydrology.

Although most tributaries to the Pawtuxet River in Cranston are rated class B, some are severely impacted by nonpoint source contamination. The main stem of the Pawtuxet River is rated class C, but fails to meet the goals for that classification. A 1991 study by Tutela Engineering Associates (TEA) concluded that nonpoint source pollution had a significant effect on water quality in the Pawtuxet River and its watershed. Areas most impacted by nonpoint source contamination included Capuano Stream, Meshanticut Brook, and those receiving drainage from Interstate 95. Additionally, the study found that it may not be possible to achieve desired water quality improvements in the Pawtuxet River solely by upgrading wastewater treatment facility (WWTF) discharges. Rather a combination of WWTF improvements and a reduction in nonpoint source pollution will be required.

The net effects on water quality of implementing options considered in this feasibility study will be improvements in areas affected by landfills, septic tank systems, or sewer pipe or pump station overloadings. Changes in water quality will be too diffuse to describe quantitatively. There will be water quality impacts during construction, but these will be temporary and can be mitigated by proper construction and erosion control techniques. Effects on groundwater will come from eliminating septic systems and their associated effects on groundwater, and improvements in areas around landfills.

The exact nature of water quality and hydrologic effects will depend on which areas are serviced. As the Corps project is for "trunk sewers," it is the extent of sewer lines and house connections feeding those trunks, rather than the trunks themselves, which will determine the ultimate extent of impacts.

Hydrologic effects due to implementing these options will be very small. Flows which presently reach surface water through septic systems will be sent through sewer pipes to

the WWTF, resulting in flow reductions in tributaries to the Pawtuxet River; however, this change will be small. Furthermore, since most of this flow originated in the Scituate Reservoir watershed, which is outside the study area, natural streamflow will be affected only slightly in areas where sewers are being considered. Groundwater pumped from beneath landfills and sent to the WWTF would represent a reduction in streamflow. However, amounts would be very small compared to natural streamflows. Finally, there will be a reduction in tributary stream flows due to infiltration and inflow (I/I) in any new sewer systems in the area. However, because it is expensive to pump and treat excess flows, it is in the city's best interests to use sewer construction techniques that keep I/I very small, and it is likely I/I, due to new sewer construction, will be minimal and have little impact on streamflows.

2. SURFACE WATER QUALITY GENERAL

a. General Watershed. Important water bodies within the study area are Meshanticut Brook, the lower part of the Pocasset River, and portions of the Pawtuxet. The bulk of the study area is within the watersheds of Meshanticut Brook and its major tributary, Furnace Hill Brook. Although it mostly flows through eastern Cranston and outside the study area, the Pocasset River is important to this study because runoff from the Central Landfill goes into the Simmons Reservoirs which are tributaries to the Pocasset. The Pawtuxet River is important because the entire study area is within its watershed. Finally, the very small Capuano Stream is significant because it drains the Capuano landfill site.

b. Water Quality Classification. Although its upper watershed is mostly designated class A and suitable for public water supply, by the time the Pawtuxet River reaches Cranston it is a class C stream. The Pocasset River from Print Works Pond to the Pawtuxet, which represents most of its length through Cranston, is also a class C stream. Meshanticut Brook and its tributaries are classified "B". Streams, such as Capuano, which are too small to be given specific classifications, are generally classified "B". Class B waters are suitable for public water supply after appropriate treatment, agricultural uses, swimming, and fish and wildlife habitat. Class C waters are suitable for secondary contact recreation, fish and wildlife habitat, and certain industrial processes.

c. Future Water Quality Classification. As required by the Clean Water Act, all freshwater rivers must now have their classifications upgraded to a goal of "B"--"fishable/

swimmable--or better. Consequently, the Rhode Island Department of Environmental Management (RIDEM) is proposing to upgrade the goal for the Pawtuxet River to "B" in 1994. However, as there will still be elevated coliform levels in the river, a subcategory of class B will be used to indicate an advisory or warning about actually swimming in the river. The Pocasset River, on the other hand, will be upgraded to a straight class B. A draft of these changes is proposed to be available for public comment in spring 1994, with the final issued in the summer (Carey, 1993).

d. Pawtuxet River. Data were not collected by the Corps for this study; however, based on available information and past reports, it is clear that the Pawtuxet River is one of the most polluted in Rhode Island. From the confluence of the North and South Branches to tidewater, including the section bordering Cranston, the river is designated class C. Such waters are neither fishable nor swimmable but are suitable for boating, fish habitat, and industrial processes. However, the main stem Pawtuxet River does not consistently meet class C water quality standards. Dissolved oxygen (DO) is the primary concern. Effects of toxic substances, including ammonia and heavy metals, are secondary and unresolved concerns. Heavy metals and ammonia have been measured at or estimated to occur at levels exceeding U.S. Environmental Protection Agency (EPA) criteria to protect aquatic life (RIDEM, 1990a, 1992; M&E, 1984). However, no studies have ever confirmed that harm is actually occurring. Additionally, some metals such as copper, lead, and silver occur extensively throughout the watershed in ground and surface water at levels exceeding EPA chronic criteria (RIDEM, 1990a). Consequently, the city is attempting to convince EPA that site specific criteria for these metals in the Pawtuxet River should be used rather than EPA's national criteria (RIDEM, 1992). Fecal coliform bacteria are elevated in the Pawtuxet River, as well as other parts of the watershed, but are not high enough to violate existing standards or limit uses of the water. Elevated levels of color, sodium, chloride, phosphorus, and nitrate have been observed, but not in concentrations which would limit uses of the water (RIDEM, 1990a, 1992).

3. POLLUTION SOURCES

Surface water quality in the Pawtuxet River Basin is primarily degraded by nonpoint sources, and effluents from three wastewater treatment facilities (WWTF): Cranston, Warwick, and West Warwick. Groundwater quality is affected by nonpoint sources and one major point source--the Central Landfill which is also the only location of an EPA Superfund

site in the watershed (RIDEM, 1992). Outside of areas around the landfill and immediately downstream, groundwater in the study area is primarily degraded by nonpoint sources, including septic tank systems, leaking underground storage tanks, and fertilizers.

a. Point Source Discharges. The "Pawtuxet River Waste Load Allocation Strategy for the Development of RIPDES Permit Limits" (RIDEM, 1988a) lists five significant point source discharges. Two are industrial point source discharges--Hoechst Celanese Corporation and Original Bradford Soap Works, both located on the South Branch; and three are municipal wastewater treatment facilities (WWTF)--Cranston, Warwick, and West Warwick, all located on the main stem. There also are 11 other point sources located on either the North Branch of the main stem Pawtuxet, or their tributaries (TEA, 1991). All point source facilities are regulated by RIDEM. However, their contributions were considered too small to be included in the wasteload allocation study.

In the Pawtuxet River waste load allocation study (RIDEM, 1988a), Original Bradford Soap Works was found to have minimal effects on instream concentrations of pollutants, and was not considered significant in the study. Excluding groundwater and nonpoint sources, Hoechst Celanese was the major contributor of trace metals upstream from the three municipal WWTFs. However, its influence on downstream concentrations was not enough to address this industry as part of the municipal WWTF's allocation of trace metals. Numerous simulations have shown that Hoechst Celanese's discharge has an insignificant impact on the DO concentration of the main stem Pawtuxet River. The allocation study used flows of 1.05 and 0.11 million gallons per day (mgd) for Hoechst Celanese and Bradford Soap, respectively. Of the three municipal WWTFs in the watershed, Cranston's has the largest discharge. The allocation study used flows of 23, 7.89, and 5 mgd for Cranston, West Warwick, and Warwick, respectively. However, Cranston's current actual discharge is closer to 12 mgd (TEA, 1991). All three municipal WWTFs have primary and secondary treatment; however, the allocation study concluded that the only realistic option to ensure the Pawtuxet River main stem reaches its low flow DO and NH_3 criteria is to require advanced treatment (RIDEM, 1988a).

b. Nonpoint Source Pollution. A 1991 TEA study found that nonpoint source pollution had a significant effect on water quality in the Pawtuxet River and its tributaries. Potential origins of nonpoint source pollution include agricultural activities, landfills, individual subsurface disposal systems, road salt storage areas, cross connections

from sanitary sewers, and runoff from highways, industrial, commercial, and residential areas. The study concluded that it may not be possible to achieve desired water quality improvements in the river solely by upgrading WWTF discharges. Rather a combination of WWTF improvements and a reduction in nonpoint source pollution will be required. Areas in Cranston most impacted by nonpoint source contamination included Capuano Stream, Meshanticut Brook, and streams receiving drainage from Interstate 95.

c. Pawtuxet River Sediments. Although generally included with nonpoint sources, Pawtuxet River sediments are given special attention because of their effects on DO levels. At the present time, the main stem Pawtuxet River does not consistently meet its class C designation due to low DO levels. The "Pawtuxet River Use Attainability Study" (M&E, 1984) reported that oxygen demand from sediment was a dominant factor in evaluating alternatives for achieving DO standards. This report states that either a reduction in sediment oxygen demand, or implementation of instream aeration, would be necessary to meet desired water quality objectives in the entire length of the river during critical low flow periods. Dredging of oxygen-depleting materials in the river, especially behind Pawtuxet Cove and Pontiac Dams where oxygen consumption is a major problem, could provide some benefits. However, these would be short-lived unless future organic deposition to the river is also reduced. Sediments also contain toxic materials including heavy metals and organic compounds in concentrations potentially harmful to aquatic life.

4. SURFACE WATER QUALITY CONDITIONS

a. Main Stem Pawtuxet River. The main stem Pawtuxet River is, and historically has been, one of the most polluted rivers in Rhode Island. Sources of pollution include industrial and municipal discharges, urban storm water runoff, agricultural runoff, effects from failed or overloaded septic systems, and buildup of contaminated sediments.

Water quality in the entire length of the main stem Pawtuxet River is considered by RIDEM not to be in support of designated uses, mainly aquatic habitat. Heavy metals including cadmium, copper, lead, mercury, and silver, petroleum hydrocarbons, ammonia, and low DO are causes of noncompliance (RIDEM, 1990a, 1992). Additionally, elevated levels of color, sodium, chloride, phosphorus, nitrate, and coliform bacteria have been observed, but not in concentrations exceeding class C criteria (RIDEM, 1990a, 1992). Pollutant sources to the main stem include Warwick, West Warwick, and

Cranston WWTFs; agricultural runoff, urban and highway runoff, and contaminated river sediments. Of the various water quality problems afflicting this stretch of river, low DO and elevated ammonia levels appear to be of most concern because of effects on fish habitat. Some metals, especially lead and silver, are found extensively throughout the watershed in surface and groundwater at levels exceeding criteria, including upper reaches of the North and South Branches. Consequently, RIDEM (1988a) reported that criteria for these metals in the Pawtuxet River need to be reevaluated and the sources identified.

Upgradings to the municipal WWTFs on the Pawtuxet River are being considered. However, even if these are implemented, it is likely that nonpoint sources and contamination from sediments will prevent the main stem Pawtuxet River from consistently meeting the goals of its water quality classification. Parameters which will likely have violations include DO metals, and petroleum hydrocarbons (RIDEM, 1992).

b. Tributaries--Pocasset River. The Pocasset River and its tributaries upstream from Print Works Pond are designated class B. From Print Works Pond to the Pawtuxet River the rating is class C. Upper and Lower Simmons Reservoirs, which receive runoff from Central and Vinagro Landfills, and Simmons Brook from Lower Simmons Reservoir to Print Works Pond, are designated class B. Although conditions in these waters are not considered meeting class B criteria, fishable/swimmable conditions are considered attainable according to RIDEM's 1990 report to Congress. Sampling in August 1989, by Goldberg-Zoino & Associates (GZA, 1990), showed extremely high levels of fecal coliform bacteria in Cedar Pond Brook after it passed the landfill, and even higher levels at the entrance to Upper Simmons Reservoir. This may explain Solid Waste Management Corporation's (operators of the Central Landfill) actions in buying and closing all homes on Simmons Reservoir. At Print Works Pond, class B conditions are not supported and fishable/swimmable conditions are not considered attainable by RIDEM. There are no significant point source discharges to Print Works Pond. RIDEM gives the principal problems at Print Works Pond as being due to urban runoff and contaminated sediments. Sources of these sediments are not given; however, Central and Vinagro Landfills are upstream and it is possible contaminants from these landfills were carried in by Simmons Brook (RIDEM, 1990a).

c. Tributaries--Meshanticut Brook. Meshanticut Brook and its tributaries are rated class B, and considered by RIDEM to be meeting conditions of its class B designation (RIDEM, 1988b). However, there is little information on the

condition of Furnace Hill Brook, a major tributary to Meshanticut. The Meshanticut Brook watershed includes much of "service area 2" in this feasibility study. A groundwater map for the area shows Furnace Hill Brook watershed as being entirely glacial till, where it is not exposed bedrock. Glacial till has very low permeability, making it poor quality for wells or septic systems. Since the area is not sewered and relies on septic systems for disposal of domestic wastewater, pollution of surface waters including Furnace Hill Brook would be expected, especially during rainstorms. A 1991 nonpoint source pollution study by TEA bore this out. Meshanticut Brook contained elevated levels of coliform bacteria and phosphorus, which are common contaminants in domestic wastewater. When homes are connected to properly functioning individual subsurface wastewater disposal systems, movement of wastewater through the soil effectively removes bacteria and phosphorus. Their presence, in elevated concentrations in Meshanticut Brook, indicates septic systems discharging to saturated soils, or experiencing other serious problems.

TEA's 1991 study concluded that the ultimate solution, to correct the problems of individual subsurface disposal systems polluting Meshanticut brook, was to provide municipal sewer collection and conveyance systems within the watershed.

d. Tributaries--Capuano Stream. This small stream has a watershed of only 120 acres, and flows through the Howard Industrial Park and along the perimeter of Capuano Landfill, and was included in the TEA 1991 nonpoint source study. Results of an initial dry-weather sampling showed very high concentrations of heavy metals, including cadmium, chromium, copper, lead, nickel, and zinc; and a pH as low as 3.5 SU. Later samplings did not repeat these initial results, leading TEA to speculate that possible periodic phenomenon such as illegal industrial discharges from the Howard Center might be occurring. Wet weather samplings showed high levels of BOD in drainage from the Howard Center; this was attributed to the "first flush" of solids at this location. Phosphorus and silver found in the stream were hypothesized by TEA to be coming from the landfill, or upstream sources including the Howard Center or Rhode Island Medical Center.

e. Tributaries--Interstate Highway Drainage. The TEA 1991 nonpoint pollution study included runoff measurements from Interstate Highway Route 95. Although samples were taken in eastern Cranston, which is not part of this feasibility study area, results are likely typical of I-95 and I-295 in western Cranston. Sampling of dry weather flow

found lead, but no detectable levels of total petroleum hydro-carbons (TPH). Wet weather sampling found lead, copper, zinc, and high levels of TPH, which were attributed to vehicular traffic.

5. GROUNDWATER QUALITY

a. General. There are no sole source aquifers (SSA) within the study area. To qualify as a SSA, an area must rely on groundwater for more than 50 percent of its drinking water supply and have no feasible supply alternatives, among other requirements. Additionally, there are no groundwater reservoirs or critical portions of their recharge areas within the study area (RIDEM, 1992).

b. Classification. Most of the study area's groundwater is classified as threatened, except for portions under more developed portions of eastern Cranston which are considered impacted. Threatened areas have groundwater which is presumed suitable for drinking water use, except for localized degradation. Nonpoint sources are prevalent in these areas, and threaten groundwater quality. Impacted areas have groundwater which is presumed not suitable for drinking water use, due in large part to nonpoint source pollution.

c. Quality. Groundwater throughout the watershed is generally clean or has trace levels of organic contaminants. An exception is groundwater immediately within or downstream from Central Landfill; this has higher concentrations of organic contaminants and metals. Highest levels of contamination are found in shallow wells directly within the landfill. Elsewhere in the watershed, groundwater contamination is principally caused by leaking underground storage tanks, salt storage sites, agricultural fertilizers, pesticides, and septic tank systems. Contaminants most commonly associated with groundwater pollution in Rhode Island include volatile organic compounds (VOCs), the pesticide aldicarb, nitrates, chlorides, bacteria, and metals. VOCs found in groundwater wells in the watershed are typically substances like tricholorethylene, formerly used as a degreasing compound in septic tanks, and methyl tertiary butyl ether, an anti-knock compound in gasoline. Groundwater contamination with the pesticide aldicarb appears to be a problem mostly in the southern part of the State and outside the study area (RIDEM, 1992). Nitrates enter ground through septic tanks, and excessive fertilizer applications. Chlorides in groundwater originate in road salt storage sites and septic tanks. Bacteria and metals most commonly enter groundwater through septic tank systems.

6. LANDFILLS

a. Introduction. Three landfills in the study area are of particular concern: Central, Vinagro, and Capuano (figure 1). Concerns about these landfills include that they are and will continue to cause significant pollution, unless leachate and contaminated groundwater are collected and treated.

b. Central Landfill. The Central Landfill, also known as the Johnston Landfill, is located in Johnston, Rhode Island, 1 mile north of the Cranston border, and across Green Hill Avenue from Simmons Upper Reservoir. Operated by the Solid Waste Management Corporation, the Central Landfill receives 80 percent of the State's solid waste.

(1) Water Quality Classification. Cedar Swamp Brook flows through the Central Landfill site into Upper and Lower Simmons Reservoirs, Simmons Brook, Print Works Pond, the Pocasset River, and finally the main stem Pawtuxet River. From Cedar Swamp Brook to the discharge from Print Works Pond, these waters are designated class B by the Rhode Island Department of Environmental Management. From Print Works Pond to the Pawtuxet River, they are designated class C.

(2) Surface Water Quality. Limited data are available on water quality in Cedar Swamp Brook upstream from the Central Landfill; however, the relatively undeveloped nature of the watershed indicates class B fishable and swimmable conditions are probably met. Sampling data for Cedar Swamp Brook below the landfill show small increases in metal levels including aluminum, zinc, nickel, and lead; large increases in turbidity and suspended solids; and an enormous increase in fecal coliform bacteria (GZA, 1989). Cedar Swamp Brook does not meet class B water quality conditions after receiving runoff and groundwater leachate from the Central Landfill. However, class B conditions are considered possible after the landfill is capped, and runoff and leachate from the landfill are controlled. When the landfill is properly capped, it is expected that conditions in Cedar Swamp Brook will meet class B conditions, except possibly during rainstorms when elevated levels of turbidity and suspended solids may occur in runoff from the Central Landfill Site.

(3) Groundwater Quality. Groundwater monitoring data indicate Central Landfill has an adverse impact on water quality in the vicinity of the landfill. However, the full vertical and lateral extent of contamination has not yet been defined. The most severe contamination has been observed in relatively shallow wells located within the landfill proper.

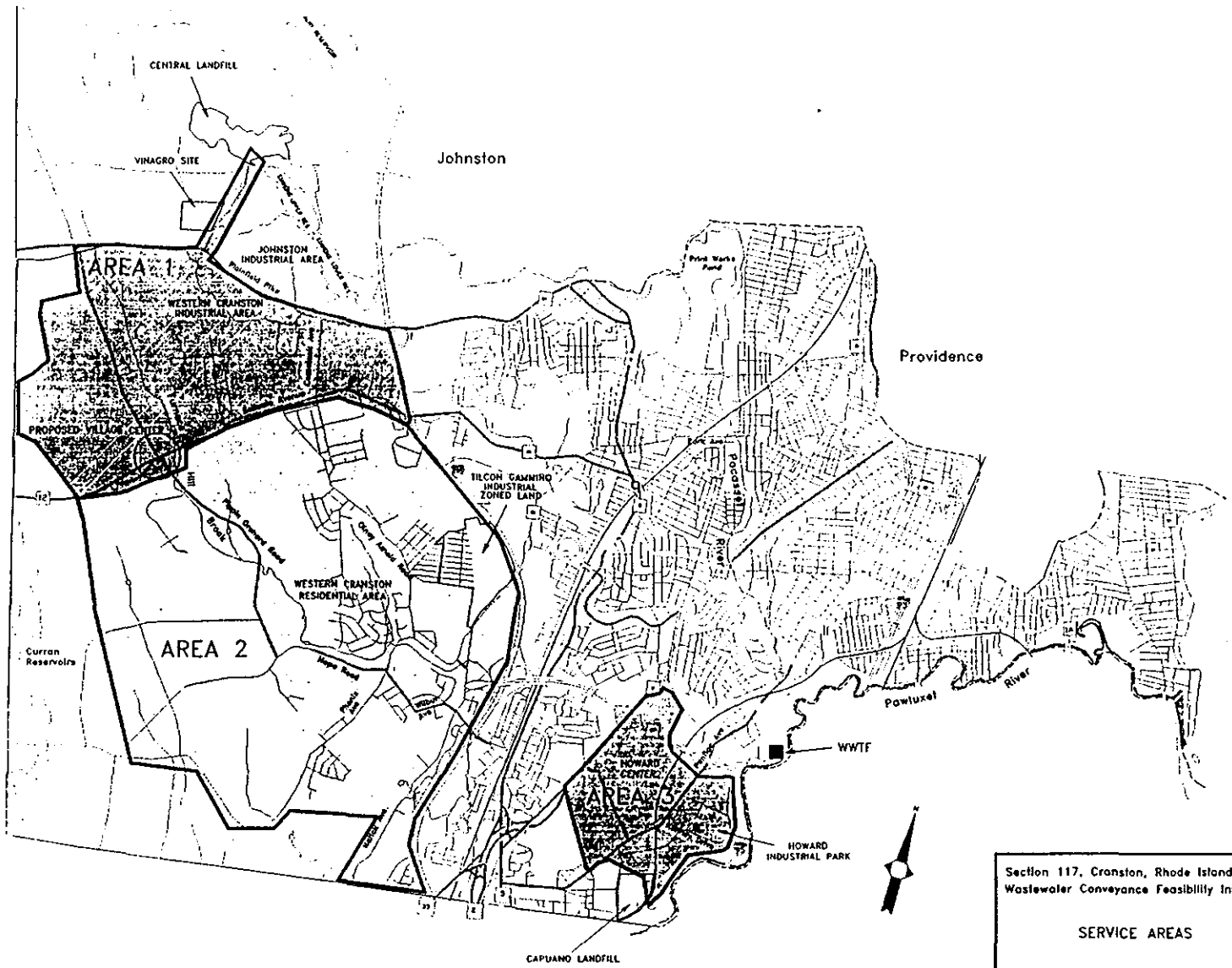
Groundwater taken immediately within or downstream from Central Landfill has higher concentrations of a variety of contaminants, including chloride, nitrate, sulfate, dissolved metals, and volatile and semivolatile organic compounds. However, only volatile organic compounds (VOCs) regularly show up in significantly elevated concentrations. Metal levels in monitoring wells during a February 1986 sampling, for example, were found only in concentrations below drinking water criteria (GZA, 1986).

Upgradient wells have shown VOCs levels generally below 10 parts per billion (ppb), although up to 100 ppb (mostly TCE) have been observed. In wells within and immediately downgradient of the landfill, VOCs concentrations from more than 100 to more than 1,000 ppb have been observed. These have been primarily chlorobenzenes, toluene, and total xylenes. Highest concentration of VOCs was in two wells downgradient of the former hazardous waste disposal area. During a May 1986 sampling, 94,000 ppb of chlorobenzene were measured in one of these wells (GZA, 1986). By comparison, drinking water criteria for chlorobenzenes are 5 to 600 ppb, depending on the specific compound.

c. Vinagro Landfill. This landfill is located in Johnston on Green Hill Avenue between Plainfield Pike and the Central Landfill. Past activities at this site have included farming of over 3,000 pigs at a time, disposal and burning of construction debris and other solid waste. Currently the site is used for stockpiling construction and demolition debris. Future plans include operating a recycling center and cogeneration facility. There also remains a stockpile of pig waste, which is planned for disposal by onsite composting.

The Vinagro site has been cited by RIDEM for pollution of Cedar Swamp Brook through uncontrolled surface runoff. In addition, the Vinagro site is currently on EPA's Comprehensive Environmental Compensation and Liability Act list as a potentially contaminated hazardous waste site. RIDEM is working with EPA to investigate this site further.

(1) Water Quality Classification. Drainage from the Vinagro Site flows by way of an unnamed brook into Upper Simmons Reservoir, through Lower Simmons Reservoir into Simmons Brook, Print Works Pond, the Pocasset River, and finally the main stem of the Pawtuxet. The unnamed brook is too small to receive an individual water quality classification by RIDEM. In the absence of an individual classification, the waters can be assumed as designated class B, with a goal of being fishable and swimmable. From Simmons Reservoirs to the



Section 117, Cranston, Rhode Island
Wastewater Conveyance Feasibility Investigation

SERVICE AREAS

U.S. Army Corps of Engineers
New England Division March 1993

FIGURE 1

discharge from Print Works Pond, the waters are designated class B, and from Print Works Pond to the Pawtuxet River, waters are designated class C.

(2) Surface Water Quality. The pig farm and landfill have been cited by RIDEM for pollution of Cedar Swamp Brook through uncontrolled surface runoff. However, limited data are available on water quality in the unnamed brook upstream or downstream from the Vinagro site. The relatively undeveloped nature of the watershed indicates class B conditions are probably met upstream from the site. Available data indicate this brook is negatively impacted by the site, particularly during storms.

Sampling of the brook has shown elevated levels of VOCs and heavy metals. Based on the history of usage at this site, and limited sampling data, it is likely that the Vinagro site also causes high levels of sedimentation, turbidity, and coliform bacteria in the unnamed brook during rainstorms. These effects likely extend through Cedar Swamp Brook into Upper Simmons Reservoir, but are masked by effects of the Central Landfill site on that body of water.

The owner is under court order to cap the landfill. Additionally, EPA is considering the site for inclusion in the Superfund program (EPA, 1992). Soils at the site have been found to contain elevated levels of VOCs, semi-volatile organic compounds, pesticides, PCBs, and lead. If cleanup is undertaken, conditions in the unnamed brook should improve to class B conditions.

(3) Groundwater Quality. Studies by NUS Corporation for the EPA (1989, 1990) found elevated levels of VOCs in groundwater at the Vinagro landfill. Metals in groundwater at the site appear to be a lesser concern. No data was located on nitrate levels in groundwater; however, they are likely high at the site because of pig waste disposal. Extent of VOC migration offsite has not been determined, but will likely be a part of future EPA studies.

d. Capuano Landfill. This landfill, also known as the Pontiac Avenue Landfill, is located just north of the intersection of Pawtuxet River and the Cranston-Warwick border, between Pontiac Avenue and the CONRAIL tracks. It is a closed, capped landfill with an operating transfer station.

According to a study by Ecology and Environment, Inc. (EEI, 1982), the Capuano Landfill site appears to be contaminating ground and surface water with organic compounds and heavy metals. Areas of heaviest contamination are along

the east and northeast sides. Vegetative stress has been observed on the Pawtuxet River flood plain downgradient of the landfill. Contaminated ground and surface waters appear to be flowing towards the Pawtuxet River.

(1) Water Quality Classification. Drainage from the landfill flows across a marsh and directly into the main stem Pawtuxet River. This wetland is too small to receive an individual water quality classification. In the absence of an individual classification, waters can be assumed as class B, with a goal of being fishable and swimmable. From confluence of the North and South Branches to Pawtuxet Cove, the main stem Pawtuxet River is designated class C by the Rhode Island Department of Environmental Management.

(2) Surface Water Quality. The landfill forms a steep mound which rises sharply above surrounding land. Consequently, runoff originating above the landfill is diverted around it, and direct precipitation produces the only runoff from the landfill. The presence of a wetland at the base of the landfill means that the groundwater table is high and leachate can affect surface water in the immediate vicinity.

Vegetative stress has been observed on the Pawtuxet River flood plain downgradient of the landfill. Aerial photographs taken in 1980 by the Region I, EPA, indicate that stress is localized along surface water drainage paths and edges of two ponds nearest the eastern side of the landfill (EEI, 1982).

Samples of surface water above and below the landfill show increases in total dissolved solids, sulfates, chlorides, Kjeldahl nitrogen, and iron downgradient from the landfill. Other tests, including coliform and chlorides, have shown marked increases in concentrations along the face and downstream of the landfill. Dissolved oxygen and pH measurements are slightly lower than levels observed upstream. It is likely, based on the solvents and heavy metals disposed at this site in the past, that organic compounds and heavy metals are contaminating surface water; iron, sulfates, chlorides, and Kjeldahl nitrogen are not likely to be causing the reported vegetative stress. However, because of inconsistencies in analyses of surface water samples, specific information on the amount of organic chemical and heavy metal contamination originating in the landfill is not available (EEI, 1982).

(3) Groundwater Quality. Studies indicate that a plume of groundwater, contaminated by numerous organic and

inorganic compounds not detected in background wells, is moving horizontally and vertically away from the landfill. Heaviest contamination is currently at two wells along the downgradient, east and northeast sides of the landfill. The distance this plume has traveled is not known. From types of soil and glacial materials present downgradient of the site, it is possible the plume has reached and is discharging into the Pawtuxet River (EEI, 1982).

Analyses have found many organic compounds at elevated levels in groundwater at the site. Compounds, detected at 100 ppb or more in at least one sampling, include acetone, benzene, chlorobenzene, ethyl benzene, methylene chloride, TCE, PCE, tetrahydrofuran, toluene, and xylene (EEI, 1982, Malafronte, 1989). Metals including lead, mercury, barium, and iron are found at elevated levels in wells downgradient from the landfill. Arsenic was found at an extremely high concentration (10,500 ppb) during one sampling round in a downgradient well (EEI, 1982).

7. SEPTIC SYSTEMS

a. General. Septic systems deserve special attention because they are the primary potential source of pollution that can be reduced or eliminated by constructing new sewers.

b. Normal Systems. A properly functioning septic system that receives no improper materials will not pollute surface or groundwater. Contamination of surface water mainly occurs when leaching fields for septic tank systems are located in soils with low permeabilities or high water tables. Except for localized problems, groundwater contamination mainly occurs from disposal of improper materials such as degreasers.

(1) Design. Septic tanks are designed to settle and remove solids and provide some biological degradation of dissolved and suspended organics. Clarified water from the tank flows into a leaching field of gravel or small stones. According to RIDEM regulations (1989), this field should be designed so the bottom of the stone is at least 3 feet above the maximum elevation of the groundwater table. Leaching fields for septic tanks typically consist of 500 to 600 square feet of drain bed, 1 and 1/2 to 2 feet below the ground surface. Under ideal conditions, i.e., a percolation rate of 5 minutes per inch or less, RIDEM requires a minimum of 375 square feet of effective leaching area for a 3-bedroom dwelling. With percolation rates of 40 inches per minute, 870 square feet of trench would be required for the same dwelling. Soil with a percolation rate of over 40 minutes

per inch is unsuitable for disposal of sewage by any means of subsurface leaching. Shallow bed depth allows some evaporation and uptake of contaminants by plants. Placing the drain field near the surface permits aerobic conditions, with the result that some degradation of the waste and bacterial die-off occurs before the wastewater reaches the groundwater. A zone of unsaturated soil between the leach bed and the water table is important so that septic tank effluent does not discharge directly into the groundwater, especially if it is an aquifer used for drinking water supply.

(2) Groundwater Contamination. Even a properly designed and maintained septic tank system can cause localized pollution of groundwater with nitrates, chlorides, and bacteria. The average septic tank effluent contains 40 mg/l of total nitrogen, and almost inevitably causes localized groundwater contamination. In addition, there may be metal contamination including copper, lead, and cadmium from plumbing drainage fixtures. However, the metals and bacteria are usually removed by adsorption, filtration, and die-off as the water moves through the soil, and nitrates and chlorides are diluted. As long as wells are not located too close to septic systems, the presence of such systems will not make the aquifer unsafe.

(3) Pathogens. The issue of groundwater contamination by pathogenic organisms is complex. The likelihood that pathogens, entering groundwater through septic tank systems, will survive long enough and travel far enough to cause illness, depends on a number of factors. The two most important survivability factors are temperature and soil moisture. Bacteria survive best in low temperatures and saturated conditions. Survival times among viruses vary greatly, depending on soil moisture, temperature and other environmental factors. Viruses are readily absorbed in clays, sandy loams, and soils with high organic content and, therefore, are not thought to be able to move as easily through an aquifer of these compositions as one of gravel or rock fractures. Waterborne parasites, including protozoa, worms, and fungi, are less commonly found in groundwater because their large size results in removal by soil filtration. Overall, the scientific studies of the vertical and horizontal distance that bacteria or viruses may migrate from septic leach fields under different conditions varies widely (RIDEM, 1992). Shallow dug wells are at greatest risk for contamination, and deep drilled wells are least likely to have such problems.

(4) Organic Compounds. Serious groundwater contamination can occur with even the best designed and maintained system if organic compounds such as pesticides, paint thinners, and especially septic system cleaners and degreasing

agents such as trichloroethane are allowed into them. Rhode Island has banned the use of septic system cleaners with organic solvents and those using acids, but this is difficult to enforce.

c. Failing Systems. Septic tank systems fail when they are improperly located, designed, installed, or maintained. This can lead to contamination of surface or groundwater.

(1) Surface Water Contamination. If the groundwater table is too high, or soils not sufficiently permeable or becoming clogged, wastewaters can seep to the surface. This may result directly in surface water contamination, but more commonly, pollutants do not reach streams until rainfall washes them into a water body. Contaminants of most concern under these conditions are bacteria and viruses, the algal nutrients nitrogen and phosphorus, metals, and organic solvents or pesticides, improperly disposed of in the system.

(2) Western Cranston. In western Cranston, soils consist largely of glacial till which has a low permeability and, therefore, is of poor quality for septic tank systems. Records from the Rhode Island Department of Health, and its successor in this area, the Division of Groundwater and Individual Subsurface Disposal Systems, show a number of complaints of septic system waste at the ground surface.

(3) Groundwater Contamination. When a septic tank system is installed with insufficient depth between the bottom of the field and water table, contaminants enter the groundwater without first passing through an aerobic layer of soil. Pathogens are the greatest concern. Bacteria survive best in low temperatures and saturated conditions. If they can enter the groundwater table directly, without having to pass through an aerobic layer of soil, their chances for survival will be increased. Metals and phosphates are more likely to be immobilized in an aerobic zone. Consequently, discharge of septic tank waste directly into the groundwater zone will increase the zone of contamination from these substances.

8. WATER QUALITY EFFECTS OF ALTERNATIVES

a. General. Effects of the options (alternatives) on water quality depend on which combinations are chosen for construction, since most options are not mutually exclusive. Options 2A, 2B, and 2C are mutually exclusive; however, water quality effects would be the same for each. As the Corps project is for "trunk sewers," it is the extent of sewer lines and house connections feeding those trunks, rather than

the trunks themselves, which will determine the ultimate extent of impacts. Expected effects of implementing these options are improvements in water quality in areas affected by landfills or failing septic systems; additional benefits would accrue from reduction or elimination of wastewater overflows from overloaded pumping stations or surcharged sewer pipes.

b. Water Quality During Construction. There will be water quality impacts during construction, mainly increases in turbidity and sedimentation from erosion during excavation activities. However, these will be temporary and can be controlled by proper construction and erosion control techniques, including silt fences, hay bales, and other means to control runoff from construction sites; covering stockpiled soil to limit erosion; and other similar activities.

c. Specific Options. The following paragraphs describe qualitative improvements in water quality that can be expected from each different option. Changes in water quality will be too diffuse to describe quantitatively.

(1) Option 1A provides for conveyance of projected wastewater flows from northwest Cranston, the proposed Village Center, Central Landfill, Vinagro, and Johnston sites, as well as projected flows from east Cranston. Expected water quality improvements would come from areas in northwestern Cranston that are experiencing pollution from septic system failures, and elimination of potential overflows from overloaded pumping stations or surcharged sewer pipes in portions of east Cranston. Additional benefits would derive from the ability to handle pretreated leachate pumped from beneath Central Landfill, and possibly the Vinagro site. Changes in water quality would be most evident in local streams, including upper reaches of Furnace Hill Brook, a tributary to Meshanticut Brook. Improvements in Pawtuxet River water quality would be smaller and more difficult to observe.

(2) Option 1B includes the same conditions as option 1A, except projected flows from Vinagro and Johnston sites are not included. Water quality improvements would be basically the same as in option 1A. Vinagro and Johnston are not included because it is assumed they are treated in some other manner; further studies of Vinagro and lack of development in Johnston result in there being no flows requiring treatment.

(3) Options 2A through 2D provide for conveyance of projected flows from the proposed Wilbur pump station district in southwest Cranston. Option 2D involves a trunk

sewer to collect flows from service area 2, and deliver them to the proposed Wilbur pump station. Options 2A, 2B, and 2C provide for conveyance of flows from the Wilbur station to the WWTF. Implementation of option 2D requires implementation of options 2A, 2B, or 2C also. Expected water quality improvements would be mainly due to extending sewers to previously unsewered areas with failing septic systems. Because the southwestern Cranston area served by these options has suspected water quality problems due to failing individual subsurface disposal systems, implementing these options should result in improvements. Meshanticut Brook in particular would see improvements in the form of lower coliform bacteria levels. Improvements in Pawtuxet River quality would be smaller and not as easily noticed.

(4) Option 3A provides for conveyance of projected flows from the Howard Center, Howard Industrial Park, and Capuano site. It examines existing sewers from Pontiac Avenue through the Howard pump station to the WWTF. Water quality improvements would mainly come from eliminating potential for overflows from overloaded pumping stations. These are not much of a problem now, but could be in the future if the system is not upgraded. Additional benefits could accrue if the Capuano site is determined to be a source of contamination, and a collection and treatment system is installed and connected to the sewer system. Water quality improvements would be most noticeable in Capuano Stream and less obvious in the Pawtuxet River.

d. Without Project Condition. If no sewer upgradings are implemented, water quality in the watershed will continue to be severely impacted by nonpoint sources. In addition, increased development in currently sewered areas will be curtailed or decreased to avoid overloading sewer lines and pump stations, which causes spills of raw wastewater into surface waters.

10. HYDROLOGY

Hydrologic changes in the watershed, resulting from implementing options in this feasibility study, will be very small. Flows which presently reach surface water through septic systems will be sent through sewer pipes to the WWTF. This will result in a reduction in flow in surface tributaries to the Pawtuxet River, but basically the same amount of flow in the Pawtuxet River itself. However, these reductions in tributary flows will be very small. Furthermore, since water supply for these homes originates in the Scituate Reservoir watershed which is outside the study area, natural streamflow, in areas where sewers are being considered, will be affected only slightly.

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APPENDIX L

Task 10d - Archaeological/Historic Assessment

Section 117, Cranston Rhode Island
Wastewater Conveyance Feasibility Study

Task 10d - Historic and Archaeological Assessment of Study Options

Department of the Army
Corps of Engineers, New England Division
Waltham, Massachusetts

November 1993

TABLE OF CONTENTS

	PAGE
Introduction	L-1
Historic Overview	L-1
Assessment of Study Options	L-4
The Without Project Conditions	L-7
Summary of Impacts	L-7
Conclusions	L-11
References	L-12

LIST OF TABLES

Table 1	Cultural Resource Sensitivity	L-8

Cranston, Rhode Island Feasibility Study

Introduction

The purpose of this report is to review the alternatives and assess and compare the construction and operation impacts on archaeological and historic resources, as well as to assess the without project condition. These observations are based upon background research, limited walkover survey, and preliminary information from the Rhode Island State Historic Preservation Office (RI SHPO). Attached is a copy of preliminary comments and a scope of work received from the RI SHPO in regard to the study options. Several areas have been identified for further assessment and testing. These areas are described in the Conclusions section and are located on the map at the end of the report. Depending upon the outcome of these studies, archaeological survey, including excavation, may be required in some areas prior to construction.

Historic Overview

The prehistoric period is usually divided into distinct time periods based on environmental changes and cultural adaptations: Paleo-Indian Period (10,000-8,000 Before Present (B.P.)), Archaic Period (8,000-2,700 B.P.), Woodland Period (2,700-1524 A.D.), and the Contact Period (1524-1636 A.D.).

Paleo-Indian Period

The Paleo-Indian Period represents the earliest human presence in the Northeast following the last glacial retreat. The environment at that time probably supported a spruce and pine forest and large game animals such as caribou, mastodon and mammoth. The Native American populations consisted of small groups of nomadic hunters who "...followed herds of mastodon and caribou into the bleak subarctic landscape of southeastern New England. Because Paleo-Indian populations were both small and mobile, little evidence of them remains." (Rhode Island Historic Preservation Commission (RIHPC) 1980). There are no known Paleo-Indian sites in Cranston.

Archaic Period

"Broadly defined, the Archaic Period marks a change in environment, adaptation and artifact styles...and is divided into four sub-periods corresponding to environmental and cultural changes." (RIHPC 1986). These sub-periods are Early Archaic (10,000-8,000 B.P.), Middle Archaic (8,000-6,000 B.P.), Late Archaic (6,000-3,700 B.P.), and Terminal Archaic (3,700-2,700 B.P.).

During the Archaic Period, the climate grew warmer, herds of big-game animals disappeared, and the environment became more diverse. The Amerindian groups increased in population size and utilized a wider variety of plants and animals. This is reflected in the archaeological record by the variety of Archaic Period sites. Archaic sites are found on small streams, adjacent to wetlands, on major rivers and lakes and along the coast and estuaries. Rock shelters and caves were also used as temporary camps. West Cranston is rich in Archaic and Early Woodland sites. A major site exists along Furnace Hill Brook:

"...this habitation area, ideally located on a knoll above the confluence of Meshanticut Brook, Furnace Hill Brook, and Church Brook, revealed many projectile points and other tools from the Late Archaic and Early Woodland periods with fragments of semifinished soapstone or steatite bowls from a nearby quarry. The Oaklawn Quarry, located less than a mile to the west, is one of the two known Rhode Island soapstone or steatite quarries from which Late Archaic peoples extracted this workable stone for fashioning bowls and other vessels." (RIHPC 1980).

The Furnace Hill Brook Historical and Archaeological District, which includes the Oaklawn Quarry, is listed on the National Register of Historic Places.

Woodland Period

The Woodland Period is characterized by the presence of pottery in archaeological remains. The sites from this period can be divided into Early, Middle, and Late Woodland periods. Plant domestication and horticulture were probably first introduced during this period. This period is further identified by large habitation sites located near major rivers and small temporary camps situated on smaller rivers and streams. Sites are also found along the coast, particularly in estuarine areas. Examples of large habitation sites were probably present along the Pawtuxet River. However, small seasonal camps were probably also located along smaller streams such as Furnace Hill Brook. A rock shelter utilized during the Late Archaic and Woodland periods is found at Church Brook in the vicinity of I-295.

Contact Period

The Contact Period begins with Verrazano's explorations of Narragansett Bay and ends with initial settlement of the area by Roger Williams in 1636.

> "At the time the first European settlers arrived, the Narragansett Indians lived in large, semi-permanent coastal villages surrounded by extensive fields which had been cleared for cultivation. The Narragansetts, members of the large Algonquin nation, were the most populous Indian tribe in southern New England. When the first white settlers arrived, it is said that there were at least six Indian villages in Cranston." (RIHPC 1980:6).

One of these Indian villages, Pontiac, was reportedly located near the intersection of Hope and Pippin Orchard Roads.

European Settlement

The first European to settle in what is today Cranston was William Arnold, one of the original Providence proprietors. He and three other men, William Harris, William Carpenter, and Zechariah Rhodes settled along the Pawtuxet River in 1638 (Clausen 1904:5). This area became known as the Pawtuxet Purchase, under the control of Providence and included all of what is now Cranston, Scituate, Foster and parts of Johnston and West Warwick (RIHPC 1980:7). The population of the area slowly increased until 1676, when during King Philip's War, the settlers abandoned their homes and the Indians destroyed the entire settlement (Clausen 1904:7). The settlers gradually returned and rebuilt their homesteads.

The residents of Cranston began to agitate for separation from Providence as early as 1660. However, they were not successful until 1754 when an act of incorporation was submitted and adopted (Clausen 1904:13). The town was named after Thomas Cranston, Speaker of the House of Representatives at that time. The population after incorporation was 1,460.

Cranston was essentially an agricultural community throughout the 18th and early 19th Centuries. "Western Cranston still contains a number of individual houses and entire farmsteads that evoke the quality of the landscape as it looked in the early years of the nineteenth century...These farms and others like them on Phenix Avenue, Hope Road, Pippin Orchard Road, and Plainfield Pike consisted of acres of cultivated fields." (RIHPC 1980:15). These include the Lippitt Hill Historic District on Hope Road and the Potter-Remington House, both eligible for the National Register.

The town did, however, have several small industries during this time. A grist mill was established on Meshanticut Brook, a large saw mill was situated at Scituate Avenue and Pippin Orchard Road and a bog iron bed and furnace were established on Furnace Hill Brook. The furnace remained in use only during the late 17th Century, but the iron bed was worked until the 19th Century. The iron ore from Cranston was transported to the Hope Furnace in Scituate during the Revolutionary War and used to manufacture cannonballs (RIHPC 1980:12). The Cranston Furnace is included in the Furnace Hill Brook Historical and Archaeological District which is listed on the National Register of Historic Places.

There were four main sites of textile manufacture in Cranston by 1820: Fiskeville, Dugaway Hill, Pawtuxet and the Cranston Print Works. By the early 19th Century Cranston had three woolen factories, seven cotton mills, a gin distillery, six grist mills, and a fulling and wadding mill (Clausen 1904:31).

The most influential manufacturers in Cranston between 1821 and 1873 were the Sprague family, who owned and operated the Cranston Print Works. The Spragues controlled a manufacturing dynasty that stretched from Maine to North Carolina. Their factory system produced cotton material as well as printing the calico design, a revolutionary innovation at the time. "The output of the Sprague mills was greater than that of all the other factories in the United States combined." (Clausen 1904:38). A company town developed at the Print Works with the mills, worker housing, and a company store providing occupations and services for over 2,000 employees (RIHPC 1980:20). The Print Works failed during the Depression of 1873. The collapse of the Sprague empire was the largest business failure in the nation's history and caused the failure of numerous banks which had extended credit and loans to the company (Clausen 1904:40).

During the latter part of the 19th Century, railroad, horsecar lines and later electric streetcars made travel between Providence and Cranston more convenient.

> "The increased and simplified communication between Providence and Cranston gradually changed the town's character from that of a rural farm community to an integral part of the emerging metropolitan area...The town's population jumped from 4,311 in 1850 to 13,349 in 1900. Cranston was also the site of the region's reservoir, pumping station, and penal

institutions. The town provided numerous recreation facilities for the diversion of the Providence population and vast truck farms for their sustenance." (RIHPC 1980:22).

Historic Properties

There are numerous historic properties within the area of Cranston under investigation. Listed below are those properties that the Rhode Island Historic Preservation Commission considers significant historic and archaeological sites. Those sites eligible for or listed on the National Register of Historic Places are noted. In addition, there are at least 83 known prehistoric archaeological sites in the area, of which varying information is available.

Furnace Hill Brook Archaeological District - The district includes the Oaklawn Soapstone Quarry, the Cranston Furnace and the Cranston Ore Beds and is listed on the National Register. This area has been used for habitation and industry for at least the last 4,000 years.

Ruins of Henry Jordan's Sawmill - This mill was established in 1823 at the intersection of Pippin Orchard Road and Scituate Avenue and operated into the 1870s. The stone ruins of the mill are still present.

Nathan Westcott House, Joy Homestead, Sheldon House - These three historic houses are located on Scituate Avenue and were constructed between 1728 and 1778. All three structures are eligible for the National Register.

Potter-Remington Farmhouse - This farmhouse, located on Natick Avenue, was built by Caleb Potter in 1795 and sold to Benjamin Remington in 1804. Remington's son, Jonathan acquired the house in 1812. Jonathan Remington was one of the wealthiest farmers in western Cranston during the first half of the 19th Century. The Potter-Remington Farmhouse is eligible for the National Register.

Oaklawn Village Historic District - Oaklawn was one of Cranston's first suburban commuter villages. In 1872, Oaklawn has only eight houses and was known as Searle's Corner. However, in 1872, property was subdivided in this area and lots sold. The main advantage of the area was its proximity to the railroad into Providence. The district is made up of about 35 houses, most of which date to the late 19th Century. This district is National Register eligible.

The State Institutions at Howard - "Occupying the old Stukely Westcott and William S. Howard Farms, the state institutions at Howard represent, in architecture and physical layout, the evolution of the state's role as agent of public welfare for its citizens." (RIHPC 1980:70). The first institutional buildings were constructed in 1873 and several other large scale structures were completed before the turn of the century. Between 1900-1918, six other large, red brick buildings were constructed, with 28 buildings erected by the WPA during the 1930s.

Assessment of Study Options

Construction and Operation Impacts

Service Area 1 - Option A

This option appears to have a limited potential to impact cultural resources assuming that the alignment is situated within existing roadways as is currently proposed. The western Cranston area is relatively rural and undeveloped and is therefore considered to have a good potential for archaeological remains. However if sewers remain within existing roadways, the potential for any impacts become low. The portion of the alignment within eastern Cranston would have a low potential for archaeological resources as this area is more densely populated and developed. Any construction or operations outside of these roadways or in undeveloped areas has the potential to disturb cultural resources. The area of construction for the Scituate Pump Station (PS) will need a site disturbance assessment and may have to be tested archaeologically. It is located within an area considered to have a moderate potential for cultural resources. Indirect impacts are possible due to increased development in Johnston and Northwest Cranston.

Service Area 1 - Option B

Possible impacts would be the same as above, without the indirect impact in Johnston.

Service Area 2 - Option A

This option is located in East Cranston within existing roadways, along major highways, the northwest corner of the Howard Center, and an abandoned railroad right-of-way. The Howard Center complex, a range of state institutions represents "in architecture and physical layout, the evolution of the state's role as agent of public welfare for its citizens." (RIHPC 1980:70) The area as a whole exhibits the potential for containing both historic and prehistoric resources. However, the area is today heavily developed and urbanized and may have a low sensitivity for archaeological remains due to previous disturbance. Most of the sewer alignments are located within existing roadways, along major highways, or existing railroad beds. Locations where these alignments run cross-country or in undeveloped areas would have to be investigated further. Areas of concern for cultural resources include the following: the location of the Wilbur PS within the Oaklawn Village Historic District will need site disturbance assessment and possibly archaeological survey and testing, and within the Garden Hills alignment a historic cemetery along Route 2 will have to be avoided during construction with at least a 25-foot buffer area. Construction of the Wilbur PS will also have to conform to restrictions for new buildings within a historic district. The structure would most likely require clapboards and a gable or hipped roof as well as a front entryway facing the street. Further guidance will be available from the RI SHPO when the feasibility study is reviewed by their office.

Service Area 2 - Option B

Possible impacts are the same as for Option A above.

Service Area 2 - Option C

Impacts to cultural resources for this option are similar to those indicated for Options A and B above. This alignment appears to be located within a more densely populated and developed area than the above options. Most of the sewer is within existing roadways. As above, the location for the Wilbur pump station would have to be investigated for any impact upon cultural resources prior to construction and restrictions concerning the building within a historic district would need to be met. This option would appear to have a limited potential to impact resources depending upon the amount of development or previous disturbance in the area.

Service Area 2 - Option D

Of all the options studied for this investigation, Option D for Service Area 2 could have the greatest potential to impact historic and archaeological resources. Most of the sewer alignments are located in west Cranston, a less populated and developed area in comparison to locations farther east. In addition, a portion of the sewer runs through the Furnace Hill Brook and vicinity which is a part of the Furnace Hill Brook Historic and Archaeological District, an important prehistoric and industrial archaeological district listed on the National Register of Historic Places. A walkover survey of the area has indicated that much new development and disturbance has occurred in the vicinity of the brook. However, important archaeological information may yet be available along the brook itself and further west where remains of the Cranston Furnace are reputedly located. Areas within existing roadways should not impact cultural resources, however, they may indirectly affect resources during construction or in the future due to increased development in the area. Portions of the alignment which run cross-country would have to be further investigated. It is recommended that a disturbance assessment be performed in areas which are located offroad and an archaeological survey would be required for areas that cannot be conclusively shown to have been previously impacted by development or disturbance, particularly in areas within or in the vicinity of the Furnace Hill Brook Historic and Archaeological District. The following offroad areas have been determined to require further study: the area east of Brookdale Street, west of the Hines Farm Road area within the Furnace Hill Brook District, a portion east of Kimberly Lane North in the rear of several homes, an area north of the South Comstock Parkway (Comstock sewer), an area between Natick and Glenham Roads (Natick/Phenix sewer), and the proposed location for the Phenix pumping station on Phenix Avenue south of the Cranston Country Club.

Service Area 3 - Option A

This option involves only modifications to the existing Howard pump station, therefore limiting any impacts to historic or archaeological resources. However, areas along the Pawtuxet River may have to be field

checked to determine the effects of previous disturbance and the integrity of the location for any possible archaeological remains, if any construction is expected in the future. Due to heavy development, it appears that this option would have a limited effect upon cultural resources.

The Without Project Condition

It has been determined that there would be no effect upon historic and archaeological resources should the above project not be implemented. Possible direct impacts due to construction of the various sewers and pump stations would be eliminated. However, indirect impacts to cultural resources due to development in West Cranston would likely occur whether or not the sewer project is constructed.

Summary of Impacts

Table 1 lists each service area and its respective option together with its potential for cultural resources. This is a preliminary determination. Only after assessment and possible archaeological study can more definite conclusions be drawn.

TABLE 1
CULTURAL RESOURCE SENSITIVITY

Option	Current Land Use	Previous Disturbance	Known Cult Resources	Potential Cult Res	Evaluation Needed
1A					
Scituate PS	Agricultural Field	?	?	Mod	Yes
Scituate FM/VGS	In road	--	--	--	No
I-295 PS	Industrial Area	Yes	--	--	No
Improve Cranston St.	In road	--	--	--	No
Park Ave and Pocasset Int	Existing	--	--	--	No
Pontiac PS	Existing	--	--	--	No
Replace Pontiac FM after 2015	Sewer easement	Yes	?	--	No
1B	Same as Option 1A				
2A					
Wilbur PS	Residential	Possible	Oaklawn Historic Dist	?	Yes
Garden Hills FM/VGS	-Brayton Ave (Inroad)	--	--	--	No
	-Route 2	Yes	Cemetery	Low	Yes
	-Howard Center NW	Yes	None	None	No
	-Railroad Right-of-way	Yes	None	None	No
	-Webb Street (Inroad)	Yes	None	None	No
2B	Same as above for Wilbur PS and Garden Hills FM and GS.				
Improvements to WWTF	Wastewater Treatment Fac.	Yes	--	--	No

TABLE 1
CULTURAL RESOURCE SENSITIVITY (continued)

Option	Current Land Use	Previous Disturbance	Known Cult Resources	Potential Cult Res	Evaluation Needed
2C					
Wilbur PS	Same as above				
Wilbur FM	Inroad	Yes	--	--	No
Improvements Sockanosset Int	Sewer easement/ Residential	Yes	--	--	No
Improvements to WWTF	Wastewater Treatment Fac.	Yes	--	--	No
2D					
Brookdale	-Herod St. (Inroad)	--	--	--	No
	-E of Brookdale St (residential)	Possible	?	Mod	Yes
Tilcon	-Natick Ave/ Phenix Ave (Inroad)	Yes	--	--	No
	-Offroad (gravel mining)	Possible	Known sites	Low	Yes
Comstock	-W of Hines Farm Rd (residential)	?	Furnace Hill Brook Hist District	Mod	Yes
	-E of Kimberly Lane North (residential)	Possible	?	?	Yes
	-Above South Comstock Parkway (Res.)	Possible	Known Site	Low-Mod	Yes

TABLE 1
CULTURAL RESOURCE SENSITIVITY (continued)

Option	Current Land Use	Previous Disturbance	Known Cult Resources	Potential Cult Res	Evaluation Needed
Natick/Phenix	-Sewer Easement West of I-295 (Res.)	Possible	Oaklawn Hist District	?	Yes
	-Natick Rd-Glenham Rd (undeveloped)	?	?	Low-Mod	Yes
Phenix PS	Undeveloped	Possible	Arch Sites in area	Mod	Yes
Phenix FM	Inroad	--	--	--	No
3A Kenny Drive, Ross-Simmons Drive and Sharpe Drive GS	Existing	--	--	--	No
Improvements to Howard PS	Existing	--	--	--	No
Existing Howard FM	Existing	--	--	--	No

Conclusions

On the basis of a preliminary assessment of the preceding alternatives, it appears that some portions of the project area will require further study, notably a disturbance assessment to identify areas which may have been disturbed by construction and development, as well as areas which may have archaeological potential. After this assessment, any portions of the project area which are deemed sensitive for archaeological resources would have to be surveyed and tested during the Plans and Specifications phase of the study prior to construction. The areas which will require further study are:

-Scituate Pump Station at the intersection of Pippin Orchard Road and Scituate Avenue

-Wilbur Pump Station near Wilbur Avenue and I-295

-Area east of Brookdale Street

-West of the Hines Farm Road area within the Furnace Hill Brook Historic and Archaeological District

-East of Kimberly Lane North portion

-An area north of South Comstock Parkway

-Area between Natick and Glenham Roads

-Area from Wilbur Pump Station to Natick/Glenham along I-295

-The proposed location for the Phenix Pump Station on Phenix Avenue south of the Cranston Country Club

REFERENCES

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Rhode Island Historical Preservation Commission

1986 The Rhode Island Historic Preservation Plan. Published by the Rhode Island Historic Preservation Commission.

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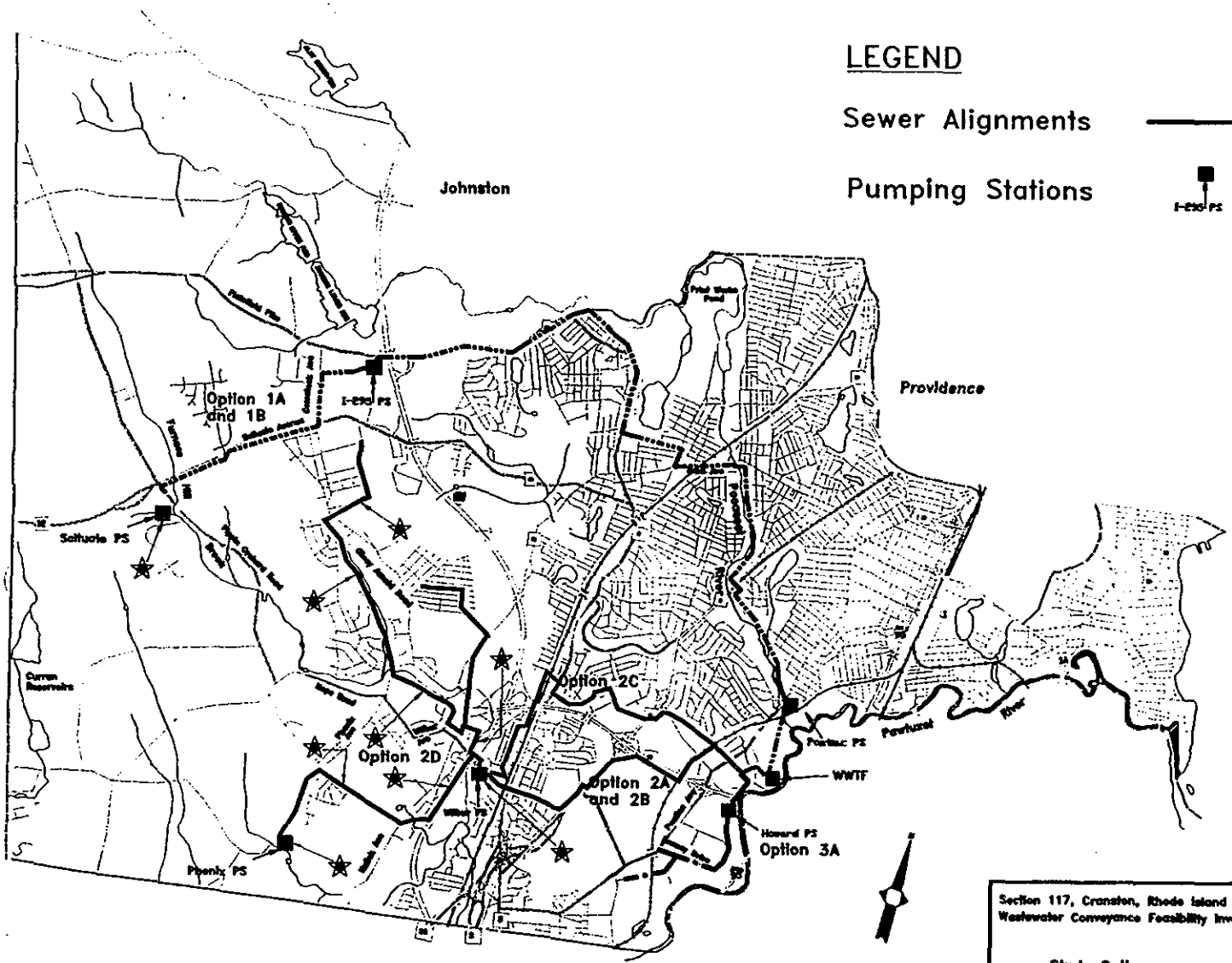


★ - Approximate areas requiring further study and testing.

NOT TO SCALE

Section 117, Cranston, Rhode Island
Wastewater Conveyance Feasibility Investigation

Study Options

U.S. Army Corps of Engineers
New England Division

November 1993

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

HISTORICAL PRESERVATION COMMISSION
Old State House
150 Benefit Street
Providence, Rhode Island 02903
401-277-2678 • FAX 401-277-2968 • TDD 401-277-3700

July 28, 1993

Mr. Marcos Paiva
Planning Directorate
Impact Analysis Division
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

Re: Sewer Interceptor Project
Cranston

Dear Mr. Paiva:

The Rhode Island Historical Preservation Commission has received and reviewed the information you have provided our staff on the above-referenced project.

The Cranston Sewer Interceptor Project includes several locations that are potentially sensitive for archaeological resources. They include the Furnace Brook and the Howard Center areas. Due to the recent development in the former area and the potential for previous disturbance at Howard, it is our conclusion that an archaeologist should conduct a disturbance assessment along these two and any other sections of proposed sewer lines that pass through presently undeveloped lands. A scope of work for this type of archaeological assessment is enclosed for your information.

These comments are provided in accordance with Section 106 of the National Historic Preservation Act.

Very truly yours,

Richard E. Greenwood
Project Review Coordinator

Enclosure

(3:90)

PRESERVATION 1968 25 1993 PROGRESS

Scope of Work

Archeological Assessment Studies

for Dot "3R" Projects and Similar Undertakings

Many "3R" highway projects generally involve small-scale construction activities such as pavement recycling, installing new curbing or sidewalks, repairing or installing new drainage facilities, and road widening within the state highway right-of-way line. Other similar undertakings include the installation of utility lines, or larger projects within areas with a high potential for previous disturbance. It may be expected that some of these activities will take place within previously disturbed soils while others will take place within undisturbed soils. These undisturbed areas may contain important archaeological resources.

The objectives of an assessment study are to determine if impact areas are undisturbed and whether archaeological material are present or absent. The following scope of work is recommended to achieve these objectives:

1. Conduct a background study of the project area, including, but not limited to, a check of the historical and archaeological property files at the Rhode Island Historical Preservation Commission, town and local histories, historic maps and soil maps.

2. Conduct a windshield survey and walkover to determine the extent of land modification and the presence of surface features such as historic foundations.

3. Conduct limited subsurface testing (soil auger or shovel) as indicated by the windshield/walkover survey to evaluate the extent of land modification and soil disturbance.

4. If soils are undisturbed, conduct limited shovel test pit testing to determine the presence or absence of archaeological materials.

5. Prepare a short memorandum that contains the engineering map of impact areas, a description of soil conditions or other justification of decision to conduct subsurface testing, a description of any archaeological materials recovered, and recommendations for additional investigation, if necessary.

6. Supervisory personnel must be well acquainted with the historic and prehistoric archaeology of Rhode Island and must meet the professional qualifications set by the National Park Service (36 CFR) 66, appendix C).

7. A permit from the Rhode Island Historical Preservation Commission is required.

APPENDIX M

Task 10e - Ecological Assessment

Section 117, Cranston Rhode Island
Wastewater Conveyance Feasibility Investigation

APPENDIX M

TASK 10e - Ecological Assessment

Department of the Army
Corps of Engineers, New England Division
Waltham, Mass

January 1994

PREFACE

Wetlands impacts presented in this report are for feasibility study options. These estimates were adjusted for the "Environmental Assessment" report to reflect changes in sewer alignments and selection of pumping station locations. These changes are result of the on-going planning and design process conducted throughout the study. Wetland estimates presented in this report are for planning purposes and do not represent field measurements or actual wetland delineations.

TABLE OF CONTENTS

	PAGE
Environmental Setting	M-1
Evaluation Process	M-1
Impacts to Endangered Species	M-3
Impacts to the Terrestrial Ecosystem	M-4
Impacts to the Aquatic Ecosystem	M-5
References	M-15
Correspondence	M-15

LIST OF TABLES

Table 1	Freshwater Wetlands Summary of Impacts . . .	M-8
Table 2	Freshwater Wetland Impacts - Service Area 1 - Options A and B	M-10
Table 3	Freshwater Wetland Impacts - Service Area 2 - Options A and B and C	M-11
Table 4	Freshwater Wetland Impacts - Service Area 2 - Option D	M-12
Table 5	Freshwater Wetland Impacts - Service Area 3 - Option A	M-14

ECOLOGICAL ASSESSMENT OF THE PROPOSED WASTEWATER CONVEYANCE OPTIONS

TASK 10 REPORT APPENDIX
CRANSTON, RHODE ISLAND

A. Environmental Setting

The City of Cranston occupies a land area of approximately 17,750 acres. Several major highways provide access to the City including Interstate 95, Interstate 295 and Route 37. Existing land use includes residential, commercial, industrial, institutional development, farmland and undeveloped land. The majority of the area is characterized by urban/suburban development with some undeveloped space remaining in the western Cranston area (approximately 5,840 acres according to the City of Cranston land census). Wildlife species common to the area are generally species which are tolerant of human interaction such as the raccoon (*Procyon lotor*), opposum (*Didelphis marsupialis*) and the striped skunk (*Mephitis mephitis*).

The study area is within the Pawtuxet River basin. The main stem of the Pawtuxet River flows south to east along the easterly boundary of Cranston and empties into Pawtuxet Cove adjacent to the Providence River. Topography in the study area ranges from rolling uplands in western Cranston to glacial outwash plains adjacent to the Pawtuxet River. Water resources in the area which have close alignments or would be transversed by the proposed project options include Furnace Hill Brook, Meshanticut Brook, an unnamed tributary to Meshanticut Brook, the Pocasset River and the Pawtuxet River. Most surface waters in the Pawtuxet River basin are classified "B" however many are severely impacted by nonpoint source contamination. The main stem Pawtuxet River is classified "C" but fails to consistently meet the goals for this classification. A review of water quality reports prepared by the Rhode Island Department of Environmental Management (RIDEM) and others is included in the Water Quality and Hydrology Assessment Appendix prepared for this feasibility study (ACOE, 1993). Limited information is available concerning fisheries resources in the study area (See Section G. Correspondence for a letter from the Rhode Island Department of Fish and Wildlife (RIDFW) dated 28 March 1991).

B. Evaluation Process

The Ecological Assessment of the proposed wastewater conveyance options considers the impacts to endangered species, the terrestrial ecosystem (upland vegetation and wildlife), and the aquatic ecosystem (fisheries and wetlands). Impacts to water quality, cultural resources and socio-economic impacts are discussed in other Task 10 assessment reports. The Environmental Assessment will incorporate findings from these reports and other work efforts. To determine impacts to natural resources in the project area as a result of

implementing the options proposed in this feasibility study, the with project condition is compared to the without project condition over the life of the project (to year 2045). In the with project condition, sewering the western Cranston area will provide wastewater collection and conveyance to existing and future development. Future development as presented in the City of Cranston Comprehensive Plan (1992) includes the promotion of cluster housing which simultaneously preserves open space, an increase of minimum lot size to five acres around the planned village center area unless developed as a cluster, and planned denser development of the village commercial center and residential area. The growth management objectives for western Cranston include protection of wildlife habitat through the preservation of large continuous tracts of open space (City of Cranston Comprehensive Plan, 1992). It is anticipated that development would continue in the western Cranston area in the without project condition.

The Task 10c Water Quality and Hydrology Assessment concluded that "The net effects on water quality of implementing the options considered in the feasibility study will be improvements in areas affected by landfills, failing septic systems, or sewer pipe or pump station overloadings. Changes in water quality will be too diffuse to describe quantitatively. There will be water quality impacts during construction, but these will be temporary and can be mitigated by proper construction and erosion control techniques. Effects on ground water will come from eliminating septic systems and their associated effects on groundwaater, and improvements in areas around landfills."

Federal and State natural resource agencies were contacted to solicit preliminary comments on the proposed project including the Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (FWS), Rhode Island Division of Fish, Wildlife and Estuarine Resources and the Rhode Island Division of Freshwater Wetlands. The Rhode Island Division of Fish, Wildlife and Estuarine Resources did not anticipate significant impacts to fisheries and wildlife resources as a result of the proposed project. The general consensus of all agencies was that wetland impacts during construction were the primary concern however, secondary developmental impacts were also a concern. The impacts associated with the proposed project are generally temporary, associated with the construction timeframe and time required to revegetate.

Wetlands are regulated by the Rhode Island Division of Freshwater Wetlands (DFW) pursuant to the Rhode Island Department of Environmental Management Rules and Regulations Governing the Enforcement of the Fresh Water Wetlands Act (RIDEM, 1981). A permit

is required from the DFW prior to conducting activities in freshwater wetlands and/or their regulated buffer zones. By definition, "a freshwater wetland shall include, but not be limited to, marshes;swamps;bogs;ponds;rivers;river and stream floodplains and banks; areas subject to flooding or storm flowage; emergent and submergent plant communities in any body of fresh water including rivers and streams and that area of land within fifty (50') feet of the edge of a bog, marsh, swamp or pond" (RIDEM, 1981). A river bank is described as being "land within one hundred feet (100') of the edge of a flowing water body ten feet (10') in width or less and land within two hundred feet (200') of the edge of a flowing water body ten feet (10') in width or more" (RIDEM, 1981).

Wetland impacts were quantitatively evaluated for each option alignment by determining the number of stream crossings or construction within the regulated buffer zone. A thirty foot (30') wide construction work area was determined to be necessary for installation of sewers and a one hundred by one hundred foot (100x100') area was determined to be necessary as a construction work area and future maintenance area for pumping stations. A wetland impact acreage figure was calculated for each option for comparison purposes. See Section E. Impacts to the Aquatic Ecosystem for a more detailed discussion of these impacts.

C. Impacts to Endangered Species

During the Section 22 reconnaissance level study (ACOE, 1991) for the Cranston wastewater conveyance system project, the U.S. Fish and Wildlife Service (USFWS) determined in a letter dated 8 March 1991 that no known Federally listed or proposed, threatened and endangered species were known to occur in the project area with the exception of occasional, transient endangered bald eagles (Haliaeetus leucocephalus) or peregrine falcons (Falco peregrinus anatum). In addition, the Rhode Island Natural Heritage Program provided information regarding rare species and ecologically significant natural communities in the project area. Three populations of rare species were identified in the area south of Route 6 and Route 14 and their general locations provided (see Section G. Correspondence for further information). None of the populations described would be impacted by the proposed project or would be affected by any secondary impacts such as increased development due to sewering.

The U.S. Fish and Wildlife Service and the Natural Heritage Program were requested to provide current endangered species information in letters dated 22 October 1993. However, the database search performed in 1991 included the geographical range of the current project and therefore, no changes to endangered species determinations are anticipated.

D. Impacts to the Terrestrial Ecosystem

Upland vegetation provides food, cover, breeding and nesting habitat to terrestrial wildlife species. In addition, vegetated tracts of land provide travel corridors for wildlife to move through developed areas. This is an important function for larger mammals such as white-tailed deer (Odocoileus virginianus) which need larger areas and a diversity of habitat types to satisfy their life history requirements. Travel corridors are also important to migrating song birds which frequently stop to rest and eat during their migration. The consequence of urban development in Cranston has been a significant reduction in the number and diversity of wildlife species.

The proposed location of the Wilbur Pump Station may require the removal of several large silver maples (Acer saccharinum). These trees are part of a vegetated travel corridor for wildlife and also provide a visual and noise barrier to adjacent homeowners from the effects of Interstate 295. It would be valuable to consider alternate locations such as between the north and south travel lanes of Interstate 295 where terrestrial habitat impacts have already occurred.

The proposed location of the Phenix Pump Station may impact large trees however, construction is not recommended until after year 2015. The construction of this pumping station is dependent upon the need to provide sewer service to handle areas of failing septic systems in the upper portion of the Phenix/Natick Line (Service Area 2). It is difficult to determine specific vegetation and wildlife impacts at this time. Due to its location adjacent to a stream (an unnamed tributary to Meshanticut Brook), a wetlands permit would be required from the DFW prior to construction due to activities in the regulated buffer zone.

Direct impacts to terrestrial wildlife as a result of the sewer and pump station construction would generally be temporary construction related disturbances such as noise and dust. Wildlife would move from the area during construction but would reutilize the habitat once construction is completed.

In the without project condition, approximately 2,470 acres of undeveloped space will be converted to residential use. However, growth management objectives for western Cranston include protection of wildlife habitat through the preservation of open space in conjunction with cluster development. The city of Cranston Comprehensive Plan recommends that approximately 124 acres of open space be preserved through cluster development of the village center and 370 acres preserved through further cluster development in the western Cranston area (City of Cranston Comprehensive Plan, 1992). In the with project condition, providing a framework for a sewer system may facilitate the proposed cluster development.

Residential growth is anticipated in the future without project condition which reduces available habitat to resident wildlife. Cluster housing, the anticipated type of development with implementing the sewering project, is a better means of preserving wildlife habitat as long as the associated open space areas are protected from development. However, with the loss of half of the existing undeveloped land in western Cranston in the with project condition, additional compensation measures for loss of wildlife habitat value should be considered by the City of Cranston in their Natural Resources Action Program (City of Cranston Comprehensive Plan, 1992). Habitat loss could be compensated through environmental enhancement of remaining land such as increasing habitat diversity through forestry practices (selective cutting), installation of nest boxes, planting wildlife food plots, etc. There would be maintenance and monitoring requirements to sustain the effects of environmental enhancement features.

E. Impacts to the Aquatic Ecosystem

This section deals primarily with the impacts to wetlands. The Rhode Island Division of Fish, Wildlife and Estuarine Resources did not anticipate significant impacts to fisheries and wildlife resources as a result of the proposed project and water quality impacts are addressed in a separate report.

Wetlands have many valuable functions including flood control, fish and wildlife habitat, nutrient retention, sediment trapping, shoreline anchoring and dissipation of erosive forces and visual/ aesthetic quality. In the past, urban development in Cranston has resulted in a significant reduction in the amount of wetlands. Wetland habitat provides food, cover, breeding and nesting habitat to a variety of wildlife species. When upland habitat is reduced such as in an urban/suburban setting, wetlands become increasing valuable to terrestrial species as well. Some upland species such as the white-tailed deer, may be forced to adapt to the wetland environment when the upland environment is developed for human use. Wetlands are often the only remaining vegetated tracts left in an urban environment and may function as travel corridors for wildlife to move through developed areas.

An enhanced understanding of the beneficial functions of wetlands has afforded greater protection through Federal and State laws and regulations in the recent past. Permitting would be required from the Rhode Island Division of Freshwater Wetlands for proposed activities in wetlands or regulated wetland buffer zones.

Wetland impacts were quantitatively evaluated for each option alignment by determining the number of stream crossings or work within a wetland or regulated buffer zone. This evaluation was based on aerial photographs (scale 1 inch equals 400 feet), U.S. Geological Survey Quadrangles (scale 1 inch equals 2000'), sewer plans (scale 1 inch equals 600 feet) and field observations. These estimates are provided for planning purposes and do not represent field measurements or actual wetland delineations. A thirty foot (30') wide construction work area was determined to be necessary for installation of sewer options and a one hundred by one hundred foot (100x100') area was determined to be necessary as a construction work area and future maintenance area for pumping stations. An acreage figure was calculated for each option for comparison purposes. Tables 2 through 5 on the following pages outlines the wetland impacts associated with each of the proposed options.

The impacts to freshwater wetlands include loss or disturbance of vegetation and disturbance of soil in the designated construction work area. Top soil and subsoil should be excavated and stored separately and replaced in proper order to minimized soil mixing. In addition, excavated soil should be placed adjacent to the sewer corridor to minimize mixing of wetland and upland soils. Losses to vegetation and soil disturbance should be mitigated through replanting. Replanting mitigates the loss of wildlife habitat and minimizes impacts to other values associated with the wetland ecosystem. The impacts associated with the proposed project are generally temporary, associated with the construction timeframe and time required to revegetate.

A summary of wetland impacts for the proposed project is presented in Table 1 on the following page.

TABLE 1

FRESHWATER WETLAND IMPACTS SUMMARY

SECTION 117 CRANSTON WASTEWATER CONVEYANCE SYSTEM
FEASIBILITY INVESTIGATION

Location	Wetland* (acres)	Wetland Buffer** (acres)	River Bank*** (acres)	Stream Crossing (number)
Service Area 1				
Option A & B	0	1.03	0.42	2
Service Area 2				
Option A & B	I----- 0.62-----I		0	0
Option C	0	0	0	0
Option D				
Brookdale	0	0	1.04	1
Comstock	I------1.37-----I		2.23	3
Tilcon	I------0.41-----I		1.52	4
Phenix/Natick	I------1.17-----I		0.51	2
Service Area 3				
Option A	0	0	0	0

*Wetland - This term includes marshes; swamps; bogs; rivers; river and stream flood plains; areas subject to flooding or storm flowage; emergent and submergent plant communities in any body of fresh water including rivers and streams.

**Wetland Buffer - This term includes land within fifty feet (50') of the edge of any bog, marsh, swamp or pond.

***River Bank - This term includes land within two hundred feet (200') of the edge of any flowing body of water having a width of ten feet (10') or more and land within one hundred feet (100') of the edge of any flowing body of water having a width of less than ten feet (10') during normal flow.

Wetland impacts associated with Service Area 1 - Option A and B (see Table 2) include two river crossings and 400 feet of work in the 50' wetland buffer zone adjacent to the Pawtuxet River Reservation which is a large freshwater marsh (a total of 1.45 acres). The existing Pontiac Pump Station force main to the wastewater treatment plant needs to be upgraded to a 42" force main after year 2015 to accommodate increased flows. The existing force main is located along the periphery of the Pawtuxet River Reservation along the toe of the slope to adjacent uplands. There is adequate access along this current alignment for construction equipment without significant damage to wetland vegetation or large trees. With proper sediment erosion control practices, impacts to the adjacent wetland should be minor. Construction windows may be required to reduce impacts to wildlife utilizing the Pawtuxet River Reservation as breeding and nesting habitat.

Wetland impacts associated with Service Area 2 - Option A and B (see Table 3) include work in a forested wetland and/or the 50' wetland buffer adjacent to the Rt. 37 entrance ramp (0.62 acres). This wetland was part of a formerly larger wetland that has already been severely impacted by highway construction and construction by the maximum security prison. The DFW would scrutinize a permit requesting further allowances for work in that wetland (phone coordination with Dean Albro, DFW on 12 October 1993). The applicant will be required to demonstrate no other reasonable alternative is available. It may be difficult to realign this option due to the adjacent highway and prison property. However, if realignment were possible it would be more attainable with Option A, a variable grade sewer than with Option B, a gravity sewer. Service Area 2 - Option C provides an alternative to convey wastewater from the west Cranston residential area to the wastewater treatment plant of which no wetlands impacts are associated.

The majority of wetland impacts are associated with the installation of trunk sewers in the western Cranston area, Option D (see Table 4). The sewer lines follow roads as much as possible however, topography in some areas necessitates alignments adjacent to streams to achieve a gravity flow system. Wetland impacts associated with the Brookdale Line are the result of one stream crossing and construction in the river bank (1.04 acres). Wetland impacts associated with the Comstock Line are the result of three stream crossing and construction in the river bank (2.23 acres) and construction in wetlands and/or the 50' wetland buffer zone (1.37 acres) for a total of 3.61 acres. Wetland impacts associated with the Tilcon Line are the result of four stream crossings and construction in the river bank (1.52 acres) and construction in wetlands and/or the 50' wetland buffer zone (0.41 acres) for a total

of 1.93 acres. It may be possible to reduce the number of stream crossings through adjustments to the alignment below Patti Avenue. Wetland impacts associated with the Phenix/Natick Line are the result of two stream crossings and construction in the river bank (0.51 acres) and construction in wetlands and/or the 50' wetland buffer zone (1.17 acres) for a total of 1.68 acres. It may be possible to reduce freshwater wetland impacts for construction of the sewers, depending on topography, through adjustments to move the sewer line out of the river bank, wetlands and/or the 50' wetland buffer zone.

There are no wetland related impacts to proposed activities in Service Area 3 - Option A (see Table 5) which includes modifications to the Howard Pump Station.

Secondary impacts to the proposed sewering of the west Cranston residential area are increased development in certain areas. It is anticipated that development would continue in the without project condition. Cluster housing, which might be facilitated with sewering is preferred as long as associated open areas are protected from development. Although wetlands may not be developed for building sites due to strict permitting requirements, wetland systems may be impacted through fragmentation.

The DFW closely evaluates proposals which may effect the values associated with wetlands defined by the Fresh Water Wetlands Act, Rules and Regulations. The applicant will be required to demonstrate that there are no reasonable alternatives to the proposed option alignment. If wetlands cannot be avoided, impacts to wetlands must be minimized and a mitigation plan to compensate wetland impacts may be required. The Rhode Island Division of Freshwater Wetlands will consider the advantages and disadvantages of sewering the western Cranston residential area during the permitting process. Should a permit be granted, design criteria would have to include sediment erosion controls, temporary culverts or diversions on stream crossings, a revegetation plan and potential construction windows to protect wildlife from construction disturbances.

TABLE 2

FRESHWATER WETLAND IMPACTS

SECTION 117 CRANSTON WASTEWATER CONVEYANCE SYSTEM
FEASIBILITY INVESTIGATION

SERVICE AREA 1 - OPTION A AND B

LOCATION	WORK IN FRESHWATER WETLANDS
Scituate Pump Station	No impacts
Scituate Ave. FM/VGS	Stream (<10) crossing. Work in river bank 30x200' (0.14 acre)
I-295 Pump Station	Under construction by City of Cranston
Existing 14" FM/VGS to Cranston Street	No impacts
800' of new 24" sewer along Cranston Street	No impacts
Existing sewer Park Ave. to Pontiac Pump Station	No impacts
Pontiac Pump Station Force Main to WWTF (42" force main after year 2015)	River (>10') crossing. Work in the river bank - 30x400'(0.28 acres) Force main adjacent to Pawtuxet River Reservation. Work within 50' of marsh 30x1500'(1.03 acres).

Total Freshwater Wetland Impact - 1.45 Acres

TABLE 3

FRESHWATER WETLAND IMPACTS

SECTION 117 CRANSTON WASTEWATER CONVEYANCE SYSTEM
FEASIBILITY INVESTIGATION

SERVICE AREA 2 - OPTION A AND B

LOCATION	WORK IN FRESHWATER WETLANDS
Garden Hills Interceptor	Wilbur Pump Station. No wetland impacts. Impacts to large trees (wildlife corridor).
	Work in forested wetland (swamp) and/or 50' swamp buffer zone along the Rt. 37 entrance ramp - 30x900' (0.62 acres).

Total Freshwater Wetland Impact
For Garden Hills Interceptor - 0.62 Acres

SERVICE AREA 2 - OPTION C

LOCATION	WORK IN FRESHWATER WETLANDS
West Cranston/ Sockanosett Interceptor	Wilbur Pump Station. No wetland impacts. Impacts to large trees (wildlife corridor).

Total Freshwater Wetland Impact
For West Cranston/Sockanosett Interceptor - 0 Acres

TABLE 4

FRESHWATER WETLAND IMPACTS

SECTION 117 CRANSTON WASTEWATER CONVEYANCE SYSTEM
FEASIBILITY INVESTIGATION

SERVICE AREA 2 - OPTION D

LOCATION	WORK IN FRESHWATER WETLANDS
Brookdale Line	Adjacent to Meshanticut Brook (>10') along Brookdale Street. Work in river bank 30x1200' (0.83 acres).
	Stream (>10') crossing behind Brookdale Street. Work in river bank- 30x300' (0.21 acres).
	Total Freshwater Wetland Impact For Brookdale Line - 1.04 Acres
Comstock Line	Stream (<10') crossing below Echo Lane. Work in the river bank - 30x200'(0.14 acres).
	Stream (<10') crossing below Iroquois. Work in the river bank - 30x200'(0.14).
	Adjacent to stream (>10') Iroquois to Kimberly Lane. Work in wetlands/wetland buffer/river bank - 30x2000'(1.37 acres).
	Stream (>10') crossing at the end of Kimberly Lane. Work in the river bank 30x300'(0.21 acres).
	Adjacent to stream (>10') behind Mollie Drive and Hines Farm Road. Work in river bank - 30x2500' (1.72 acres).
	Adjacent to stream (<10') along Hines Farm Road. Work in the river bank - 30x30' (0.02 acres).
	Total Freshwater Wetland Impact For Comstock Line - 3.61 Acres

TABLE 4 (CONTINUED)

SERVICE AREA 2 - OPTION D

LOCATION	WORK IN FRESHWATER WETLANDS
Tilcon Line	Wetlands and stream crossings starting at the end of Patti Ave. to 10th St. Three stream (<10') crossings with work in the river bank 30x200' times 3 (a total of 0.41 acres). Work in wetlands and/or 50' wetland buffer zone - 30x600' (0.41 acres). Adjacent to stream (<10') north of Phenix Ave. Work in the river bank - 30X900' (0.62 acres). Adjacent to stream (<10') south of Phenix Ave. Work in the river bank - 30X300' (0.21 acres). Stream (>10') crossing - Furnace Hill Brook. Work in the river bank - 30X400' (0.28 acres).
	Total Freshwater Wetland For Tilcon Line - 1.93 Acres
Phenix Pumping Station Force Main	Phenix Pump Station construction in river bank of stream (>10') - 100x100' (0.23 acres).
Phenix/Natick Line	Stream crossing (<10') x-country between Hillock Road and Natick Ave. Work in the river bank - 30x200' (0.14 acres). Stream crossing (<10') Natick Ave. Work in the river bank - 30x200' (0.14 acres). Adjacent to stream (>10'). Work in wetlands/ 50' wetland buffer zone/river bank - 30x1700' (1.17 acres).
	Total Freshwater Wetland Impact For Phenix/Natick Line - 1.68 Acres

Total Freshwater Wetland Impacts for Option D - 8.25 Acres

TABLE 5

FRESHWATER WETLAND IMPACTS

SECTION 117 CRANSTON WASTEWATER CONVEYANCE SYSTEM
FEASIBILITY INVESTIGATION

SERVICE AREA 3 - OPTION A

LOCATION	WORK IN FRESHWATER WETLANDS
Modifications to Howard Pump Station	No impacts

Total Freshwater Wetland Impact
Howard Pump Station - 0 Acres

F. References Cited

Army Corps of Engineers (ACOE). 1991. Section 22, Cranston, R.I. Wastewater Investigation.

Army Corps of Engineers (ACOE). 1993. Draft Feasibility Report Appendix. Water Quality and Hydrology Assessment, Cranston Rhode Island. October 1993.

City of Cranston Comprehensive Plan. 1992. City Plan Commission, Cranston, Rhode Island. February 1992.

Rhode Island Department of Environmental Management (RIDEM). 1981. Rules and Regulations Governing the Enforcement of the Fresh Water Wetlands Act. March 1981.

Rhode Island Division of Fish and Wildlife (RIDFW). 1991. Letter dated 28 March 1991 in response to a request for information concerning fisheries resources in the study area.

Rhode Island Division of Freshwater Wetlands. 1991. Phone coordination with Dean Albro on 12 October 1991.

Rhode Island Natural Heritage Program (NHP). 1991. Letter dated 22 March 1991 concerning State listed endangered species in the proposed project area.

Tutela Engineering Associates (TEA). 1991. Non-Point Source Pollution Study, Cranston, R.I. Tutela Engineering Associates, Providence, R.I. October 1991.

U.S. Fish and Wildlife Service (FWS). 1991. Letter dated 8 March 1991 concerning Federally listed endangered species in the proposed project area.

G. Correspondence

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

Department of Environmental Management
DIVISION OF FISH AND WILDLIFE
Field Headquarters
Box 218
West Kingston, R.I. 02892
Tel. (401) 789-0281
(401) 277-1267

March 28, 1991

Mr. Joseph L. Ignazio
Department of the Army
New England Division,
Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

Dear Mr.Ignazio:

I am writing in response to your letter requesting information regarding fishery resources in the Cranston and Johnston, Rhode Island areas.

Unfortunately, we do not have very much information regarding the fishery resources of that area, particularly for the streams you listed. We do, however, have some information for most of the ponds that appear in your list. You will find them listed in the enclosed publication.

Please feel free to contact me if you have any further questions.

Sincerely,

William J. Lapin

William J. Lapin
Supervising Biologist
(freshwater fisheries)

WJL:clb

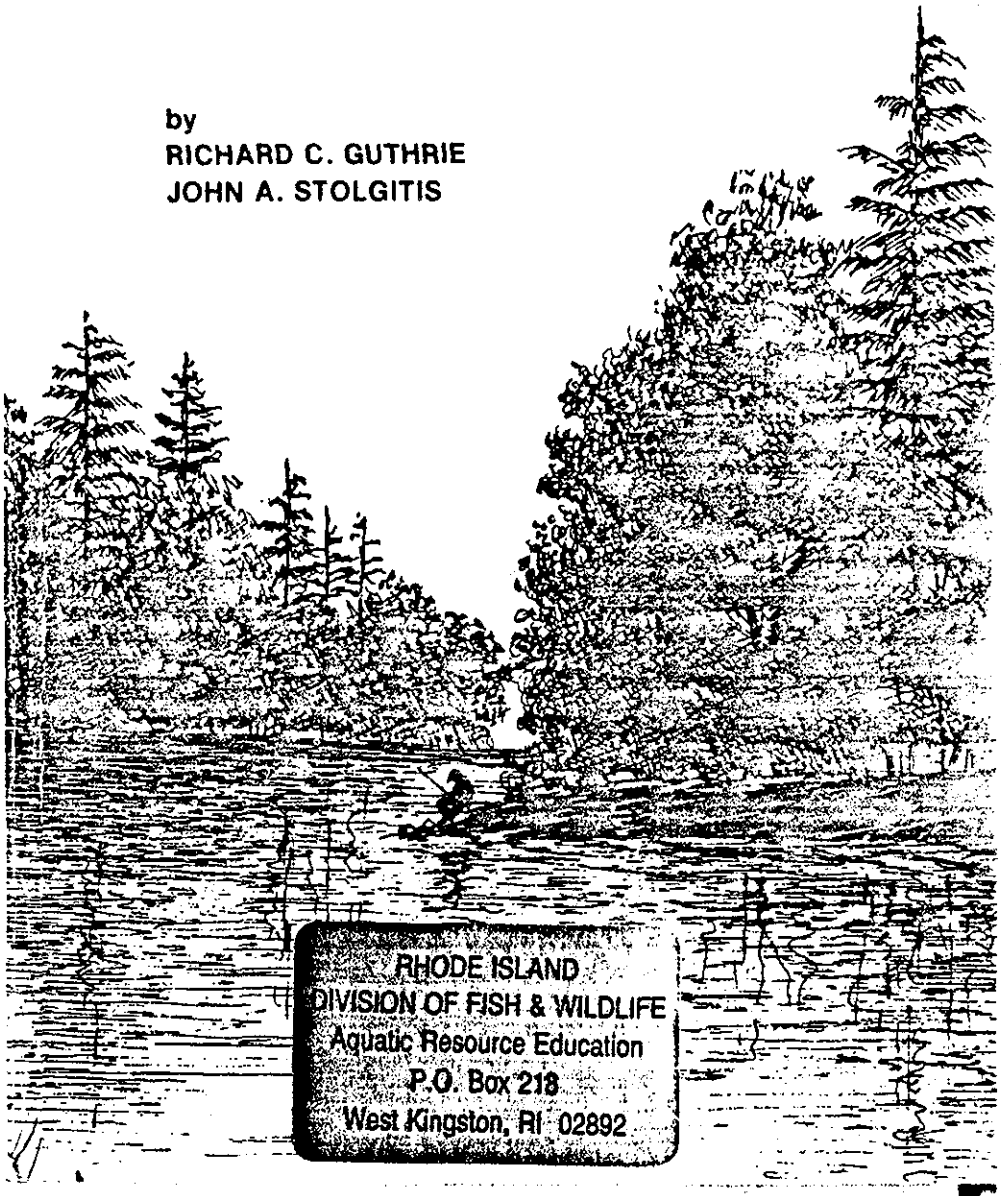
Enc.

FISHERIES INVESTIGATIONS and MANAGEMENT in RHODE ISLAND LAKES and PONDS

RHODE ISLAND DIVISION of FISH and WILDLIFE

FISHERIES REPORT NO. 3

by
RICHARD C. GUTHRIE
JOHN A. STOLGITIS



RHODE ISLAND
DIVISION OF FISH & WILDLIFE
Aquatic Resource Education
P.O. Box 218
West Kingston, RI 02892

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

Department of Environmental Management
DIVISION OF PLANNING AND DEVELOPMENT
83 Park Street
Providence, R.I. 02903-1037
(401) 277-2776

March 22, 1991

Joseph Ignazio
Director of Planning
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Rd.
Waltham, MA 02254-9149

RE: Wastewater Investigation
Cranston, RI

Dear Mr. Ignazio,

Thank you for contacting the Rhode Island Natural Heritage Program for information regarding rare species and ecologically significant natural communities in Cranston and in Johnston (south of Route 6 to Route 14).

At this time, we are aware of three populations of rare species in this area. These occurrences and their general locations are listed below:

1. Actea rubra (Red Baneberry) a species of Special Interest, occurs near the Windsor School, near the intersection of Rts. 6 and RI 195 in Johnston.

2. Agalinis tenuifolia (Slender Gerardia), a State Threatened species, occurs along a right-of-way near Fiskeville, in Cranston.

3. Corallorhiza trifida (Early Coralroot), a Species of Special Interest, occurs near Clarke Brook south of Curran Lower Reservoir in Cranston.

Please feel free to contact me if more information is required. As our inventory is ongoing, more information on this area may become available in the future.

Sincerely,

Joanne Michaud

Joanne Michaud
Data Manager/Environmental Planner
Natural Heritage Program

JM/jm

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

Mr. Joseph Ignazio, Chief
Planning Directorate
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

March 8, 1991

ATTN: Impact Analysis Division

Dear Mr. Ignazio:

This responds to your letter dated February 25, 1991 for information on the presence of Federally listed and proposed, endangered or threatened species in accordance with the preparation of a reconnaissance level investigation of wastewater pollution solutions in Cranston and Johnston, Rhode Island.

Based on information currently available to us, no Federally listed or proposed, threatened and endangered species under the jurisdiction of the U.S. Fish and Wildlife Service are known to occur in the project area, with the exception of occasional, transient endangered bald eagles (*Haliaeetus leucocephalus*) or peregrine falcons (*Falco peregrinus anatum*).

However, we suggest that you contact Rick Enser of the Rhode Island Natural Heritage Program, 83 Park Street, Providence, Rhode Island 02903, at 401-277-2776, for information on state listed species that may be present.

This response relates only to endangered species under our jurisdiction. It does not address other legislation or our responsibilities under the Fish and Wildlife Coordination Act.

A list of Federally designated endangered and threatened species in Rhode Island is inclosed for your information. Thank you for your cooperation and please contact Michael Amaral of this office at 603-225-1411 if we can be of further assistance regarding endangered species.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

Inclosure

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES IN RHODE ISLAND

Common Name	Scientific Name	Status	Distribution
FISHES:			
Sturgeon, shortnose*	Acipenser brevirostrum	E	Atlantic coastal waters
REPTILES:			
Turtle, green*	Chelonia mydas	T	Oceanic straggler in southern New England
Turtle, hawksbill*	Eretmochelys imbricata	E	Oceanic straggler in southern New England
Turtle, leatherback*	Dermochelys coriacea	E	Oceanic summer resident
Turtle, loggerhead*	Caretta caretta	T	Oceanic summer resident
Turtle, Atlantic ridley*	Lepidochelys kempii	E	Oceanic summer resident
BIRDS:			
Eagle, bald	Haliaeetus leucocephalus	E	Entire state
Falcon, American peregrine	Falco peregrinus anatum	E	Entire state-reestablishment to former breeding range in progress
Falcon, Arctic peregrine	Falco peregrinus tundrius	E	Entire state migratory-no nesting
Plover, Piping	Charadrius melodus	T	Atlantic coast
Roseate Tern	Sterna dougallii dougallii	E	Atlantic coast
MAMMALS:			
Cougar, eastern	Felis concolor couguar	E	Entire state-may be extinct
Whale, blue*	Balaenoptera musculus	E	Oceanic
Whale, finback*	Balaenoptera physalus	E	Oceanic
Whale, humpback*	Megaptera novaeangliae	E	Oceanic
Whale, right*	Eubalaena spp. (all species)	E	Oceanic
Whale, sei*	Balaenoptera borealis	E	Oceanic
Whale, sperm*	Physeter catodon	E	Oceanic
MOLLUSKS:			
NONE			
INSECTS:			
Beetle, American burying	Nicrophorus americanus	E	Washington
Beetle, northeastern beach tiger	Cicindela dorsalis dorsalis	T	Washington, probably extirpated
Beetle, Puritan tiger	Cicindela puritana	T	Extirpated
PLANTS:			
Small Whorled Pogonia	Isotria medeoloides	E	Providence, Kent Counties
Gerardia, Sandplain	Agalinus acuta	E	Washington

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service

Rev. 11-13-90