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WASTEWATER ENGINEERING AND MANAGEMENT PLAN FOR BOSTON HARBOR - --ETC(U)

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WASTEWATER ENGINEERING AND MANAGEMENT PLAN FOR BOSTON HARBOR - EASTERN MASSACHUSETTS METROPOLITAN AREA

EMMA STUDY

TECHNICAL DATA VOL. 10
DEER ISLAND WASTEWATER TREATMENT PLANT ANALYSIS AND IMPROVEMEMTS

ADA036804

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COVER PHOTO

Aerial photograph of the Deer Island Wastewater Treatment Plant - 1972.

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WASTEWATER ENGINEERING AND MANAGEMENT PLAN FOR BOSTON HARBOR – EASTERN MASSACHUSETTS METROPOLITAN AREA EMMA STUDY.

TECHNICAL DATA ~~VOL. 10~~ Volume 10.
DEER ISLAND WASTEWATER TREATMENT PLANT ANALYSIS AND IMPROVEMENTS.

FOR THE

METROPOLITAN DISTRICT COMMISSION

COMMONWEALTH OF MASSACHUSETTS

BY

METCALF & EDDY, INC.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

REPORT

CHAPTER 1

INTRODUCTION

Report Structure

As shown on the inside cover, the study results are presented in a series of volumes.

This report is Technical Data Vol. 10, Deer Island Wastewater Treatment Plant Analysis and Improvements and covers the basic design criteria for upgrading the existing primary plant and providing those facilities that would be required to accomplish secondary treatment including flows and costs.

Various site options that were investigated during the study are also presented, together with a detailed inventory of the existing Deer Island Wastewater Treatment Plant. Due to the nature and length of this inventory, it has not been included in all copies of the report. However, in order to acquaint the reader with its content, the first sheet of the inventory is included. A complete copy of the inventory is available for review at the Metropolitan District Commission, 20 Somerset Street, Boston, Massachusetts.

CHAPTER 2

EXISTING FACILITIES

General

The Deer Island Treatment Plant is designed to provide primary treatment for an average daily flow of 343 million gallons per day (mgd) and a peak flow of 848 mgd. A breakdown of the sources of these flows is presented in Table 2-1. Preliminary treatment is provided by four headworks, of which, all except one, are at off-site locations. The headworks are discussed in detail in Technical Data Vol. 9 and for that reason are not considered further here.

TABLE 2-1. DEER ISLAND WASTEWATER TREATMENT PLANT - FLOW DATA

System	Design, (mgd)	Maximum storm, (mgd)
Boston Main Drainage Tunnel	179.1	438.4
North Metropolitan Relief Tunnel	139.7	350.0
Existing North Metropolitan Sewer	24.2	60.4
	343.0	848.8
Pumped directly to outfalls	-	75.0
Total	343.0	923.8

Plant Description

A flow diagram for the plant is shown on Figure 2-1. As indicated on the diagram, wastewaters from the Main Pumping Station and the Winthrop Terminal facility are discharged to the treatment plant.

Wastewater is conveyed to the Main Pumping Station by gravity through two independent tunnel systems. The Main Pumping Station is designed to handle an average flow

NOTE:

→ PATH OF FLOW THROUGH WWTP

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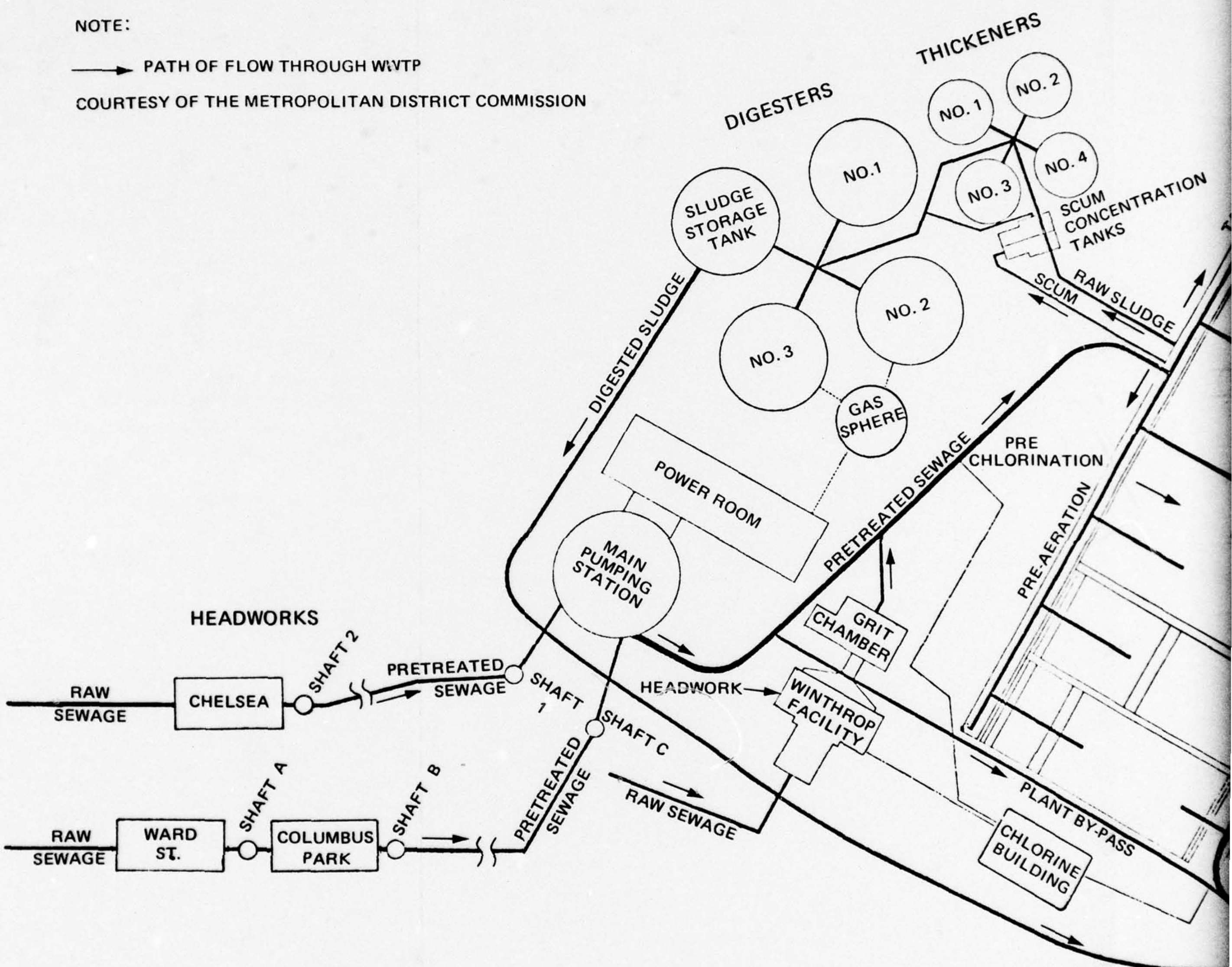


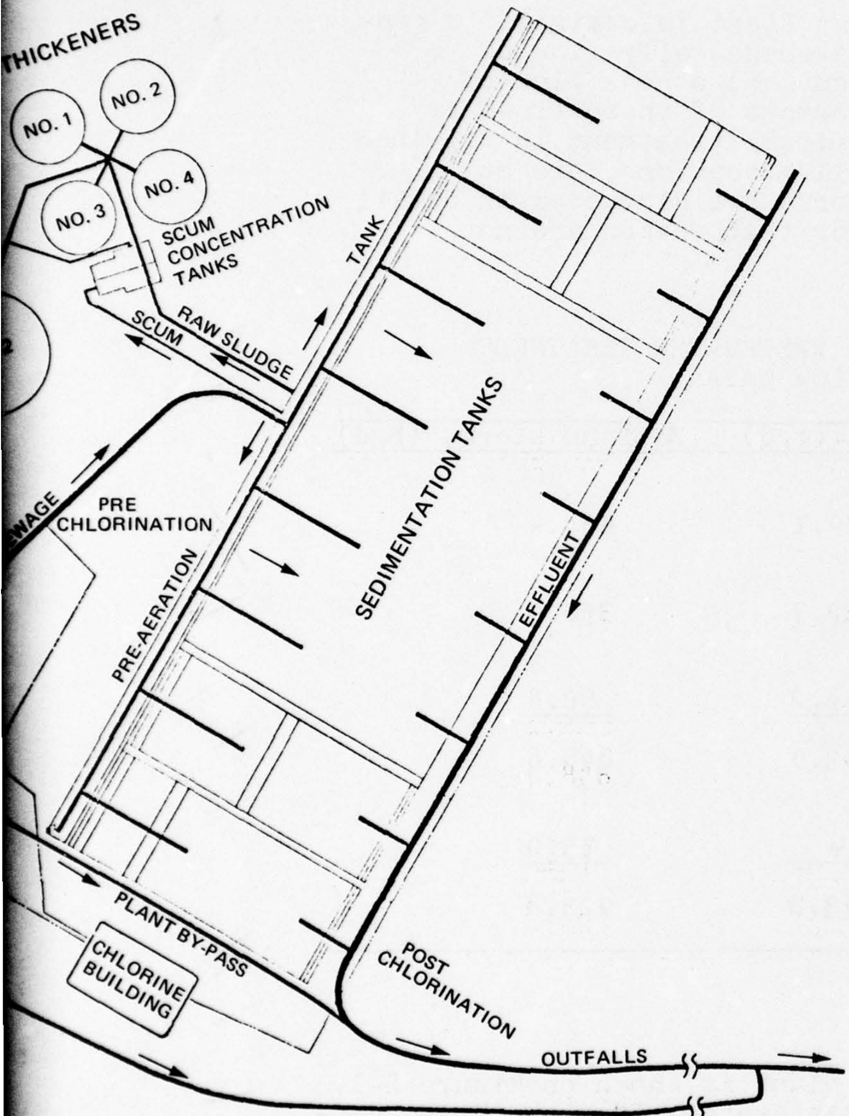


FIG. 2-1 FLOW DIAGRAM-DEER ISLAND WASTEWATER TREATMENT PLANT

of 319 mgd and a peak flow of 788 mgd. The flow from the Winthrop Terminal facility which has a capacity to pretreat an average flow of 24 mgd and a peak flow of 60 mgd is mixed with the effluent from the main pumping station. The combined flow (343 mgd average - 848 mgd peak) is then discharged to the primary treatment plant.

The Winthrop Terminal facility was designed to divert a flow of 75 mgd from that facility directly to the plant outfall system. This capability will be used when excessive storm runoff occurs in the combined system which is tributary to that facility. To handle this quantity of flow as well as the peak flow through the plant, the outfall system has been designed to have a capacity of 923 mgd at the highest tide of record (El 115.7 MDC Datum) as shown in Table 2-1.

The Deer Island Treatment Plant consists of two preaeration channels, eight primary sedimentation tanks, four thickening tanks and four digesters. Particulars relating to this and other principal equipment are presented in Appendix A.

An engineering evaluation of the main pumping station is presented in Appendix B.

As part of this investigation, a detailed inventory was taken of the existing equipment. The inventory is presented in Appendix C.

Plant Operations

The plant and headworks are maintained and operated by a staff of 239 people. Of these, approximately 60 are employed at the headworks. Of the remaining 179 who are assigned to the plant, 10 undertake administrative and general office work, 69 are assigned to operations, 91 are employed to maintain the plant and nine are used for laboratory and engineering control purposes.

A partial summary of operational data for the period of July 1, 1973 to June 30, 1974 is presented in Table 2-2.

TABLE 2-2. PLANT OPERATIONAL DATA - 1974(1)

Process flow, mgd(2)	
Average daily	299
Maximum 24 hour	4[illegible]
Minimum 24 hour	237

TABLE 2-2 (Continued). PLANT OPERATIONAL DATA - 1974[1]

Suspended solids	
Influent - ppm[3]	129
Effluent - ppm	56
Removal, percent	56
Removal, lb/day[4]	182,000
Grease, petroleum ether solubles	
Influent - ppm	21.7
Effluent - ppm	11.3
Removal, percent	48
Removal, lb/day	26,000
Settleable solids	
Influent - mg/L	3.9
Effluent - mg/L	0.86
Removal, percent	78
BOD, 5 day	
Influent - ppm	132
Effluent - ppm	88
Removal, percent	33
Removal, lb/day	109,000
Bacterial concentration	
Influent - MF/100 ml[5]	62,400,000
Effluent - MF/100 ml	762
Percent kill	99.999
Chlorine requirement (demand)	
Influent - ppm	7.9
Effluent - ppm	4.6

Note: The chlorine requirement fluctuates greatly because of significant salt water inflow occurring at high tides.

Chlorine usage	
Applied - ppm	12.3
Average daily, tons	15.3
Total for year, tons	5,598

TABLE 2-2 (Continued). PLANT OPERATIONAL DATA - 1974(1)

Chlorine residual	
Effluent - ppm	0.56

1. Does not include wet weather flows diverted at the headworks to the Cottage Farm or Moon Island facilities, nor overflows.
2. Fiscal year - July 1, 1973 - June 31, 1974.
3. Parts per million.
4. Pounds per day.
5. Millipore filter units/100 milliliters.

Adequacy of Existing Facilities

The Deer Island Wastewater Treatment Plant was placed in service in June of 1968 and has, therefore, been in operation for approximately seven years. This operational period represents only a short period of the normal operating life of most of the equipment at this installation. Since this is so and since the equipment has received good day to day maintenance, it can be anticipated that the condition of most of the major equipment is such that it can be used in an expanded facility.

The comments made here, relative to the condition of the major elements of the existing facilities, are based on the inventory survey, plant inspections, interviews with plant operating staff, and review of previous reports, where such were concerned with the condition of the existing facilities at the plant.

Main Pumping Station

The pumping facilities at this station consist of nine centrifugal sewage pumps driven by direct connected dual fuel radial engines. Although the pumps are manually turned on and off, the capacity of the pumps is regulated by automatically controlling the speed to maintain a constant level in the drop shaft at the appropriate headwork. Each pump discharges into a 60-inch steel pipe that rises some 90 feet to ground level, and discharges through a siphon connection to a common effluent channel. The siphon connection is equipped with a vacuum relief device which is designed to prevent back flow through the pump.

The condition of the equipment at this installation is covered in a letter report presented in Appendix B. This report recommends that the radial dual fuel engine drives be replaced with electric motors. This recommendation is repeated here to emphasize the importance of undertaking a study concerning electrification so that findings may be properly integrated with an upgraded Deer Island Treatment Plant.

Preaeration Facilities

The preaeration channels and the air diffusion systems are in good structural and mechanical condition. These facilities can be used in an upgrading situation. At times, a silty-grit material is deposited in part of the preaeration channels. Deposition occurs in front of primary sedimentation tanks No. 1 through 4, but not appreciably in front of tanks 5 through 8. This deposition may be caused by the hydraulic inlet conditions to the preaeration channels or the inadequacy of the air diffuser system to maintain the solids in suspension. In either case, this condition should be corrected when the plant facilities are upgraded by using water jets, by tapering the channel, by correcting the hydraulic inlet condition, or by any combination thereof.

Primary Sedimentation Tanks. The primary sedimentation tanks and the equipment associated with them, with the exception of the scum collection system, can be used in an upgrading situation.

Scum Collection System. The scum collection system consists of reciprocating scum skimmers which move the scum transversely across the tanks to V notch weirs that discharge into sumps. The scum is pumped from the sumps to scum concentration tanks. Reciprocating scum skimmers are not designed to handle thick concentrations of scum. For this reason, the plant operators are often required to paddle the scum by hand into the sumps. This happens frequently enough so that consideration should be given to replacing the reciprocating skimmers with helical scum collectors or ramp type operations in conjunction with helical scum collectors, when the plant is upgraded.

The remainder of the scum collection system should also be upgraded so that, in accordance with present plans, the scum may be incinerated along with the sludge that is removed from the wastewater.

Chlorination Facilities. The chlorination system is of modern design and consists of duplicate 16 ton liquid chlorine containers, eight evaporators and eight chlorinators. This equipment can be incorporated into an expanded plant facility. In order to insure sufficient contact time before the chlorinated effluent is discharged, a regulating gate was provided in the main plant outfall. This gate was automatically raised or lowered, according to tide level, to maintain a specific level in the effluent channel from the primary sedimentation tanks. The control system through which this gate was operated was not properly responsive to a rapid rise in level in the effluent channel and for this reason this gate is now operated manually. This control system should be abandoned in an upgrading situation.

Heating-Electrical Plant. The heating plant which consists of three steam boilers is in good condition and can be used in an upgrading situation.

The electrical plant has capacity for future electrical needs as well as space for expansion. Some minor repairs are required on that equipment which is exposed to salt air spray.

Plant Outfall System

The existing outfall system as shown on Figure 2-2 has two submerged outfalls that are normally used and a so called temporary submerged outfall that may be used under higher flow and tide conditions. The existing outfall system is provided with two relief outfalls that discharge directly to the bay. These relief outfalls are located at Gate Chambers A and C.

The submerged outfalls that are normally used consist of the "Old Outfall" that served the former Deer Island Pumping Station, and a "New Outfall" that was constructed at the same time as the primary treatment facilities.

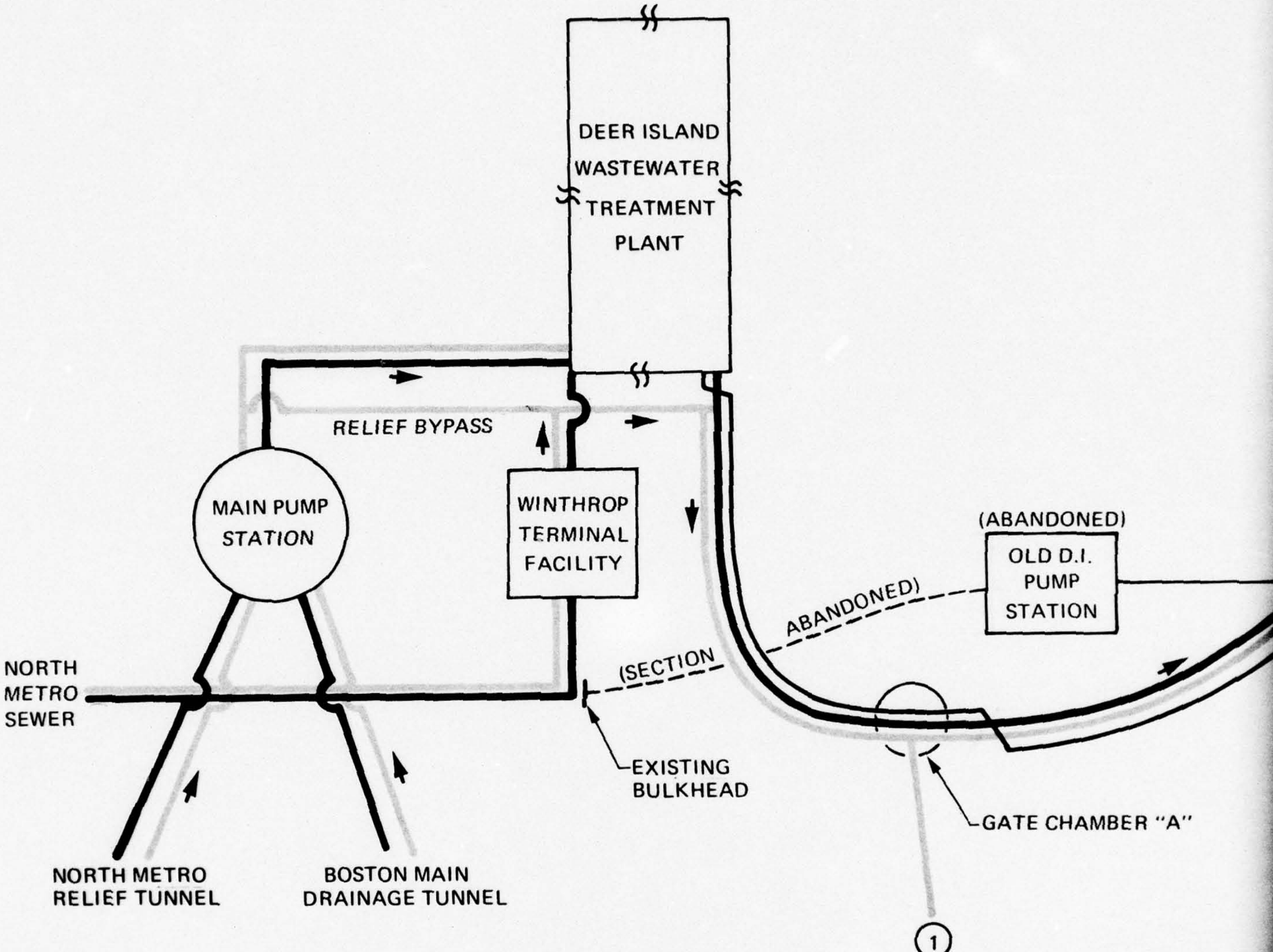
A survey was recently undertaken to determine the conditions of the submerged portions of the existing outfall system at the Deer Island Wastewater Treatment Plant. The results of the survey were presented in a report prepared for the Metropolitan District Commission.*

This report notes the following:

"OLD OUTFALL"

"The iron outfall pipe appears to be in satisfactory conditions despite heavy rusting. The rims of the

*Structural Evaluations and Ecological Observations in Boston Harbor, TCE Incorporated, Boston, Massachusetts, March 1973.



LEGEND

1 RELIEF OUTFALL A
2 RELIEF OUTFALL C
3 EXISTING OUTFALL (NEW OUTFALL)
4 DEER ISLAND OUTFALL (OLD OUTFALL)
5 EXISTING TEMPORARY OUTFALL
NORMAL FLOW PATH
EMERGENCY FLOW PATH

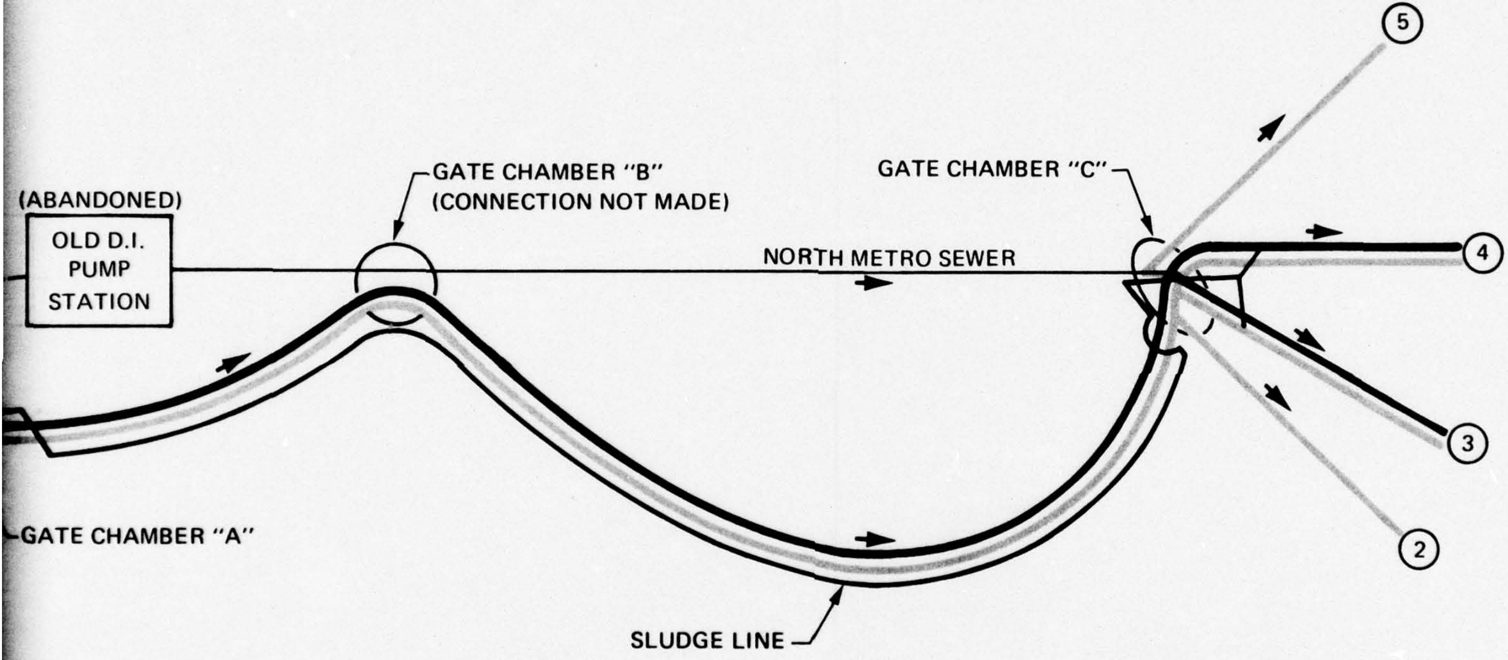


FIG. 2-2 DEER ISLAND WASTEWATER TREATMENT PLANT – OUTFALL SYSTEM

diffusion ports, however, have been considerably weakened by corrosion. Diffuser port No. 9 has been completely occluded by rocks and No. 7 is partially blocked by a tangle of wire rope."

"NEW OUTFALL"

"The Deer Island Treatment Plant "new outfall" is no longer efficient in its operation." Of the fifty-two (52) diffuser ports: ten (10) are completely buried beneath the seabed, four (4) are completely occluded but not buried, five (5) are partially blocked by a variety of debris and ten (10) are in immediate danger of becoming occluded by nearby rocks."

The report recommends with respect to the "new outfall:"

"It is recommended that the conditions of the outfall be monitored in early spring to determine if the winter storms occurring since our inspection have resulted in additional blockage of diffuser ports. Divers could also enter the outfall through a diffuser port to determine the extent to which debris has accumulated within the seaward end of the diffuser section. This information would appear vital for the evaluation of effective measures to restore the outfall to design capacity. Additionally, an inspection of the interior of the pipe would reveal the difficulty of cleaning the outfall which might lead to the alternative of removing the elbow of port No. 1 by an explosive charge."

We have reviewed these recommendations and generally concur with them.

CHAPTER 3

PRIMARY TREATMENT FACILITIES

General

The purpose of this chapter is to discuss the need for providing additional primary treatment facilities to meet year 2000 needs at the Deer Island Treatment Plant. Primary treatment facilities at the present site consist of preaeration channels, primary tanks, chlorination facilities and an outfall system. As previously noted, all of these facilities, some with modification, can be used in an upgrading situation.

Basic Design Criteria

The basic design criteria developed for expansion of the existing primary plant are presented in Table 3-1.

The flows have been developed in accordance with the techniques and parameters set forth in Technical Data Vol. 2. The flows allow for major and minor industrial, commercial and residential wastewater flows and include an allowance for infiltration. Major industrial flows were determined by survey. Peak day flows have been arrived at by applying, according to source, appropriate factors to dry weather flows and include an allowance for peak-wet weather rates of infiltration.

A peak flow of 930 mgd which represents the flow fall capacity of the incoming sewers, has been used for both 2000 and 2050. An incoming flow of this magnitude has not been historically realized, because all of the pumps at the main pumping station have not been capable of operation at one time. It is anticipated that the full capacity of the incoming sewer system would be utilized in the future during storm runoff periods.

Present biochemical oxygen demand (BOD) and suspended solids (SS) loads were determined by computer analysis of existing plant data covering the period from January 1971 to March 1973. The analysis established the yearly average and peak 1-day loads for both BOD_5 and SS.

A present average load of 439,000 pounds per day of BOD_5, and 374,000 pounds per day of suspended solids are equivalent to an overall daily per capita contribution of 0.33 pounds of BOD_5 and 0.28 pounds of suspended solids. To determine future average BOD_5 and suspended solids

TABLE 3-1. BASIC DESIGN CRITERIA DEER ISLAND TREATMENT PLANT PRIMARY EXPANSION

	Present	2000 design	2050
Flow (mgd)			
Average day	336	400	430
Peak day	573	731	782
Peak	845(1)	930	930
BOD_5 (lb/day)			
Average	439,000	555,000	571,000
Peak	930,000	1,176,000	1,210,000
SS (lb/day)			
Average	374,000	511,000	
Peak	1,128,000	1,678,000	
Preaeration channels			
Number of units	2	4	4
Unit length, (ft)	400	2 at 400 2 at 300	2 at 400 2 at 300
Unit width, (ft)	20	20	20
Detention time, (minutes)			
At average day	7.9	11.6	10.8
At peak day	4.8	6.5	6.1
Primary tanks			
Number of units	8	14	14
Unit length, (ft)	245	245	245
Unit width, (ft)	98	98	98
Overflow rate, (gpd/sq ft)			
Average day	1,749	1,190	1,279
Peak day	2,983	2,174	2,326
Peak	4,399	2,767	2,767
Chlorine contact chamber			
Number of units	--	2	
Unit length, (ft)	--	320	
Unit width, (ft)	--	72	
Unit depth, (ft)	--	15	

TABLE 3-1 (Continued). BASIC DESIGN CRITERIA DEER ISLAND TREATMENT PLANT PRIMARY EXPANSION

	Present	2000 design	2050
Detention time, (minutes)			
At average flow			
Outfall(2)	--	16	
Chamber	--	19	
Total	--	35	
At peak flow			
Outfall	--	7	
Chamber	--	8	
Total	--	15	
Effluent pumping station			
(Operational frequency keyed to hydraulic capacity of gravity discharge through outfall)			
Flow, (mgd)			
Average day	336	440	
Peak day	573	731	
Peak	845	930	

1. Occurred between 7-1-72 and 6-30-73.
2. Assumes outfall conduit flows full.

quantities, the BOD_5 per capita contribution has been increased to 0.38 pounds per day and the suspended solids per capita contribution to 0.35 pounds per day. This increase can be expected due to improvement in the standard of living of the serviced population with an accompanying increase in the use of garbage grinders, and in wastage.

Analysis of present plant operating data established peak 1-day loads. The ratio between peak 1-day loads and average loads was then determined, and the ratio so determined was used to forecast future peak 1-day loads.

Main Pumping Station - Winthrop Terminal Facility

The primary treatment plant receives flow from two sources; the Main Pumping Station, and the Winthrop Terminal facility. It is estimated that under peak flow conditions (930 mgd), 795 mgd will be contributed by the Main Pumping Station and approximately 135 mgd by the Winthrop Terminal facility.

The main pumping station has a peak capacity in excess of 810 mgd, under existing operating conditions. Accordingly, the facility has sufficient capacity to meet projected peak demands of 795 mgd. As noted in Chapter 2 and in Appendix B, it is recommended that the radial dual fuel engines that drive the pumping units be replaced with electric motors.

The Winthrop Terminal facility has been designed to screen and pump a peak flow of 135 mgd, 60 mgd of which passes through aerated grit chambers before discharge to the primary treatment system. The facility is so arranged that the remaining 75 mgd can be bypassed around the grit removal and the existing primary treatment facilities and discharged directly to the outfall system. Since all wastewaters will require treatment, this arrangement must be modified. This can be done by providing additional grit removal facilities and routing the effluent from these new facilities as well as from the existing grit chambers to the primary treatment system.

Preaeration Channels

The existing preaeration channels provide retention time of approximately 4.8 and 7.9 minutes at present peak and average daily flow rates. Based on experience elsewhere, these retention times are not long enough to permit sufficient preflocculation of the wastewater to materially aid the following settling process. Preaeration does, however, aid in keeping the solids in suspension and in improval scum removal. For these reasons, the preaeration features of the existing facility are retained and expanded. Two additional preaeration tanks, each 20 feet wide by 300 feet long, would be provided in the expanded facility. The number and the size of the additional units has been selected on the basis that six additional primary tanks would be provided. With the new units, the retention times at design average and peak flows will be increased to approximately 11.6 and 6.5 minutes, respectively.

Primary Sedimentation Tanks

The settling performance of primary tanks is related to the surface hydraulic loading (overflow rate) which is expressed in units of gallons per day per square foot (gpd per s.f.) of surface area. Under present conditions, the overflow rates on the average day, peak day and under peak conditions are 1,749, 2,983 and 4,349, respectively, which were common design parameters. These overflow rates when compared to present design standards are considered to be excessive. This is particularly true at peak flow since we would anticipate that there would be a tendency to wash solids out of the tanks at an overflow rate of 4,349 gpd per sf. For this reason, it is recommended that the number of primary tanks be increased from 8 to 14. The resulting overflow rates under design conditions are satisfactory provided that secondary treatment follows the primary treatment process.

In the event that primary treatment in conjunction with a deep ocean discharge is considered, then the number of primary tanks should be increased from 8 to 16. Under design conditions, this number of primary tanks will provide on the average day, peak day and at times of peak flows, overflow rates of 1,041, 1,902 and 2,420 gpd per s.f., respectively. These overflow rates are in conformance with good design practice for primary treatment facilities that treat combined wastewaters.

Outfall System

The existing outfall system consists of a single conduit that contains three gate chambers A, B and C. At Gate Chamber C, the conduit discharges into two submerged outfalls, the "Old Outfall" that served the old Deer Island Pumping Station and a "New Outfall" that was constructed at the same time as the treatment plant. Two relief outfalls were provided in the outfall system, one at Gate Chamber A and the other at Gate Chamber C. Both relief outfalls were designed to discharge either directly to or just beyond the Deer Island shoreline. Provision was also made at Gate Chamber B to interconnect the new outfall conduit to the land portion of the outfall system that served the Old Deer Island Pumping Station. However, this connection was never completed.

It is recommended that the interconnection at Gate Chamber B to the Old Deer Island outfall system be completed.

Chlorination Facilities

Pre- and post-chlorination is practiced at the Deer Island Treatment Plant. Prechlorination is not used routinely and is applied only when odor control is required or in the event there is a breakdown in the post-chlorination system. On the average, a post-chlorination dosage of 12.3 milligrams per liter (mg/L) is applied in the primary effluent channel, and approximately 15.3 tons of chlorine are used each day.

Regulatory authorities require that sufficient chlorine be applied to a treatment plant effluent to obtain a residual of 1 mg/L after a 15 minute retention period. Although the actual application rate must be determined by test, primary effluents usually require a dosage of approximately 12 mg/L to meet this criteria. At the design period a dosage of 12 mg/L will require chlorine application at the rate of 19, 36 and 46 tons per day under average day, peak day and peak conditions, respectively. Since these application rates exceed the 29 ton capacity of the existing chlorinators (seven at 8,000 pounds per day (lb/day) and one at 2,000 lb/day), additional chlorination facilities may be required. These facilities should be sized to provide standby equipment.

Under existing operating conditions, the retention time for the chlorination system is provided by the outfall system. Calculations indicate that, if the interconnection at Gate Chamber B is provided, then the retention time within this system will be seven minutes at the design peak flow. To increase the retention period to 15 minutes, construction of two chlorine retention tanks, each 72 feet in width and 320 feet in length is recommended.

With secondary treatment required, the elevation of the water surface in the chlorine contact tanks (see Figures 3-1 and 4-1 presented later in this report) will be substantially lower than that level which will exist under primary treatment conditions. For this reason, the tanks should be initially constructed deep enough, so that an adequate retention period will be obtainable when secondary treatment is provided.

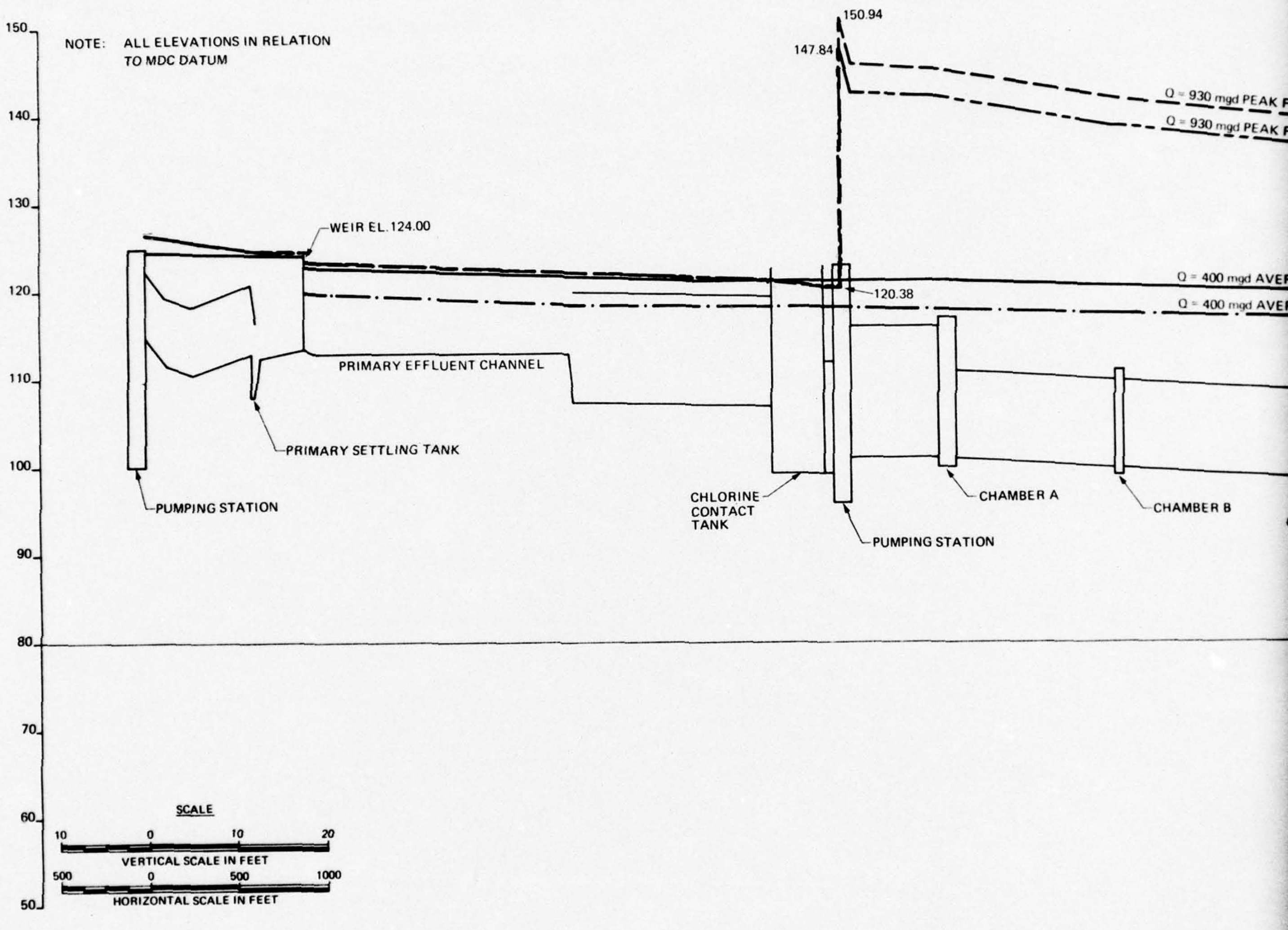
Effluent Pumping Station

In developing a preliminary hydraulic profile for the Deer Island Treatment Plant, certain assumptions were made. The more important assumptions are:

1. that the interconnection at Gate Chamber B between the land portions of the "Old" and "New" outfall would be completed, and

2. that the submerged portions of the outfalls would be restored to their original capacity.

A preliminary hydraulic profile for the primary treatment plant is shown on Figure 3-1. The profile indicates that at maximum tide of record El 115.7 feet (MDC DATUM) and peak flow (930 mgd), gravity discharge from the primary tanks to the sea would not be possible. It is estimated that approximately 2.5 percent of the time, it would be necessary to pump in order to discharge the treated effluent. The station would be equipped with 10 pumping units each capable of pumping approximately 103 mgd against 30 feet of head. The need for this pumping station should be considered further during detailed facilities planning and discussed with officials from the EPA and other regulatory agencies.


NOTE: ALL ELEVATIONS IN RELATION TO MDC DATUM
150
140
130
120
110
100
90
80
70
60
50
150.94
147.84
Q = 930 mgd PEAK FL
Q = 930 mgd PEAK FL
WEIR EL. 124.00
120.38
Q = 400 mgd AVERA
Q = 400 mgd AVERA
PRIMARY EFFLUENT CHANNEL
PRIMARY SETTLING TANK
PUMPING STATION
CHLORINE CONTACT TANK
PUMPING STATION
CHAMBER A
CHAMBER B
SCALE
10 0 10 20
VERTICAL SCALE IN FEET
500 0 500 1000
HORIZONTAL SCALE IN FEET

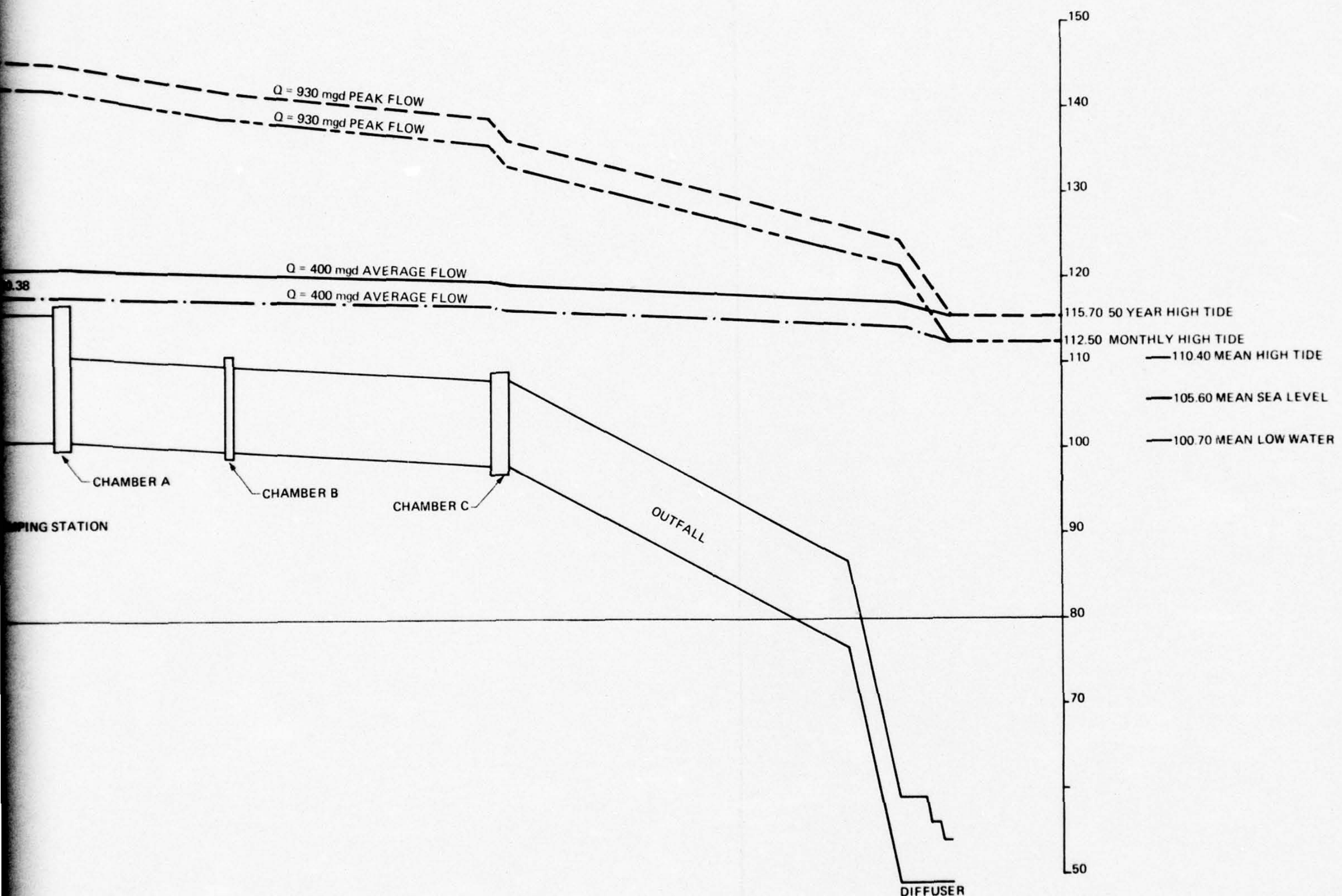


FIG. 3-1 DEER ISLAND WASTEWATER TREATMENT PLANT PRELIMINARY HYDRAULIC PROFILE PRIMARY EXPANSION

CHAPTER 4

SECONDARY TREATMENT FACILITIES

General

Extension to secondary treatment is provided to meet the minimum treatment established for the Deer Island Treatment Plant as defined in Technical Data Vol. 2. In this particular situation, the activated sludge process has been selected to achieve this treatment. Those unit processes that constitute an activated sludge process are discussed in this chapter along with the effect, if any, of this extension on the proposed primary plant facilities as outlined in Chapter 3.

Additional Facilities

The activated sludge process, through the use of a biological mass, has the ability of reducing the organic and suspended solids load that is characteristically found in primary treatment plant effluents. The biological mass called mixed liquor suspended solids (MLSS) is maintained in tanks which are equipped with various devices to supply oxygen to insure that the biological mass will remain viable. Air is normally used as a source of oxygen. For this reason, these tanks are denoted as aeration tanks. Food (BOD_5) for the biological mass is obtained from the primary treatment plant effluent.

To insure that the biological mass developed in the aeration tanks is not discharged to the receiving waters, it is necessary to separate the solids within the aeration tank mixed liquor from the final effluent. This is done in final settling tanks. A portion of the settled sludge is returned to the system to maintain the required biological mass, and excess sludge which develops from the growth of the biological mass in the aeration tanks is wasted. The wasted sludge can be handled by various methods to insure acceptable disposal for each condition.

Sludge management alternatives and a recommended plan for the Deer Island Treatment Plant are presented in a report* on sludge management for Deer Island and Nut Island treatment plant wastes. For this reason, considerations regarding sludge handling are excluded from this report.

---

*Havens and Emerson Consulting Engineers, <u>A Plan for Sludge Management</u>, prepared for the Commonwealth of Massachusetts Metropolitan District Commission, August 1973.

The activated sludge process can be designed using various concentrations of biological mass, organic loading rates, aeration detention times, sources of oxygen supply and rates of returned sludge. For this reason, many process modifications can be developed that will produce effluents of similar quality.

For purposes of this study, the step aeration modification of the activated sludge process has been selected. Because of the higher permissible organic loadings per unit of volume, this process permits smaller aeration tanks than the conventional activated sludge process. It also has the advantage that a great deal of operational flexibility is readily available. The step aeration process is designed to maintain 2,000 to 3,000 mg/L of mixed liquor suspended solids (MLSS) within the aeration system and to accept a food to MLSS ratio varying from 0.25 to 0.40. With these design parameters, the system will reduce BOD_5 by 85 percent or better, and will produce approximately 0.6 of a pound of excess sludge per pound of BOD_5 removed.

Since the available site is limited, it is important to keep the aeration tank sizes to a minimum so that any fill requirements will be correspondingly minimized. There is available an activated sludge process that utilizes pure oxygen rather than air as a source of oxygen supply. This process is capable of accepting significantly higher loadings within the aeration system and operate at higher MLSS than the step-aeration process. For these reasons, the size of the aeration units can be smaller than those required in the step aeration process for the same removal efficiencies. Similarly, the aeration tanks can be reduced by increasing their depth. This, however, is done at an increase in energy costs. The applicability of using pure oxygen on all types of wastewaters has not been fully demonstrated. This process should be piloted, preferably at a large scale, to prove its acceptability before it is considered for design.

In addition, comparative pilot plant testing is deemed desirable to determine maximum organic loading rates, settling tank overflow rates and solids loading rates, oxygen requirements and sludge generation factors. In addition, effect of highly variable organic load associated with storms and high chloride concentrations (6,000 mg/L) should be investigated.

Since such pilot work is beyond the scope of this study, this system has not been chosen for preliminary consideration. Such pilot work, however, should be undertaken before any particular process is selected for actual design. This is extremely important in this case because adoption of the pure oxygen activated sludge system may result in savings in total capital expenditure due to the smaller land and corresponding fill requirements. However, the cost savings available from the use of smaller oxygen aeration tankage are at least partially offset by the crosswalls required for staged reactors, the gas tight covers and expensive cryogenic oxygen generating systems. In addition, due to the higher MLSS concentration used with oxygen systems, the final settling tanks may have to be made larger to avoid solids loading problems. In addition, consideration must be given to relative operating and maintenance cost of more complicated oxygen generator and numerous mechanical aerators compared to blower systems. Similarly cost analysis should be carried out to establish an optimum depth for normal aeration tanks as opposed to energy requirements.

Basic Design Criteria

The basic design criteria relative to the secondary extension of the Deer Island Wastewater Treatment Plant are presented in Table 4-1. The average and peak BOD_5 loads that the secondary units will treat are also set forth in this table. These loads have been established as previously described under Basic Design Criteria in Chapter 3, and allow for a 30 percent removal in the primary process and recycled loads.

Aeration Tanks

Under design conditions 20 aeration tanks, each 370 feet long, 80 feet wide and 15 feet in depth, would be required. Each tank would be so arranged that four passes, each 20 feet wide, would be available. Returned sludge from the final settling tanks would be introduced into the first pass. The aeration tank would be so channeled that the incoming primary effluent may be introduced at the head end of each pass.

Studies undertaken for similar sized plants have indicated that a diffused air system is more economical than a mechanical aeration system to supply the necessary oxygen. Accordingly, for costing purposes a fixed diffused air system has been selected. Such a system would require the construction of a blower building to house the blowers that would supply the diffused air system.

TABLE 4-1. BASIC DESIGN CRITERIA DEER ISLAND TREATMENT PLANT SECONDARY EXTENSION

	Present	2000 design	2050
Flow, (mgd)			
Average day	336	400	430
Peak day	573	731	782
Peak	845(1)	930	930
Aeration tanks			
BOD_5, (lb/day)(2)			
Average day		444,000	457,000
Peak		941,000	968,000
Number of units		20	20
Unit length, (ft)		370	370
Unit width, (ft)		80	80
Unit depth, (ft)		15	15
Loading, (lb of BOD_5/ 1,000 cu ft)			
Average day		50	51.5
Peak day		106	109
Final tanks			
Number of units		48	48
Type		Circular	Circular
Diameter, (ft)		145	145
Depth, (ft)		14	14
Overflow rate, (gpd/ sq ft)			
Average day		505	542
Peak		1,174	1,174

1. Occurred between 7-1-72 and 6-30-73.
2. Includes 10 percent recycle load.

Each aeration tank would be equipped with a foam control system which would consist of a series of jet nozzles placed around the periphery of the tank. Screened final effluent would be used as a source of water for the foam control system.

Final Tanks

Forty-eight circular tanks would be provided, each 145 feet in diameter and 14 feet in depth. At a peak flow of 930 mgd the overflow rate would be 1,174 gallons per day per square foot. This rate is low enough to insure that the solids within the tank would not be washed out with the effluent at times of peak flow.

Each tank would be equipped with a sludge collection system of the suction type to insure timely and complete removal of the settled solids. Each tank would also be equipped with a scum collection system.

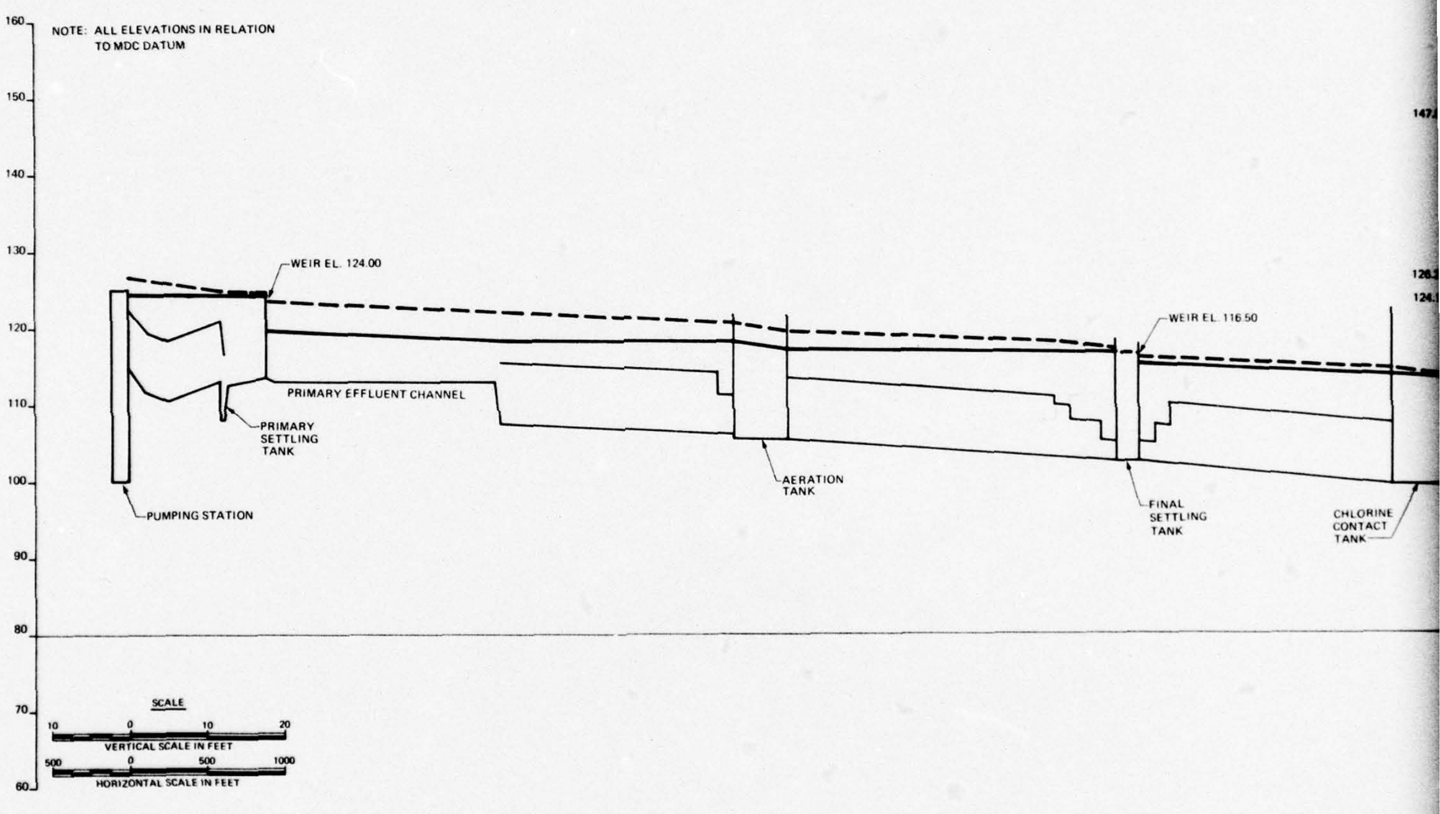
The sludge taken from the final tanks would be conveyed by gravity to return and waste activated sludge pumping stations. One return and waste sludge pumping station would be provided to serve 24 final tanks. The return sludge pumping station would be equipped with variable speed pumps so that the rate of return sludge may be modified to meet different operational requirements. While shorter sludge detention times are desirable and achievable with circular units, limited space availability may dictate use of rectangular tanks in final design.

Effluent Pumping Station

Since the peak flow through the secondary plant is the same as that established for the primary plant, there will be no need to increase the capacity of this facility.

A preliminary hydraulic profile for the secondary treatment plant is shown in Figure 4-1. As indicated in that profile, at times of peak flow (930 mgd) and maximum tide of record El 115.7 (MDC Datum) gravity discharge would not be possible. Due to the additional hydraulic loss within the secondary system the pumps will be required to discharge against a maximum head of approximately 37 feet. When the primary effluent pumping station is constructed, this condition should be recognized so that the pumps may be readily modified at a later date to meet the new head-discharge conditions.

The pumping facility would be required to operate approximately 25 percent of the time.


NOTE: ALL ELEVATIONS IN RELATION TO MDC DATUM
160
150
140
130
120
110
100
90
80
70
60
WEIR EL. 124.00
WEIR EL. 116.50
PRIMARY EFFLUENT CHANNEL
PRIMARY SETTLING TANK
PUMPING STATION
AERATION TANK
FINAL SETTLING TANK
CHLORINE CONTACT TANK
SCALE
10 0 10 20
VERTICAL SCALE IN FEET
500 0 500 1000
HORIZONTAL SCALE IN FEET

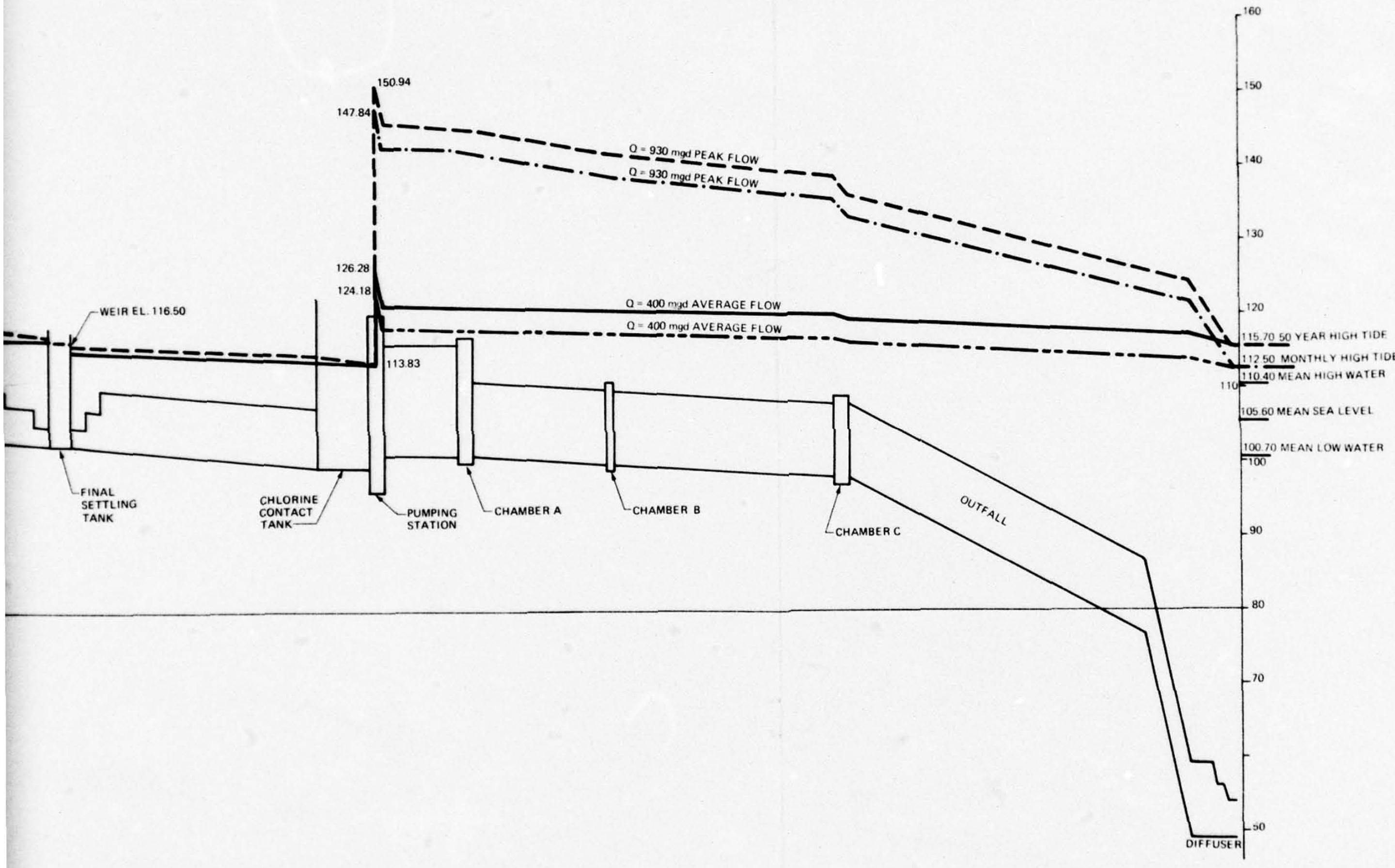


FIG. 4-1
DEER ISLAND WASTEWATER TREATMENT PLANT PRELIMINARY HYDRAULIC PROFILE- SECONDARY EXTENSION

2

Primary Tanks and Chlorination Facilities

Since the design of both of these facilities is on the basis of peak flows and since the estimated peak flow is not changed with the secondary expansion, these facilities would not require modification.

CHAPTER 5

ALTERNATIVE LAYOUTS

General

Deer Island is presently occupied by a County House of Correction, the Deer Island Wastewater Treatment Plant and an inactive military installation. The Boston Harbor Islands Comprehensive Plan* recommends that the southern portion of the island that is occupied by the inactive military installation be developed for recreational purposes. The plan also recognizes that land will be required for expansion of the Deer Island Treatment Plant. For this purpose, it recommends the use of the site of the correctional institution and some 10 acres of fill on the north side of the Island.

The major topographic feature on the island is a drumlin that rises some 100 feet above sea level, and which is located just south of the existing Deer Island Treatment Plant. This natural geological feature has a high potential for development for recreational use as well as enhancing the natural appearance of the Harbor.

Site Options

Expansion of the existing primary treatment facilities presents no particular difficulties. From an engineering standpoint, expansion of the primary tanks is best accomplished through construction of similar units adjacent and to the east of the existing facilities. Since six more primary tanks can be so arranged all within the existing MDC property, this expansion is not in conflict with the other proposed uses of Deer Island. In the event the deep ocean discharge alternative materializes, eight more primary tanks could similarly be accommodated. In this case a small amount of fill (1.3 acres) would be required on the north side of the Island.

The major difficulty in site development is finding sufficient area to accommodate the aeration and final tanks that are required to provide secondary treatment. This is evident when it is recognized that these facilities will occupy approximately 75 acres, an appreciable portion of the total 210 acres of land on Deer Island.

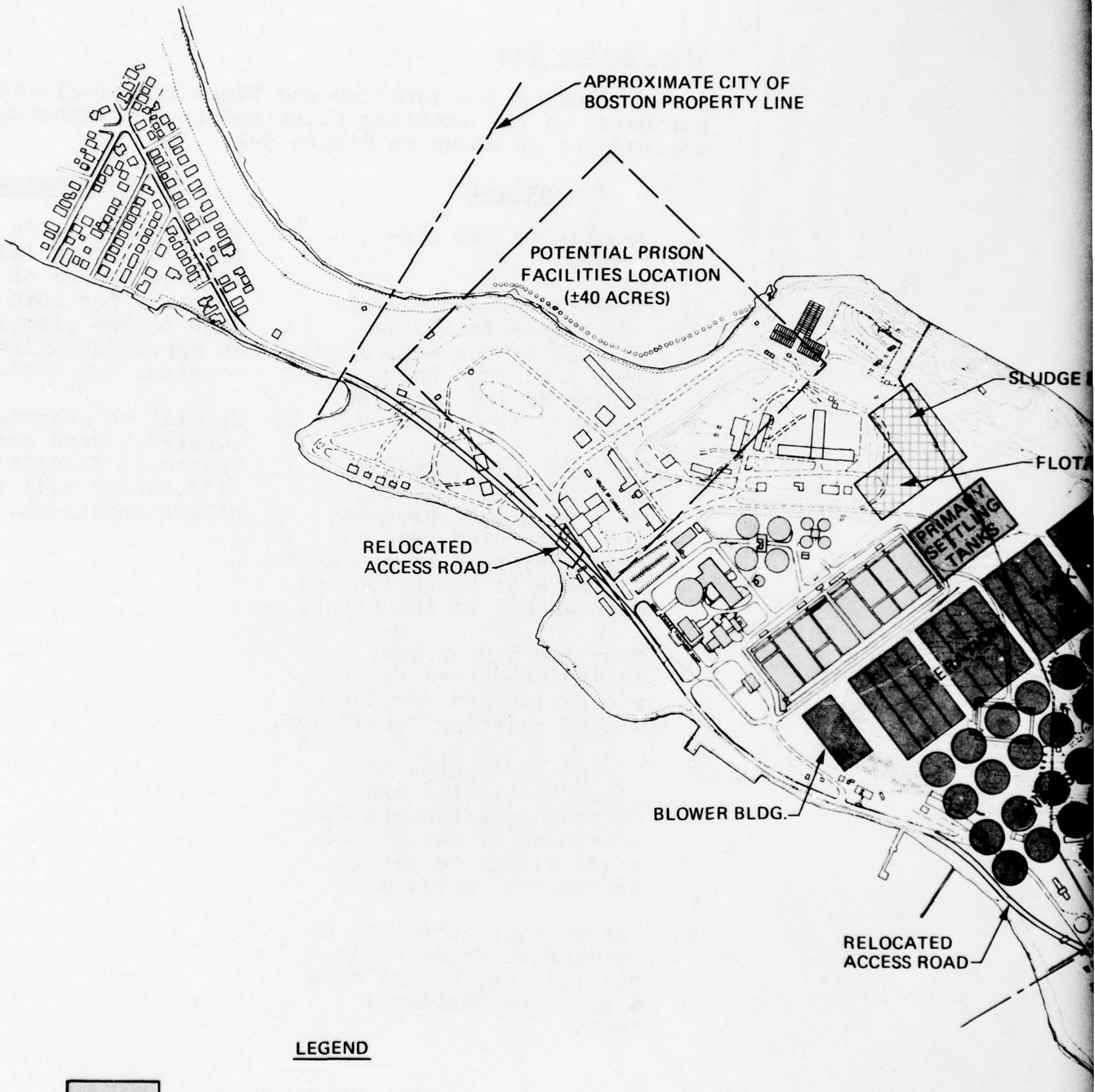
*Boston Harbor Islands Comprehensive Plan for Massachusetts Department of Natural Resources, by Metropolitan Area Planning Council, October 1972.

Because it is the intent to develop the Island for multi-purpose use with a minimum amount of fill, seven site options were considered which are briefly described as follows together with the noted advantages and disadvantages of each.

Site Option One

Placing the aeration and final tank facilities just southeast of the existing plant as shown on Figure 5-1.

Advantages	Disadvantages
1. Excess fill from excavation of the drumlin can be used for site preparation of new prison facilities and/or barged to Nut Island STP. This availability of fill for Nut Island represents an appreciable cost savings.	1. Requires leveling of the drumlin.
2. Hydraulic distribution of primary effluent to secondary reactors is most efficient, due to the close proximity of primary and secondary facilities.	2. Alternative locations for prison facilities require filling.
3. Final effluent piping close to existing outfall sewers.	3. Requires extensive piping galleries and greater pumping requirements for transport of waste activated sludge to sludge processing facilities.
4. Southern tip of Deer Island preserved for recreation and continued use of existing facilities.	4. Some loss of recreational land.



LEGEND

EXISTING FACILITIES

PROPOSED PRIMARY TREATMENT FACILITIES

PROPOSED SECONDARY TREATMENT FACILITIES

PROPOSED SLUDGE PROCESSING FACILITIES

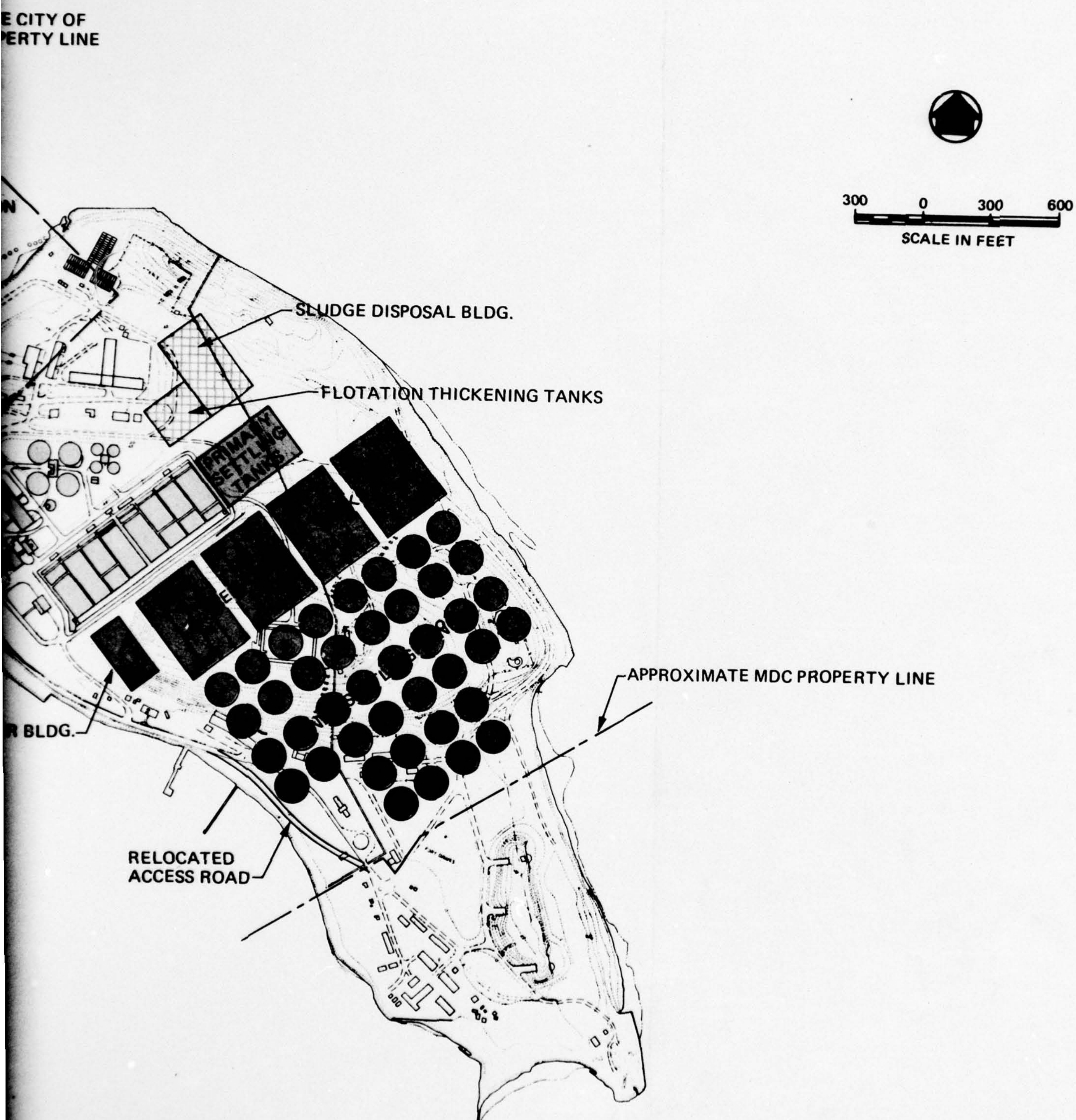


FIG. 5-1 DEER ISLAND WWTP-SITE OPTION 1

2

Site Option Two

Placing the aeration and final tank facilities northwest of the existing plant and in a symmetrical arrangement as shown on Figure 5-2.

Advantages

1. Drumlin is not disturbed.

2. Location of additional wastewater facilities located in the same general area that Boston Harbor Islands Comprehensive Plan proposed.

3. Primary and secondary treatment facilities, as well as sludge processing facilities, are self-contained in one area for ease of operation and maintenance of the plant.

4. Southern tip of Deer Island preserved for recreation and continued use of existing facilities.

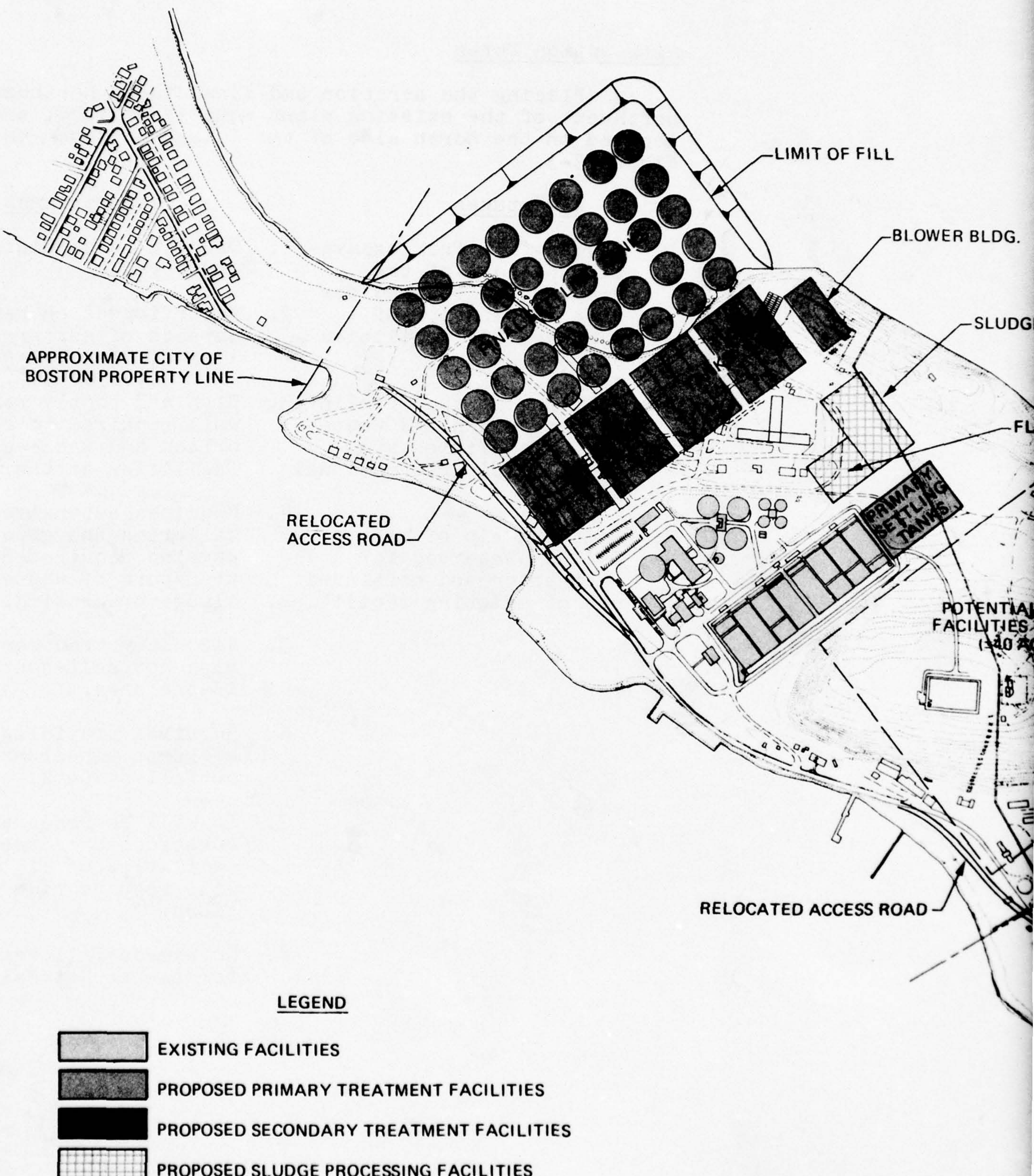
5. Minimizes lengths of piping galleries and pumping requirements for transport of waste activated sludge to sludge processing facilities.

6. Prison facilities can be located on drumlin without filling, but at some loss in recreational land.

Disadvantages

1. No excess fill is generated for use at Nut Island STP. Outside source of fill required for both Nut and Deer Island plants, with an appreciable increase in construction cost.

2. It will be necessary to construct some secondary treatment facilities on fill, which will require pile foundations.



LIMIT OF FILL
BLOWER BLDG.
APPROXIMATE CITY OF BOSTON PROPERTY LINE
RELOCATED ACCESS ROAD
PRIMARY SETTLING TANKS
RELOCATED ACCESS ROAD
LEGEND
EXISTING FACILITIES
PROPOSED PRIMARY TREATMENT FACILITIES
PROPOSED SECONDARY TREATMENT FACILITIES
PROPOSED SLUDGE PROCESSING FACILITIES

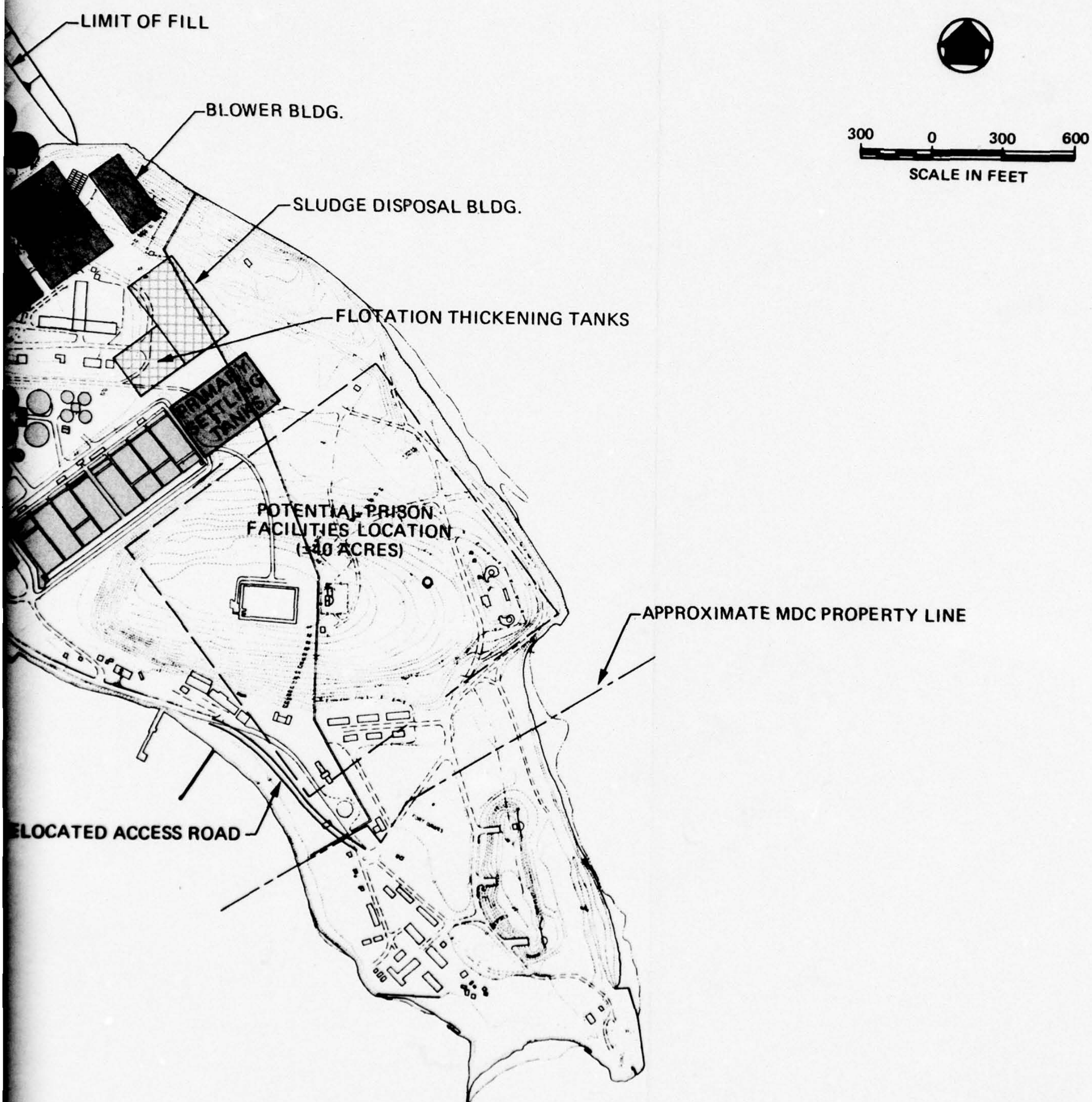


FIG. 5-2 DEER ISLAND WWTP-SITE OPTION 2

Site Option Three

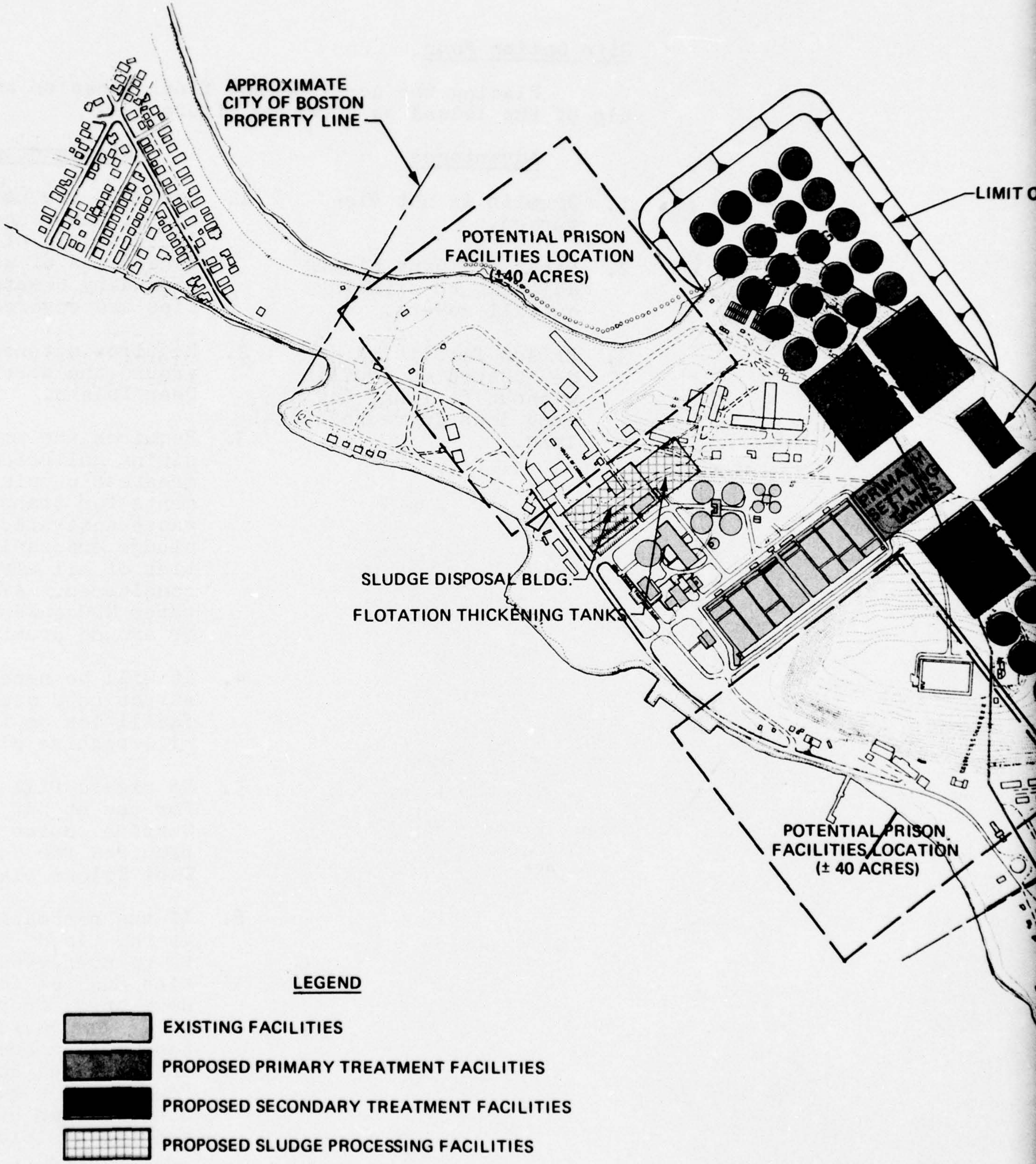
Placing the aeration and final tanks northeast and northwest of the existing plant equally divided, and located on the north side of the Island as shown on Figure 5-3.

Advantages

1. Excess fill from excavation of part of the drumlin can be used for site preparation of expanded STP facilities at Deer Island.
2. Dual-use of the drumlin by the prison and wastewater facilities at some loss in recreational land.
3. Southern tip of Deer Island preserved for recreation and continued use of existing facilities.

Disadvantages

1. Drumlin is partially destroyed.
2. Major impact on recreation aspects of eastern shoreline of Deer Island.
3. High and costly retaining wall required to separate prison and wastewater facilities at the drumlin.
4. Requires extensive piping galleries and greater pumping requirements for transport of waste activated sludge processing.
5. Secondary treatment facilities not self-contained in one area.
6. Requires providing two effluent pipelines to outfall systems.
7. It will be necessary to construct some secondary facilities on fill, which will require pile foundations.
8. No excess fill generated for use at Nut Island STP.


APPROXIMATE
CITY OF BOSTON
PROPERTY LINE
POTENTIAL PRISON
FACILITIES LOCATION
(±40 ACRES)
LIMIT O
PRIMARY
SETTLING
TANKS
SLUDGE DISPOSAL BLDG.
FLOTATION THICKENING TANKS
POTENTIAL PRISON
FACILITIES LOCATION
(± 40 ACRES)
LEGEND
EXISTING FACILITIES
PROPOSED PRIMARY TREATMENT FACILITIES
PROPOSED SECONDARY TREATMENT FACILITIES
PROPOSED SLUDGE PROCESSING FACILITIES

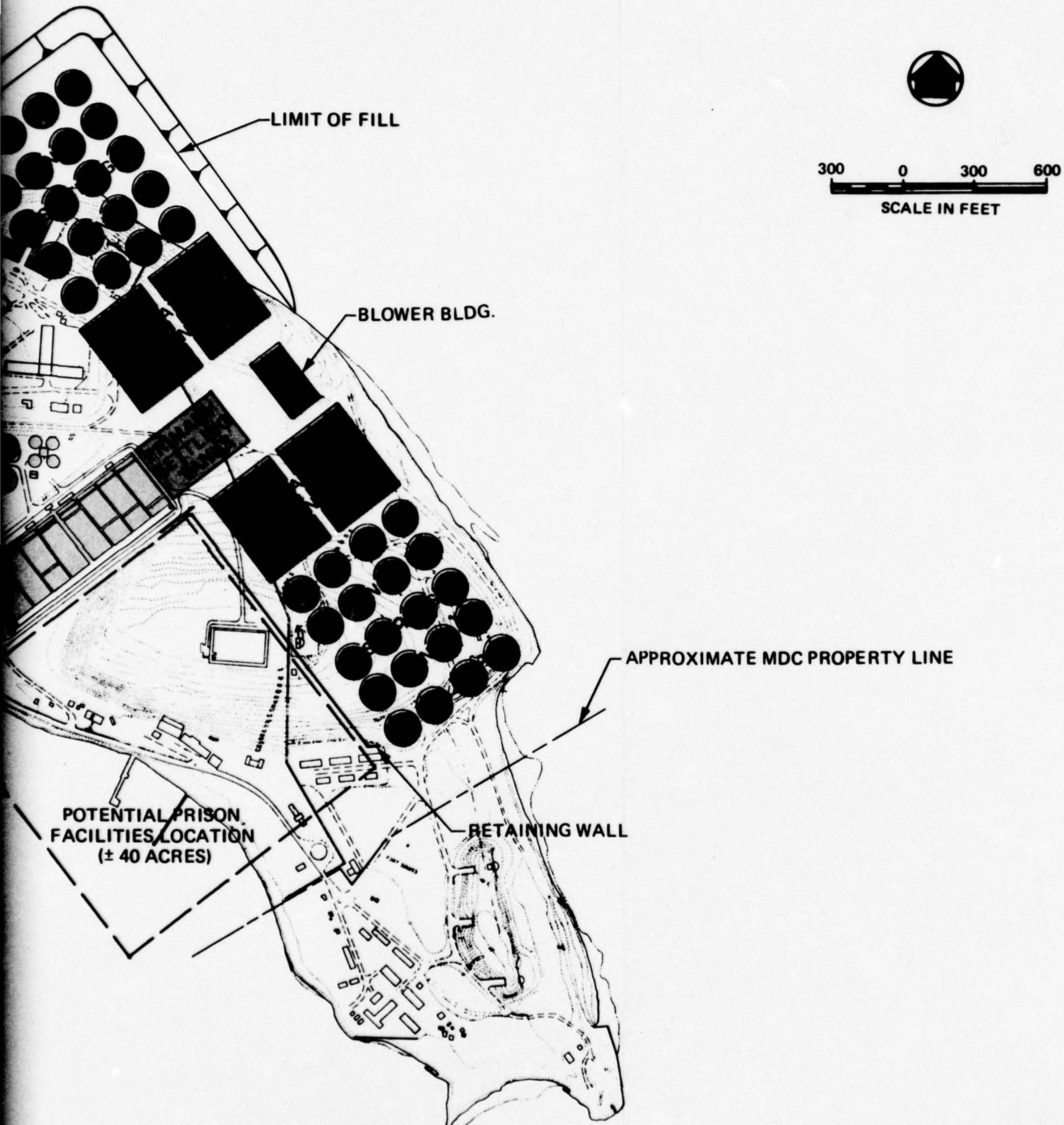


FIG. 5-3 DEER ISLAND WWTP-SITE OPTION 3

Site Option Four

Placing the aeration and final tanks on the outer tip of the Island as shown on Figure 5-4.

Advantages

1. Drumlin is not disturbed.

2. Final effluent piping adjacent to existing outfall sewers.

3. Prison facilities can be located on drumlin without filling, but at some loss in recreational land.

Disadvantages

1. Destroys the natural recreational environment of the southern tip of Deer Island regardless of whether the secondary treatment facilities are covered or not.

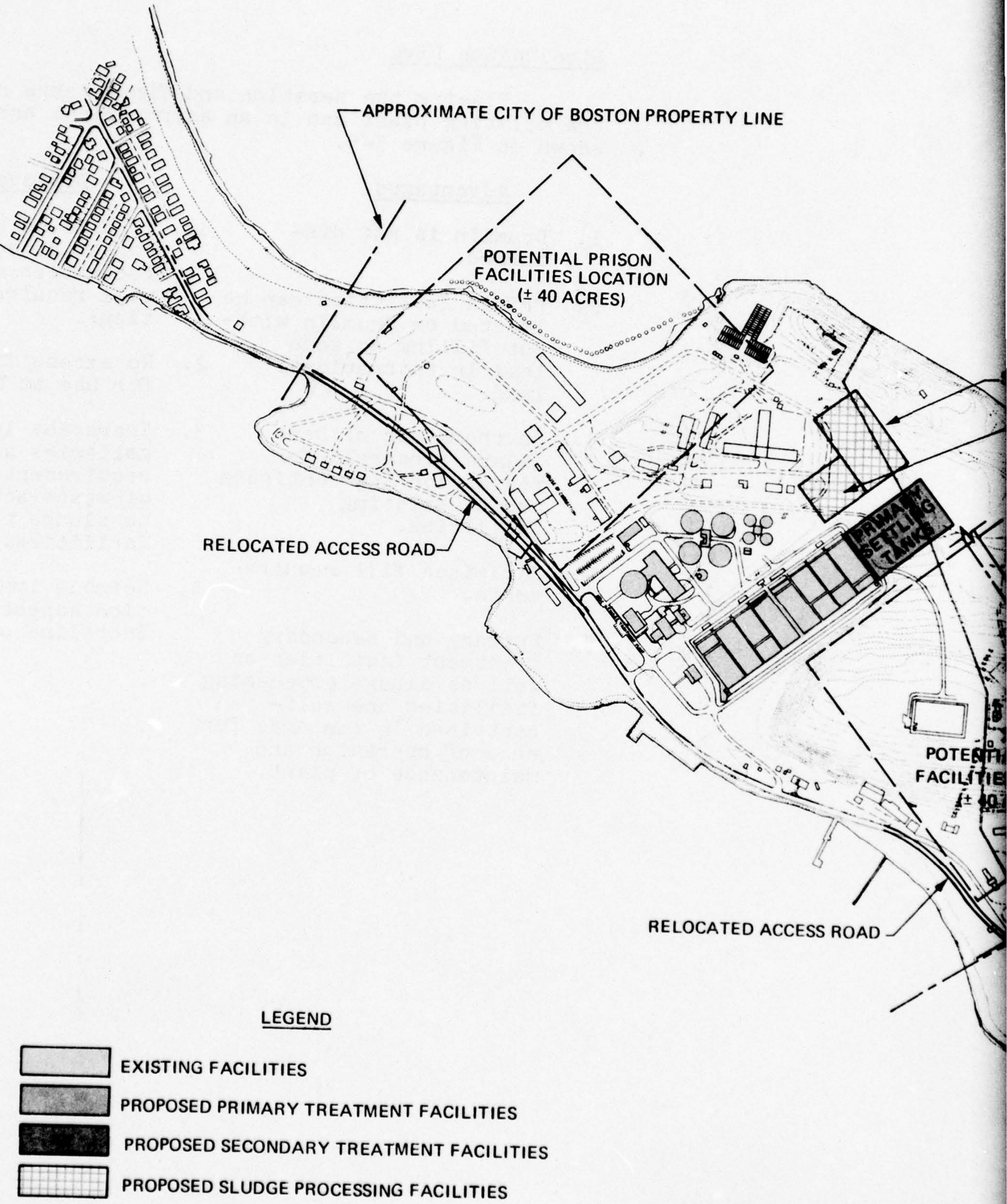
2. Requires extensive landfill around the southern tip of Deer Island.

3. Requires the most extensive piping galleries and the greatest pumping requirements for transport of waste activated sludge to sludge processing facilities of all alternatives considered. Also necessitates MDC easement through or around drumlin.

4. It will be necessary to construct some secondary facilities on fill, which will require pile foundations.

5. No excess fill generated for use at Nut Island STP. Outside source of fill required for both Nut and Deer Island plants.

6. If the recreational function at the tip of the island is to be preserved, the facilities must be covered and developed for recreational use. To provide these facilities will appreciably increase the cost due to the increased foundation requirements, the construction of the cover, and the additional landscaping required.


APPROXIMATE CITY OF BOSTON PROPERTY LINE
POTENTIAL PRISON FACILITIES LOCATION (± 40 ACRES)
PRIMARY SETTLING TANKS
RELOCATED ACCESS ROAD
RELOCATED ACCESS ROAD
LEGEND
EXISTING FACILITIES
PROPOSED PRIMARY TREATMENT FACILITIES
PROPOSED SECONDARY TREATMENT FACILITIES
PROPOSED SLUDGE PROCESSING FACILITIES

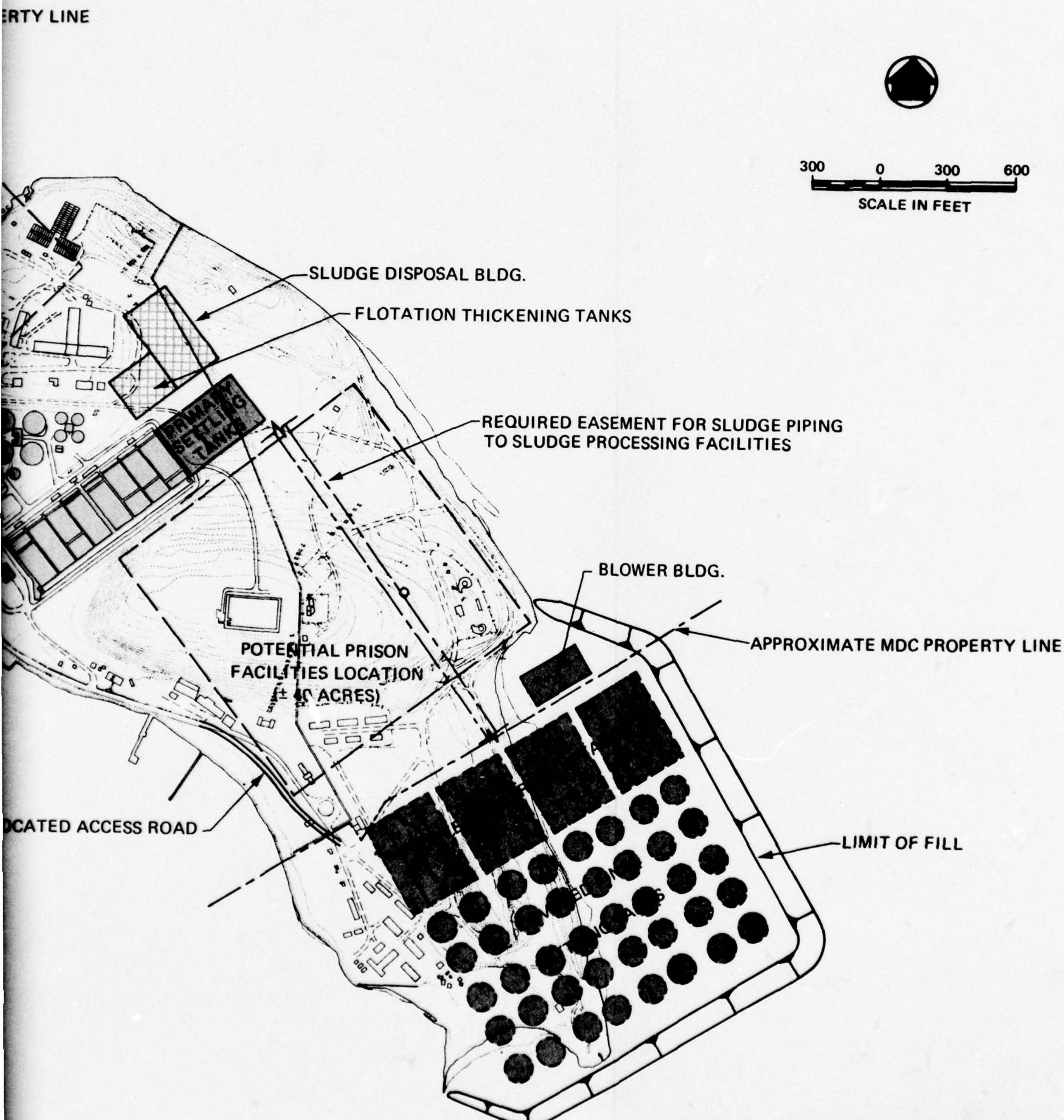


FIG. 5-4 DEER ISLAND WWTP-SITE OPTION 4

Site Option Five

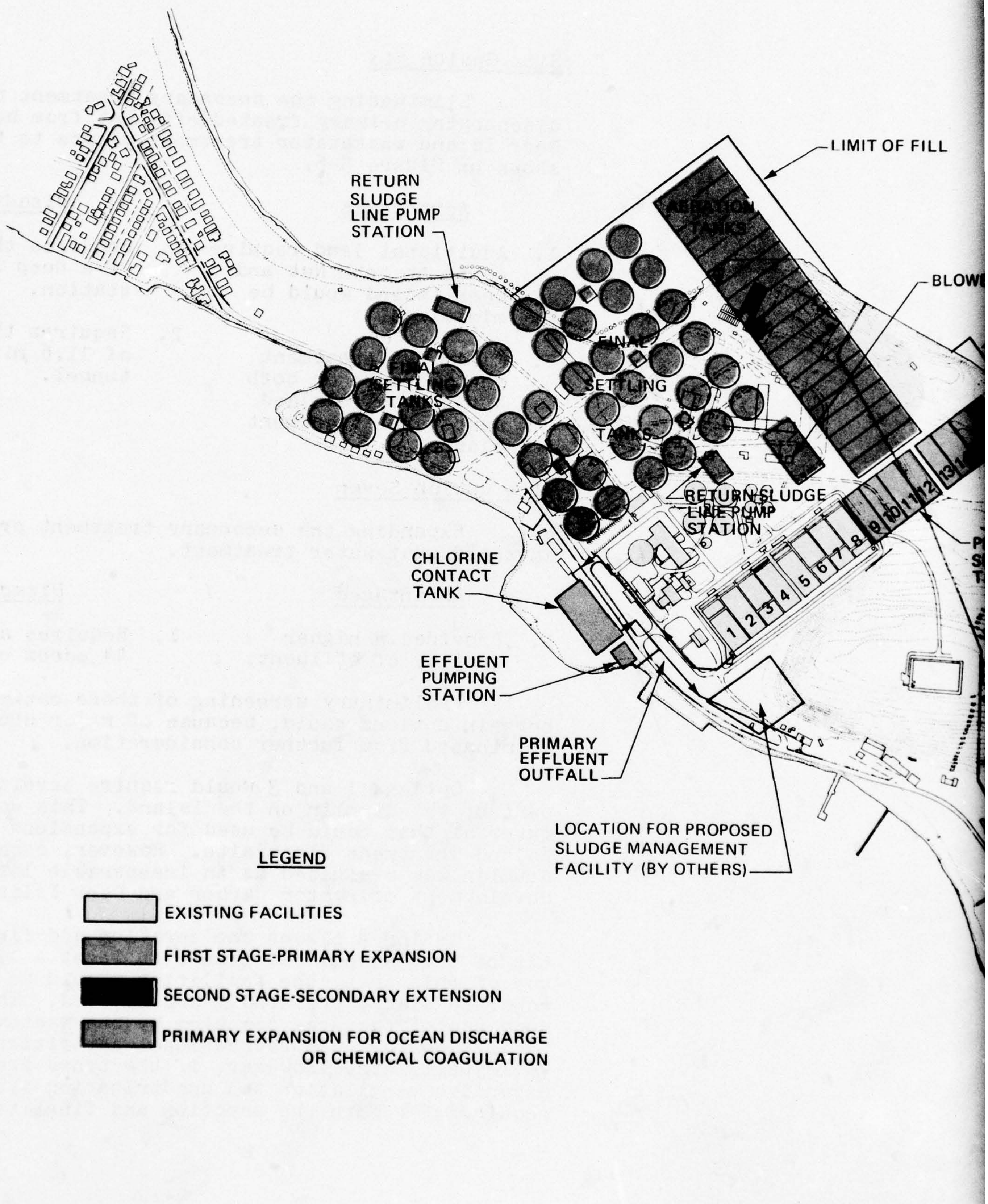
Placing the aeration and final tanks northwest of the existing plant and in an asymmetrical arrangement as shown on Figure 5-5.

Advantages

1. Drumlin is not disturbed.
2. Prison facilities can be located on drumlin without filling at some loss in recreational land.
3. Southern tip of Deer Island preserved for recreation and continued use of existing facilities.
4. Minimizes fill requirements.
5. Primary and secondary treatment facilities as well as sludge processing facilities are self-contained in one area for ease of operation and maintenance of plant.

Disadvantages

1. It will be necessary to construct some secondary facilities on fill which will require pile foundations.
2. No excess fill generated for use at Nut Island.
3. Increases length of piping galleries and pumping requirements for transport of waste activated sludge to sludge processing facilities.
4. Notable impact on recreation aspects of Eastern Shoreline of Deer Island.



RETURN SLUDGE LINE PUMP STATION
LIMIT OF FILL
FINAL SETTLING TANKS
FINAL SETTLING TANKS
RETURN SLUDGE LINE PUMP STATION
CHLORINE CONTACT TANK
EFFLUENT PUMPING STATION
PRIMARY EFFLUENT OUTFALL
LOCATION FOR PROPOSED SLUDGE MANAGEMENT FACILITY (BY OTHERS)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
LEGEND
EXISTING FACILITIES
FIRST STAGE-PRIMARY EXPANSION
SECOND STAGE-SECONDARY EXTENSION
PRIMARY EXPANSION FOR OCEAN DISCHARGE OR CHEMICAL COAGULATION

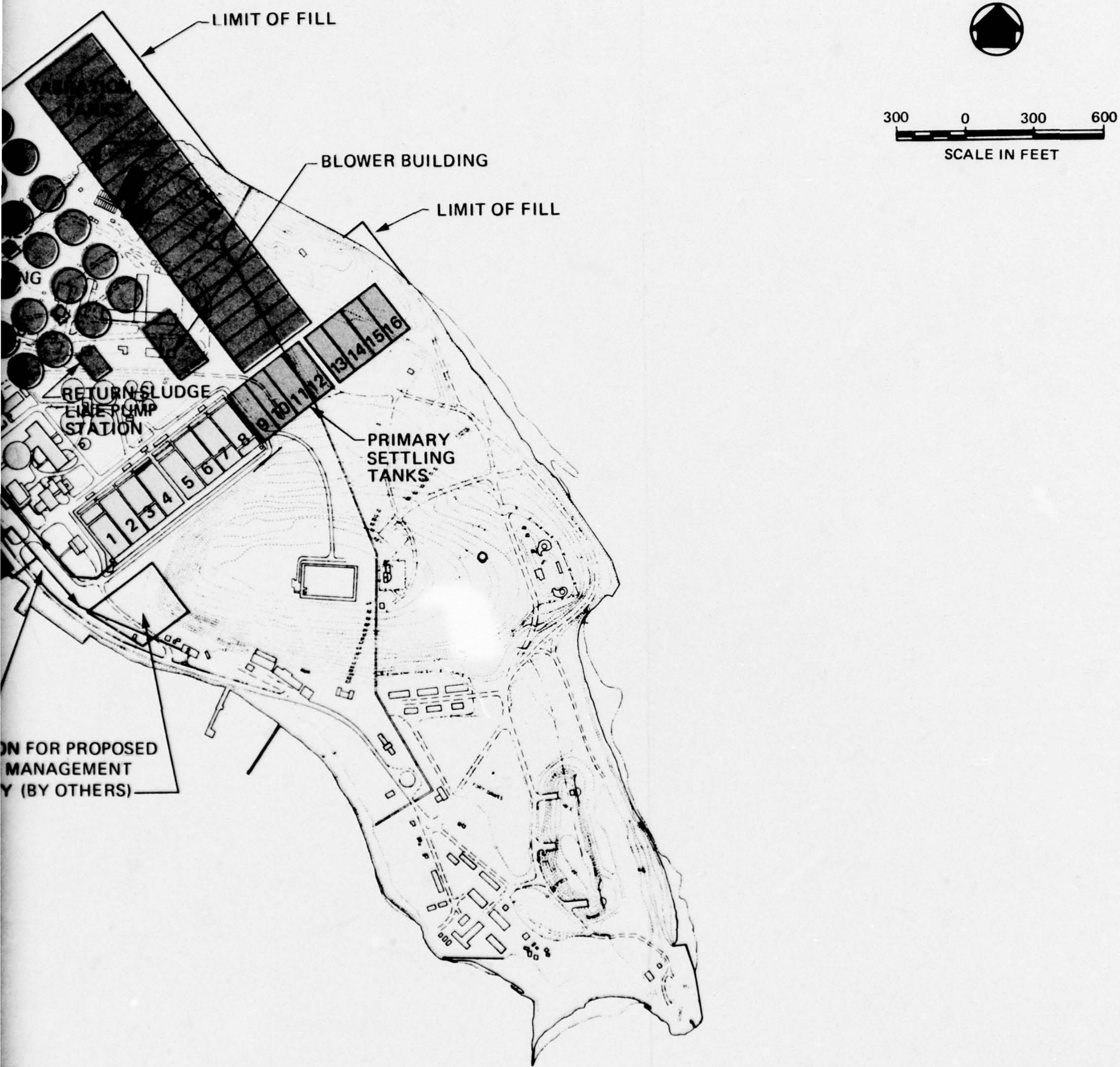


**FIG. 5-5 DEER ISLAND WWTP –
SITE OPTION 5 – RECOMMENDED PLAN**

Site Option Six

Eliminating the secondary treatment process and discharging primary treated effluent from both Nut and Deer Island wastewater treatment plants to the ocean as shown on Figure 5-6.

Advantages

1. Additional land requirements at both Nut and Deer Island would be minimized.
2. Minimizes treatment requirements at both Nut and Deer Island wastewater treatment plants.

Disadvantages

1. Requires the construction of a deep large pumping station.
2. Requires the construction of 11.6 miles of deep tunnel.

Site Option Seven

Expanding the secondary treatment process to include advanced wastewater treatment.

Advantages

1. Provides a higher quality of effluent.

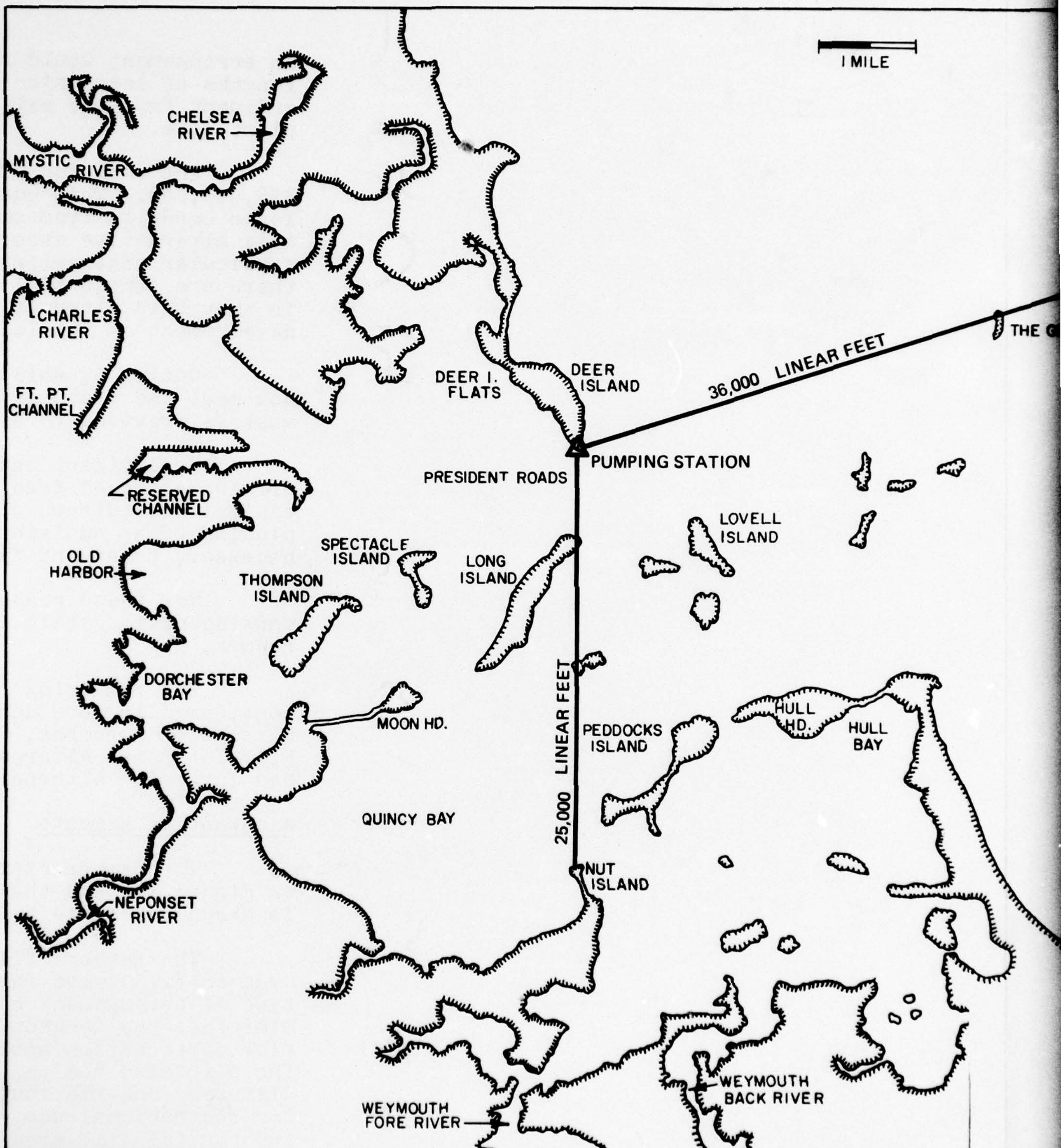
Disadvantages

1. Requires an additional 44 acres of fill.

Preliminary screening of these options indicate that certain options could, because of major disadvantages, be eliminated from further consideration.

Options 1 and 3 would require leveling of all or part of the drumlin on the Island. This would produce material that could be used for expansions of the Nut Island Treatment Plant site. However, excavation of the drumlin was evaluated as an inseparable loss to the planned development of Boston Harbor and Deer Island.

Option 4 places the aeration and final tanks at the tip of the Island. To insure at least a limited recreational use of this area, the facilities should be provided with concrete slabs, preferably sod covered. This would permit some use of the area occupied by the wastewater treatment facilities for such recreational activities as tennis, volleyball, etc. However, if the tanks are covered, an extensive ventilation and deodorization system would be required for both the aeration and final tanks. Also, such



1 MILE
CHELSEA RIVER
MYSTIC RIVER
CHARLES RIVER
FT. PT. CHANNEL
DEER I. FLATS
DEER ISLAND
36,000 LINEAR FEET
THE G
PUMPING STATION
PRESIDENT ROADS
RESERVED CHANNEL
LOVELL ISLAND
OLD HARBOR
SPECTACLE ISLAND
LONG ISLAND
THOMPSON ISLAND
DORCHESTER BAY
MOON HD.
25,000 LINEAR FEET
PEDDOCKS ISLAND
HULL HD.
HULL BAY
QUINCY BAY
NUT ISLAND
NEPONSET RIVER
WEYMOUTH BACK RIVER
WEYMOUTH FORE RIVER

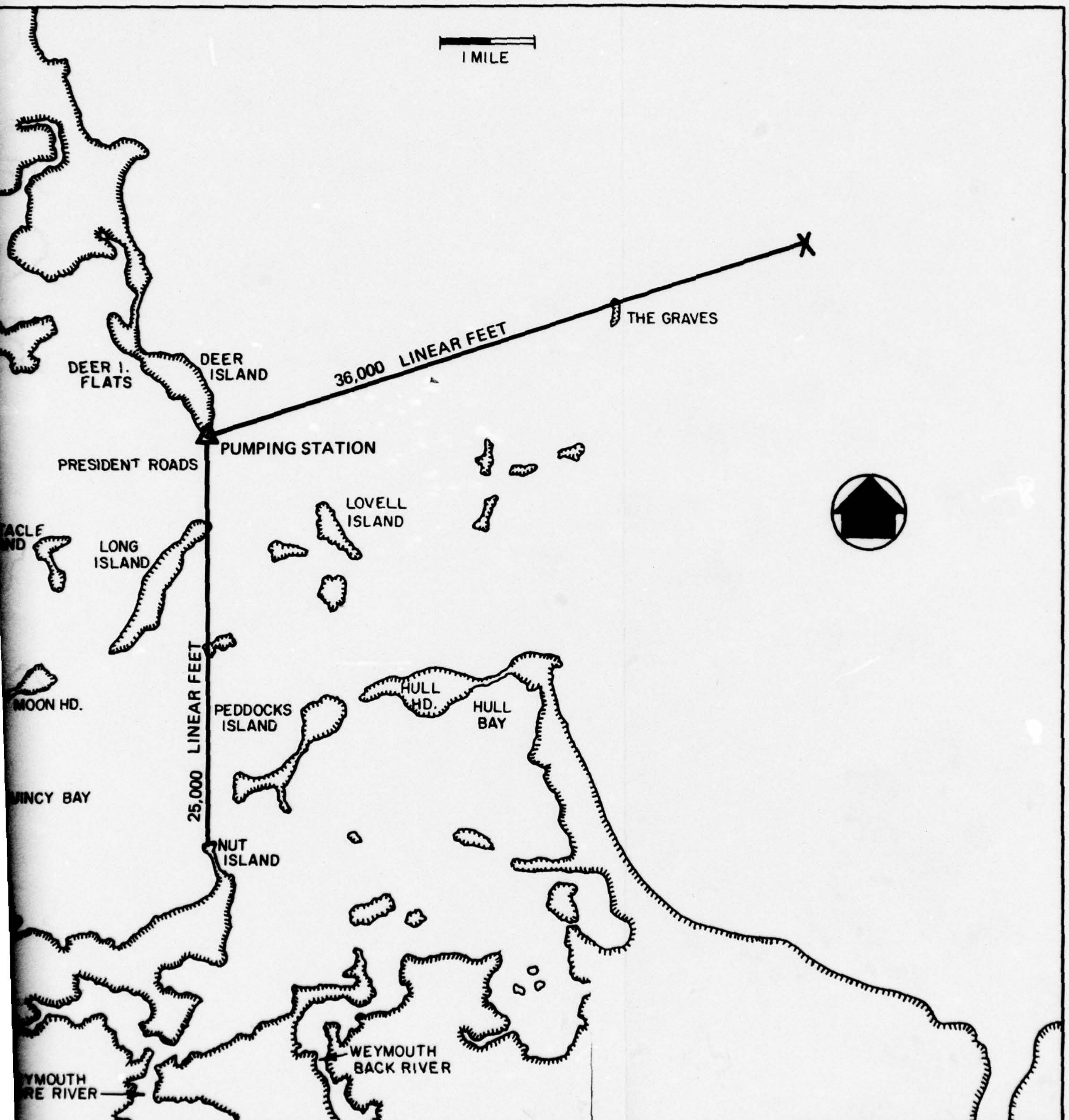


FIG. 5-6 SITE OPTION 6-
OCEAN OUTFALL DISCHARGE PLAN

an arrangement would require the installation of long lengths of large size conduits to convey the primary effluent from the existing site to the secondary treatment plant site.

The cost for site preparation would be in excess of $38,000,000. This cost coupled with the cost of providing large conduits from the primary to the secondary site makes this alternative exceedingly expensive. There is no particular engineering advantage in this location, and there are substantial disadvantages both economically, and in that this alternative will limit the proper recreational development of the Island.

Option 6, while cost-effective, (see Table 6-1) does not meet the statutory requirement that secondary treatment must be provided to all ocean wastewater discharges.

Preliminary analysis of Option 7, indicates that to provide advanced treatment would require an additional capital expenditure of approximately $256,000,000 and the placing of an additional 44 acres of fill to accommodate the necessary treatment facilities.

For these reasons Options 1, 3, 4, 6 and 7 are not considered in detail in the following sections of this report.

The remaining two options, Option 2 and Option 5, are considered in more detail in the following paragraphs. For discussion purposes, Option 2 is referred to as the Harbor Fill Intensive Alternative Plan, and Option 5 as the Land Use Intensive Alternative Plan.

Alternative Layouts

The Harbor Fill Intensive Alternative Plan is shown on Figure 5-2 and the Land Use Intensive Alternative Plan is shown on Figure 5-5.

The Harbor Fill Intensive Alternative Plan permits a symmetrical layout for the aeration and final tanks. This type of arrangement has engineering advantages in that it minimizes the lengths of interconnecting piping and an equal flow distribution between units is more readily obtained. The plan also has the advantages that the drumlin is not disturbed and the southern tip of Deer Island is preserved for recreational use. It has the disadvantages that a substantial fill area (some 24 acres) would be required and that the area occupied by the County House of Correction would be lost for that purpose. However, the County House of Correction facilities could be located on the drumlin and so designed to retain the topographic characteristics of the drumlin. Such a development, however, would limit if not exclude the use of the drumlin for recreational purposes.

The Land Use Intensive Alternative Plan as shown on Figure 5-5 minimizes the amount of area that would require fill (some 14 acres), at some loss in the most appropriate engineering arrangement of aeration and final tanks. The arrangement of aeration and final tanks as indicated has been investigated as to layout of influent and effluent piping, returned sludge piping, etc. This investigation indicates that the proposed layout is workable, without utilizing any unusual internal pumping facilities. This plan has the same general advantages and disadvantages as previously described for the Harbor Fill Intensive Alternative Plan. One additional difference, however, should be noted. Under this plan, the main entrance road to the recreational area at the southern tip of the island would pass through the Treatment Plant. However, we believe that this arrangement should impose no difficulty in either access to the recreational area or in the day to day operation of the plant.

The estimated construction cost for the Land Use Intensive Plan is shown in Table 5-1. The estimated cost is based on an ENR index of 2200, and includes a 35 percent allowance for engineering and contingencies. The cost does not provide for electrification of the main pumping station, for securing outside sources of power, land, legal fees or interest during construction.

The cost for the Harbor Fill Intensive Alternative would be higher than that given in Table 5-1 by the cost that would be incurred for the additional fill and subsurface construction required by that plan. This additional cost is estimated to be $7,000,000, including a 35 percent allowance for engineering and contingencies.

This analysis indicates that the cost differential between the two alternatives is less than 4 percent which is well within the percent reliability of standard preliminary estimating procedures. Accordingly, there is no basic economic reason for selection of either plan. However, it should be noted that the Harbor Fill Intensive Alternative would require the construction of at least 27 final tanks on fill area within Boston Harbor. This would require pile foundations and thicker bottom concrete slabs

TABLE 5-1. CONSTRUCTION COST - LAND USE INTENSIVE ALTERNATIVE

Item	Cost
Primary tanks	$10,431,000
Aeration tanks	33,578,000
Final tanks	37,778,000
Return sludge pumping stations	6,138,000
Blower building	23,840,000
Operations building	2,534,000
Storage building	520,000
Chlorine contact tanks	6,614,000
Effluent pumping station	11,711,000
Channels-conduits-gallaries	13,626,000
Outside piping, roads and grading	14,667,000
Electrical and instrumentation	16,550,000
Extraordinary site development	13,913,000
Total	$191,900,000

to support these tanks. The additional cost of this work is estimated in the light of the best information available at this time. It should be noted that such an estimate is at best preliminary in nature and when test borings are taken, it may well be found that the cost of placing the final tanks in the proposed fill area may appreciably increase the estimated additional cost of $7,000,000.

Furthermore, the Harbor Fill Intensive Alternative would have the greater impact on the existing shoreline of Deer Island by virtue of the larger quantity of fill that is required.

Considering the advantages and disadvantages of the two alternatives, the Land Use Intensive Plan was selected at this time as the recommended plan.

CHAPTER 6

PHASED DEVELOPMENT

General

In accordance with discussions held with the Technical Subcommittee and in agreement with comments submitted at public meetings, priorities for improvements, additions or extensions to the Metropolitan District Commission sewerage system have been established. This chapter discusses a phased development of the recommended Deer Island Treatment Plant in conformance with the established priorities. The chapter also presents the phased cost of constructing and operating such facilities.

Except as noted all estimated capital costs given in this chapter are based on an ENR Index of 2200, and include a 35 percent allowance for engineering and contingencies. Costs do not include land (except fill), legal fees or interest costs during construction.

Phased Development

The existing Deer Island Treatment Plant provides primary treatment and was designed for an average daily and peak flow of 343 and 848 mgd, respectively. Since the estimated design flow rates as given in Chapter 2 exceed these values, the first priority is to upgrade the existing facilities to meet these new flow requirements. As part of this upgrading procedure, the existing facilities should be expanded or revamped to meet the latest acceptable water quality effluent standards. Such a program is discussed and outlined in Chapters 2 and 3.

Two alternatives are available for second phase development of the Deer Island Treatment Plant. One alternative would be to expand the primary tanks from 14 to 16 in number which, with proper investigation of an adequate outfall location, could provide an acceptable level of treatment for deep ocean discharge. The other alternative would be to provide secondary treatment as described in Chapter 5. This level of treatment would permit discharge of the effluent to the outer harbor through the existing outfall system in conformance with agreements with the regulatory agencies.*

*Massachusetts Division of Water Pollution Control and the U. S. Environmental Protection Agency.

These two treatment alternatives, including both Deer and Nut Island, have been compared on a capital cost basis and the findings of that analysis are shown in Table 6-1.

TABLE 6-1. COMPARATIVE CAPITAL COSTS FOR RECOMMENDED SECONDARY TREATMENT AND OCEAN DISCHARGE

Description	Secondary treatment, millions $	Ocean discharge in lieu of secondary treatment, millions $
Sludge management (D.I. and N.I. primary)	25.6	25.6
Satellite treatment plants implementation	90.7	90.7
Nut Island primary plant and outfall upgrading	50.5	40.2
Deer Island primary plant expansion	41.9	30.1(1)
Deer and Nut Island secondary plant and sludge management extension	264.8	-
Ocean discharge tunnels, diffusers and pump station	-	187.3
Total capital cost	473.5	373.9

1. $41.9 million + $6.5 million for two additional primary tanks = $48.4 million.
$48.4 million - $18.3 million for the pumping station and chlorine contact tanks = $30.1 million.

As indicated in Table 6-1, the deep ocean discharge alternative would cost approximately 100 million dollars less than the secondary treatment alternative. However, due to the present uncertainties about the effect of deep ocean discharge on the environment, the technical subcommittee has agreed that secondary treatment is, at this time, the appropriate alternative to select for second phase development.

This discussion is limited to the wastewater treatment and does not include the development of those facilities required for sludge management. The development of such facilities would be required concurrently and added to the phased program outlined here.

First Phase Construction Cost

The first phase development would consist of undertaking that work described in Chapters 2 and 3. Essentially, this work would consist of constructing additional primary tanks, chlorination facilities and a new effluent pumping station. The cost of providing these facilities is presented in Table 6-2.

TABLE 6-2. CONSTRUCTION COST - FIRST PHASE(1)

Item	Cost, dollars
Primary tanks	$10,431,000
Chlorine contact tanks	6,614,000
Effluent pumping station	11,711,000
Channels-conduits-galleries	5,588,000
Outside piping, roads and grading	3,400,000
Electrical and instrumentation	4,156,000
Total	$41,900,000

1. Costs for sludge management first phase program for combined Deer and Nut Island plants must be added.

Second Phase Construction Cost

The work that is discussed in Chapter 4 which consists mainly of the construction of aeration tanks, final settling tanks, return sludge pumping stations and other appurtenant work would be undertaken under the second phase of the program. The cost of these facilities is set forth in Table 6-3.

TABLE 6-3. CONSTRUCTION COST - SECOND PHASE[1]

Item	Cost, dollars
Aeration tanks	$ 33,578,000
Final tanks	37,778,000
Return sludge pumping station	6,138,000
Blower building	23,840,000
Channels-conduits-galleries	8,038,000
Operations building	2,534,000
Storage building	520,000
Outside piping, roads and grading	11,267,000
Electrical and instrumentation	12,394,000
Extraordinary site development	13,913,000
Total	$150,000,000

1. Costs for sludge management second phase program for combined Deer and Nut Island plants must be added.

Operating and Maintenance Cost

The annual operating and maintenance costs for first phase and second phase development at Deer Island are set forth in Table 6-4.

TABLE 6-4. ANNUAL OPERATING AND MAINTENANCE COST[1]

Item	Cost, dollars
First phase	
Manpower (169)[2]	
Operation and maintenance	$2,189,000
Fuel and electric power	
Fuel	146,000
Electric power	1,809,000
Chemical	
Chlorine	1,496,000
Maintenance	453,000
Total	$6,093,000
Second phase	
Manpower (221)[2]	
Operations and maintenance	$2,862,000
Fuel and electric power	
Fuel	190,000
Electric power	4,041,000
Chemical	
Chlorine	998,000
Maintenance	1,175,000
Total	$9,266,000

1. Operation and maintenance costs for sludge management facilities serving both Deer and Nut Island plants are reported in Havens and Emerson Consulting Engineers, A Plan for Sludge Management, prepared for the Commonwealth of Massachusetts Metropolitan District Commission, June 1973.
2. Manpower requirement to operate and maintain the treatment plant, headworks and the Deer Island Pumping Station, but does not include the manpower related to the sludge management facilities.

The total annual operating and maintenance costs does not provide for sludge management. Manpower costs are based on today's labor rates and include fringe benefits. Fuel costs are computed at a unit price of 35.6 cents per gallon and power costs at a unit price of 3 cents per kilowatt hour. Chlorine costs are computed at the rate of 205 dollars per ton.

Cost Distribution

The cost of constructing, operating and maintaining a preliminary or secondary wastewater treatment plant may be proportioned among the user communities in various ways. One method is to assess each community in accordance with the flow, organic (BOD_5) and suspended solids load that each contributes. As an aid in preparing such an assessment, Table 6-5 is presented. This table denotes that percentage of the total construction cost and operating and maintenance cost that should be distributed to each of these cost distribution parameters.

TABLE 6-5. COST DISTRIBUTION[1] DEER ISLAND WASTEWATER TREATMENT PLANT

Item		Percent of total cost		
		Q	BOD_5	SS
Construction cost, $				
Deer Island				
First phase	41,900,000	69.2	13.5	17.3
Second phase	150,000,000	9.1	68.8	22.1
Operating and maintenance cost, $				
First phase	6,093,000	84.7	3.8	11.5
Second phase	9,266,000	53.7	34.7	5.6

1. Sludge management costs for combined Deer and Nut Island facilities must be added.

As in the case of the previous cost tables, no allowance is made for sludge management cost in deriving the distribution set forth in this table.

APPENDIX A

PRINCIPAL EQUIPMENT

APPENDIX A

PRINCIPAL EQUIPMENT

Main Pumping Station

9 - 12 cylinder, two cycle radial, dual fuel type engines. Bore and stroke 14 inch by 16 inch with a speed range of 250 to 400 revolutions per minute (rpm). 2,125 brake horsepower (bhp) at 400 rpm. Engines are automatically controlled through governors from pump control equipment.

9 - Nonclogging, vertical, single end suction, mixed flow, centrifugal sewage pumps, rated capacity at 400 rpm, 90 mgd and a total dynamic head of 105 feet.

1 - Graphic control room, tunnel-pump control system, microwave and telemetry instrumentation, complete sewage flow indicating and recording equipment, remote gate controls.

Main Power Plant

5 - 8 cylinder, four cycle, in line, dual fuel type engines rated at 998 hp, at 514 rpm. Drives 700 kilowatts (kw), 875 kilovolt-ampere (kva) generators at 514 rpm.

5 - Maximum heat recovery silencers. Generates steam at 15 pounds per square inch (psi) under full automatic operation.

3 - Boilers, each with a rated pressure of 15 psi.

1 - 300 hp, input 12,000,000 BTU/hour 80 percent efficient, output 9,600,000 BTU/hour. Converted for operation using sewage gas for fuel.

2 - 350 hp, input 14,000,000 BTU/hour 80 percent efficient, output 11,200,000 BTU/hour.

Metering

9 - Low-loss venturi meters 60 inch by 38 inch.

Preaeration System

2 - Aeration channels, each 400 feet by 20 feet by 14 feet, 44 swing air diffusers at 0.02 cubic feet per gallon. Detention time - 10 minutes.

Sedimentation

8 - Sedimentation tanks, 245 feet by 100 feet by 10 feet with traveling bridge type collectors. Detention period - 60 minutes.

Scum collection by traveling bridge collectors with chain cross-collectors which return grease to a collection pit by gravity flow at the effluent end of sedimentation tanks, then pumped to scum concentration tanks.

4 - Raw sludge pumping stations - each equipped with three (3) Wemco pumps with variable speed magnetic drive to 800 gpm at 45 foot total dynamic head (tdh).

2 - Raw scum Wemco pumps, 1,400 gpm at 30 foot tdh.

Process Water Plant

4 - 125 hp pumps, 2,700 gpm used to fill reservoir and to maintain a prescribed level of water for efficient plant operation.

2 - Traveling water screens.

2 - Andale strainers.

1 - 1,000 lb/day capacity chlorinator used to chlorinate salt water being pumped to reservoir.

Chlorination

7 - Chlorinators, each of 8,000 lb/day capacity, providing pre- and post-chlorination.

1 - Chlorinator 2,000 lb/day capacity.

2 - Weighing bays for 16 ton liquid chlorine containers, each scale capacity 100,000 pounds.

Outfalls

1 - 9 foot by 10 foot main outfall section terminating in President Roads at approximately 50 foot depth, mean low water.

1 - 6 foot by 6-1/2 foot main outfall section terminating in President Roads at approximately 50 foot depth, mean low water.

1 - 6-foot diameter emergency relief off-shore outfall.

1 - 9-foot diameter emergency relief off-shore outfall.

1 - 9-foot diameter emergency relief off-shore outfall (Additional).

Note: Emergency relief outfalls controlled by gate operation to accommodate storm flow conditions only.

Administration Building

Engineering and Drafting Offices

Clerical Offices

Chemical and Bacteriological Laboratory

First Aid Room

Assembly and Lecture Room

APPENDIX B

DEER ISLAND WASTEWATER TREATMENT PLANT - MAIN PUMPING STATION

Allen J. Burdoin
CONSULTING ENGINEER

June, 1973

Deer Island Treatment Plant
Main Pumping Station

Description This station contains 9 vertical shaft, bottom suction 48" x 36" centrifugal sewage pumps made by Allis-Chalmers and rated 90 mgd each @ 105 ft. head at 400 rpm. Impellers are 4 vane Francis type with a specific speed of 3050. Space is provided for a 10th pump.

The pumps are located at Elev.32 and are driven through 90 ft. long shafts by direct connected Nordberg 12 cyl. radial diesel engines rated 2125 hp. at 400 rpm located at the main floor level, El. 130. Engines are 2 cycle, 14 in. bore x 16 in. stroke, designed to operate as dual fuel engines on various proportions of diesel fuel and digester gas over a speed range of 250 to 400 rpm. Steady bearings are located at each intermediate floor level, but the entire weight of the shaft and hydraulic thrust of the pump are carried by a thrust bearing in the engine.

The sewage arrives at the pumping station through two deep rock tunnels located 300 ft. below Boston Harbor, one 4 miles long from the Chelsea Creek Headworks, and the other 7 miles long from the Ward St. Headworks and the Columbus Park Headworks. The station has no wet well and the two tunnels are not connected. Each pump can draw from either tunnel, the suction connections to each tunnel being provided with motor operated butterfly valves. Each pump discharge rises individually as a 60 in. steel pipe to a ground level siphon discharge and contains a 60" x 38" venturi meter with a full scale capacity of

150 mgd each. The pumps operate normally with a positive head on the suction, which decreases as the flow increases. The capacity is regulated by automatically adjusting the speed of the engines to maintain a constant set sewage level in the drop shafts at the headworks. This level is transmitted from the headworks by a dual system using both telemetering over leased telephone wires and a microwave system.

The engine auxiliaries are driven mechanically by a gear train located at the basement level, El. 115, and driven by the main shaft connecting the engine and the pump. The driven auxiliaries consist of the scavenging air blower, the cooling water pump, the lube oil pump, and auxiliary lube oil pump feeding the bypass lube oil filter. The barring gear motor operates through this gear train. An electric motor driven "before and after" lube oil pump is provided for each engine. Combustion air is taken from the pump room level through automatic travelling screen viscous impingement air filters. Plant effluent or sea water can be used for cooling.

The starting air compressors, 2 electric and 2 diesel, and the starting air tanks are located at the sub-basement level, El.97. On this level are located also the plant air compressors, storage tanks and air dryers.

Power Supply All plant power is furnished by five Enterprise 700 Kw dual fuel 4 cycle in line 8 cylinder engine generator units located in the attached Power Bldg. on the other side of the main control room. There is no connection to the public power supply.

Sewage Flow vs. Design Capacity   The design capacity of the pumping station is as follows:

Flow, mgd.	Chelsea Creek	Ward St. and Columbus Park	Total
Average daily	140	179	319
Max. hour	350	438	788

The reported flows for the year July 1, 1971 to June 30, 1972 are as follows:

Flow, mgd	Chelsea Creek	Ward St. and Columbus Park	Total
Min. hour	62	52	114
Min. 24 hour	86	122	208
Average daily	146	178*	324*
Max. 24 hour	266	320	586
Max. hour	330	485*	815*

*Excessive flow due to salt water infiltration in sewers tributary to Columbus Park Headworks.

These flows are less than the design capacity of the treatment plant because they do not include the flow pumped by the Winthrop Facility.

Age of Equipment The Station and equipment are relatively new. Pumping operations began in 1967 bypassing the treatment plant. Pumping to the treatment plant began in May, 1968.

As of April 19, 1973, the hours of operation and availability for service of the pumping units were as follows (the availability for service had not changed by June 29, 1973, when inspected by the writer):

Unit No.	Cumulative Hours	Availability
1.	20,151	Yes
2.	16,555	No
3.	22,529	Yes
4.	21,921	No
5.	24,077	Yes
6.	26,900	No
7.	27,982	Yes
8.	19,360	No
9.	21,349	Yes
Total	200,824 hrs.	
Av. hours	22,315	

Overall percentage utilization. Based on a full 5 years of operation, continuous use would have amounted to 5 x 8760 = 43,800 hrs. Engines were in operation, therefore, an average of 51% of the time per engine.

Equipment Condition Only five pumping units are operable. Four units are in various stages of disassembly, a condition which has existed for over two months. Engines No.2 and 4 are inoperable due to failure of the gear trains which drive the essential engine auxiliaries. Engines No.6 and 8 are inoperable due to failure of the thrust bearings.

Engines No.1,3,5,7, and 9 are operating but are said to be due for an overhaul. Piston head failures have been experienced periodically on all engines. In this connection, the recent announcement that Nordberg is giving up the manufacture of diesel engines should be noted.

Four pump impellers have been replaced, and two additional impellers are on the pump room floor ready for installation in two more pumps which need new impellers. One of the new impellers to be installed is stainless steel and the other is said to be nickel iron. The four impellers which have been removed are still on the pump room floor. A close inspection and comparison with the new impellers shows that there has been considerable loss of metal due to corrosion. In fact, the vanes have been eaten through completely close to the inlet at the bottom edge. Metal stitching repairs in this area during maintenance prior to removal are still visible in some cases. The impellers show no evidence of cavitation erosion.

It was reported that pump bearings are replaced approximately once a year.

The engines were operating on 100% diesel fuel. It was stated that difficulties had been encountered using digester gas, but that changes had been made and they were about ready to try operating again as dual fuel engines. The five engine generator units were reported to be operating satisfactorily as dual fuel engines using digester gas and pilot oil.

<u>Building Vibrations</u> Vibrations of the building columns and floors were very noticeable throughout the structure. These appeared to

be just as intense at the lowest level as in the engine room. Unbalancing of the pump impellers due to corrosion may be partly responsible.

Evaluation This is a sad state of affairs. The pumping installation must be rated a failure from the standpoint of reliability. With only five engines available for service, the station is incapable of pumping the maximum hourly flow under either design or actually experienced conditions. Even allowing for an increase in capacity to 110 mgd. per unit, it is incapable of pumping the maximum 24 hr. flow. This would require three pumps pumping from each tunnel and only five are available for service.

The maintenance staff is not to blame for this state of affairs. Maintenance has been much more severe than anticipated, and the conditions in industry today are such that replacement parts cannot be obtained off the shelf or in a reasonable time. The shortness of the operating history of this installation with failures undoubtedly accelerating with time has made it impossible to budget a sufficiently large supply of spare parts and manpower to keep eight of these units in operation at all times.

Furthermore, one can only speculate on when additional units will fail.

Peak flows are experienced during and following every heavy rain and periods of intense snow melt. The situation has been handled by the operating staff backing up the sewage and temporarily storing it in the large sewers tributary to the headworks, by utilization of the Detention Facility in Cambridge, bypassing of flows to the East Boston Pumping Station, and occasional use of the diesel engine driven pumps in the old Deer Island Pumping Station.

Effect of Seawater Infiltration Infiltration of seawater through leaking sewers and tidegates has increased the flow tributary to the Columbus Park Headworks by 16.7% over the design average flow and 12.6% over the design maximum hour. Chlorides in the incoming sewage vary with the tide level throughout the day from 600 to 6000 ppm, averaging 2800 ppm. From these figures it can be concluded that the raw sewage contains from 3 to 30% seawater. This has caused difficulties with the operation of the digesters, and, due to the accompanying sulfates in seawater has resulted in an H_2S content in the digester gas of 135 grains per/cu.ft. 100 It should be noted that an H_2S content of 60 grains per 100 cu.ft. is generally considered the maximum in fuel to be used in internal combustion engines.

Seawater is known also to be particularly corrosive, requiring the use of special metals or alloys such as admiralty metal or nickel to avoid excessive corrosion in certain uses. It should be noted that the use of straight seawater for cooling, flushing, gland sealing and chlorine solutions has been discontinued, and the use of process water or plant effluent substituted. The excessive corrosion of the pump impellers is probably due mainly to the large proportion of seawater in the incoming sewage.

Recommendations. As a result of the above considerations resulting from my limited study of this pumping station, I make the following recommendations:

1. That the MDC proceed immediately with the design and installation of an electric motor driven pumping unit in the space provided for Unit No.10. It is recommended that the pump be identical with the existing units and that the motor be located on the floor level immediately above the pump room, and that consideration be given to the installation of a variable speed unit, either a wound rotor motor or a synchronous

motor with a magnetic drive, motors to be direct connected without the use of reduction gears.

2. That a study be undertaken to determine the best program for the progressive replacement of the radial diesel engine drives with electric motors so that all units would be similar to the proposed Unit No.10, with the exception that some units might be constant speed and some variable speed. It is recommended that this study include negotiations with the Boston Edison Co. for furnishing a power supply to the plant adequate for the pumping of peak flows at all times, and that to insure continuity of service the Edison Co. be required to install and maintain gas turbine peaking and standby units at the Deer Island treatment plant.

The study should include the determination of the best method of utilizing the existing engine power plant in conjunction with the purchased power supply under existing conditions. Future power requirements of the enlarged plant for secondary treatment should be considered to the extent warranted by the progress of planning.

3. A survey should be undertaken to determine the source of sea-water infiltration with special attention paid to the condition of existing tide gate structures and a program of remedial measures adopted and prosecuted vigorously to a satisfactory conclusion, following which a system of weekly or semi-monthly inspections should be set up and maintained.

Respectfully submitted,

COMMONWEALTH OF MASSACHUSETTS
ALLEN
J.
BURDOIN
No. 1170
REGISTERED
PROFESSIONAL ENGINEER

Allen J. Burdoin

Allen J. Burdoin

Allen J. Burdoin
CONSULTING ENGINEER

J-2456 July 20, 1973

Memorandum of Telephone Conversation with S.A. Lubetkin, Chief Engineer, Passaic Valley Sewerage Commissioners

Subject: Nordberg Radial Diesel Engines

He is not happy with his two engine driven pumps. They do the job, but the maintenance is terrific. He would not install them again except as standby units, and he plans to put these units on standby to the extent practicable.

He confirmed Ross Crane's comment that it was almost impossible to keep pistons in one of the units, and it costs $900 every time one fails. Pistons are aluminum with steel inserts to form the piston ring grooves and these work loose. Blow-by and carbon buildup on ports results.

The main crank shaft is fabricated construction and it failed. It had to be returned to Nordberg: cost, $15,000. The pump was out of service till they got it back. They were told by Nordberg that they should have checked on this item as part of preventive maintenance. Apparently, it flexes and shows wear. However, it costs $5000 just to inspect it. They have been in touch with the Aluminum Co. which has 120 engines in one plant. Sy did not know of the Aluminum Co. having junked any engines but they also reported heavy maintenance. Their policy on the crankshafts is to wait until they break and then replace them, since it costs practically as much just to inspect them, and Sy has adopted this policy.

Sy had not heard that Nordberg was going to stop building diesel engines.

I told him about the mechanical driven accessories and failure of the gear trains at Deer Island, and he said the scavenging air blowers at Newark Bay P.S. should have been electric driven. They run at variable speed but do not provide sufficient air at maximum speed, and even though centrifugal type, they have a lot of inertia which has caused three shafts to snap. The maximum stress occurs when an engine fails at high speed. Each failure cost in excess of $800.

The Farrel gears furnished with the units were fabricated steel units, welded together, with large openings between the rim and the shaft. I suggested that the AGMA factor of 1.5 perhaps should have been 2.0, but Sy said he thought the trouble was poor fabrication instead, in that his tests indicated that the gears had not been stress relieved after welding. Furthermore, both gears failed at the same number of hours. The replacement gears were heavy cast type, not fabricated. The first one cost $45,000 and the second one $25,000. Their lawsuit re payment of these costs comes up in September. Sy has been unable to obtain any drawings of the gears from Farrel, or the composition of the castings, i.e., whether steel or cast iron, let alone the analysis of the metal.

I suggested that they would have been better off with electric motor driven pumps and standby engine generators of box car design out in the yard. He agreed, and stated that the station would also have been quieter. To meet OSHA regulations, his operators have to wear ear muffs, and Sy stated that they <u>do</u> wear them.

Allen J. Burdoin

APPENDIX C

DEER ISLAND WASTEWATER TREATMENT PLANT - INVENTORY

Note: This Appendix to Technical Data Vol. 10 has not been included in all copies of the report due to the nature of its content. However, in order to acquaint the reader with its content the first sheet of the inventory is included. A complete copy of the inventory is available for review at the Metropolitan District Commission, 20 Somerset Street, Boston, Massachusetts.

Deer Island Treatment Plant
Main Pumping Station

1. <u>Equipment:</u>
   Vertical, Single End Suction, Mixed Flow, Centrifugal Sewage Pumps. Pump No. 1 through 9
   Data taken on No. 8.

   Location:
   Level 1 (Elevation 32.00')

   Manufacturer:
   Allis Chalmers, Size No. 48" x 36", Model. No. 306-073-502, Type SSV, Serial No. 838-1140-3, Impeller Dia.-A-56-in., B-FV, 62,500 GPM @ 105 ft. Hd., 400 RPM

   Equipment Condition:
   In general pumps are in good condition.
   a) Pump bearings are replaced approx. every year.
   b) 4-impellers have been replaced over the past 5 years.
   c) 2-pumps require new impellers. These are on the site and will be installed.
   d) Recorded hours of operation as of 4-19-73:

   Pump #1 - 20,151 hrs.
   Pump #2 - 16,555 hrs.
   Pump #3 - 22,529 hrs.
   Pump #4 - 21,921 hrs.
   Pump #5 - 24,077 hrs.
   Pump #6 - 26,900 hrs.
   Pump #7 - 27,982 hrs.
   Pump #8 - 19,360 hrs.
   Pump #9 - 21.349 hrs.

2. <u>Equipment:</u>
   Two Cycle Radial Dual Fuel Pump Engines Nos.1 through 9
   Data taken on No.4.

   Location:
   Level 16 (Elevation 130.00')